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DYNAMIC QUERY PLANNING AND EXECUTION

Abstract

Embodiments of the disclosed technologies include receiving a first query including at least one first query term and configuring at least one prompt to cause a large language model to translate the at least one first query term into a set of functions that can be executed to obtain at least one second query term and generate and output a plan that is executable to create a modified version of the first query based on the at least one second query term. The plan is obtained by applying the large language model to the at least one prompt as configured. The plan is executed to determine the at least one second query term and create the modified version of the first query. The modified version of the first query is executed to provide, via the user interface, a response to the first query.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present application is a continuation of U.S. patent application Ser. No. 18/429,219 filed Jan. 31, 2024, which claims the benefit under 35 U.S.C. § 119 (e) of U.S. Provisional Patent Application Ser. No. 63/587,393 filed Oct. 2, 2023, each of which is incorporated herein by this reference in its entirety.

TECHNICAL FIELD
[0002] A technical field to which this disclosure relates includes query planning for information retrieval systems.
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BACKGROUND
[0004] A content distribution system is a computer system that is designed to distribute information, such as posts, articles, videos, images, web pages, user profiles, and job postings, to computing devices for viewing and interaction by users of those devices. Examples of content distribution systems include news feeds, social network services, messaging systems, and search engines. An information retrieval system retrieves stored content in response to queries. A chatbot (or chat bot) is a software application that can retrieve content and answer questions by simulating a natural language conversation with a human user.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0005] The disclosure will be understood more fully from the detailed description given below and from the accompanying drawings of various embodiments of the disclosure. The drawings are for explanation and understanding only and should not be taken to limit the disclosure to the specific embodiments shown.
[0006] FIG. **1**A is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.
[0007] FIG. **1**B is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.
[0008] FIG. **2** is a flow diagram of an example method for configuring an input classification prompt using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.
[0009] FIG. **3** is a flow diagram of an example method for configuring a plan generation prompt using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.
[0010] FIG. **4** is a flow diagram of an example method for generating a query plan using

components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0011] FIG. **5**A illustrates an example of at least one user interface flow including a screen capture of a user interface screen for information retrieval using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0012] FIG. **5**B illustrates an example of at least one user interface flow including a screen capture of a user interface screen for information retrieval using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0013] FIG. **6** is a block diagram of a computing system that includes a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0014] FIG. **7**A is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0015] FIG. **7**B is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0016] FIG. **8** is a block diagram of an example computer system including components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0017] Computer systems commonly employ facets and filters to facilitate information retrieval. Filters can be applied during query execution to limit the number of search results that are retrieved. For example, in a search for job candidates, filtering criteria such as geographic location and job title can reduce the size of a result set to profiles of only those candidates who reside in a particular location or have a particular job title in their work history. When filters are applied, typically, the filtered result set is presented to the user instead of the unfiltered set. Thus, filters can help remove irrelevant or unwanted items from the result set. However, if filters are not carefully designed, they can overly restrict the result set, such that relevant or desired items are not presented to the user, sometimes returning no results at all. On the other hand, poorly designed filters can cause the result set to be overinclusive such that many irrelevant items are presented to the user.

[0018] Facets can be applied during query execution to group the items in a result set according to specific categories or attributes and their associated values. For example, if a query specifies a particular job title, then during query execution the results may be grouped by facets such as geographic location, years of experience, and skills. A common way to present facets to the user is to indicate the count of search results that correspond to each facet and facet value; for example: "Location|Bay Area: 100; Greater New York City: 95; Austin, Texas: 85; Experience|10+years' experience: 30; 1-5 years' experience: 200; Skills|Java: 230; Machine Learning: 175," where, in each case, word before the "|" indicates the facet, the words after the "|" indicate the respective facet values found in the search results, and the numerical value indicates the number of items having the respective facet value.

[0019] With facets, the categorical groupings and counts of the number of items in each grouping are determined after a search has been executed and before or while the search results are being presented to the user. Also, the facets are not necessarily mutually exclusive. That is, the same search result can be grouped into multiple different facets. For example, a Java programmer in Austin with 4 years of experience can be grouped under the following facets: location=Austin, Texas, skill=Java, and work experience=1-5 years.

[0020] Traditionally, facets are presented to the user as a set of selectable items such as check boxes, list items, or selectable button-shaped graphics. Typically, the facets are designed to be toggled. This allows users to turn facets on and off to see how the result set changes. As such, facets can provide users with a more explorative or free-flowing search experience that enables the discovery of information about a dataset as well as the specific results in the set.

[0021] However, facets can overwhelm the user if there are too many choices. This can happen with datasets that have many different categorical attributes and associated attribute values. For instance, a geographic location attribute can have thousands or more possible values corresponding to many different cities and towns across the globe. Forcing the user to select each and every facet and/or facet value that they want included in a result set is tedious and time consuming for the user, as well as a potential source of error. Additionally, presenting all of these facets and facet values to the user may not be practical given the technical specifications of the user's computing device. For example, if the user's device has a small form factor, like a smart phone or wearable device, it may be impossible to fit all of the facets on the user's display screen and impractical to require the user to scroll through multiple pages of facets. Another technical problem is that the categorical definitions or meanings of different facets may be very for different users. In a traditional filter selection process, the results displayed would be dependent upon the user's definitions of these terms due because traditional database categorizations of these terms are inflexible. For example, the definition of the term “Fortune 500” is established at the time of system development to encompass a certain set of companies, but this term may have changed in meaning very recently, such that the predefined, static definition (i.e., the original list of companies) has become outdated.
[0022] To address these and other technical challenges, embodiments of the disclosed technologies provide a dynamic query planning system that uses a large language model to automatically select functions, such as functions for determining filters and facets, to be included in a plan for executing a search query based on the user's natural language input, without requiring the user to explicitly select those facets, filters, or other functions. For example, if the user requests “fortune 500 companies on the west coast,” embodiments automatically determine the names of the fortune 500 companies located in Washington, Oregon, and California and add them as facets without requiring the user to explicitly select those company names as query terms.
[0023] Embodiments improve upon conventional information retrieval systems by, for example, removing the need for the user to make explicit facet and/or filter selections, and also by improving the system's interpretation of ambiguous words or phrases in the user's input. For instance, conventional systems receiving user input containing the phrase “fortune 500” would not recognize that phrase as referring to a group of companies and simply include the phrase in the query verbatim, such that the result set would include items that mention the phrase “fortune 500” whether or not the item actually matches a company that is in the Fortune 500.
[0024] Instead of the conventional approach, embodiments of the disclosed technologies can interpret the user's input, “fortune 500,” into the specific names of companies that are in the Fortune 500 and automatically modify the query to include those company names. This enables the information retrieval system to return relevant results without requiring the user to know of the relevant facet values (e.g., all of the names of all of the companies that are in the Fortune 500) (i.e., removing the requirement that the user needs to know the definition of “Fortune 500” and which companies are currently in that list, as well as removing the requirement that the system store and maintain a static definition in a data structure), and without requiring the user to explicitly select all of those facets. This aspect can be particularly helpful for sets of facet values that can frequently change, such as rankings (e.g., top ten colleges for biochemistry, etc.). As another example, if the user selects a facet, embodiments can automatically modify the query to include not only the user-selected facet but also other unselected but related facets, which are obtained via execution of a query plan generated by a large language model. For instance, if the user inputs a request for “engineers with Al experience” and selects “ChatGPT 3.0” as a facet, embodiments can automatically expand the query to include earlier or subsequent versions of ChatGPT (e.g., ChatGPT 3.5, ChatGPT 4.0, etc.) without requiring the user to explicitly identify all of those subsequent versions.
[0025] To accomplish these and other improvements to conventional information retrieval systems, embodiments can dynamically configure a prompt to include instructions to cause one or more

generative artificial intelligence models (e.g., one or more large language models) to generate and output a plan for executing a query. In accordance with the instructions set forth in the prompt, the large language model is to generate a query execution plan that includes a set of functions, where the set of functions are executable using a set of data resources to create a modified version of the initial query. Also in accordance with the instructions set forth in the prompt, the large language model is to select the set of functions in accordance with the user's explicit and/or implicit signals, e.g., the query input by the user and/or the user's history of interactions with the user interface.
[0026] A generative artificial intelligence (GAI) model or generative model uses artificial intelligence technology, e.g., neural networks, to machine-generate new digital content based on model inputs and the previously existing data with which the model has been trained. Whereas discriminative models are based on conditional probabilities P (y|x), that is, the probability of an output y given an input x (e.g., is this a photo of a dog?), generative models capture joint probabilities P (x, y), that is, the likelihood of x and y occurring together (e.g., given this photo of a dog and an unknown person, what is the likelihood that the person is the dog's owner, Sam?).
[0027] A generative language model is a particular type of GAI model that is capable of generating new text in response to model input. The model input includes a task description, also referred to as a prompt. The task description can include instructions and/or examples of digital content. A task description can be in the form of natural language text, such as a question or a statement, and can include non-text forms of content, such as digital imagery and/or digital audio.
[0028] Given a task description, a generative model can generate a set of task description-output pairs, where each pair contains a different output. In some implementations, the generative model assigns a score to each of the generated task description-output pairs. The output in a given task description-output pair contains text that is generated by the model itself rather than provided to the model as an input. The score associated by the model with a given task description-output pair represents a probabilistic or statistical likelihood of there being a relationship between the output and the corresponding task description in the task description-output pair. The score for a given task description-output pair is dependent upon the way the generative model has been trained and the data used to perform the model training. The generative model can sort the task description-output pairs by score and output only the pair or pairs with the top scores. For example, the generative model could discard the lower-scoring pairs and only output the top-scoring pair as its final output.
[0029] A large language model (LLM) is a type of generative language model that is trained in an unsupervised way on massive amounts of unlabeled data, such as publicly available texts extracted from the Internet, using deep learning techniques. A large language model can be configured to perform one or more natural language processing (NLP) tasks, such as generating text, classifying text, answering questions in a conversational manner, and translating text from one language to another.
[0030] However, large language models have technical challenges including hallucination and latency. In artificial intelligence, a hallucination is often defined as model output, e.g., generated content, that diverges from the model input, e.g., is nonsensical, incorrect, or unrelated to the provided input. If the model input is not clearly defined or is repetitive, the risk of AI hallucination increases. Additionally, large language models consume large amounts of computing resources and as such can introduce nontrivial amounts of latency into the information retrieval pipeline. As a result of these and other concerns, it is a technical challenge to incorporate the use of LLMs and/or other GAI models into the operational flows of an information retrieval system while mitigating the risks of, e.g., AI hallucination and latency.
[0031] Another technical challenge is how to reduce the burden of user input when processing and executing queries; for example, how to reduce the need for the user to explicitly select facets. Yet another technical challenge is how to scale a GAI-based query planning system to a large number of users (e.g., hundreds of thousands to millions or more users of an Internet-based information

retrieval system) without needing to increase the size of the system linearly. An additional technical challenge is how to configure a GAI-based query planning system efficiently over a variety of user devices, e.g., adapting the inputs to and outputs of the GAI-based system to different applications and/or to different form factors of user devices, e.g., different sizes of display screens, different device types, different operating systems, etc.

[0032] To address these and other technical challenges, embodiments of the disclosed technologies can dynamically constrain the output of a GAI model by providing the GAI model with instructions (e.g., statements, questions, examples, conditions, and/or constraints) that are configured based on the most recent current context. As an example, the disclosed technologies may generate a prompt that instructs the GAI model to develop a plan with a constraint that the query should not include more than a certain maximum number of facets. If, based on subsequent context data such as zero results returned or user feedback indicating that the user did not view any items in the result set, the disclosed technologies can dynamically modify the prompt to, for example, increase or decrease the maximum number of facets specified in the constraint, in accordance with the subsequent context data. As another example, embodiments can dynamically select or omit certain prompt portions (e.g., include or omit certain instructions), or dynamically change the prompt type (e.g., switch from a few-shot prompt to a zero-shot prompt or from a chain-of-thought prompt to a few-shot prompt) in response to changes in performance metrics associated with large language model, availability of data resources, and/or other context data.

[0033] Alternatively or in addition, embodiments dynamically manage communications with the one or more GAI models to address latency and/or other performance issues associated with a computing system or network. For example, the disclosed technologies may assign weights to data sources based on performance metrics associated with the data sources. Based on subsequent context data such as the user abandoning a search due to high latency, the disclosed technologies can dynamically modify the prompt to instruct the GAI model to increase or decrease the weights so that high latency data sources can be excluded from the plan and other data sources may be included in the plan, in accordance with the subsequent context data.

[0034] Further additionally and/or alternatively, embodiments can configure one or more prompts to cause a GAI model to generate a query execution plan that can be executed by, e.g., the information retrieval system, to perform query expansion on the user's input. In other words, whereas prior techniques may simply instruct a GAI model to output additional query terms based on a model input (i.e., the GAI model itself generates and outputs the additional terms), embodiments of the disclosed technologies instead prompt the GAI model to generate a query execution plan that can be executed by, e.g., the information retrieval system, to obtain additional terms that can be added to the query (i.e., the GAI model outputs a plan that can be executed by the information retrieval system to obtain the additional terms from one or more data resources).

[0035] Whereas prior techniques may utilize a GAI model (e.g., a large language model) to generate additional query terms for query enhancement, those prior techniques suffer from the problems discussed above, including AI hallucination and latency issues. For instance, using a GAI model to generate additional query terms can result in multiple calls to the GAI model just to perform query enhancement for a single query. Also, multiple calls to the GAI model, or calls without context-adjusted constraints, can cause the GAI model to output query terms that aren't relevant or helpful at all.

[0036] By contrast, the disclosed approach can reduce the number of calls to the GAI model by using the GAI model to generate a query execution plan, rather than merely using the GAI model to generate additional query terms. Of course, the query execution plan produced by the GAI model could include a function that calls a GAI model to obtain additional query terms from the GAI model, but, according to the disclosed technologies, the inclusion of such a function in the plan, or the execution of that function, can be conditioned on the availability of the GAI model and other performance metrics associated with the GAI model.

[0037] Certain aspects of the disclosed technologies are described in the context of generative artificial intelligence models that receive text input and output text. However, the disclosed technologies are not limited to generative models that receive text input and produce text output. For example, aspects of the disclosed technologies can be used to receive input and/or generate output that includes non-text forms of content, such as digital imagery, videos, multimedia, audio, hyperlinks, and/or platform-independent file formats.
[0038] Certain aspects of the disclosed technologies are described in the context of electronic dialogs conducted via a network with at least one information retrieval system, such as a message- or chat-based information retrieval system or a search service of an online system such as a social network system. However, aspects of the disclosed technologies are not limited to message- or chat-based information retrieval systems or social network services, but can be used to improve various types of applications. Any network-based application can act as an application to which the disclosed technologies can be applied. For example, news, entertainment, and e-commerce apps installed on mobile devices, enterprise systems, messaging systems, notification systems, search engines, workflow management systems, collaboration tools, and social graph-based applications can all function as applications with which the disclosed technologies can be used.
[0039] The disclosure will be understood more fully from the detailed description given below, which references the accompanying drawings. The detailed description of the drawings is for explanation and understanding, and should not be taken to limit the disclosure to the specific embodiments described.
[0040] In the drawings and the following description, references may be made to components that have the same name but different reference numbers in different figures. The use of different reference numbers in different figures indicates that the components having the same name can represent the same embodiment or different embodiments of the same component. For example, components with the same name but different reference numbers in different figures can have the same or similar functionality such that a description of one of those components with respect to one drawing can apply to other components with the same name in other drawings, in some embodiments.
[0041] Also, in the drawings and the following description, components shown and described in connection with some embodiments can be used with or incorporated into other embodiments. For example, a component illustrated in a certain drawing is not limited to use in connection with the embodiment to which the drawing pertains, but can be used with or incorporated into other embodiments, including embodiments shown in other drawings.
[0042] As used herein, dialog, chat, or conversation may refer to one or more conversational threads involving a user of a computing device and an application. For example, a dialog or conversation can have an associated user identifier, session identifier, conversation identifier, or dialog identifier, and an associated timestamp. Thread as used here may refer to one or more rounds of dialog involving the user and an application. A round of dialog as used herein may refer to a user input and an associated system-generated response, e.g., a reply to the user input that is generated at least in part via a generative artificial intelligence model. Any dialog or thread can include one or more different types of digital content, including natural language text, audio, video, digital imagery, hyperlinks, and/or multimodal content such as web pages.
[0043] FIG. **1**A is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.
[0044] The method is performed by processing logic that includes hardware (e.g., processing device, circuitry, dedicated logic, programmable logic, microcode, hardware of a device, integrated circuit, etc.), software (e.g., instructions run or executed on a processing device), or a combination thereof. In some embodiments, the method is performed by components of dynamic query planning system **110**, including, in some embodiments, components or flows shown in FIG. **1**A that may not

be specifically shown in other figures and/or including, in some embodiments, components or flows shown in other figures that may not be specifically shown in FIG. **1**A. Although shown in a particular sequence or order, unless otherwise specified, the order of the processes can be modified. Thus, the illustrated embodiments should be understood only as examples, and the illustrated processes can be performed in a different order, and some processes can be performed in parallel. Additionally, at least one process can be omitted in various embodiments. Thus, not all processes are required in every embodiment. Other process flows are possible.

