TRAVEL-RELATED WEIGHTED COGNITIVE PERSONAS AND PROFILES

Applicant: Cognite, Inc., Austin, TX (US)

Inventors: John N. Faith, Austin, TX (US); Kyle W. Kothe, Austin, TX (US)

Assignee: COGNITE, INC., Austin, TX (US)

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ABSTRACT

A method, system and computer-readable medium for performing cognitive computing operations comprising receiving streams of data from a plurality of data sources; processing the streams of data from the plurality of data sources, the processing the streams of data from the plurality of data sources performing data enriching for incorporation into a cognitive graph; defining a travel-related cognitive persona within the cognitive graph, the travel-related cognitive persona corresponding to an archetype user model, the travel-related cognitive persona comprising a set of nodes in the cognitive graph, links among the set of nodes being weighted to provide a weighted cognitive graph; associating a user with the travel-related cognitive persona; and, performing a cognitive computing operation based upon the travel-related cognitive persona associated with the user.
Figure 1
Figure 3
Figure 4a
Figure 8

Figure 9
Start Cognitive Persona And Profile Operations 1302

Cognitive Application Requests API Key 1304

Issue Session Token To Cognitive Application To Initiate Travel-Related Cognitive Session 1306

Receive Direct And Indirect User Input For Processing 1308

User Identified? 1310

Has Session Token Expired? 1342

Yes

No

Does Relevant Cognitive Profile Exist For User? 1312

Select Relevant Cognitive Persona For User 1316

Use Direct And Indirect User Input Data With Cognitive Persona Or Cognitive Profile To Generate And Present Contextually-Relevant Composite Cognitive Insights To User 1318

Retrieve Relevant Cognitive Profile For User 1314

Figure 13a
Figure 13b
TRAVEL-RELATED WEIGHTED COGNITIVE PERSONAS AND PROFILES

CROSS-REFERENCE TO RELATED APPLICATION


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates in general to the field of computers and similar technologies, and in particular to software utilized in this field. Still more particularly, it relates to a method, system and computer-usable medium for using travel-related weighted cognitive personas and profiles in the performance of travel-related cognitive inference and learning operations.

[0004] 2. Description of the Related Art

[0005] In general, “big data” refers to a collection of datasets so large and complex that they become difficult to process using typical database management tools and traditional data processing approaches. These datasets can originate from a wide variety of sources, including computer systems, mobile devices, credit card transactions, television broadcasts, and medical equipment, as well as infrastructures associated with cities, sensor-equipped buildings and factories, and transportation systems. Challenges commonly associated with big data, which may be a combination of structured, unstructured, and semi-structured data, include its capture, curation, storage, search, sharing, analysis and visualization. In combination, these challenges make it difficult to efficiently process large quantities of data within tolerable time intervals.

[0006] Nonetheless, big data analytics hold the promise of extracting insights by uncovering difficult-to-discover patterns and connections, as well as providing assistance in making complex decisions by analyzing different and potentially conflicting options. As such, individuals and organizations alike can be provided new opportunities to innovate, compete, and capture value.

[0007] One aspect of big data is “dark data,” which generally refers to data that is either not collected, neglected, or underutilized. Examples of data that is not currently being collected includes location data prior to the emergence of companies such as Foursquare or social data prior to the advent companies such as Facebook. An example of data that is being collected, but is difficult to access at the right time and place, includes data associated with the side effects of certain spider bites while on a camping trip. As another example, data that is collected and available, but has not yet been produced or utilized, may include disease insights from population-wide healthcare records and social media feeds. As a result, a case can be made that dark data may in fact be of higher value than big data in general, especially as it can likely provide actionable insights when it is combined with readily-available data.

SUMMARY OF THE INVENTION

[0008] A method, system and computer-usable medium are disclosed for cognitive inference and learning operations.

[0009] In one embodiment, the invention relates to a method for performing cognitive computing operations comprising receiving streams of data from a plurality of data sources; processing the streams of data from the plurality of data sources, the processing the streams of data from the plurality of data sources performing data enriching for incorporation into a cognitive graph; defining a travel-related cognitive persona within the cognitive graph, the travel-related cognitive persona corresponding to an archetype user model, the travel-related cognitive persona comprising a set of nodes in the cognitive graph, links among the set of nodes being weighted to provide a weighted cognitive graph; associating a user with the travel-related cognitive persona; and, performing a cognitive computing operation based upon the travel-related cognitive persona associated with the user.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present invention may be better understood, and its numerous objects, features and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference number throughout the several figures designates a like or similar element.