[0045] In FIG. **1**A, an example computing system **100** is shown, which includes an example dynamic query planning system **110**. In the example of FIG. **1**A, the components of the dynamic query planning system **110** are implemented using an application server or server cluster, which can include a secure environment (e.g., secure enclave, encryption system, etc.) for the processing of data. In other implementations, one or more components of the dynamic query planning system **110** are implemented on a client device, such as a user system **610**, described herein with reference to FIG. **6**, running an application **102**. For example, some or all of dynamic query planning system **110** is implemented directly on the user's client device in some implementations, thereby avoiding the need to communicate with servers over a network such as the Internet. In some implementations, the dynamic query planning system **110** is in bidirectional communication with one or more applications **102** via a computer network. The one or more applications **102** include front end user interface functionality that, in some embodiments, is considered part of or is in communication with dynamic query planning system **110**.

[0046] In the embodiment of FIG. **1**A, the dynamic query planning system **110** includes an input classification prompt generator **112**, a plan generation prompt generator **120**, and an executor **126**. A large language model **116** can be part of the dynamic query planning system **110** or a separate component. For example, the large language model **116** can be hosted by an AI model service, such as AI model service **690** described herein with reference to FIG. **6**. Data resources **134** can be part of the dynamic query planning system **110** or separate components. For example, data resources **134** can be part of data resources **650** described herein with reference to FIG. **6**.

[0047] Prompt as used herein may refer to one or more instructions that are readable by a GAI model, such as large language model **116**, along with the input to which the GAI model is to apply the instructions, and a set of parameter values that constrain the operations of the GAI model during the processing of the prompt and generating and outputting a response to the prompt. The input can include user input and/or context data. The input can be specified explicitly in the prompt or as a reference that is processed at execution time. The instructions can include one or more statements, questions, conditions, constraints, or examples. The examples can include examples of the types of output to be produced by the GAI model and/or examples of the types of processing steps the large language model is to perform in order to generate output. The parameter values contained in the prompt can be specified by the GAI model and may be adjustable in accordance with the requirements of a particular design or implementation. Examples of parameter values include the maximum length or size of the prompt and the temperature, or degree to which the model produces deterministic output versus random output. The way in which the elements of the prompt are organized and the phrasing used to articulate the prompt elements can significantly affect the output produced by the GAI model in response to the prompt. For example, a small change in the prompt content or structure can cause the GAI model to generate a very different output.

[0048] The input classification prompt generator **112** configures an input classification prompt for input to large language model **116**. The input classification prompt includes one or more instructions that can be input to the large language model **116**, such that when the large language model **116** reads and processes the instructions, the large language model **116** translates the user input (e.g., first query **106** received via user interface mechanism **104** of application **102**) and/or associated context data (e.g., context data **108**) into a corresponding intent and outputs the intent.

Intent as used herein may refer to a structured representation of a user input such as the first query **106**. An example of a structured representation of a user input includes a canonical representation of an action (e.g., job_search, people_search), and at least one attribute value associated with the action (e.g., search criteria). For instance, if the user input is “find backfill for Amelia,” a corresponding intent that could be output by the large language model **116** in response to the input classification prompt provided by the input classification prompt generator **112** is people_search (Amelia).

[0049] Examples of context data **108** include data logged during the user's use of a particular application **102**, such as data input, output, or interacted with, the timestamp at the user's login in to the application, and actions taken by the user during the login session, including implicit and/or explicit user interactions with the application's user interface elements. Alternatively or in addition, context data may refer to historical data logged during the user's prior uses of the application and/or aggregate data that represents usage statistics across a group or population of users of the application **102**. For example, context data **108** can include implicit signals such as a count of the number of times suggestions or insights have been presented to the user, the number of times users acted upon suggestions or insights provided by the system, the latency in the user's response to a suggestion or insight. As another example, context data **108** can include explicit signals such as explicit social reactions (e.g., thumbs-up, thumbs-down, comments, shares, follows) and/or other explicit or implicit feedback signals. Context data **108** can be included in the input classification prompt **114** as an input along with an instruction to cause the large language model **116** to determine the input classification **118** based on the context data **108**.

[0050] In some implementations, the input classification prompt generator **112** configures the input classification prompt as a zero-shot prompt. As used herein, zero-shot prompt may refer to a type of large language model prompt that does not include any examples, e.g., the prompt only includes an input and a task description that does not include any examples to guide the large language model as to how to perform the task. An example of a zero-shot input classification prompt that can be generated by the input classification prompt generator **112** is “classify the user input [input1] into job_search, people_search, or company_search,” where [input1] is a placeholder for the user input and/or associated context data and job_search, people_search, and company_search are the possible intents into which the large language model may classify input1.

[0051] In some implementations, the input classification prompt generator **112** configures the input classification prompt as a few-shot prompt that includes examples of input classifications along with an instruction to cause the large language model to follow the examples when processing a new input. An example of a few-shot prompt that can be generated by the input classification prompt generator **112** is “‘software engineering’.fwdarw.job_search; ‘fill’.fwdarw.job_candidate_search; what is the intent of [input1]?” where input1 includes the user input (e.g., first query **106**) and/or context data **108**.

[0052] While not specifically shown in the drawings, in some implementations, the input classification prompt generator **112** does not use the large language model **116** to perform input classification. For example, input classification prompt generator **112** could be configured to formulate a feature set for input to a classical machine learning model (e.g., a binary classifier) or to apply a set of heuristics to the user input (e.g., first query **106**) and associated context data, instead of formulating the LLM prompt. For instance, depending upon performance metrics associated with the large language model **116**, the input classification prompt generator **112** could use one of these and/or other alternative techniques, instead of the large language model **116**, for translating the user input (e.g., first query **106**) into an intent.

[0053] In the example of FIG. **1**A, the input classification prompt generator **112** outputs an input classification prompt **114** for input to the large language model **116**. An example method that may be performed by the input classification prompt generator **112** is shown in more detail in FIG. **2**, described below. In response to and based on the input classification prompt **114**, the large language model **116** reads and processes the input classification prompt **114**, translates the user input (e.g., first query **106**) into an intent, and outputs the intent as input classification **118**.

[0054] The plan generation prompt generator **120** configures a plan generation prompt **122** based on the input classification **118** produced by the large language model **116**. The plan generation prompt **122** is designed to cause the large language model **116** to generate and output a query execution plan. A query execution plan includes a set of functions which can be executed by executor **126** to create a modified version of the user input (e.g., a modified version of first query **106**). For example, a query execution plan can include a set of functions that retrieve data from multiple different data resources **134** and incorporate at least some of that retrieved data into the modified version of the user input. Examples of functions that can be included in the set of functions selected by the large language model **116** to be included in the plan **124**, based on the plan generation prompt **122**, include a function to retrieve entity data related to the first query **106** using a taxonomy (e.g., retrieve facet values), to retrieve entity data related to the first query **106** using an entity graph (e.g., to retrieve facet values, facets, or filters), to execute a client application command related to the first query **106**, to execute a server command related to the first query **106**, to cause a generative model to generate and output content related to the first query **106**, or to cause a generative model to generate and output at least one embedding related to the first query **106**.

[0055] In some implementations, the plan generation prompt generator **120** configures the plan generation prompt **122** as a few-shot prompt. A few-shot prompt as used herein may refer to a type of large language model prompt that includes an input and an instruction, where the instruction includes one or more examples, e.g., demonstrations of the type of output the large language model is to produce based on the input. For instance, the few-shot prompt could include one or more examples of query execution plans that have been generated based on other inputs and an instruction to generate a query execution plan based on the current user input and the one or more examples.

[0056] In some implementations, the plan generation prompt generator **120** configures the plan generation prompt **122** as a chain-of-thought prompt. A chain-of-thought prompt as used herein may refer to a type of large language model prompt that includes an input and an example of the types of steps the large language model is to perform; for example, intermediate steps or reasoning. For example, the chain-of-thought prompt could include examples that illustrate to the large language model examples of how to select functions or logical groupings of functions to be included in the query execution plan.

[0057] In some implementations, the plan generation prompt generator **120** configures the plan generation prompt **122** as multi-step prompt, for example using prompt chaining. Prompt chaining as used herein may refer to a series of prompts or a prompt that includes an ordered set of sub-prompts, where each prompt or sub-prompt is to cause the large language model to perform a smaller or discrete step of the overall process of generating a query execution plan.

[0058] In some implementations, the plan generation prompt generator **120** configures the plan generation prompt **122** as a zero-shot prompt. For example, if the input classification **118** indicates that only a single function needs to be performed to resolve the intent or the intent maps to a predetermined plan that does not need to be modified or configured, then a zero-shot prompt may be used.

[0059] In the example of FIG. **1**A, the plan generation prompt generator **120** outputs the plan generation prompt **122** for input to the large language model **116**. An example method that may be performed by the plan generation prompt generator **120** is shown in more detail in FIG. **3**, described below. In response to and based on the plan generation prompt **122**, the large language model **116** reads and processes the plan generation prompt **122**, selects a set of functions, and generates and outputs the query execution plan **124**, which includes the selected set of functions. An example method that may be performed by the large language model **116** in processing the plan generation prompt **122** is shown in more detail in FIG. **4**, described below.

[0060] In some instances or iterations, the plan generation prompt generator **120** is not used (e.g., skipped) and the large language model **116** is not used to generate a query execution plan. For example, in instances or iterations in which the input classification (e.g., intent) **118** is unambiguous and/or does not require execution of more than one function for resolution, the executor **126** can formulate the modified version of the user input directly based on the input classification **118** without needing to execute a plan.
[0061] The executor **126** executes the plan **124** to translate the user input (e.g., first query **106**) to a modified version of the user input (e.g., a modified version of first query **106**). For example, the executor **126** executes a set of functions contained in the plan **124** according to an order of execution specified in the plan **124** to obtain at least one second query term **128** from one or more data resources **134**, formulates a second query **130** based on or including the at least one second query term **128**, executes the second query **130** using one or more of the data resources **134** to obtain query results **132**, formulates a response and/or commands **150** based on the query results **132**, and provides the response and/or commands **150** to the application **102**. For example, the executor **126** executes the plan to query one or more of the data resources **134** to obtain facet values and includes those facet values in the second query **130**. The executor **126** then executes the second query **130**, which is a modified version of the first query **106** (e.g., an expanded version of the first query **106** that includes the facet values retrieved from the one or more data resources **134**), to obtain the query results **132** and formulate the response and/or commands **150**.
[0062] A benefit of executing the plan is that if the system were to only process the initial query without creating and executing the plan as described herein, the system would not return all of the relevant results, e.g., those candidates that are responsive to the search for backfill for Amelia. The lack of relevant results causes additional search query iterations between the user and the system, or potentially causes the user to completely abandon the search without obtaining the desired information. Thus, the modification of the query using the plan generation and execution approach described improves the relevance and completeness of the information retrieved and provided in the result set, e.g., the list of candidates who would be best suited to backfill Amelia's positions, and also improves the efficiency and reliability of the search system.
[0063] Examples of responses that can be formulated by executor **126** as a result of executing the plan **124** include job search results related to the first query **106**, job candidate search result related to the first query **106**, entity profile pages related to the first query, blog pages related to the first query **106**, learning content items related to the first query **106**, and/or recommendations to improve the first query **106**. Examples of commands that can be formulated by executor **126** as a result of executing the plan **124** include at least one command to modify a component of the user interface of application **102** as a result of execution of the plan **124**, to navigate to a content item or component via the user interface of application **102** as a result of execution of the plan **124**, to populate a component of the user interface of application **102** with information obtained as a result of execution of the plan **124**, to store information created at the user interface of application **102** as a result of execution of the plan **124**, to send an electronic communication to at least one second user of the application **102** identified as a result of execution of the plan **124**, and/or to schedule an action to be performed by the application **102** as a result of execution of the plan **124**.
[0064] The data resources **134** include, for example, entity profile data **136** (e.g., user profiles data, company profiles, job postings, etc.), activity data **138** (e.g., historical interaction data such as search histories, chat histories, and/or interaction histories associated with the user's use of application **102**), electronic documents **140**, including documents and other content items that are accessible via Internet search engines, such as web pages and multimedia content, taxonomies, data stores, services, or artificial intelligence models **142**, entity graphs and knowledge graphs **144**, applications **146**, such as other vertical applications and/or external applications which may be in communication with application **102**, and metrics **148**, such as performance metrics associated with the large language model **116** or any of the data resources **134**. Entity profile data **136** includes, for

example, current and/or historical attribute data associated with the user (e.g., user preferences and/or biographical data such as skills, work experiences, and education history) or another entity associated with the user (such as a company or a computing resource), which may be logged by event logging service **670** and/or stored in entity data store **662**, described below with reference to FIG. **6**. Activity data **138** includes, for example, current and/or historical user interaction data logged by event logging service **670** and/or stored in activity data store **664**, described below with reference to FIG. **6**. Entity graphs and knowledge graphs **144** include, for example, current and/or historical data that describe various relationships between or among different entities in a social graph. For example, entity graphs and knowledge graphs **144** can include one or more portions of entity graph **632** and/or knowledge graph **634**, described below with reference to FIG. **6**.

[0065] Large language model **116** includes one or more neural network-based machine learning models. In some implementations, large language model **116** is constructed using a neural network-based deep learning model architecture. In some implementations, the neural network-based architecture includes one or more input layers that receive model inputs, generate one or more embeddings based on the model inputs, and pass the one or more embeddings to one or more other layers of the neural network. In other implementations, the one or more embeddings are generated based on the model input by a pre-processor, the embeddings are input to the neural network model, and the neural network model generates output based on the embeddings.

[0066] In some implementations, the neural network-based machine learning model architecture includes one or more self-attention layers that allow the model to assign different weights to portions of the model input. Alternatively or in addition, the neural network architecture includes feed-forward layers and residual connections that allow the model to machine-learn complex data patterns including relationships between different portions of the model input in multiple different contexts. In some implementations, the neural network-based machine learning model architecture is constructed using a transformer-based architecture that includes self-attention layers, feed-forward layers, and residual connections between the layers. The exact number and arrangement of layers of each type as well as the hyperparameter values used to configure the model are determined based on the requirements of a particular design or implementation of the dynamic query planning system **110**.

[0067] In some examples, the neural network-based machine learning model architecture includes or is based on one or more generative transformer models, one or more generative pre-trained transformer (GPT) models, one or more bidirectional encoder representations from transformers (BERT) models, one or more large language models (LLMs), one or more XLNet models, and/or one or more other natural language processing (NL) models. In some examples, the neural network-based machine learning model architecture includes or is based on one or more predictive text neural models that can receive text input and generate one or more outputs based on processing the text with one or more neural network models. Examples of predictive neural models include, but are not limited to, Generative Pre-Trained Transformers (GPT), BERT, and/or Recurrent Neural Networks (RNNs). In some examples, one or more types of neural network-based machine learning model architectures include or are based on one or more multimodal neural networks capable of outputting different modalities (e.g., text, image, sound, etc.) separately and/or in combination based on textual input. Accordingly, in some examples, a multimodal neural network implemented in the dynamic query planning system is capable of outputting digital content that includes a combination of two or more of text, images, video or audio.

[0068] In some implementations, large language model **116** is trained on a large dataset of digital content such as natural language text, images, videos, audio files, or multi-modal data sets. For example, training samples of digital content such as natural language text extracted from publicly available data sources are used to train one or more generative models used by the dynamic query planning system. The size and composition of the datasets used to train one or more models used by the dynamic query planning system can vary according to the requirements of a particular design or implementation of the dynamic query planning system. In some implementations, one or more of the datasets used to train one or more models used by the dynamic query planning system includes hundreds of thousands to millions or more different training samples.

[0069] In some embodiments, one or more models used by the dynamic query planning system include multiple generative models trained on differently sized datasets. For example, a dynamic query planning system can include a comprehensive but low capacity generative model that is trained on a large data set, and the same generative model also can include a less comprehensive but high capacity model that is trained on a smaller data set, where the high capacity model is used to generate outputs based on examples obtained from the low capacity model. In some implementations, reinforcement learning is used to further improve the output of one or more models used by the dynamic query planning system. In reinforcement learning, ground-truth examples of desired model output are paired with respective inputs, and these input-example output pairs are used to train or fine tune one or more models.

[0070] In an illustrative example of an operation of the dynamic query planning system **110**, a user interacting with application **102** inputs a first query **106** of “find backfill for Amelia” into a chat-style input box **104**. The dynamic query planning system **110** receives the first query **106** and associated context data **108** (e.g., the name, type, or identifier of the application **102**). The input classification prompt generator **112** generates and outputs an input classification prompt **114** that instructs the large language model **116** to classify the first query **106** based on the text of the query and the application identifier. The large language model **116** outputs an input classification **118** of Candidate_Search (Amelia), indicating that the large language model **116** has translated “find backfill” as an intent to search for job candidates.

[0071] The plan generation prompt generator **120** configures a prompt that instructs the large language model **116** to create a plan to find job candidates similar to Amelia. The specific context of looking for job candidates can be determined based on the application identifier, which may indicate that the application **102** is an application that allows users to search for job candidates. The large language model **116** outputs a plan **124** that includes a set of functions arranged in an order of execution, as needed, such that the output of one function can be used as an input to another function if needed. For example, to resolve the intent of Candidate_Search (Amelia), the executor **126** executes a set of functions to determine the user identifier associated with Amelia, obtain Amelia's profile page, extract relevant information such as job title and skills from Amelia's profile page, generate a job description based on one or more of the extracted skills (possibly using the large language model **116** to generate the job description text based on the information extracted from Amelia's profile page), and then search for job candidates that match Amelia's job title, skills, and/or the generated job description.

[0072] In generating the final candidate search query (e.g., second query **130**), the original input is modified to include one or more second query terms **128**, e.g., facets such as particular skills and/or filters such as particular job titles and/or particular search criteria such as a job description. In doing so, the executor **126** may obtain the additional facets, filters, and/or search criteria from one or more of the data resources **134**. For example, executor **126** may query the entity graph and knowledge graph **144** or data stores or taxonomies **142** to obtain related skills.

[0073] Based on the results of executing the second query **130** against, e.g., a database of job candidates, the query results **132** are obtained and used to formulate the response and/or commands **150**. For example, the response and/or commands **150** includes a listing of relevant job candidates **152** that has been generated based on the execution of the second query **130** and an insight or recommendation **154** that has been subsequently generated based on the user's interactions with the listing **152**. For example, subsequent context data **108** including interaction data logged in response to the presentation of the search results **152** is used to generate the insight or recommendation **154**.

[0074] The examples shown in FIG. **1**A and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples. Additional or alternative details and implementations are described herein.

[0075] FIG. **1**B is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0076] The method is performed by processing logic that includes hardware (e.g., processing device, circuitry, dedicated logic, programmable logic, microcode, hardware of a device, integrated circuit, etc.), software (e.g., instructions run or executed on a processing device), or a combination thereof. In some embodiments, the method is performed by components of dynamic query planning system **110**, including, in some embodiments, components or flows shown in FIG. **1**B that may not be specifically shown in other figures and/or including, in some embodiments, components or flows shown in other figures that may not be specifically shown in FIG. **1**B. Although shown in a particular sequence or order, unless otherwise specified, the order of the processes can be modified. Thus, the illustrated embodiments should be understood only as examples, and the illustrated processes can be performed in a different order, and some processes can be performed in parallel. Additionally, at least one process can be omitted in various embodiments. Thus, not all processes are required in every embodiment. Other process flows are possible.

[0077] In FIG. **1**B, an example computing system **160** is similar or identical to the computing system **100**, except that FIG. **1**B illustrates the dynamic nature of the dynamic query planning system **110** in terms of how the dynamic query planning system **110** automatically generates different prompts and different corresponding query execution plans using, potentially, different data resources, in response to different combinations of user input and/or context data.

[0078] In the illustrative example of FIG. **1**B, a user interacting with application **102** inputs a first query **164** of “west coast fortune 500 software engineers” into a chat-style input box **162**. The dynamic query planning system **110** receives the first query **164** and associated context data **165** (e.g., the name, type, or identifier of the application **102** and/or interaction history data such as a previous search query). The input classification prompt generator **112** generates and outputs an input classification prompt **166** that instructs the large language model **116** to classify the first query **164** based on the text of the query and the associated context data **165**, such as the application identifier. The large language model **116** outputs an input classification **168** of Job_Search (“west coast fortune 500 software engineers”), indicating that the large language model **116** has translated “west coast fortune 500 software engineers” into an intent to search for jobs for software engineers, where the jobs have been posted by west coast fortune 500 companies. For example, if the application identifier indicates that the user has navigated to the job search application, this information can be used as an input that is provided to the large language model **116** as part of the input classification prompt **166**.

[0079] The plan generation prompt generator **120** configures a plan generation prompt **172** that instructs the large language model **116** to create a plan to find west coast Fortune 500 companies that are hiring software engineers. The large language model **116** outputs a plan **174** that includes a set of functions arranged in an order of execution, as needed, such that the output of one function can be used as an input to another function if needed. For example, to resolve the intent of Job_Search(“west coast fortune 500 software engineers”), the executor **126** executes a set of functions to disambiguate “west coast,” disambiguate “fortune 500,” find the intersection of the set of west coast companies and Fortune 500 companies, query a jobs database for job postings for software engineers at the west coast Fortune 500 companies, and generate a summary of the search results (possibly using the large language model **116** to summarize, for the user, the search results or individual job postings).

[0080] In generating the final job search query (e.g., second query **180**), the original user input is modified to include one or more second query terms **178**, e.g., facets such as particular skills associated with software engineering and/or filters such as particular company names. In doing so, the executor **126** may obtain the additional facets, filters, and/or search criteria from one or more of the data resources **176**. For example, executor **126** may query an external data source **142**, such as Internet web pages, to obtain a list of Fortune 500 companies, and/or search a knowledge graph **144** to determine which of those Fortune 500 companies are located on the west coast. The data resources **176** used by executor **126** to execute the plan **174** can be selected and included in the plan **174** by the large language model **116** based on the input classification **168** and/or other factors, such as performance metrics or availability of the data resources. The data resources **176** used to process and execute the first query **164** can be different from the data resources **134** used to process and execute the first query **106** of the example of FIG. **1**A.

[0081] Based on the results of executing the second query **180** against, e.g., a database of job postings, the query results **182** are obtained and used to formulate the response and/or commands **183**. For example, the response and/or commands **183** includes a listing of relevant job postings **184** that has been generated based on the execution of the second query **180** and an explanation **186** of how the dynamic query planning system **110** formulated the second query **180**.

[0082] For example, the list of job postings **184** includes a restatement of the user's original input (e.g., first query **164**), and presents the list of facets **188** that were automatically selected by the executor **126**, for review and verification by the user. If the restatement and/or facet selections are incorrect, the user can click on the thumbs-down feedback mechanism **190** to register the feedback with the dynamic query planning system **110** (which can be added to the context data **165** for subsequent query iterations) and proceed to modify the query by unselecting facets that were automatically selected by the dynamic query planning system **110** and/or selecting other facets that were not automatically selected by the dynamic query system. In other words, the user does not have to review or scroll through the search results in order to figure out whether the dynamic query planning system **110** correctly interpreted their input. If the dynamic query planning system **110** correctly interpreted the user's input, the user can click on the thumbs-up feedback mechanism **190** to provide the feedback to the query planning system **110** for inclusion in the context data **165** for subsequent query iterations, and/or review the list of search results. The list of search results **184** has been curated and summarized by the executor **126** executing the query execution plan **174** provided by the large language model **116**. For example, the job postings are grouped by facet value (e.g., company name) and a count of the number of job postings associated with each facet value is provided.

[0083] The examples shown in FIG. **1**B and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples. Additional or alternative details and implementations are described herein.

[0084] FIG. **2** is a flow diagram of an example method for configuring an input classification prompt using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0085] The method is performed by processing logic that includes hardware (e.g., processing device, circuitry, dedicated logic, programmable logic, microcode, hardware of a device, integrated circuit, etc.), software (e.g., instructions run or executed on a processing device), or a combination thereof. In some embodiments, the method is performed by components of dynamic query planning system **110**, including, in some embodiments, components or flows shown in FIG. **2** that may not be specifically shown in other figures and/or including, in some embodiments, components or flows shown in other figures that may not be specifically shown in FIG. **2**. Although shown in a particular sequence or order, unless otherwise specified, the order of the processes can be modified. Thus, the illustrated embodiments should be understood only as examples, and the illustrated processes can be performed in a different order, and some processes can be performed in parallel. Additionally, at least one process can be omitted in various embodiments. Thus, not all processes are required in every embodiment. Other process flows are possible.

[0086] In FIG. **2**, an embodiment of intent classification prompt generator **112** is shown as intent classification prompt generator **200**. Intent classification prompt generator **200** includes a configure

input classification prompt component **206**, an intent library **212**, and a classification instruction library **220**. Configure input classification prompt component **206** includes a determine possible intents executable component **208**, a select instruction(s) executable component **216**, and a configure prompt including the instructions and possible intents executable component **224**. The intent library **212** and the classification instruction library **220** are included in data resources **650**, or are part of AI model service **690**, or are stored in one or more data stores of data storage system **660**, described herein with reference to FIG. **6**.
[0087] Intent library **212** stores N templatized intents, and associated metadata, such as contexts with which each intent is associated. As used herein, N may represent a positive integer whose value is determined based on the requirements or design of a particular implementation, and the value of N can be different in different instances. For instance, the total number of N intents can be different than a total number of N contexts or instructions. Intent library **212** can include an index that maps intents with associated contexts. In the example of FIG. **2**, context examples can be denoted as C1, C2 . . . . CN. For instance, both Intent1 and IntentN map to the context C1, and each of the intents Intent1, Intent2, IntentN maps to more than one context, although this need not be the case.
[0088] Classification instruction library **220** stores N templatized large language model instructions, which can be used as building blocks or components of an input classification prompt configured for input to large language model **116**. For instance, the instructions contained in classification instruction library **220** pertain to the large language model task of input classification. Instruction as used herein includes various possible types of instructions or portions of instructions, such as statements, questions, examples, conditions, and constraints, which can be used to formulate a large language model prompt for input classification. Instruction can also refer to a set or logical grouping of instructions, such as a series of statements or a combination of statements and examples or a combination of conditions and examples. In the example of FIG. **2**, instruction examples can be denoted instructionN:pN where instruction represents the particular instruction and its associated metadata (e.g., instruction type, such as statement, question, example, condition, or constraint), and each p represents a parameter or argument that the instruction uses as input or to which the instruction can be applied. For instance, each of StatementN, QuestionN, and ConstraintN use the parameter p1, and each of the instructions includes more than one parameter, although this need not be the case.
[0089] In operation, configure input classification prompt component **206** receives user input **202** and context data **204** from an application or client device (e.g., application **102**). Determine possible intents component **208** formulates an intent query **210** including the user input **202** and context data **204** as parameters. The intent query **210** is executed against the intent library **212**. Based on the intent query **210**, a set of one or more possible intents **214** that match the intent query **210** are returned to the determine possible intents component **208**. The possible intents **208** are a subset of the templatized intents that are selected from the intent library **212** as relevant to the user input **202** and context data **204** based on the intent query **210**. The possible intents **208** are included in the input classification prompt **226** so that when the large language model **116** reads and processes the input classification prompt **226**, the processing performed by the large language model **116** is constrained to the possible intents **208** that are relevant for the user input **202** and the context data **204**. For instance, when the large language model processes the input classification prompt **226**, the large language model **116** does not have to select an intent from the entire intent library **212** but only from the relevant subset of possible intents **214**.
[0090] Select instructions component **216** formulates an instruction query **218** including the user input **202**, context data **204**, and possible intents **214** as parameters. The instruction query **218** is executed against the classification instruction library **220**. Based on the instruction query **218**, a set of one or more selected instructions that match the instruction query are returned to the select instructions component **216**. The selected instructions **222** are a subset of the templatized

instructions that are selected from the classification instruction library **220** as relevant to the user input **202**, context data **204**, and possible intents **214** based on the instruction query **218**. The selected instructions **222** are included in the input classification prompt **226** so that when the large language model **116** reads and processes the input classification prompt **226**, the processing performed by the large language model **116** is constrained to the selected instructions **222** that are relevant for the user input **202**, context data **204**, and possible intents **214**. For instance, when the large language model processes the input classification prompt **226**, the large language model **116** only processes the selected instructions **222**, e.g., only those instructions that are applicable to the possible intents **214**.

[0091] The configure prompt including the selected instructions and possible intents **224** includes the possible intents **214** and the selected instructions **222** in the input classification prompt **226**. The configure input classification prompt **206** outputs the input classification prompt **228** to the large language model **116**.

[0092] The examples shown in FIG. **2** and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples. Additional or alternative details and implementations are described herein.

[0093] FIG. **3** is a flow diagram of an example method for configuring a plan generation prompt using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0094] In FIG. **3**, an embodiment of plan generation prompt generator **120** is shown as plan generation prompt generator **300**. Plan generation prompt generator **300** includes a configure plan generation prompt component **304**, a function library **310**, a function dependency graph **318**, a resource library **326**, and a plan generation instruction library **334**. Configure plan generation prompt component **304** includes a determine possible functions executable component **306**, an obtain function dependency data component **314**, a determine possible resources component **322**, and a configure prompt including the instructions, possible functions, possible resources, and function dependency data executable component **330**.

[0095] The function library **310**, function dependency graph **318**, resource library **326**, and plan generation instruction library **334** are included in data resources **650**, or are part of AI model service **690**, or are stored in one or more data stores of data storage system **660**, described herein with reference to FIG. **6**.

[0096] Function library **310** stores N templatized functions, and associated metadata, such as intents with which each function is associated. Function library **310** can include an index that maps functions with associated intents. In the example of FIG. **3**, intent examples can be denoted as I1, I2 . . . . CN. For instance, both Function and Function2 map to the intent I2 and map to more than one intent, while FunctionN maps to only one intent, although this need not be the case.

[0097] Function dependency graph **318** stores information about dependencies between or among functions of the function library **310**. For example, function dependency graph **318** is implemented as a portion of entity graph and knowledge graph **144** such that nodes in the graph represent functions and links or edges between the nodes represent dependencies. An example of a function dependency is a relationship between the input of one function and the output of another function; for instance, an input to one function can be or include the output of a different function.

[0098] Resource library **326** stores metadata and/or performance data about various data resources, e.g., data resources **134**, data resources **176**, or data resources **650**. For example, resource library **326** stores metadata about the kinds of facets or filters that are stored in each data resource **176**, the keys that are used to access the data in the data resource, or the applicable format of an API call to obtain data from the data resource. Resource library **326** can include an index that maps data resources with associated functions.

[0099] Plan generation instruction library **334** stores N templatized large language model instructions, which can be used as building blocks or components of a plan generation prompt configured for input to large language model **116**. For instance, the instructions contained in plan generation instruction library **334** pertain to the large language model task of generating a query execution plan. In the example of FIG. **3**, instruction examples can be denoted instructionN:pN where instruction represents the particular instruction and its associated metadata (e.g., instruction type, such as statement, question, example, condition, or constraint), and each p represents a parameter or argument that the instruction uses as input or to which the instruction can be applied. For instance, each of StatementN, QuestionN, ExampleN, ConditionN, and ConstraintN use different parameters, and some of the instructions includes more than one parameter while other instructions only include one parameter, although this need not be the case.

[0100] In operation, configure plan generation prompt component **304** receives input classification **302** from the large language model **116**. The input classification **302** includes, for example, an intent determined and output by the large language model **116** in response to an input classification prompt **226**. Determine possible functions component **306** formulates a function query **308** including the input classification **302** (e.g., intent) as a parameter. The function query **308** is executed against the function library **310**. Based on the function query **308**, a set of one or more possible functions **312** that match the function query **308** are returned to the determine possible functions component **306**. The possible functions **312** are a subset of the templatized functions, which are selected from the function library **310** as relevant to the input classification **302** based on the function query **308**. The possible functions **312** are included in the plan generation prompt **338** so that when the large language model **116** reads and processes the plan generation prompt **338**, the processing performed by the large language model **116** is constrained to the possible functions **306** that are relevant for the input classification **302**. For instance, when the large language model processes the plan generation prompt **336**, the large language model **116** does not have to select functions from the entire function library **310** but only from the relevant subset of possible functions **306**.