[0011] FIG. 1 depicts an exemplary client computer in which the present invention may be implemented;

[0012] FIG. 2 is a simplified block diagram of a cognitive inference and learning system (CILS);

[0013] FIG. 3 is a simplified block diagram of a CILS reference model implemented in accordance with an embodiment of the invention;

[0014] FIGS. 4a through 4c depict additional components of the CILS reference model shown in FIG. 3;

[0015] FIG. 5 is a simplified process diagram of CILS operations;

[0016] FIG. 6 depicts the lifecycle of CILS agents implemented to perform CILS operations;

[0017] FIG. 7 is a simplified block diagram of a plurality of cognitive platforms implemented in a hybrid cloud environment;

[0018] FIG. 8 depicts a travel-related cognitive persona defined by a first set of nodes in a cognitive graph;

[0019] FIG. 9 depicts a travel-related cognitive profile defined by the addition of a second set of nodes to the first set of nodes shown in FIG. 8;

[0020] FIG. 10 depicts a travel-related cognitive persona defined by a first set of nodes in a weighted cognitive graph;

[0021] FIG. 11 depicts a travel-related cognitive profile defined by the addition of a second set of nodes to the first set of nodes shown in FIG. 10;

[0022] FIGS. 12a and 12b are a simplified process flow diagram showing the use of travel-related cognitive personas and cognitive profiles to generate travel-related composite cognitive insights; and

[0023] FIGS. 13a and 13b are a generalized flowchart of travel-related cognitive personas and cognitive profile operations performed in the generation of travel-related composite cognitive insights.

DETAILED DESCRIPTION

[0024] A method, system and computer-usable medium are disclosed for cognitive inference and learning operations.
The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media, (e.g., light pulses passing through a fiber optic cable), or electrical signals transmitted through a wire.

Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction set architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or other source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++, and the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/acts specified in the flowchart and/or block diagram block or blocks.

The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

FIG. 1 is a generalized illustration of an information processing system 100 that can be used to implement the system and method of the present invention. The information processing system 100 includes a processor (e.g., central
processor unit or “CPU”) 102, input/output (I/O) devices 104, such as a display, a keyboard, a mouse, and associated controllers, a hard drive or disk storage 106, and various other subsystems 108. In various embodiments, the information processing system 100 also includes network port 110 operable to connect to a network 140, which is likewise accessible by a service provider server 142. The information processing system 100 likewise includes system memory 112, which is interconnected to the foregoing via one or more buses 114. System memory 112 further comprises operating system (OS) 116 and in various embodiments may also comprise cognitive inference and learning system (CILS) 118. In these and other embodiments, the CILS 118 may likewise comprise invention modules 120. In one embodiment, the information processing system 100 is able to download the CILS 118 from the service provider server 142. In another embodiment, the CILS 118 is provided as a service from the service provider server 142.

In various embodiments, the CILS 118 is implemented to perform various cognitive computing operations described in greater detail herein. As used herein, cognitive computing broadly refers to a class of computing involving self-learning systems that use techniques such as spatial navigation, machine vision, and pattern recognition to increasingly mimic the way the human brain works. To be more specific, earlier approaches to computing typically solved problems by executing a set of instructions codified within software. In contrast, cognitive computing approaches are data-driven, sense-making, insight-extracting, problem-solving systems that have more in common with the structure of the human brain than with the architecture of contemporary, instruction-driven computers.

To further differentiate these distinctions, traditional computers must first be programmed by humans to perform specific tasks, while cognitive systems learn from their interactions with data and humans alike, and in a sense, program themselves to perform new tasks. To summarize the difference between the two, traditional computers are designed to calculate rapidly. Cognitive systems are designed to quickly draw inferences from data and gain new knowledge.

Cognitive systems achieve these abilities by combining various aspects of artificial intelligence, natural language processing, dynamic learning, and hypothesis generation to render vast quantities of intelligible data to assist humans in making better decisions. As such, cognitive systems can be characterized as having the ability to interact naturally with people to extend what either humans, or machines, could do on their own. Furthermore, they are typically able to process natural language, multi-structured data, and experience much in the same way as humans. Moreover, they are also typically able to learn a knowledge domain based upon the best available data and get better, and more immersive, over time.

It will be appreciated that more data is currently being produced every day than was recently produced by human beings from the beginning of recorded time. Deep within this ever-growing mass of data is a class of data known as “dark data,” which includes neglected information, ambient signals, and insights that can assist organizations and individuals in augmenting their intelligence and deliver actionable insights through the implementation of cognitive applications. As used herein, cognitive applications, or “cognitive apps,” broadly refer to cloud-based, big data interpretable applications that learn from user engagement and data interactions. Such cognitive applications extract patterns and insights from dark data sources that are currently almost completely opaque. Examples of such dark data include disease insights from population-wide healthcare records and social media feeds, or from new sources of information, such as sensors monitoring pollution in delicate marine environments.