[0101] Obtain function dependency data component **314** formulates a function dependency query **316** including the possible functions **312** as parameters. The function dependency query **316** is executed against the function dependency graph **318**. Based on the function dependency query **316**, function dependency data **320** that matches the function dependency query **316** are returned to the obtain function dependency data component **314**. The function dependency data **320** are a subgraph of the function dependency graph **318** that are selected from the function dependency graph **318** as relevant to the possible functions **312** based on the function dependency query **316**. The function dependency data **320** is included in the plan generation prompt **338** so that when the large language model **116** reads and processes the plan generation prompt **338**, the processing performed by the large language model **116** is constrained to the function dependency data **320** that are relevant for the possible functions **312**. For instance, when the large language model processes the plan generation prompt **338**, the large language model **116** only processes the function dependency data **320**, e.g., only those function dependencies that are applicable to the possible functions **312**, instead of the entire function dependency graph **318**.

[0102] Determine possible resources component **322** formulates a resource query **324** including the possible functions **312** and function dependency data **320** as parameters. The resource query **324** is executed against the resource library **326**. Based on the resource query **324**, possible resources **328** that match the resource query **324** are returned to the determine possible resources component **322**. The possible resources **328** are a subset of the data resources contained in the resource library **326**, which are selected from resource library **326** as relevant to the possible functions **312** based on the resource query **324** and available in accordance with availability and/or performance metrics contained in the resource query **324**. The possible resources **328** are included in the plan generation prompt **338** so that when the large language model **116** reads and processes the plan generation prompt **338**, the processing performed by the large language model **116** is constrained to the possible resources **328** that are relevant for the possible functions **312** and function dependency data **320**, and which are available in accordance with any applicable performance criteria. For instance, when the large language model processes the plan generation prompt **338**, the large language model **116** only reads data pertaining to the possible resources, e.g., only those data resources that are applicable to the possible functions **312**, instead of the entire resource library **326**.

[0103] Select instructions component **329** formulates an instruction query **332** including the possible functions **312**, possible resources **328**, and function dependency data **320** as parameters. The instruction query **332** is executed against the plan generation instruction library **334**. Based on the instruction query **332**, a set of one or more selected instructions that match the instruction query **332** are returned to the select instructions component **329**. The selected instructions **336** are a subset of the templatized instructions that are selected from the plan generation instruction library **334** as relevant to the possible functions **312**, possible resources **328**, and function dependency data **320** based on the instruction query **332**. The selected instructions **336** are included in the plan generation prompt **338** so that when the large language model **116** reads and processes the plan generation prompt **338**, the processing performed by the large language model **116** is constrained to the selected instructions **336** that are relevant for the possible functions **312**, possible resources **328**, and function dependency data **320**. For instance, when the large language model processes the plan generation prompt **338**, the large language model **116** only processes the selected instructions **336**, e.g., only those instructions that are applicable to the possible functions **312**, possible resources **328**, and function dependency data **320**.

[0104] The configure prompt including the instructions, possible functions, possible resources, and function dependency data component **330** includes the possible functions **312**, the function dependency data **320**, the possible resources **328**, and the selected instructions **336** in the plan generation prompt **338**. The configure plan generation prompt component **304** outputs the plan generation prompt **338** to the large language model **116**.

[0105] The examples shown in FIG. **3** and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples. Additional or alternative details and implementations are described herein.

[0106] FIG. **4** is a flow diagram of an example method for generating a query plan using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0107] In FIG. **4**, an embodiment of computing system **100** including large language model **116** is shown as a computing system **400** including large language model **404**. Computing system **400** includes possible functions **408**, possible resources **414**, function dependency data **418**, and large language model **404**. Possible functions **408** include, for example, the possible functions **312** determined by the determine possible functions component **306** and included in or referenced by the plan generation prompt **338** of FIG. **3**. Possible resources **414** include, for example, the possible resources **328** determined by the determine possible resources component **322** and included in or referenced by the plan generation prompt **338** of FIG. **3**. Function dependency data **418** includes, for example, the function dependency data **320** determined by the obtain function dependency data component **314** and included in or referenced by the plan generation prompt **338** of FIG. **3**.

[0108] The large language model **404** receives a plan generation prompt **402**, e.g., the plan generation prompt **338** configured by the process and components described with reference to FIG. **3**. The large language model **404** reads and executes the instructions contained in the plan generation prompt **402** to generate and output a query execution plan **422** for execution by a plan executor (e.g., plan executor **126**). Examples of the types of instructions that can be included in the plan generation prompt **402** and read and processed by the large language model **404** include select function set **406**, determine function parameters **410**, select resources **412**, determine order of operation **416**, and generate plan **422**.

[0109] Select function set prompt section **406** includes one or more instructions that cause the large language model **404** to select a set of functions from the possible functions **408**, for inclusion in the query execution plan **422**. For example, select function set **406** may include one or more examples of the types of functions that are applicable to certain types of inputs or intents along with an instruction to cause the large language model **404** to select the set of functions based on the examples provided in the select function set **4056** portion of the prompt **402**.

[0110] Determine function parameters prompt section **410** includes one or more instructions that cause the large language model **404** to map parameter values from the input to the corresponding function parameters, in order to, in the plan **422**, configure the set of functions for execution by the executor **126**. For example, determine function parameters **410** may include one or more examples of the types of parameter values that are applicable to certain functions along with an instruction to cause the large language model **404** to determine the function parameters **410** based on the examples provided in the determine function parameters **410** portion of the prompt **402**.

[0111] Select resources prompt section **412** includes one or more instructions that cause the large language model **404** to select one or more resources from the possible resources **414** for inclusion in the plan **422**. For example, select resources **412** may include one or more examples of the types of criteria that can be used to select resources to which the selected set of functions are to be applied, along with an instruction to cause the large language model **404** to select resources to include in the plan **422** based on the examples provided in the select resources **412** portion of the prompt **402**.

[0112] Determine order of operation prompt section **416** includes one or more instructions that cause the large language model **404** to determine the order in which the selected set of functions is to be arranged in the plan **422**. For example, determine order of operation **416** may include one or more conditions or constraints to be applied to the function dependency data, along with an instruction to cause the large language model **404** to arrange the selected set of functions in the plan **422** based on the conditions or constraints provided in the determine order of operation **416** portion of the prompt **402**.

[0113] Generate plan **420** includes one or more instructions that cause the large language model **404** to generate and output a query execution plan including the selected function set with the corresponding function parameters and selected resources, arranged according to the determined order of operation. The large language model **404** processes the plan generation prompt **402** including the prompt sections **406**, **410**, **412**, **416**, **420**, to generate and output the plan **422** for execution by, e.g., plan executor **126**.

[0114] The examples shown in FIG. **4** and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples. Additional or alternative details and implementations are described herein.

[0115] FIG. **5**A illustrates an example of at least one user interface flow including a screen capture of a user interface screen for information retrieval using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0116] In the user interface shown in FIG. **5**A, certain data that would normally be displayed may be anonymized for the purpose of this disclosure. In a live example, the actual data and not the anonymized version of the data would be displayed. For instance, the text “CompanyName” would be replaced with a name of an actual company and “FirstName LastName” would be replaced with a user's actual name.

[0117] The user interface shown in FIG. **5**A is presented to a user by an application systems, such as application **102**. In some implementations, the user interface is implemented as a web page that is stored, e.g., at a server or in a cache of a user device, and then loaded into a display of a user device via the user device sending a page load request to the server or fetching data from the cache.

[0118] The graphical user interface control elements (e.g., fields, boxes, buttons, etc.) shown in the screen capture are implemented via software used to construct the user interface screens. While the screen capture illustrates examples of user interface components, e.g., visual displays, buttons, input boxes, etc., this disclosure is not limited to the illustrated embodiments, or to visual displays, or to graphical user interfaces.

[0119] In FIG. 5A, a user interface **500** includes a display of search results **506** that have been returned for a user's query **502**. Each search result includes profile information **508** about the entity associated with the search result (e.g., profile data for job candidates), as well as a set of action mechanisms **510** that enable the user viewing the result set **506** to perform actions in relation to the search result, such as storing the result for future use, hiding the result, and initiating the sending of a message. Selection of any of these actions can be recorded as context data that can be used by embodiments of the dynamic query planning system to configure large language model prompts.

[0120] The user interface **500** includes a display of the modified version **504** of the user's query **502**, where the modified version **504** has been automatically generated using the techniques described herein. The display includes a selectable mechanism **505** by which the user can view all of the available search filters and further refine the system-generated modified version **504**, e.g., by selecting or unselecting certain filters or facets. For example, using the disclosed technologies, the accounting, corporate tax, and four other skills have been automatically included in the modified version **504**, and by selecting the mechanism **505** the user can deselect any of these skills and/or include different skills in the query.

[0121] User interface **500** includes a recommendation or insight section (e.g., hire better **514**) **512**, including recommendations **516**, **518**, **520**, **522** for improving the user's query **502**, which have been generated using the techniques described herein, are presented to the user. The items displayed in the section **512** are dynamically generated and updated as the user interacts with the search results **506** and/or modified version **504** of the user's query **502**. For example, item **516** contains an insight that has been generated using the disclosed techniques based on the user's interactions with the search results including scrolling without selecting many of the search results. The items **518**, **520**, **522** are suggestions that have been generated using the disclosed technologies based on the insight **516** and historical interaction data, including the user's historical search and interaction data as well as aggregate historical interaction data and trends generated based on populations of users. Section **512** further includes an input mechanism **524** by which the user can provide feedback relating to the insights and/or suggestions, start a new query, or input a natural language comment, statement, or question to modify the user's query **502** or the modified version **504**.

[0122] The examples shown in FIG. 5A and the accompanying description are provided for illustration purposes. For example, while the examples may be illustrated as user interface screens for a smaller form factor such as smart phones, tablet computers, or wearable devices, the user interfaces can be configured for other forms of electronic devices, such as desktop computers and/or laptop devices, or vice versa. This disclosure is not limited to the described examples. Additional or alternative details and implementations are described herein.

[0123] FIG. 5B illustrates an example of at least one user interface flow including a screen capture of a user interface screen for information retrieval using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0124] In the user interface shown in FIG. 5B, certain data that would normally be displayed may be anonymized for the purpose of this disclosure. In a live example, the actual data and not the anonymized version of the data would be displayed. For instance, the text “CompanyName” would be replaced with a name of an actual company and “FirstName LastName” would be replaced with a user's actual name.

[0125] The user interface shown in FIG. 5B is presented to a user by an application systems, such as application **102**. In some implementations, the user interface is implemented as a web page that is stored, e.g., at a server or in a cache of a user device, and then loaded into a display of a user device via the user device sending a page load request to the server or fetching data from the cache.

[0126] The graphical user interface control elements (e.g., fields, boxes, buttons, etc.) shown in the screen capture are implemented via software used to construct the user interface screens. While the screen capture illustrates examples of user interface components, e.g., visual displays, buttons, input boxes, etc., this disclosure is not limited to the illustrated embodiments, or to visual displays, or to graphical user interfaces.

[0127] In FIG. 5B, a user interface **550** includes a display of search results **556** that have been returned for a user's query **552**. Each search result includes profile information about the entity associated with the search result (e.g., profile data for job candidates), as well as a set of action mechanisms that enable the user viewing the result set **556** to perform actions in relation to the search result, such as storing the result for future use, hiding the result, and initiating the sending of a message. Selection of any of these actions can be recorded as context data that can be used by embodiments of the dynamic query planning system to configure large language model prompts.

[0128] The user interface **550** includes a display of a modified version **554** of the user's query **552**, where the modified version **554** has been automatically generated using the techniques described herein, potentially based on user feedback. For example, in response to user feedback on the previous result set, using the disclosed technologies, company names have been automatically added to the previous modified version **504**.

[0129] User interface **550** includes a recommendation or insight section **558**, including insight **562** and recommendations **564**, **566** for improving the user's query **552**, which have been generated using the techniques described herein, are presented to the user. The items displayed in the section **558** are dynamically generated and updated as the user interacts with the search results **556** and/or modified version **554** of the user's query **552**. For example, item **562** contains an insight that has been generated using the disclosed techniques based on the user's interactions with the search results including viewing several of the search results. The items **564**, **566** are suggestions that have been generated using the disclosed technologies based on the insight **562** and historical interaction data, including the user's historical search and interaction data as well as aggregate historical search and interaction data and trends generated based on populations of users.

[0130] User interface **550** includes a chat section **568**. The chat section **568** includes a chat style dialog box **570**, a system-generated response to the user's input in the dialog box **570**, including selectable action mechanisms **574**, and a chat style input mechanism **576** by which the user can provide feedback relating to the system output including the insights and/or suggestions, start a new query, or input a natural language comment, statement, or question to modify the user's query **552** or the modified version **554**.

[0131] As shown in FIG. 5A and FIG. 5B, the disclosed technologies are not limited to the generation of search queries, but can be used to automatically generate other kinds of helpful information in context, such as insights and recommendations.

[0132] The examples shown in FIG. 5B and the accompanying description are provided for illustration purposes. For example, while the examples may be illustrated as user interface screens for a smaller form factor such as smart phones, tablet computers, or wearable devices, the user interfaces can be configured for other forms of electronic devices, such as desktop computers and/or laptop devices, or vice versa. This disclosure is not limited to the described examples. Additional or alternative details and implementations are described herein.

[0133] FIG. **6** is a block diagram of a computing system that includes a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0134] In the embodiment of FIG. **6**, a computing system **600** includes one or more user systems **610**, a network **620**, an application system **630**, a dynamic query planning system **680**, a data storage system **660**, and an event logging service **670**.

[0135] All or at least some components of dynamic query planning system **680** are implemented at the user system **610**, in some implementations. For example, portions of dynamic query planning system **680** are implemented directly upon a single client device such that communications involving applications running on user system **610** and dynamic query planning system **680** occur

on-device without the need to communicate with, e.g., one or more servers, over the Internet. Dashed lines are used in FIG. **6** to indicate that all or portions of dynamic query planning system **680** can be implemented directly on the user system **610**, e.g., the user's client device. In other words, both user system **610** and dynamic query planning system **680** can be implemented on the same computing device, in some implementations. In other implementations, all or portions of dynamic query planning system **680** are implemented on one or more servers and in communication with user systems **610** via network **620**. Components of the computing system **600** including the dynamic query planning system **680** are described in more detail herein.
[0136] A user system **610** includes at least one computing device, such as a personal computing device, a server, a mobile computing device, a wearable electronic device, or a smart appliance, and at least one software application that the at least one computing device is capable of executing, such as an operating system or a front end of an online system. Many different user systems **610** can be connected to network **620** at the same time or at different times. Different user systems **610** can contain similar components as described in connection with the illustrated user system **610**. For example, many different end users of computing system **600** can be interacting with many different instances of application system **630** through their respective user systems **610**, at the same time or at different times.
[0137] User system **610** includes a user interface **612**. User interface **612** is installed on user system **610** or accessible to user system **610** via network **620**. Embodiments of user interface **612** include a front end portion of a search engine (e.g., search engine **640**) and/or dynamic query planning system **680**.
[0138] User interface **612** includes, for example, a graphical display screen that includes graphical user interface elements such as at least one input box or other input mechanism and at least one slot. A slot as used herein refers to a space on a graphical display such as a web page or mobile device screen, into which digital content such as search results, feed items, chat boxes, or threads, can be loaded for display to the user. For example, user interface **612** may be configured with a scrollable arrangement of variable-length slots that simulates an online chat or instant messaging session and/or a scrollable arrangement of slots that contain search results. The locations and dimensions of a particular graphical user interface element on a screen are specified using, for example, a markup language such as HTML (Hypertext Markup Language). On a typical display screen, a graphical user interface element is defined by two-dimensional coordinates. In other implementations such as virtual reality or augmented reality implementations, a slot may be defined using a three-dimensional coordinate system. Example screen captures of user interface screens that can be included in user interface **612** are shown in the drawings and described herein.
[0139] User interface **612** can be used to interact with one or more application systems **630** and/or to switch between applications. For example, user interface **612** enables the user of a user system **610** to create, edit, send, view, receive, process, and organize search queries, search results, content items, news feeds, and/or portions of online dialogs. In some implementations, user interface **612** enables the user to input requests (e.g., queries) for various different types of information, to initiate user interface events, and to view or otherwise perceive output such as data and/or digital content produced by, e.g., an application system **630**, dynamic query planning system **680**, content distribution service **638** and/or search engine **640**. For example, user interface **612** can include a graphical user interface (GUI), a conversational voice/speech interface, a virtual reality, augmented reality, or mixed reality interface, and/or a haptic interface. User interface **612** includes a mechanism for entering search queries and/or selecting search criteria (e.g., facets, filters, etc.), selecting GUI user input control elements, and interacting with digital content such as search results, entity profiles, posts, articles, feeds, and online dialogs. Examples of user interface **612** include web browsers, command line interfaces, and mobile app front ends. User interface **612** as used herein can include application programming interfaces (APIs).
[0140] Network **620** includes an electronic communications network. Network **620** can be

implemented on any medium or mechanism that provides for the exchange of digital data, signals, and/or instructions between the various components of computing system **600**. Examples of network **620** include, without limitation, a Local Area Network (LAN), a Wide Area Network (WAN), an Ethernet network or the Internet, or at least one terrestrial, satellite or wireless link, or a combination of any number of different networks and/or communication links.