Over time, it is anticipated that cognitive applications will fundamentally change the way in which many organizations operate as they invert current issues associated with data volume and variety to enable a smart, interactive data supply chain. Ultimately, cognitive applications hold the promise of receiving a user query and immediately providing a data-driven answer from a masked data supply chain. As they evolve, it is likewise anticipated that cognitive applications may enable a new class of “sixth sense” applications that intelligently detect and learn from relevant data and events to offer insights, predictions and advice rather than wait for commands. Just as web and mobile applications changed the way people access data, cognitive applications may change the way people listen to, and become empowered by, multi-structured data such as emails, social media feeds, doctors notes, transaction records, and call logs.

However, the evolution of such cognitive applications has associated challenges, such as how to detect events, ideas, images, and other content that may be of interest. For example, assuming that the role and preferences of a given user are known, how is the most relevant information discovered, prioritized, and summarized from large streams of multi-structured data such as news feeds, blogs, social media, structured data, and various knowledge bases? To further the example, what can a healthcare executive be told about their competitor’s market share? Other challenges include the creation of a contextually-appropriate visual summary of responses to questions or queries.

FIG. 2 is a simplified block diagram of a cognitive inference and learning system (CILS) implemented in accordance with an embodiment of the invention. In various embodiments, the CILS 118 is implemented to incorporate a variety of processes, including semantic analysis 202, goal optimization 204, collaborative filtering 206, common sense reasoning 208, natural language processing 210, summarization 212, temporal/spatial reasoning 214, and entity resolution 216 to generate cognitive insights.

As used herein, semantic analysis 202 broadly refers to performing various analysis operations to achieve a semantic level of understanding about language by relating syntactic structures. In various embodiments, various syntactic structures are related from the levels of phrases, clauses, sentences and paragraphs, to the level of the body of content as a whole and to its language-independent meaning. In certain embodiments, the semantic analysis 202 process includes processing a target sentence to parse it into its individual parts of speech, tag sentence elements that are related to predetermined items of interest, identify dependencies between individual words, and perform co-reference resolution. For example, if a sentence states that the author really likes the hamburgers served by a particular restaurant, then the name of the “particular restaurant” is co-referenced to “hamburgers.”

As likewise used herein, goal optimization 204 broadly refers to performing multi-criteria decision making operations to achieve a given goal or target objective. In
various embodiments, one or more goal optimization processes are implemented by the CILS to define predetermined goals, which in turn contribute to the generation of a cognitive insight. For example, goals for planning a vacation trip may include low cost (e.g., transportation and accommodations), location (e.g., by the beach), and speed (e.g., short travel time). In this example, it will be appreciated that certain goals may be in conflict with another. As a result, a cognitive insight provided by the CILS to a traveler may indicate that hotel accommodations by a beach may cost more than they care to spend.

[0042] Collaborative filtering 206, as used herein, broadly refers to the process of filtering for information or patterns through the collaborative involvement of multiple agents, viewpoints, data sources, and so forth. The application of such collaborative filtering 206 processes typically involves very large and different kinds of data sets, including sensing and monitoring data, financial data, and user data of various kinds. Collaborative filtering 206 may also refer to the process of making automatic predictions associated with predetermined interests of a user by collecting preferences or other information from many users. For example, if person ‘A’ has the same opinion as person ‘B’ for a given issue ‘x’, then an assertion can be made that person ‘A’ is more likely to have the same opinion as person ‘B’ on a different issue ‘y’ than to have the same opinion on issue ‘x’ as a randomly chosen person. In various embodiments, the collaborative filtering 206 process is implemented with various recommendation engines familiar to those of skill in the art to make recommendations.

[0043] As used herein, common sense reasoning 208 broadly refers to simulating the human ability to make deductions from common facts they inherently know. Such deductions may be made from inherent knowledge about the physical properties, purpose, intentions and possible behavior of ordinary things, such as people, animals, objects, devices, and so on. In various embodiments, common sense reasoning 208 processes are implemented to assist the CILS in understanding and disambiguating words within a predetermined context. In certain embodiments, the common sense reasoning 208 processes are implemented to allow the CILS to generate text or phrases related to a target word or phrase to perform deeper searches for the same terms. It will be appreciated that if the context of a word is better understood, then a common sense understanding of the word can then be used to assist in finding better or more accurate information. In certain embodiments, this better or more accurate understanding of the context of a word, and its related information, allows the CILS to make more accurate deductions, which are in turn used to generate cognitive insights.

[0044] As likewise used herein, natural language processing (NLP) 210 broadly refers to interactions with a system, such as the CILS, through the use of human, or natural, languages. In various embodiments, NLP processes are implemented by the CILS to achieve natural language understanding, which enables it to not only derive meaning from human or natural language input, but to also generate natural language output.

[0045] Summarization 212, as used herein, broadly refers to processing a set of information, organizing and ranking it, and then generating a corresponding summary. As an example, a news article may be processed to identify its primary topic and associated observations, which are then extracted, ranked, and then presented to the user. As another example, page ranking operations may be performed on the same news article to identify individual sentences, rank them, order them, and determine which of the sentences are most impactful in describing the article and its content. As yet another example, a structured data record, such as a patient’s electronic medical record (EMR), may be processed using the summarization 212 process to generate sentences and phrases that describes the content of the EMR. In various embodiments, various summarization 212 processes are implemented by the CILS to generate summaries of content streams, which are in turn used to generate cognitive insights.

[0046] As used herein, temporal/spatial reasoning 214 broadly refers to reasoning based upon qualitative abstractions of temporal and spatial aspects of common sense knowledge, described in greater detail herein. For example, it is not uncommon for a predetermined set of data to change over time. Likewise, other attributes, such as its associated metadata, may likewise change over time. As a result, these changes may affect the context of the data. To further the example, the context of asking someone what they believe they should be doing at 3:00 in the afternoon during the workday while they are at work may be quite different that asking the same user the same question at 3:00 on a Sunday afternoon when they are at home. In various embodiments, various temporal/spatial reasoning 214 processes are implemented by the CILS to determine the context of queries, and associated data, which are in turn used to generate cognitive insights.

[0047] As likewise used herein, entity resolution 216 broadly refers to the process of finding elements in a set of data that refer to the same entity across different data sources (e.g., structured, non-structured, streams, devices, etc.), where the target entity does not share a common identifier. In various embodiments, the entity resolution 216 process is implemented by the CILS to identify significant nouns, adjectives, phrases or sentence elements that represent various predetermined entities within one or more domains. From the foregoing, it will be appreciated that the implementation of one or more of the semantic analysis 202, goal optimization 204, collaborative filtering 206, common sense reasoning 208, natural language processing 210, summarization 212, temporal/spatial reasoning 214, and entity resolution 216 processes by the CILS can facilitate the generation of a semantic, cognitive model.

[0048] In various embodiments, the CILS receives ambient signals 220, curated data 222, and learned knowledge, which is then processed by the CILS to generate one or more cognitive graphs 226. In turn, the one or more cognitive graphs 226 are further used by the CILS to generate cognitive insights streams, which are then delivered to one or more destinations 230, as described in greater detail herein.

[0049] As used herein, ambient signals 220 broadly refer to input signals, or other data streams, that may contain data providing additional insight or context to the curated data 222 and learned knowledge 224 received by the CILS. For example, ambient signals may allow the CILS to understand that a user is currently using their mobile device, at location ‘x’, at time ‘y’, doing activity ‘z’. To further the example, there is a difference between the user using their mobile device while they are on an airplane versus using their mobile device after landing at an airport and walking between one terminal and another. To extend the example even further,
ambient signals may add additional context, such as the user is in the middle of a three leg trip and has two hours before their next flight. Further, they may be in terminal A1, but their next flight is out of C1, it is lunchtime, and they want to know the best place to eat. Given the available time the user has, their current location, restaurants that are proximate to their predicted route, and other factors such as food preferences, the CILS 118 can perform various cognitive operations and provide a recommendation for where the user can eat.

In various embodiments, the curated data 222 may include structured, unstructured, social, public, private, streaming, device or other types of data described in greater detail herein. In certain embodiments, the learned knowledge 224 is based upon past observations and feedback from the presentation of prior cognitive insight streams and recommendations. In various embodiments, the learned knowledge 224 is provided via a feedback loop that provides the learned knowledge 224 in the form of a learning stream of data.

As likewise used herein, a cognitive graph 226 refers to a representation of expert knowledge, associated with individuals and groups over a period of time, to depict relationships between people, places, and things using words, ideas, audio and images. As such, it is a machine-readable formalism for knowledge representation that provides a common framework allowing data and knowledge to be shared and reused across user, application, organization, and community boundaries.

In various embodiments, the information contained in, and referenced by, a cognitive graph 226 is derived from many sources (e.g., public, private, social, device), such as curated data 222. In certain of these embodiments, the cognitive graph 226 assists in the identification and organization of information associated with how people, places and things are related to one other. In various embodiments, the cognitive graph 226 enables automated agents, described in greater detail herein, to access the Web more intelligently, enumerate inferences through utilization of curated, structured data 222, and provide answers to questions by serving as a computational knowledge engine.