[0141] Application system **630** can include, for example, one or more online systems that provide social network services, general-purpose search engines, specific-purpose search engines, messaging systems, content distribution platforms, e-commerce software, enterprise software, or any combination of any of the foregoing or other types of software. Application system **630** includes any type of application system that provides or enables the retrieval of and interactions with at least one form of digital content, including machine-generated content via user interface **612**. In some implementations, portions of dynamic query planning system **680** are components of application system **630**. An application system **630** can include one or more of an entity graph **632** and/or knowledge graph **634**, a user connection network **636**, a content distribution service **638**, a search engine **640**, and/or one or more modeling systems **642**.

[0142] In some implementations, a front end portion of application system **630** can operate in user system **610**, for example as a plugin or widget in a graphical user interface of a web application, mobile software application, or as a web browser executing user interface **612**. In an embodiment, a mobile app or a web browser of a user system **610** can transmit a network communication such as an HTTP request over network **620** in response to user input that is received through a user interface provided by the web application, mobile app, or web browser, such as user interface **612**. A server running application system **630** can receive the input from the web application, mobile app, or browser executing user interface **612**, perform at least one operation using the input, and return output to the user interface **612** using a network communication such as an HTTP response, which the web application, mobile app, or browser receives and processes at the user system **610**.

[0143] In the example of FIG. **6**, an application system **630** includes an entity graph **632** and/or a knowledge graph **634**. Entity graph **632** and/or knowledge graph **634** include data organized according to graph-based data structures that can be traversed via queries and/or indexes to determine relationships between entities. For instance, entity graph **632** and/or knowledge graph **634** can be used to compute various types of relationship weights, affinity scores, similarity measurements, and/or statistics between, among, or relating to entities.

[0144] Entity graph **632**, knowledge graph **634** includes a graph-based representation of data stored in data storage system **660**, described herein. For example, entity graph **632**, knowledge graph **634** represents entities, such as users, organizations (e.g., companies, schools, institutions), content items (e.g., job postings, announcements, articles, comments, and shares), and computing resources (e.g., databases, models, applications, and services), as nodes of a graph. Entity graph **632**, knowledge graph **634** represents relationships, also referred to as mappings or links, between or among entities as edges, or combinations of edges, between the nodes of the graph. In some implementations, mappings between different pieces of data used by an application system **630** are represented by one or more entity graphs. In some implementations, the edges, mappings, or links indicate relationships, online interactions, or activities relating to the entities connected by the edges, mappings, or links. For example, if a user clicks on a search result, an edge may be created connecting the user entity with the search result entity in the entity graph, where the edge may be tagged with a label such as “viewed.” If a user viewing a list of search results skip over a search result without clicking on the search result, an edge may not be created between the user entity and the search result entity in the entity graph.

[0145] Portions of entity graph **632**, knowledge graph **634** can be automatically re-generated or updated from time to time based on changes and updates to the stored data, e.g., updates to entity data and/or activity data. Also, entity graph **632**, knowledge graph **634** can refer to an entire system-wide entity graph or to only a portion of a system-wide graph. For instance, entity graph

632, knowledge graph **634** can refer to a subset of a system-wide graph, where the subset pertains to a particular user or group of users of application system **630**.

[0146] Knowledge graph **634** includes a graph-based representation of data stored in data storage system **660**, described herein. Knowledge graph **634** represents relationships, also referred to as links or mappings, between entities or concepts as edges, or combinations of edges, between the nodes of the graph. In some implementations, mappings between different pieces of data used by application system **630** or across multiple different application systems are represented by the knowledge graph **634**.

[0147] In some implementations, knowledge graph **634** is a subset or a superset of entity graph **632**. For example, in some implementations, knowledge graph **634** includes multiple different entity graphs **632** that are joined by cross-application or cross-domain edges. For instance, knowledge graph **634** can join entity graphs **632** that have been created across multiple different databases or across different software products. In some implementations, the entity nodes of the knowledge graph **634** represent concepts, such as product surfaces, verticals, or application domains. In some implementations, knowledge graph **634** includes a platform that extracts and stores different concepts that can be used to establish links between data across multiple different software applications. Examples of concepts include topics, industries, and skills. As with other portions of entity graph **632**, knowledge graph **634** can be used to compute various types of relationship weights, affinity scores, similarity measurements, and/or statistical correlations between or among entities and/or concepts.

[0148] In the example of FIG. **6**, application system **630** includes a user connection network **636**. User connection network **636** includes, for instance, a social network service, professional social network system and/or other social graph-based applications. Content distribution service **638** includes, for example, a feed, chatbot or chat-style system, or a messaging system, such as a peer-to-peer messaging system that enables the creation and exchange of messages between users of application system **630** and the application system **630**. Search engine **640** includes a search engine that enables users of application system **630** to input and execute search queries to retrieve information from one or more sources of information, such as user connection network **636**, entity graph **632**, knowledge graph **634**, one or more data stores of data storage system **660**, or one or more data resources **650**.

[0149] In the example of FIG. **6**, application system **630** includes a content distribution service **638**. The content distribution service **638** can include a data storage service, such as a web server, which stores digital content items, and transmits digital content items to users via user interface **612**. In some embodiments, content distribution service **638** processes requests from, for example, application system **630** and/or dynamic query planning system **680**, and distributes digital content items to user systems **610** in response to requests. For instance, aspects of the dynamic query planning system **680** can be applied to queries that are designed to populate a user's feed with content items obtained via content distribution service **638**. In other words, aspects of the dynamic query planning system **680** can be applied to system-generated queries alternatively or in addition to user-generated queries.

[0150] A request includes, for example, a network message such as an HTTP (HyperText Transfer Protocol) request for a transfer of data from an application front end to the application's back end, or from the application's back end to the front end, or, more generally, a request for a transfer of data between two different devices or systems, such as data transfers between servers and user systems. A request is formulated, e.g., by a browser or mobile app at a user device, in connection with a user interface event such as a login, click on a graphical user interface element, an input of a search query, or a page load. In some implementations, content distribution service **638** is part of application system **630**. In other implementations, content distribution service **638** interfaces with application system **630** and/or dynamic query planning system **680**, for example, via one or more application programming interfaces (APIs).

[0151] In the example of FIG. **6**, application system **630** includes a search engine **640**. Search engine **640** includes a software system designed to search for and retrieve information by executing queries on one or more data stores, such as databases, connection networks, and/or graphs. The queries are designed to find information that matches specified criteria, such as keywords and phrases contained in user input and/or system-generated queries. For example, search engine **640** is used to retrieve data in response to user input and/or system-generated queries, by executing queries on various data stores of data storage system **660** and/or data resources **650**, or by traversing entity graph **632**, knowledge graph **634**.

[0152] Data resources **650** include computing resources that can be queried to retrieve information, such as query terms that can be used to supplement or modify query terms input by a user. Data resources **650** can include computing resources that are internal to application system **630** or external to application system **630**. Examples of data resources **650** include entity graphs, knowledge graphs, indexes, databases, networks, applications, models (e.g., large language models and/or other artificial intelligence models or machine learning models), taxonomies, data services, web pages, vectors (e.g., data stores that store embeddings), and searchable digital catalogs. Each data resource **650** enables dynamic query planning system **110** to access the data resource, for example by providing an application programming interface (API). Each data resource **650** can include a monitoring service that periodically generates, publishes, or broadcasts availability and/or other performance metrics associated with the data resource. For example, each data resource **650** can provide a set of APIs that can be used by dynamic query planning system **110** to query the data resource, obtain data from the data resource, and/or obtain performance metrics for the data resource.

[0153] AI model service **690** includes one or more artificial intelligence-based models, such as large language model **116** and/or other types of models including discriminative and/or generative models, neural networks and/or other types of machine learning-based models, probabilistic models, statistical models, transformer-based models, and/or any combination of any of the foregoing. AI model service **690** enables dynamic query planning system **110** to access to these models, for example by providing an application programming interface (API). AI model service **690** can include a monitoring service that periodically generates, publishes, or broadcasts latency and/or other performance metrics associated with the models. For example, AI model service **690** can provide a set of APIs that can be used by dynamic query planning system **110** to obtain performance metrics for the large language model **116**.

[0154] Event logging service **670** captures and records network activity data generated during operation of application system **630** and/or dynamic query planning system **680**, including user interface events generated at user systems **610** via user interface **612**, in real time, and formulates the user interface events and/or other network activity data into a data stream that can be consumed by, for example, a stream processing system. Examples of network activity data include logins, page loads, input of search queries or query terms, selections of facets or filters, clicks on search results or graphical user interface control elements, scrolling lists of search results, and social action data such as likes, shares, comments, and social reactions (e.g., “insightful,” “curious,” etc.). For instance, when a user of application system **630** via a user system **610** enters input or clicks on a user interface element, such as a search result, or a user interface control element such as a view, comment, share, or reaction button, or uploads a file, or inputs a query, or scrolls through a feed, etc., event logging service **670** fires an event to capture and store log data including an identifier, such as a session identifier, an event type, a date/timestamp at which the user interface event occurred, and possibly other information about the user interface event, such as the impression portal and/or the impression channel involved in the user interface event. Examples of impression portals and channels include, for example, device types, operating systems, and software platforms, e.g., web applications and mobile applications.

[0155] For instance, when a user enters input or reacts to system-generated output, such as a list of search results, event logging service **670** stores the corresponding event data in a log. Event logging service **670** generates a data stream that includes a record of real-time event data for each user interface event that has occurred. Event data logged by event logging service **670** can be pre-processed and anonymized as needed so that it can be used as context data to, for example, configure one or more instructions for one or more artificial intelligence models (e.g., large language models), or to modify weights, affinity scores, or similarity measurements that are assigned by the dynamic query planning system to search results or data resources.

[0156] Data storage system **660** includes data stores and/or data services that store digital data received, used, manipulated, and produced by application system **630** and/or dynamic query planning system **680**, including contextual data, state data, prompts and/or prompt templates for generative artificial intelligence models or large language models, user inputs, system-generated outputs, metadata, attribute data, activity data.

[0157] In the example of FIG. **6**, data storage system **660** includes an entity data store **662**, an activity data store **664**, a prompt data store **666**, and a context data store **668**. Entity data store **662** stores data, such as profile data or metadata, relating to users, companies, jobs, computing resources, and/or other entities. Activity data store **664** stores data relating to network activity, e.g., user interface event data extracted from one or more application systems **630** and/or dynamic query planning system **680** by event logging service **670**. Prompt data store **666** stores prompt templates and/or prompts which include one or more instructions that can be input to one or more artificial intelligence models (e.g., generative models, large language models). Context data store **668** stores data relating to the current state of a user system or application, including the current state of various applications that may be running on the user system, such as the current state of a search engine, data resource, and/or dynamic query planning system. While shown in FIG. **6** as components of a data storage system **660**, all or portions of each or any of the entity data store **662**, activity data store **664**, prompt data store **666**, and/or context data store **668** are implemented on the user system **610** in some embodiments. For example, a data store can include a volatile memory such as a form of random access memory (RAM) available on user system **610** for storing state data generated at the user system **610** or an application system **630**. As another example, in some implementations, a separate, personalized version of each or any of the entity data store **662**, activity data store **664**, prompt data store **666**, and/or context data store **668** is created for each user such that data is not shared between or among the separate, personalized versions of the data stores.

[0158] In some embodiments, data storage system **660** includes multiple different types of data storage and/or a distributed data service. As used herein, data service may refer to a physical, geographic grouping of machines, a logical grouping of machines, or a single machine. For example, a data service may be a data center, a cluster, a group of clusters, or a machine. Data stores of data storage system **660** can be configured to store data produced by real-time and/or offline (e.g., batch) data processing. A data store configured for real-time data processing can be referred to as a real-time data store. A data store configured for offline or batch data processing can be referred to as an offline data store. Data stores can be implemented using databases, such as key-value stores, relational databases, and/or graph databases. Data can be written to and read from data stores using query technologies, e.g., SQL or NoSQL.

[0159] A key-value database, or key-value store, is a nonrelational database that organizes and stores data records as key-value pairs. The key uniquely identifies the data record, i.e., the value associated with the key. The value associated with a given key can be, e.g., a single data value, a list of data values, or another key-value pair. For example, the value associated with a key can be either the data being identified by the key or a pointer to that data. A relational database defines a data structure as a table or group of tables in which data are stored in rows and columns, where each column of the table corresponds to a data field. Relational databases use keys to create relationships between data stored in different tables, and the keys can be used to join data stored in different tables. Graph databases organize data using a graph data structure that includes a number of interconnected graph primitives. Examples of graph primitives include nodes, edges, and predicates, where a node stores data, an edge creates a relationship between two nodes, and a predicate is assigned to an edge. The predicate defines or describes the type of relationship that exists between the nodes connected by the edge.

[0160] Data storage system **660** resides on at least one persistent and/or volatile storage device that can reside within the same local network as at least one other device of computing system **600** and/or in a network that is remote relative to at least one other device of computing system **600**. Thus, although depicted as being included in computing system **600**, portions of data storage system **660** can be part of computing system **600** or accessed by computing system **600** over a network, such as network **620**.

[0161] While not specifically shown, it should be understood that any of user system **610**, application system **630**, data resources **650**, dynamic query planning system **680**, data storage system **660**, and event logging service **670** includes an interface embodied as computer programming code stored in computer memory that when executed causes a computing device to enable bidirectional communication with any other of user system **610**, application system **630**, data resources **650**, dynamic query planning system **680**, data storage system **660**, and event logging service **670** using a communicative coupling mechanism. Examples of communicative coupling mechanisms include network interfaces, inter-process communication (IPC) interfaces and application program interfaces (APIs).

[0162] Each of user system **610**, application system **630**, data resources **650**, dynamic query planning system **680**, data storage system **660**, and event logging service **670** is implemented using at least one computing device that is communicatively coupled to electronic communications network **620**. Any of user system **610**, application system **630**, data resources **650**, dynamic query planning system **680**, data storage system **660**, and event logging service **670** can be bidirectionally communicatively coupled by network **620**. User system **610** as well as other different user systems (not shown) can be bidirectionally communicatively coupled to application system **630** and/or dynamic query planning system **680**.

[0163] A typical user of user system **610** can be an administrator or end user of application system **630** or dynamic query planning system **680**. User system **610** is configured to communicate bidirectionally with any of application system **630**, dynamic query planning system **680**, data resources **650**, data storage system **660**, and event logging service **670** over network **620**.

[0164] Terms such as component, system, and model as used herein refer to computer implemented structures, e.g., combinations of software and hardware such as computer programming logic, data, and/or data structures implemented in electrical circuitry, stored in memory, and/or executed by one or more hardware processors.

[0165] The features and functionality of user system **610**, application system **630**, dynamic query planning system **680**, data resources **650**, data storage system **660**, and event logging service **670** are implemented using computer software, hardware, or software and hardware, and can include combinations of automated functionality, data structures, and digital data, which are represented schematically in the figures. User system **610**, application system **630**, dynamic query planning system **680**, data resources **650**, data storage system **660**, and event logging service **670** are shown as separate elements in FIG. **6** for case of discussion but, except as otherwise described, the illustration is not meant to imply that separation of these elements is required. The illustrated systems, services, and data stores (or their functionality) of each of user system **610**, application system **630**, dynamic query planning system **680**, data resources **650**, data storage system **660**, and event logging service **670** can be divided over any number of physical systems, including a single physical computer system, and can communicate with each other in any appropriate manner.