In certain embodiments, the cognitive graph 226 not only elicits and maps expert knowledge by deriving associations from data, it also renders higher level insights and accounts for knowledge creation through collaborative knowledge modeling. In various embodiments, the cognitive graph 226 is a machine-readable, declarative memory system that stores and learns both episodic memory (e.g., specific personal experiences associated with an individual or entity), and semantic memory, which stores factual information (e.g., geo location of an airport or restaurant).

For example, the cognitive graph 226 may know that a given airport is a place, and that there is a list of related places such as hotels, restaurants and departure gates. Furthermore, the cognitive graph 226 may know that people such as business travelers, families and college students use the airport to board flights from various carriers, eat at various restaurants, or shop at certain retail stores. The cognitive graph 226 may also have knowledge about the key attributes from various retail rating sites that travelers have used to describe the food and their experience at various venues in the airport over the past six months.

In certain embodiments, the cognitive insight stream 228 is bidirectional, and supports flows of information both too and from destinations 230. In these embodiments, the first flow is generated in response to receiving a query, and subsequently delivered to one or more destinations 230. The second flow is generated in response to detecting information about a user of one or more of the destinations 230. Such use results in the provision of information to the CILS 118. In response, the CILS 118 processes that information, in the context of what it knows about the user, and provides additional information to the user, such as a recommendation. In various embodiments, the cognitive insight stream 228 is configured to be provided in a “push” stream configuration familiar to those of skill in the art. In certain embodiments, the cognitive insight stream 228 is implemented to use natural language approaches familiar to skilled practitioners of the art to support interactions with a user.

In various embodiments, the cognitive insight stream 228 may include a stream of visualized insights. As used herein, visualized insights broadly refers to cognitive insights that are presented in a visual manner, such as a map, an infographic, images, and so forth. In certain embodiments, these visualized insights may include various cognitive insights, such as “What happened?”, “What do I know about it?”, “What is likely to happen next?”, or “What should I do about it?” In these embodiments, the cognitive insight stream is generated by various cognitive agents, which are applied to various sources, datasets, and cognitive graphs. As used herein, a cognitive agent broadly refers to a computer program that performs a task with minimum specific directions from users and learns from each interaction with data and human users.

In various embodiments, the CILS 118 delivers Cognition as a Service (CaaS). As such, it provides a cloud-based development and execution platform that allow various cognitive applications and services to function more intelligently and intuitively. In certain embodiments, cognitive applications powered by the CILS 118 are able to think and interact with users as intelligent virtual assistants. As a result, users are able to interact with such cognitive applications by asking them questions and giving them commands. In response, these cognitive applications will be able to assist the user in completing tasks and managing their work more efficiently.

In these and other embodiments, the CILS 118 can operate as an analytics platform to process big data, and dark data as well, to provide data analytics through a public, private or hybrid cloud environment. As used herein, cloud analytics broadly refers to a service model wherein data sources, data models, processing applications, computing power, analytic models, and sharing or storage of results are implemented within a cloud environment to perform one or more aspects of analytics.

In various embodiments, users submit queries and computation requests in a natural language format to the CILS 118. In response, they are provided with a ranked list of relevant answers and aggregated information with useful links and pertinent visualizations through a graphical representation. In these embodiments, the cognitive graph 226 generates semantic and temporal maps to reflect the organization of unstructured data and to facilitate meaningful learning from potentially millions of lines of text, much in the same way as arbitrary syllables strung together can mean through the concept of language.