[0166] In the embodiment of FIG. **8**, portions of dynamic query planning system **680** that may be implemented on a front end system, such as one or more user systems, and portions of dynamic query planning system **680** that may be implemented on a back end system such as one or more

servers, are collectively represented as dynamic query planning system **850** for case of discussion only. For example, portions of dynamic query planning system **680** are not required to be implemented all on the same computing device, in the same memory, or loaded into the same memory at the same time. For instance, access to portions of dynamic query planning system **680** can be limited to different, mutually exclusive sets of user systems and/or servers. For instance, in some implementations, a separate, personalized version of dynamic query planning system **680** is created for each user of the dynamic query planning system **680** such that data is not shared between or among the separate, personalized versions of the dynamic query planning system **680**. Additionally, certain portions of dynamic query planning system **680** typically may be implemented on user systems while other portions of dynamic query planning system **680** typically may be implemented on a server computer or group of servers. In some embodiments, however, one or more portions of dynamic query planning system **680** are implemented on user systems. For example, dynamic query planning system **680** is entirely implemented on user systems, e.g., client devices, in some implementations. For instance, a version of dynamic query planning system **680** can be embedded in a client device's operating system or stored at the client device and loaded into memory at execution time. Further details with regard to the operations of dynamic query planning system **850** are described herein.
[0167] FIG. **7**A is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.
[0168] The method **700** is performed by processing logic that includes hardware (e.g., processing device, circuitry, dedicated logic, programmable logic, microcode, hardware of a device, integrated circuit, etc.), software (e.g., instructions run or executed on a processing device), or a combination thereof. In some embodiments, the method **700** is performed by one or more components of dynamic query planning system **110** of FIG. **1**A or dynamic query planning system **680** of FIG. **6**. Although shown in a particular sequence or order, unless otherwise specified, the order of the processes can be modified. Thus, the illustrated embodiments should be understood only as examples, and the illustrated processes can be performed in a different order, and some processes can be performed in parallel. Additionally, at least one process can be omitted in various embodiments. Thus, not all processes are required in every embodiment. Other process flows are possible.
[0169] In accordance with the method **700**, a large language model is selectively invoked to generate a query execution plan for processing a user input including a search query. At operation **702**, the processing device receives a first query to obtain information using a first set of data resources. The first query is received via a user interface of an application, such as a job search application or a job candidate search application. The first query includes at least one first query term. For example, the first query could be a conversational natural language input provided by a user, and the first query term could be a word or phrase contained in the conversational natural language input. Operation **702** is performed, for example, by the embodiment of dynamic query planning system **110** in communication with application **102** of FIG. **1**A and FIG. **1**B, described herein.
[0170] At operation **704**, the processing device obtains and/or updates context data associated with the first query. For example, the processing device obtains context data that indicates which of multiple applications, application pages, or user interface mechanisms the user is currently interacting with. For instance, an application can have multiple different search mechanisms such as a company search and a user profile search, and the context data could indicate that the user is currently interacting with the user profile search mechanism. The context data can also include information about the user's previous interactions with the user interface. For instance, the context data can include information about search results that the user interacted with or scrolled past. At operation **704**, the context data can be updated upon each iteration of the method **700**. For example,

context data can continue to be obtained at operation **704** while the user continues to interact with the user interface, e.g., while the user continues to interact with search results or refine the search query (e.g., by selecting or deselecting facets or filters). Operation **704** is performed, for example, by the embodiment of dynamic query planning system **110** in communication with application **102** of FIG. **1**A and FIG. **1**B, described herein.

[0171] At operation **706**, the processing device configures a first prompt to cause a large language model to translate the at least one first query term and the context data into an intent. Intent, as used herein, may refer to a structured representation of a user input. To configure the first prompt, operation **706** can, for example, merge the user input received at operation **702** and the context data obtained at operation **704** with a pre-created prompt or prompt template for input classification to create the first prompt. For instance, operation **706** can map portions of the user input and/or context data to corresponding portions of the pre-created prompt or prompt template (e.g., as parameters or arguments) or apply one or more rules to one or more portions of the user input and/or context data that, based on the application of the one or more rules, include certain pre-created sections in the first prompt or exclude certain pre-created sections from the first prompt. Operation **706** is performed, for example, by the input classification prompt generator **112** of dynamic query planning system **110**, e.g., the embodiment of the input classification prompt generator **112** shown in FIG. **2**, described herein.

[0172] At operation **708**, the processing device applies the large language model to the first prompt configured at operation **706** to obtain, from the large language model, the intent. As a result of operation **708**, the large language model executes the one or more instructions contained in the first prompt to classify the user input into an intent based on the context data and the instructions contained in the first prompt. To classify the user input, the large language model maps the user input to an intent in accordance with the context data and the instructions contained in the first prompt. For example, the first prompt may instruct the large language model to select an intent from a set of pre-defined intents based on similarity of the intent to the user input given the context data. Operation **708** is performed, for example, by the dynamic query planning system **110** in communication with the large language model **116** of FIG. **1**A and FIG. **1**B, described herein.

[0173] At operation **710**, the processing device determines whether to use the large language model to generate a plan for executing the first query. For example, the processing device may determine not to use the large language model to generate a plan if resolution of the intent determined at operation **708** does not require the execution of multiple functions. For instance, if the user's query is unambiguous, e.g., the query only contains selected facets and does not contain any natural language input that requires modification or expansion, the processing device may determine not to use the large language model to generate a plan. If the processing device at operation **710** determines not to use the large language model to generate a plan, the processing device proceeds to operation **720** where the processing device may simply execute the first query using a function based on the intent. As another example, the processing device may determine not to use the large language model if the context data obtained at operation **704** indicates that the latency associated with the large language model exceeds a maximum threshold latency value, or that some other performance metric associated with the large language model exceeds a maximum value or falls below a minimum value.

[0174] At operation **710**, the processing device determines to use the large language model to generate a plan for executing the first query if, for example, resolution of the intent determined at operation **708** requires the execution of multiple functions. For instance, if the user's query contains one or more query terms that do not map to any pre-defined facets or filters, the processing device may determine to use the large language model to generate a plan for executing the query. As another example, the processing device at operation **710** may determine to use the large language model if the context data obtained at operation **704** indicates that the a current value of the latency associated with the large language model does not exceed a maximum threshold latency value, or that a current value of some other performance metric associated with the large language model does not exceed a maximum threshold value or does not fall below a minimum threshold value. References herein to threshold values indicate values that are configurable based on the requirements of a particular design or implementation. For example, a threshold value can be configured or adjusted based on, for example, the type or version of large language model used, the network configuration and/or server configuration.

[0175] If the processing device at operation **710** determines to use the large language model to generate a plan, the processing device proceeds to operation **712**. At operation **712**, the processing device configures a second prompt to cause a large language model to translate the intent obtained at operation **708** into a set of functions that can be executed to modify the first query and output a plan for executing the first query, where the plan is to include the set of functions. To configure the second prompt, operation **708** can, for example, merge the user input received at operation **702**, the context data obtained at operation **704**, and the intent obtained at operation **708** with a pre-created prompt or prompt template for query plan generation. For instance, operation **708** can use the intent to select the set of functions, map portions of the user input and/or context data to corresponding portions of the selected set of functions (e.g., as parameter values or arguments) and merge the selected set of functions including the respective user input and/or context data with a pre-created prompt or prompt template. Alternatively or in addition, the processing device at operation **712** can apply one or more rules to the user input, the intent, the set of functions, and/or the context data such that certain pre-created prompt sections are included in the first prompt or excluded from the first prompt. For example, based on one or more of the user input, the intent, the set of functions, and/or the context data, the processing device at operation **712** can include in the second prompt instructions to cause the large language model to determine an order of operation for the functions in the set of functions and to order the functions according to the order of operation in the plan. Operation **712** is performed, for example, by the plan generation prompt generator **120** of dynamic query planning system **110**, e.g., the embodiment of the plan generation prompt generator **120** shown in FIG. **3**, described herein.

[0176] At operation **714**, the processing device applies the large language model to the second prompt configured at operation **712** to obtain the plan. As a result of operation **714**, the large language model executes the one or more instructions contained in the second prompt to generate a query execution plan for the first query based on the user input, the context data, the set of functions determined at operation **712**. For example, to generate the plan, the large language model executes the instructions contained in the second prompt to select the set of functions, map the corresponding portions of the user input and/or context data to the respective functions (e.g., as parameters or arguments), determine the order of operation for the set of functions, arrange the functions according to the order of operation, and output the plan. Operation **714** is performed, for example, by the large language model **116** in communication with the dynamic query planning system **110**, e.g., the example operation of the large language model **116** shown in FIG. **4**, described herein.

[0177] At operation **716**, the processing device executes the plan generated and output by the large language model at operation **714**. Via execution of the plan, the processing device obtains, as a result of the application of the set of functions contained in the plan to a set of data resources, at least one second query term. The at least one second query term is related to but different from the at least one first query term, and is obtained by executing the set of functions using one or more data resources. For example, the at least one second query term includes one or more facet values or filters that are related to the user input, the context data, and/or the intent, where the facet values or filters are obtained by querying one or more data resources such as an entity graph, a knowledge graph, a data base, an application, or an artificial intelligence model such as a generative model. Operation **716** is performed, for example, by the executor **126** of the dynamic query planning system **110** in communication with one or more data resources **134** of FIG. **1**A or one or more data resources **176** of FIG. **1**B, described herein.

[0178] At operation **718**, the processing device executes a second query based on the at least one second query term to provide, via the user interface, a response to the first query. For example, at operation **718**, the processing device formulates the second query to include the at least one second query term and applies the second query to one or more data resources (e.g., one or more of data resources **134** or data resources **176**) to obtain a result set, and then formulates the response based on the result set. Operation **718** is performed, for example, by the executor **126** of the dynamic query planning system **110** in communication with one or more data resources **134** of FIG. **1**A or one or more data resources **176** of FIG. **1**B, described herein.

[0179] Following operation **718**, the processing device returns to operation **702** or (not specifically shown) operation **704**, to obtain additional user input and/or additional context data, configure one or more modified prompts based on the additional user input and/or additional context data, and generate and output one or more modified responses based on the one or more modified prompts. In other words, the method **700** can be repeated iteratively as the processing device obtains additional user input and/or additional context data. The method **700** can make the determination as to whether to use the large language model independently on each iteration, e.g., the large language model may be used to generate a query execution plan on a first iteration but not used to generate a query execution plan on a second iteration.

[0180] The examples shown in FIG. **7**A and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples.

[0181] FIG. **7**B is a flow diagram of an example method for dynamic query planning using components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0182] The method **750** is performed by processing logic that includes hardware (e.g., processing device, circuitry, dedicated logic, programmable logic, microcode, hardware of a device, integrated circuit, etc.), software (e.g., instructions run or executed on a processing device), or a combination thereof. In some embodiments, the method **750** is performed by one or more components of dynamic query planning system **110** of FIG. **1**A or dynamic query planning system **680** of FIG. **6**. Although shown in a particular sequence or order, unless otherwise specified, the order of the processes can be modified. Thus, the illustrated embodiments should be understood only as examples, and the illustrated processes can be performed in a different order, and some processes can be performed in parallel. Additionally, at least one process can be omitted in various embodiments. Thus, not all processes are required in every embodiment. Other process flows are possible.

[0183] In accordance with the method **750**, a large language model is used to generate a query execution plan for processing a user input including a search query. At operation **752**, the processing device receives, via a user interface of an application, a first query that includes a user request for information retrievable using a first set of data resources, where the first query includes at least one first query term. For example, the first query could be a conversational natural language input provided by a user, and the first query term could be a word or phrase contained in the conversational natural language input. The first set of data resources includes one or more data resources from which information may be retrieved to respond to the first query. For example, if the first query is a job search, the first set of data resources may include one or more databases that store job profiles or job postings. If the first query is a company search, the first set of data resources may include an entity graph that contains information about companies and relationships between companies. Operation **752** is performed, for example, by an embodiment of dynamic query planning system **110** in communication with application **102** of FIG. **1**A and FIG. **1**B, described herein.

[0184] At operation **754**, the processing device configures at least one prompt to cause a large language model to translate the at least one first query term received at operation **752** into a set of functions that can be executed to obtain at least one second query term using a second set of data resources, and generate and output a plan that is executable to create a modified version of the first query based on the at least one second query term. For example, the processing device at operation **754** may configure a single prompt to cause the large language model to generate and output a query execution plan, or multiple prompts to classify the user input and generate the query execution plan, or multiple prompts to generate the query execution plan. The second set of data resources includes one or more data resources from which information, such as facet values and/or filter values, can be obtained to create a modified version of the first query. For example, if the first query contains the phrase "fortune 500 companies," the second set of data resources includes at least one data resource that contains a list of all of the names of companies that are currently in the Fortune 500 list. The second set of resources and the first set of data resources may include one or more of the same data resources or may be different data resources. Operation **754** is performed, for example, by an embodiment of the dynamic query planning system **110** shown in FIGS. **1**A and **1**B, described herein, which includes plan generation prompt generator **120** and/or input classification prompt generator **112**, or which may implement the input classification approach shown in FIG. **3** and/or the plan generation approach shown in FIG. **4**.

[0185] At operation **756**, the processing device applies the large language model to the at least one prompt configured at operation **754** to obtain the plan for executing the first query. As a result of operation **756**, the large language model executes the one or more instructions contained in the at least one prompt to, e.g., classify the user input into an intent and/or generate and output the query execution plan. Operation **756** is performed, for example, by the dynamic query planning system **110** in communication with the large language model **116** of FIG. **1**A and FIG. **1**B, described herein.

[0186] At operation **758**, the processing device executes the plan generated and output by the large language model at operation **756** to determine the at least one second query term (e.g., supplemental query terms, facets, or filters), and to create the modified version of the first query based on the at least one second query term. Via execution of the plan, the processing device obtains, as a result of the application of the set of functions contained in the plan to the second set of data resources, at least one second query term. The at least one second query term is related to but different from the at least one first query term, and is obtained by executing the set of functions using one or more second data resources. For example, the at least one second query term includes one or more facet values or filters that are related to the user input, the context data, and/or the intent, where the facet values or filters are obtained by querying one or more data resources such as an entity graph, a knowledge graph, a data base, an application, or an artificial intelligence model such as a generative model. Operation **716** is performed, for example, by the executor **126** of the dynamic query planning system **110** in communication with one or more data resources **134** of FIG. **1**A or one or more data resources **176** of FIG. **1**B, described herein.

[0187] At operation **760**, the processing device executes the modified version of the first query created at operation **758** based on the at least one second query term to provide, via the user interface, a response to the first query. For example, at operation **760**, the processing device formulates the modified version of the first query to include the at least one second query term and applies the modified version of the first query to one or more data resources (e.g., one or more of data resources **134** or data resources **176**) to obtain a result set, and then formulates the response based on the result set. Operation **760** is performed, for example, by the executor **126** of the dynamic query planning system **110** in communication with one or more data resources **134** of FIG. **1**A or one or more data resources **176** of FIG. **1**B, described herein.

[0188] While not specifically shown in FIG. 7B, following operation **760**, the processing device can return to operation **752** or operation **754**, to obtain additional user input and/or additional context data, configure one or more modified prompts based on the additional user input and/or additional context data, and generate and output one or more modified responses based on the one or more modified prompts. In other words, the method **750** can be repeated iteratively as the processing device obtains additional user input and/or additional context data. The method **750** can make a determination as to whether to use the large language model for input classification and/or plan generation independently on each iteration, e.g., the large language model may be used to generate a query execution plan on a first iteration but not used to generate a query execution plan on a second iteration, or the large language model may be used for input classification but not for query plan generation, or the large language model may be used for query plan generation but not for input classification.

[0189] In some implementations, the method **750** includes configuring the at least one prompt to cause the large language model to select at least one data resource of the second set of data resources based on the first query term and configure at least one function of the set of functions to obtain the at least one second query term from the selected at least one data resource. For example, if the first query term indicates that the user is looking for jobs that match a certain criteria, the at least one prompt is configured to cause the large language model to choose a data resource from among only those data resources that can supply information about available jobs. Also, the at least one prompt is configured to cause the large language model to configure at least one function so that when the at least one function is executed using the selected data resource, the at least one second query term is retrieved from the selected data resource.

[0190] In some implementations, the method **750** includes assigning different weights to at least first and second data resources of the second set of data resources based on at least one of metadata or performance data or feedback associated with the at least first and second data resources, and configuring the at least one prompt to cause the large language model to (i) select a data resource of the at least first and second data resources based on the weights, and (ii) configure at least one function of the set of functions to obtain the at least one second query term from the selected data resource. For example, metadata associated with a data resource can include an indication of the type of information that can be retrieved from the data resource or the format of the information stored in the data resource (e.g., text, images, video, audio, etc.). Performance data associated with a data resource can include information about the availability of or latency associated with use of the data resource. Feedback can include historical data about user reactions to presentations of information retrieved from the data source (e.g., likes, comments, shares, etc.). These factors can be employed to assign or adjust the weights assigned to the data resources, and the at least one prompt can instruct the large language model to compare the weights and select the data resource having, e.g., the highest weight value or lowest weight value, as the case may be.

[0191] In some implementations, the method **750** includes determining whether the first query translates to a plurality of functions; and responsive to determining that the first query translates to the plurality of functions, formulating the modified version of the first query using the plan obtained from the large language model; or responsive to determining that the first query does not translate to the plurality of functions, skipping the configuring, the applying, the executing the plan, and the executing the modified version of the first query. For example, the steps involved in using the large language model to generate an execution plan for the user's query can be avoided or skipped if the user's query is simple or straightforward (e.g., translates to only one function). The large language model can be invoked if the user's query translates to multiple functions.