FIG. 3 is a simplified block diagram of a cognitive inference and learning system (CILS) reference model implemented in accordance with an embodiment of the invention. In this embodiment, the CILS reference model is associated
with the CILS 118 shown in FIG. 2. As shown in FIG. 3, the CILS 118 includes client applications 302, application accelerators 306, a cognitive platform 310, and cloud infrastructure 340. In various embodiments, the client applications 302 include cognitive applications 304, which are implemented to understand and adapt to the user, not the other way around, by natively accepting and understanding human forms of communication, such as natural language text, audio, images, video, and so forth. [0061] In these and other embodiments, the cognitive applications 304 possess situational and temporal awareness based upon ambient signals from users and data, which facilitates understanding the user’s intent, content, context and meaning to drive goal-driven dialogs and outcomes. Further, they are designed to gain knowledge over time from a wide variety of structured, non-structured, and device data sources, continuously interpreting and autonomously reprogramming themselves to better understand a given domain. As such, they are well-suited to support human decision making, by proactively providing trusted advice, offers and recommendations while respecting user privacy and permissions. [0062] In various embodiments, the application accelerators 306 include a cognitive application framework 308. In certain embodiments, the application accelerators 306 and the cognitive application framework 308 support various plug-ins and components that facilitate the creation of client applications 302 and cognitive applications 304. In various embodiments, the application accelerators 306 include widgets, user interface (UI) components, reports, charts, and back-end integration components familiar to those of skill in the art. [0063] As likewise shown in FIG. 3, the cognitive platform 310 includes a management console 312, a development environment 314, application program interfaces (APIs) 316, sourcing agents 318, a cognitive engine 320, destination agents 336, and platform data 338, all of which are described in greater detail herein. In various embodiments, the management console 312 is implemented to manage accounts and projects, along with user-specific metadata that is used to drive processes and operations within the cognitive platform 310 for a predetermined project. [0064] In certain embodiments, the development environment 314 is implemented to create custom extensions to the CILS 118 shown in FIG. 2. In various embodiments, the development environment 314 is implemented for the development of a custom application, which may subsequently be deployed in a public, private or hybrid cloud environment. In certain embodiments, the development environment 314 is implemented for the development of a custom sourcing agent, a custom bridging agent, a custom destination agent, or various analytics applications or extensions. [0065] In various embodiments, the APIs 316 are implemented to build and manage predetermined cognitive applications 304, described in greater detail herein, which are then executed on the cognitive platform 310 to generate cognitive insights. Likewise, the sourcing agents 318 are implemented in various embodiments to source a variety of multi-site, multi-structured source streams of data described in greater detail herein. In various embodiments, the cognitive engine 320 includes a dataset engine 322, a graph query engine 326, an insight/learning engine 330, and foundation components 334. In certain embodiments, the dataset engine 322 is implemented to establish and maintain a dynamic data ingestion and enrichment pipeline. In these and other embodiments, the dataset engine 322 may be implemented to orchestrate one or more sourcing agents 318 to source data. Once the data is sourced, the data set engine 322 performs data enriching and other data processing operations, described in greater detail herein, and generates one or more sub-graphs that are subsequently incorporated into a target cognitive graph. [0066] In various embodiments, the graph query engine 326 is implemented to receive and process queries such that they can be bridged into a cognitive graph, as described in greater detail herein, through the use of a bridging agent. In certain embodiments, the graph query engine 326 performs various natural language processing (NLP) familiar to skilled practitioners of the art, to process the queries. In various embodiments, the insight/learning engine 330 is implemented to encapsulate a predetermined algorithm, which is then applied to a cognitive graph to generate a result, such as a cognitive insight or a recommendation. In certain embodiments, one or more such algorithms may contribute to answering a specific question and provide additional cognitive insights or recommendations. In various embodiments, two or more of the dataset engine 322, the graph query engine 326, and the insight/learning engine 330 may be implemented to operate collaboratively to generate a cognitive insight or recommendation. In certain embodiments, one or more of the dataset engine 322, the graph query engine 326, and the insight/learning engine 330 may operate autonomously to generate a cognitive insight or recommendation. [0067] The foundation components 334 shown in FIG. 3 include various reusable components, familiar to those of skill in the art, which are used in various embodiments to enable the dataset engine 322, the graph query engine 326, and the insight/learning engine 330 to perform their respective operations and processes. Examples of such foundation components 334 include natural language processing (NLP) components and core algorithms, such as cognitive algorithms. [0068] In various embodiments, the platform data 338 includes various data repositories, described in greater detail herein, that are accessed by the cognitive platform 310 to generate cognitive insights. In various embodiments, the destination agents 336 are implemented to publish cognitive insights to a consumer of cognitive insight data. Examples of such consumers of cognitive insight data include target databases, business intelligence applications, and mobile applications. It will be appreciated that many such examples of cognitive insight data consumers are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention. In various embodiments, as described in greater detail herein, the cloud infrastructure 340 includes cognitive cloud management 342 components and cloud analytics infrastructure components 344. [0069] FIGS. 4a through 4c depict additional cognitive inference and learning system (CILS) components implemented in accordance with an embodiment of the CILS reference model shown in FIG. 3. In this embodiment, the CILS reference model includes client applications 302, application accelerators 306, a cognitive platform 310, and cloud infrastructure 340. As shown in FIG. 4a, the client applications 302 include cognitive applications 304. In various embodiments, the cognitive applications 304 are implemented natively accept and understand human forms of communication, such as natural language text, audio, images, video, and so forth. In certain embodiments, the cognitive applications 304 may include healthcare 402, business performance 403,
travel 404, and various other 405 applications familiar to skilled practitioners of the art. As such, the foregoing is only provided as examples of such cognitive applications 304 and is not intended to limit the intent, spirit or scope of the invention.

[0070] In various embodiments, the application accelerators 306 include a cognitive application framework 308. In certain embodiments, the application accelerators 308 and the cognitive application framework 308 support various plug-ins and components that facilitate the creation of client applications 302 and cognitive applications 304. In various embodiments, the application accelerators 306 include widgets, user interface (UI) components, reports, charts, and back-end integration components familiar to those of skill in the art. It will be appreciated that many such application accelerators 306 are possible and that their provided functionality, selection, provision and support are a matter of design choice. As such, the application accelerators 306 described in greater detail herein are not intended to limit the spirit, scope or intent of the invention.

[0071] As shown in FIGS. 4a and 4b, the cognitive platform 310 includes a management console 312, a development environment 314, application program interfaces (APIs) 316, sourcing agents 318, a cognitive engine 320, destination agents 336, platform data 338, and a crawl framework 452. In various embodiments, the management console 312 is implemented to manage accounts and projects, along with management metadata 461 that is used to drive processes and operations within the cognitive platform 310 for a predetermined project.

[0072] In various embodiments, the management console 312 is implemented to run various services on the cognitive platform 310. In certain embodiments, the management console 312 is implemented to manage the configuration of the cognitive platform 310. In certain embodiments, the management console 312 is implemented to establish the development environment 314. In various embodiments, the management console 312 may be implemented to manage the development environment 314 once it is established. Skilled practitioners of the art will realize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0073] In various embodiments, the development environment 314 is implemented to create custom extensions to the CILS 118 shown in FIG. 2. In these and other embodiments, the development environment 314 is implemented to support various programming languages, such as Python, Java, R, and others familiar to skilled practitioners of the art. In various embodiments, the development environment 314 is implemented to allow one or more of these various programming languages to create a variety of analytic models and applications. As an example, the development environment 314 may be implemented to support the R programming language, which in turn can be used to create an analytic model that is then hosted on the cognitive platform 310.

[0074] In certain embodiments, the development environment 314 is implemented for the development of various custom applications or extensions related to the cognitive platform 310, which may subsequently be deployed in a public, private or hybrid cloud environment. In various embodiments, the development environment 314 is implemented for the development of various custom sourcing agents 318, custom enrichment agents 425, custom bridging agents 429, custom insight agents 433, custom destination agents 336, and custom learning agents 434, which are described in greater detail herein.

[0075] In various embodiments, the APIs 316 are implemented to build and manage predetermined cognitive applications 304, described in greater detail herein, which are then executed on the cognitive platform 310 to generate cognitive insights. In these embodiments, the APIs 316 may include one or more of a project and dataset API 408, a cognitive search API 409, a cognitive insight API 410, and other APIs. The selection of the individual APIs 316 implemented in various embodiments is a matter of design choice and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0076] In various embodiments, the project and dataset API 408 is implemented with the management console 312 to enable the management of a variety of data and metadata associated with various cognitive insight projects and user accounts hosted or supported by the cognitive platform 310. In one embodiment, the data and metadata managed by the project and dataset API 408 are associated with billing information familiar to those of skill in the art. In one embodiment, the project and dataset API 408 is used to access a data stream that is created, configured and orchestrated, as described in greater detail herein, by the dataset engine 322.

[0077] In various embodiments, the cognitive search API 409 uses natural language processes familiar to those of skill in the art to search a target cognitive graph. Likewise, the cognitive insight API 410 is implemented in various embodiments to configure the insight learning engine 330 to provide access to predetermined outputs from one or more cognitive graph algorithms that are executing in the cognitive platform 310. In certain embodiments, the cognitive insight API 410 is implemented to subscribe to, or request, such predetermined outputs.

[0078] In various embodiments, the sourcing agents 318 may include a batch upload 414 agent, an API connectors 415 agent, a real-time stream 416 agent, a Structured Query Language (SQL)/Not Only SQL (NoSQL) databases 417 agent, a message engines 418 agent, and one or more custom sourcing 420 agents. Skilled practitioners of the art will realize that other types of sourcing agents 318 may be used in various embodiments and the foregoing is not intended to limit the spirit, scope or intent of the invention. In various embodiments, the sourcing agents 318 are implemented to source a variety of multi-site, multi-structured source streams of data described in greater detail herein. In certain embodiments, each of the sourcing agents 318 has a corresponding API.