[0192] In some implementations, the method **750** includes determining a value of at least one performance metric associated with the large language model; and responsive to determining that the value of the at least one performance metric exceeds a maximum threshold value or does not exceed a minimum threshold value, configuring the at least one prompt to reduce at least one of the number of prompts contained in the at least one prompt or the number of communications with the large language model to obtain the plan or the number of instructions included in the at least one prompt to obtain the plan. For example, a prompt can be simplified (e.g., to reduce the number of examples, questions, or statements contained in the prompt) or the number of prompts can be reduced, or the number of communications with the large language model can be reduced, if the performance metric falls outside of a desired performance range for the large language model (e.g., if latency is too high, etc.). As another example, a zero-shot prompt can be used instead of a few-shot prompt, or the number of examples provided in a few-shot prompt can be reduced, or a few-shot prompt can be used instead of a multi-step prompt, prompt chaining, or a chain-of-thought prompt. As yet another example, one or more prompt parameters can be adjusted based on the performance metrics.

[0193] In some implementations, the method **750** includes obtaining context data associated with at least one of the user input or the response, where the context data includes data relating to at least one of: a state of the user interface, a state of the application, configuration data associated with a client device running the user interface, a current use of the application by a user, historical use of the application, profile data associated with the user, activity data associated with the user, data extracted from an entity graph, usage statistics associated with at least one of the user interface or the application, or performance data associated with at least one of the user interface, the application, the set of second data resources, or the large language model; modifying the at least one prompt based on the context data to include at least one instruction to cause the large language model to generate and output a modified version of the plan, the modified version of the plan executable to formulate at least one natural language recommendation for modifying the first query; applying the large language model to the modified at least one prompt to obtain, from the large language model, the modified version of the plan; executing the modified version of the plan to obtain the at least one natural language recommendation for modifying the first query; and providing, via the user interface, the at least one natural language recommendation for modifying the query. For example, context data can be continuously monitored during a user's session and prompts can be refined or modified as additional context data is obtained, so that the instructions to the large language model change as a result of the context data, which then can result in the large language model producing a different or modified plan, such as a plan that can be executed to produce natural language recommendations or insights rather than query results.

[0194] In some implementations, configuring the at least one prompt includes configuring at least one instruction to identify a plurality of functions related to context data associated with at least one of the user interface or the application and cause the large language model to select the set of functions from the plurality of functions based on the context data associated with at least one of the user interface or the application. For example, the prompt identifies a library of available functions to the large language model and instructs the large language model to select a subset of all of the available functions, e.g., to select only those functions that match the context data.

[0195] In some implementations, configuring the at least one prompt includes determining a value of at least one performance metric associated with the large language model; and responsive to determining that the value of the at least one performance metric does not exceed a maximum threshold value or exceeds a minimum threshold value, (i) configuring a first instruction to cause the large language model to translate the first query into a structured representation of the first query, (i) configuring a second instruction to cause the large language model to generate the plan based on the structured representation of the first query, and (ii) including the first instruction and the second instruction in the at least one prompt. For example, the large language model can be used to both classify a user input and generate a query execution plan. However, if the performance data for the large language model falls outside of a desired range, the large language model may be used for one but both of these tasks.

[0196] In some implementations, configuring the at least one prompt includes configuring at least one instruction to cause the large language model to (i) determine an order of execution for the set of functions based on at least one of a structured representation of the first query or function dependency data included in the at least one third instruction, and (ii) include the order of execution in the plan. For example, the order of execution can include using the output of one function as an input to another function.

[0197] In some implementations, providing the response includes retrieving, via execution of the plan, at least one of: at least one job search result related to the first query; at least one job candidate search result related to the first query; at least one entity profile page related to the first query (e.g., a user profile, business profile, or job posting); at least one blog page related to the first query (e.g., a help or FAQ page, or a business page, or a rankings page); at least one learning content item related to the first query (e.g., tutorial or coaching pages, learning videos, podcasts); or at least one recommendation to improve the first query (e.g., insights for how to modify the query to improve the search results, based on historical data). The type of response provided can vary based on the type of information retrieval system being used or the type of query requested by the user.

[0198] In some implementations, providing the response includes providing at least one command to at least one of: modify a component of the user interface as a result of execution of the plan; navigate to a content item or component via the user interface as a result of execution of the plan; populate a component of the user interface with information obtained as a result of execution of the plan; store information created at the user interface as a result of execution of the plan; send an electronic communication to at least one second user of the application identified as a result of execution of the plan (e.g., a connection request, instant message, or email); or schedule an action to be performed by the application as a result of execution of the plan (e.g., a reminder, notification, or report). For example, the response can include one or more commands that cause the user interface to perform an action, alone or in combination with information or search results.

[0199] In some implementations, executing the plan includes executing at least one function to at least one of: retrieve entity data related to the first query using a taxonomy; retrieve entity data related to the first query using an entity graph (e.g., traverse the graph to identify relevant companies, schools, skills, locations, job titles, industries); execute a client application command related to the first query (e.g., navigate to a draft the user just created, fill in a field with generated content, apply a search suggestion to a query); execute a server command related to the first query (e.g., archive content items, send an email to a job candidate, schedule a report to be sent on a certain day at a certain time); cause a generative model to generate and output content related to the first query; join data obtained from two or more data resources, e.g. join data obtained from an application with a recommendation or insight; or cause a generative model to generate and output at least one embedding related to the first query. For example, the library of available functions can include many different types of functions that may be involved in query planning and/or query execution.

[0200] The examples shown in FIG. **7**B and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples.

[0201] FIG. **8** is a block diagram of an example computer system including components of a dynamic query planning system in accordance with some embodiments of the present disclosure.

[0202] In FIG. **8**, an example machine of a computer system **800** is shown, within which a set of instructions for causing the machine to perform any of the methodologies discussed herein can be executed. In some embodiments, the computer system **800** can correspond to a component of a networked computer system (e.g., as a component of the computing system **100** of FIG. **1**A or the computer system **600** of FIG. **6**) that includes, is coupled to, or utilizes a machine to execute an operating system to perform operations corresponding to one or more components of the dynamic query planning system **110** of FIG. **1**A or the dynamic query planning system **680** of FIG. **6**. For example, computer system **800** corresponds to a portion of computing system **600** when the computing system is executing a portion of dynamic query planning system **110** or dynamic query planning system **680**.

[0203] The machine is connected (e.g., networked) to other machines in a network, such as a local area network (LAN), an intranet, an extranet, and/or the Internet. The machine can operate in the capacity of a server or a client machine in a client-server network environment, as a peer machine in a peer-to-peer (or distributed) network environment, or as a server or a client machine in a cloud computing infrastructure or environment.

[0204] The machine is a personal computer (PC), a smart phone, a tablet PC, a set-top box (STB), a Personal Digital Assistant (PDA), a cellular telephone, a web appliance, a wearable device, a server, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while a single machine is illustrated, the term “machine” includes any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any of the methodologies discussed herein.

[0205] The example computer system **800** includes a processing device **802**, a main memory **804** (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM) such as synchronous DRAM (SDRAM) or Rambus DRAM (RDRAM), etc.), a memory **803** (e.g., flash memory, static random access memory (SRAM), etc.), an input/output system **810**, and a data storage system **840**, which communicate with each other via a bus **830**.

[0206] Processing device **802** represents at least one general-purpose processing device such as a microprocessor, a central processing unit, or the like. More particularly, the processing device can be a complex instruction set computing (CISC) microprocessor, reduced instruction set computing (RISC) microprocessor, very long instruction word (VLIW) microprocessor, or a processor implementing other instruction sets, or processors implementing a combination of instruction sets. Processing device **802** can also be at least one special-purpose processing device such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a digital signal processor (DSP), network processor, or the like. The processing device **802** is configured to execute instructions **812** for performing the operations and steps discussed herein.

[0207] In some embodiments of FIG. **8**, dynamic query planning system **850** represents portions of dynamic query planning system **680** while the computer system **800** is executing those portions of dynamic query planning system **680**. Instructions **812** include portions of dynamic query planning system **850** when those portions of the dynamic query planning system **850** are being executed by processing device **802**. Thus, the dynamic query planning system **850** is shown in dashed lines as part of instructions **812** to illustrate that, at times, portions of the dynamic query planning system **850** are executed by processing device **802**. For example, when at least some portion of the dynamic query planning system **850** is embodied in instructions to cause processing device **802** to perform the method(s) described herein, some of those instructions can be read into processing device **802** (e.g., into an internal cache or other memory) from main memory **804** and/or data storage system **840**. However, it is not required that all of the dynamic query planning system **850** be included in instructions **812** at the same time and portions of the dynamic query planning system **850** are stored in at least one other component of computer system **800** at other times, e.g., when at least one portion of the dynamic query planning system **850** are not being executed by processing device **802**.

[0208] The computer system **800** further includes a network interface device **808** to communicate over the network **820**. Network interface device **808** provides a two-way data communication coupling to a network. For example, network interface device **808** can be an integrated-services digital network (ISDN) card, cable modem, satellite modem, or a modem to provide a data communication connection to a corresponding type of telephone line. As another example, network interface device **808** can be a local area network (LAN) card to provide a data communication connection to a compatible LAN. Wireless links can also be implemented. In any such implementation network interface device **808** can send and receives electrical, electromagnetic, or optical signals that carry digital data streams representing various types of information.

[0209] The network link can provide data communication through at least one network to other data devices. For example, a network link can provide a connection to the world-wide packet data communication network commonly referred to as the “Internet,” for example through a local network to a host computer or to data equipment operated by an Internet Service Provider (ISP). Local networks and the Internet use electrical, electromagnetic, or optical signals that carry digital data to and from computer system computer system **800**.

[0210] Computer system **800** can send messages and receive data, including program code, through the network(s) and network interface device **808**. In the Internet example, a server can transmit a requested code for an application program through the Internet and network interface device **808**. The received code can be executed by processing device **802** as it is received, and/or stored in data storage system **840**, or other non-volatile storage for later execution.

[0211] The input/output system **810** includes an output device, such as a display, for example a liquid crystal display (LCD) or a touchscreen display, for displaying information to a computer user, or a speaker, a haptic device, or another form of output device. The input/output system **810** can include an input device, for example, alphanumeric keys and other keys configured for communicating information and command selections to processing device **802**. An input device can, alternatively or in addition, include a cursor control, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processing device **802** and for controlling cursor movement on a display. An input device can, alternatively or in addition, include a microphone, a sensor, or an array of sensors, for communicating sensed information to processing device **802**. Sensed information can include voice commands, audio signals, geographic location information, haptic information, and/or digital imagery, for example.

[0212] The data storage system **840** includes a machine-readable storage medium **842** (also known as a computer-readable medium) on which is stored at least one set of instructions **844** or software embodying any of the methodologies or functions described herein. The instructions **844** can also reside, completely or at least partially, within the main memory **804** and/or within the processing device **802** during execution thereof by the computer system **800**, the main memory **804** and the processing device **802** also constituting machine-readable storage media. In one embodiment, the instructions **844** include instructions to implement functionality corresponding to a dynamic query planning system **850** (e.g., the dynamic query planning system **110** of FIG. **1**A or dynamic query planning system **680** of FIG. **6**).

[0213] Dashed lines are used in FIG. **8** to indicate that it is not required that the dynamic query planning system be embodied entirely in instructions **812**, **814**, and **844** at the same time. In one example, portions of the dynamic query planning system are embodied in instructions **814**, which are read into main memory **804** as instructions **814**, and portions of instructions **812** are read into processing device **802** as instructions **812** for execution. In another example, some portions of the dynamic query planning system are embodied in instructions **844** while other portions are embodied in instructions **814** and still other portions are embodied in instructions **812**.

[0214] While the machine-readable storage medium **842** is shown in an example embodiment to be a single medium, the term “machine-readable storage medium” should be taken to include a single medium or multiple media that store the instructions. The term “machine-readable storage medium” shall also be taken to include any medium that is capable of storing or encoding a set of instructions for execution by the machine and that cause the machine to perform any of the methodologies of the present disclosure. The term “machine-readable storage medium” shall accordingly be taken to include, but not be limited to, solid-state memories, optical media, and magnetic media. The examples shown in FIG. **8** and the accompanying description, above are provided for illustration purposes. This disclosure is not limited to the described examples.

[0215] Some portions of the preceding detailed description have been presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the ways used by those skilled in the data processing arts to convey the substance of their work most effectively to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of operations leading to a desired result. The operations are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

[0216] It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. The present disclosure can refer to the action and processes of a computer system, or similar electronic computing device, which manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage systems.

[0217] The present disclosure also relates to an apparatus for performing the operations herein. This apparatus can be specially constructed for the intended purposes, or it can include a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. For example, a computer system or other data processing system, such as the computing system **100** or the computing system **600**, can carry out the above-described computer-implemented methods in response to its processor executing a computer program (e.g., a sequence of instructions) contained in a memory or other non-transitory machine-readable storage medium. Such a computer program can be stored in a computer readable storage medium, such as, but not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, or any type of media suitable for storing electronic instructions, each coupled to a computer system bus.

[0218] The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems can be used with programs in accordance with the teachings herein, or it can prove convenient to construct a more specialized apparatus to perform the method. The structure for a variety of these systems will appear as set forth in the description below. In addition, the present disclosure is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages can be used to implement the teachings of the disclosure as described herein.

[0219] The present disclosure can be provided as a computer program product, or software, which can include a machine-readable medium having stored thereon instructions, which can be used to program a computer system (or other electronic devices) to perform a process according to the present disclosure. A machine-readable medium includes any mechanism for storing information in a form readable by a machine (e.g., a computer). In some embodiments, a machine-readable (e.g., computer-readable) medium includes a machine (e.g., a computer) readable storage medium such as a read only memory (“ROM”), random access memory (“RAM”), magnetic disk storage media, optical storage media, flash memory components, etc.

[0220] The techniques described herein may be implemented with privacy safeguards to protect user privacy. Furthermore, the techniques described herein may be implemented with user privacy safeguards to prevent unauthorized access to personal data and confidential data. The training of the AI models described herein is executed to benefit all users fairly, without causing or amplifying unfair bias.

[0221] According to some embodiments, the techniques for the models described herein do not make inferences or predictions about individuals unless requested to do so through an input. According to some embodiments, the models described herein do not learn from and are not trained on user data without user authorization. In instances where user data is permitted and authorized for use in AI features and tools, it is done in compliance with a user's visibility settings, privacy choices, user agreement and descriptions, and the applicable law. According to the techniques described herein, users may have full control over the visibility of their content and who sees their

content, as is controlled via the visibility settings. According to the techniques described herein, users may have full control over the level of their personal data that is shared and distributed between different AI platforms that provide different functionalities.
[0222] According to the techniques described herein, users may have full control over the level of access to their personal data that is shared with other parties. According to the techniques described herein, personal data provided by users may be processed to determine prompts when using a generative AI feature at the request of the user, but not to train generative AI models. In some embodiments, users may provide feedback while using the techniques described herein, which may be used to improve or modify the platform and products. In some embodiments, any personal data associated with a user, such as personal information provided by the user to the platform, may be deleted from storage upon user request. In some embodiments, personal information associated with a user may be permanently deleted from storage when a user deletes their account from the platform.
[0223] According to the techniques described herein, personal data may be removed from any training dataset that is used to train AI models. The techniques described herein may utilize tools for anonymizing member and customer data. For example, user's personal data may be redacted and minimized in training datasets for training AI models through delexicalization tools and other privacy enhancing tools for safeguarding user data. The techniques described herein may minimize use of any personal data in training AI models, including removing and replacing personal data. According to the techniques described herein, notices may be communicated to users to inform how their data is being used and users are provided controls to opt-out from their data being used for training AI models.
[0224] According to some embodiments, tools are used with the techniques described herein to identify and mitigate risks associated with AI in all products and AI systems. In some embodiments, notices may be provided to users when AI tools are being used to provide features.
[0225] Illustrative examples of the technologies disclosed herein are provided below. An embodiment of the technologies may include any of the examples described herein, or any combination of any of the examples described herein, or any combination of any portions of the examples described herein.
[0226] In an example 1, a method includes: receiving, via a user interface of an application, a first query including a user request for information retrievable using a first set of data resources, the first query including at least one first query term: configuring at least one prompt to cause a large language model to (i) translate the at least one first query term into a set of functions that can be executed to obtain at least one second query term using a second set of data resources, the at least one second query term related to and different from the at least one first query term, and (ii) generate and output a plan that is executable to create a modified version of the first query based on the at least one second query term, the plan including the set of functions configured by the large language model to obtain the at least one second query term using the set of second data resources; applying the large language model to the at least one prompt to obtain the plan; executing the plan generated and output by the large language model to (i) determine the at least one second query term, and (ii) create the modified version of the first query based on the at least one second query term; and executing the modified version of the first query based on the at least one second query term to provide, via the user interface, a response to the first query.
[0227] An example 2 includes the subject matter of example 1, further including: configuring the at least one prompt to cause the large language model to select at least one data resource of the second set of data resources based on the first query term and configure at least one function of the set of functions to obtain the at least one second query term from the selected at least one data resource. An example 3 includes the subject matter of example 1 or example 2, further including: assigning different weights to at least first and second data resources of the second set of data resources based on at least one of metadata or performance data or feedback associated with the at least first and

second data resources, and configuring the at least one prompt to cause the large language model to (i) select a data resource of the at least first and second data resources based on the weights, and (ii) configure at least one function of the set of functions to obtain the at least one second query term from the selected data resource. An example 4 includes the subject matter of any of examples 1-3, further including: determining whether the first query translates to a plurality of functions; and responsive to determining that the first query translates to the plurality of functions, formulating the modified version of the first query using the plan obtained from the large language model; or responsive to determining that the first query does not translate to the plurality of functions, skipping the configuring, the applying, the executing the plan, and the executing the modified version of the first query. An example 5 includes the subject matter of any of examples 1-4, further including: determining a value of at least one performance metric associated with the large language model; and responsive to determining that the value of the at least one performance metric exceeds a maximum threshold value or does not exceed a minimum threshold value, configuring the at least one prompt to reduce at least one of the number of prompts contained in the at least one prompt or the number of communications with the large language model to obtain the plan or the number of instructions included in the at least one prompt to obtain the plan. An example 6 includes the subject matter of any of examples 1-5, further including, iteratively: obtaining context data associated with at least one of the user request or the response, the context data including data relating to at least one of: a state of the user interface, a state of the application, configuration data associated with a client device running the user interface, a current use of the application by a user, historical use of the application, profile data associated with the user, activity data associated with the user, data extracted from an entity graph, usage statistics associated with at least one of the user interface or the application, or performance data associated with at least one of the user interface, the application, the set of second data resources, or the large language model; modifying the at least one prompt based on the context data to include at least one instruction to cause the large language model to generate and output a modified version of the plan, the modified version of the plan executable to formulate at least one natural language recommendation for modifying the first query; applying the large language model to the modified at least one prompt to obtain, from the large language model, the modified version of the plan; executing the modified version of the plan to obtain the at least one natural language recommendation for modifying the first query; and providing, via the user interface, the at least one natural language recommendation for modifying the query. An example 7 includes the subject matter of any of examples 1-6, where configuring the at least one prompt further includes configuring at least one instruction to identify a plurality of functions related to context data associated with at least one of the user interface or the application and cause the large language model to select the set of functions from the plurality of functions based on the context data associated with at least one of the user interface or the application. An example 8 includes the subject matter of any of examples 1-7, where configuring the at least one prompt further includes: determining a value of at least one performance metric associated with the large language model; and responsive to determining that the value of the at least one performance metric does not exceed a maximum threshold value or exceeds a minimum threshold value, (i) configuring a first instruction to cause the large language model to translate the first query into a structured representation of the first query, (i) configuring a second instruction to cause the large language model to generate the plan based on the structured representation of the first query, and (ii) including the first instruction and the second instruction in the at least one prompt. An example 9 includes the subject matter of any of examples 1-8, where configuring the at least one prompt further includes: configuring at least one instruction to cause the large language model to (i) determine an order of execution for the set of functions based on at least one of a structured representation of the first query or function dependency data, and (ii) include the order of execution in the plan. An example 10 includes the subject matter of any of examples 1-9, where providing the response further includes retrieving, via execution of the plan, at least one of: at least one job search result related to the first query; at least one job candidate search result related to the first query; at least one entity profile page related to the first query; at least one blog page related to the first query; at least one learning content item related to the first query; or at least one recommendation to improve the first query. An example 11 includes the subject matter of any of examples 1-10, where providing the response further includes providing at least one command to at least one of: modify a component of the user interface as a result of execution of the plan; navigate to a content item or component via the user interface as a result of execution of the plan; populate a component of the user interface with information obtained as a result of execution of the plan; store information created at the user interface as a result of execution of the plan; send an electronic communication to at least one second user of the application identified as a result of execution of the plan; or schedule an action to be performed by the application as a result of execution of the plan. An example 12 includes the subject matter of any of examples 1-11, where executing the plan includes executing at least one function to at least one of: retrieve entity data related to the first query using a taxonomy; retrieve entity data related to the first query using an entity graph; execute a client application command related to the first query; execute a server command related to the first query; cause a generative model to generate and output content related to the first query; or cause a generative model to generate and output at least one embedding related to the first query.

[0228] In an example 13, a system includes: at least one processor; and at least one memory coupled to the at least one processor, where the at least one memory includes at least one instruction that, when executed by the at least one processor, cause the at least one processor to perform at least one operation including: receiving, via a user interface of an application, a first query including a user request for information retrievable using a first set of data resources, the first query including at least one first query term: configuring at least one prompt to cause a large language model to (i) translate the at least one first query term into a set of functions that can be executed to obtain at least one second query term using a second set of data resources, the at least one second query term related to and different from the at least one first query term, and (ii) generate and output a plan that is executable to create a modified version of the first query based on the at least one second query term, the plan including the set of functions configured by the large language model to obtain the at least one second query term using the set of second data resources; applying the large language model to the at least one prompt to obtain the plan; executing the plan generated and output by the large language model to (i) determine the at least one second query term, and (ii) create the modified version of the first query based on the at least one second query term; and executing the modified version of the first query based on the at least one second query term to provide, via the user interface, a response to the first query.

[0229] An example 14 includes the subject matter of example 13, where the at least one instruction, when executed by the at least one processor, causes the at least one processor to perform at least one operation further including at least one of: configuring the at least one prompt to cause the large language model to select at least one data resource of the second set of data resources based on the first query term and configure at least one function of the set of functions to obtain the at least one second query term from the selected at least one data resource; or configuring the at least one prompt to cause the large language model to assign different weights to at least first and second data resources of the second set of data resources based on at least one of metadata or performance data associated with the at least first and second data resources, select a data resource of the at least first and second data resources based on the weights, and configure at least one function of the set of functions to obtain the at least one second query term from the selected data resource. An example 15 includes the subject matter of example 13 or example 14, where the at least one instruction, when executed by the at least one processor, causes the at least one processor to perform at least one operation further including: determining whether the first query translates to a plurality of functions; and responsive to determining that the first query translates to the plurality of functions, formulating the modified version of the first query using the plan obtained from the large language model; or responsive to determining that the first query does not translate to the plurality of functions, skipping the configuring, the applying, the executing the plan, and the executing the modified version of the first query. An example 16 includes the subject matter of any of examples 13-15, where the at least one instruction, when executed by the at least one processor, causes the at least one processor to perform at least one operation further including, iteratively: obtaining context data associated with at least one of the user request or the response, the context data including data relating to at least one of: a state of the user interface, a state of the application, a current use of the application by a user, historical use of the application, profile data associated with the user, activity data associated with the user, data extracted from an entity graph, usage statistics associated with at least one of the user interface or the application, or performance data associated with at least one of the user interface, the application, the set of second data resources, or the large language model; configuring at least one second prompt based on the context data, the at least one second prompt including at least one instruction to cause the large language model to generate and output a second plan executable to formulate at least one recommendation for modifying the first query; applying the large language model to the at least one second prompt to obtain, from the large language model, the second plan including a second set of functions configured by the large language model to formulate the at least one recommendation for modifying the first query; executing the second plan to obtain the at least one recommendation for modifying the query; and providing, via the user interface, a second response to the first query, the second response including the at least one recommendation for modifying the query.

[0230] In an example 17, at least one non-transitory machine-readable storage medium including at least one instruction that, when executed by at least one processor, causes the at least one processor to perform at least one operation including: receiving, via a user interface of an application, a first query including a user request for information retrievable using a first set of data resources, the first query including at least one first query term: configuring at least one prompt to cause a large language model to (i) translate the at least one first query term into a set of functions that can be executed to obtain at least one second query term using a second set of data resources, the at least one second query term related to and different from the at least one first query term, and (ii) generate and output a plan that is executable to create a modified version of the first query based on the at least one second query term, the plan including the set of functions configured by the large language model to obtain the at least one second query term using the set of second data resources; applying the large language model to the at least one prompt to obtain the plan; executing the plan generated and output by the large language model to (i) determine the at least one second query term, and (ii) create the modified version of the first query based on the at least one second query term; and executing the modified version of the first query based on the at least one second query term to provide, via the user interface, a response to the first query. An example 18 includes the subject matter of example 17, where configuring the at least one prompt further includes configuring at least one instruction to identify a plurality of functions related to context data associated with at least one of the user interface or the application and cause the large language model to select the set of functions from the plurality of functions based on context data associated with at least one of the user interface, the application, the set of second data resources, or the first query. An example 19 includes the subject matter of example 17 or example 18, where configuring the at least one prompt further includes: determining a value of at least one performance metric associated with the large language model; and responsive to determining that the value of the at least one performance metric does not exceed a threshold value, (i) configuring a first instruction to cause the large language model to translate the first query into a structured representation of the first query, (i) configuring a second instruction to cause the large language model to generate the plan based on the structured representation of the first query, and (ii) including the first instruction and the second instruction in the at least one prompt. An example 20 includes the subject matter of any of examples 17-19, where configuring the at least one prompt further includes configuring at least one instruction to cause the large language model to (i) determine an order of execution for the set of functions based on at least one of a structured representation of the first query or function dependency data, and (ii) include the order of execution in the plan.

[0231] An example 21 includes the method of any of the preceding examples, further including any one or more aspects, steps, components, elements, processes, or limitations that are at least one of described in the enclosed description or shown in the accompanying drawings. An example 22 includes a system, including: at least one processor; and at least one memory coupled to the at least one processor, where the at least one memory includes instructions that, when executed by the at least one processor, cause the at least one processor to perform at least one operation including the method of any of examples 1-21. An example 23 includes at least one non-transitory machine-readable storage medium, including instructions that, when executed by at least one processor, cause the at least one processor to perform at least one operation including the method of any of examples 1-21.

[0232] In the foregoing specification, embodiments of the disclosure have been described with reference to specific example embodiments thereof. It will be evident that various modifications can be made thereto without departing from the broader spirit and scope of embodiments of the disclosure as set forth in the following claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

Claims

1. A method comprising: receiving an input via a device; formulating an intent query using the input; identifying a plurality of intents via execution of the intent query on an intent library; formulating a prompt using the input and the plurality of intents; providing the input, the plurality of intents, and the prompt to a generative machine learning model; receiving a first output from the generative machine learning model, wherein the first output comprises a first function of a particular type selected from a plurality of function types by the generative machine learning model executing the prompt using the input and the plurality of intents; formulating a first result via execution of the first function; and causing presentation of at least one of the first result or a second result via the device.

2. The method of claim 1, wherein the input comprises a user request, the first function comprises a search function of a particular search type, and the search function of the particular search type is selected from a plurality of search function types by the generative machine learning model executing the prompt using the input and the plurality of intents.

3. The method of claim 1, wherein the first output further comprises a first function parameter determined by the generative machine learning model executing the prompt using the input and the plurality of function types.

4. The method of claim 3, wherein the first function parameter comprises a search term determined by the generative machine learning model executing the prompt using the input.

5. The method of claim 3, further comprising: obtaining the second result via execution of a second function using a second function parameter, wherein the second function is determined by the generative machine learning model using the first function parameter and the second function parameter comprises a subset of the first function parameter.

6. The method of claim 5, wherein the second function comprises a query disambiguation function and the second result comprises at least one of a facet or a filter related to the subset of the first function parameter.

7. The method of claim 6, further comprising obtaining the at least one of the facet or filter from a data resource, wherein the data resource is selected via the generative machine learning model executing the prompt using the input.

8. The method of claim 1, further comprising: receiving a second output from the generative machine learning model, wherein the second output comprises a plan generated by the generative machine learning model in response to the input and the first output, wherein the plan comprises a plurality of functions, an order of execution of the plurality of functions, and a plurality of data resources.

9. The method of claim 1, further comprising: causing presentation of reasoning via the device, wherein the reasoning comprises an explanation of how the first result was formulated using the generative machine learning model.

10. The method of claim 9, wherein the reasoning comprises at least one of a restatement of the input or a facet used to generate the first result, wherein the facet is obtained via selection of the first function by the generative machine learning model.

11. The method of claim 10, further comprising: causing presentation of a feedback mechanism via the device; and using feedback received via the feedback mechanism, excluding the facet from a subsequent execution of the first function.

12. The method of claim 1, further comprising: logging an interaction with at least one of the first result or the second result, wherein the interaction is received via the device; generating a search improvement recommendation using the interaction; and causing presentation of the search improvement recommendation via the device.

13. The method of claim 1, further comprising: formulating an instruction query using the input and the plurality of intents; causing an execution of the instruction query on an instruction library; receiving a plurality of instructions from the instruction library in response to the execution of the instruction query; and including the plurality of instructions in the prompt.

14. A system comprising: a processor; and a memory coupled to the processor, wherein the memory comprises instructions that, when executed by the processor, cause the processor to: receive an input via a device; formulate an intent query using the input; identify a plurality of intents via execution of the intent query on an intent library; formulate a prompt using the input and the plurality of intents; provide the input, the plurality of intents, and the prompt to a generative machine learning model; receive a first output from the generative machine learning model, wherein the first output comprises a first function of a particular type selected from a plurality of function types by the generative machine learning model executing the prompt using the input and the plurality of intents; formulate a first result via execution of the first function; and cause presentation of at least one of the first result or a second result via the device.

15. The system of claim 14, wherein the input comprises a user request, the first function comprises a search function of a particular search type, and the search function of the particular search type is selected from a plurality of search function types by the generative machine learning model executing the prompt using the input and the plurality of intents.

16. The system of claim 14, wherein at least one of: (a) the first output further comprises a first function parameter determined by the generative machine learning model executing the prompt using the input and the plurality of function types; or (b) the first function parameter comprises a search term determined by the generative machine learning model executing the prompt using the input, and the instructions further cause the processor to: obtain the second result via execution of a second function using a second function parameter, wherein the second function is determined by the generative machine learning model using the first function parameter, the second function parameter comprises a subset of the first function parameter, the second function comprises a query disambiguation function, and the second result comprises at least one of a facet or a filter related to the subset of the first function parameter; and obtain the at least one of the facet or filter from a data resource, wherein the data resource is selected via the generative machine learning model executing the prompt using the input.

17. The system of claim 14, wherein the instructions further cause the processor to: receive a second output from the generative machine learning model, wherein the second output comprises a plan generated by the generative machine learning model in response to the input and the first output, and wherein the plan comprises a plurality of functions, an order of execution of the plurality of functions, and a plurality of data resources.

18. The system of claim 14, wherein the instructions further cause the processor to: cause presentation of reasoning via the device, wherein the reasoning comprises an explanation of how the first result was formulated using the generative machine learning model, wherein the reasoning comprises at least one of a restatement of the input or a facet used to generate the first result, and wherein the facet is obtained via selection of the first function by the generative machine learning model; cause presentation of a feedback mechanism via the device; and using feedback received via the feedback mechanism, exclude the facet from a subsequent execution of the first function.

19. A non-transitory machine-readable storage medium comprising instructions that, when executed by a processor, causes the processor to: receive an input via a device; formulate an intent query using the input; identify a plurality of intents via execution of the intent query on an intent library; formulate a prompt using the input and the plurality of intents; provide the input, the plurality of intents, and the prompt to a generative machine learning model; receive a first output from the generative machine learning model, wherein the first output comprises a first function of a particular type selected from a plurality of function types by the generative machine learning model executing the prompt using the input and the plurality of intents; formulate a first result via execution of the first function; and cause presentation of at least one of the first result or a second result via the device.

20. The non-transitory machine-readable storage medium of claim 19, wherein the instructions further cause the processor to at least one of: (a) (i) log an interaction with at least one of the first result or the second result, wherein the interaction is received via the device; (ii) generate a search improvement recommendation using the interaction; and (iii) cause presentation of the search improvement recommendation via the device; or (b) (i) formulate an instruction query using the input and the plurality of intents; (ii) cause an execution of the instruction query on an instruction library; (iii) receive a plurality of instructions from the instruction library in response to the execution of the instruction query; and (iv) include the plurality of instructions in the prompt.