[0079] In various embodiments, the batch uploading 414 agent is implemented for batch uploading of data to the cognitive platform 310. In these embodiments, the uploaded data may include a single data element, a single data record or file, or a plurality of data records or files. In certain embodiments, the data may be uploaded from more than one source and the uploaded data may be in a homogenous or heterogeneous form. In various embodiments, the API connectors 415 agent is implemented to manage interactions with one or more predetermined APIs that are external to the cognitive platform 310. As an example, Associated Press® may have their own API for news stories, Expedia® for travel information, or the National Weather Service for weather information. In these examples, the API connectors 415 agent would be imple-
mented to determine how to respectively interact with each organization’s API such that the cognitive platform 310 can receive information.

[0080] In various embodiments, the real-time streams 416 agent is implemented to receive various streams of data, such as social media streams (e.g., Twitter feeds) or other data streams (e.g., device data streams). In these embodiments, the streams of data are received in near-real-time. In certain embodiments, the data streams include temporal attributes. As an example, as data is added to a blog file, it is time-stamped to create temporal data. Other examples of a temporal data stream include Twitter feeds, stock ticker streams, device location streams from a device that is tracking location, medical devices tracking a patient’s vital signs, and intelligent thermostats used to improve energy efficiency for homes.

[0081] In certain embodiments, the temporal attributes define a time window, which can be correlated to various elements of data contained in the stream. For example, as a given time window changes, associated data may have a corresponding change. In various embodiments, the temporal attributes do not define a time window. As an example, a social media feed may not have predetermined time windows, yet it is still temporal. As a result, the social media feed can be processed to determine what happened in the last 24 hours, what happened in the last hour, what happened in the last 15 minutes, and then determine related subject matter that is trending.

[0082] In various embodiments, the SQL/NoSQL databases 417 agent is implemented to interact with one or more target databases familiar to those of skill in the art. For example, the target database may include a SQL, NoSQL, delimited flat file, or other form of database. In various embodiments, the message engines 418 agent is implemented to provide data to the cognitive platform 310 from one or more message engines, such as a message queue (MQ) system, a message bus, a message broker, an enterprise service bus (ESB), and so forth. Skilled practitioners of the art will realize that there are many such examples of message engines with which the message engines 418 agent may interact and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0083] In various embodiments, the custom sourcing agents 420, which are purpose-built, are developed through the use of the development environment 314, described in greater detail herein. Examples of custom sourcing agents 420 include sourcing agents for various electronic medical record (EMR) systems at various healthcare facilities. Such EMR systems typically collect a variety of healthcare information, much of it the same, yet it may be collected, stored and provided in different ways. In this example, the custom sourcing agents 420 allow the cognitive platform 310 to receive information from each disparate healthcare source.

[0084] In various embodiments, the cognitive engine 320 includes a dataset engine 322, a graph engine 326, an insight/learning engine 330, learning agents 434, and foundation components 334. In these and other embodiments, the dataset engine 322 is implemented as described in greater detail to establish and maintain a dynamic data ingestion and enrichment pipeline. In various embodiments, the dataset engine 322 may include a pipelines 422 component, an enrichment 423 component, a storage component 424, and one or more enrichment agents 425.

In various embodiments, the pipelines 422 component is implemented to ingest various data provided by the sourcing agents 318. Once ingested, this data is converted by the pipelines 422 component into streams of data for processing. In certain embodiments, these managed streams are provided to the enrichment 423 component, which performs data enrichment operations familiar to those of skill in the art. As an example, a data stream may be sourced from Associated Press® by a sourcing agent 318 and provided to the dataset engine 322. The pipelines 422 component receives the data stream and routes it to the enrichment 423 component, which then enriches the data stream by performing sentiment analysis, geotagging, and entity detection operations to generate an enriched data stream. In certain embodiments, the enrichment operations include filtering operations familiar to skilled practitioners of the art. To further the preceding example, the Associated Press® data stream may be filtered by a predetermined geography attribute to generate an enriched data stream.

[0086] The enriched data stream is then subsequently stored, as described in greater detail herein, in a predetermined location. In various embodiments, the enriched data stream is cached by the storage 424 component to provide a local version of the enriched data stream. In certain embodiments, the cached, enriched data stream is implemented to be “replayed” by the cognitive engine 320. In one embodiment, the replaying of the cached, enriched data stream allows incremental ingestion of the enriched data stream instead of ingesting the entire enriched data stream at one time. In various embodiments, one or more enrichment agents 425 are implemented to be invoked by the enrichment component 423 to perform one or more enrichment operations described in greater detail herein.

[0087] In various embodiments, the graph query engine 326 is implemented to receive and process queries such that they can be bridged into a cognitive graph, as described in greater detail herein, through the use of a bridging agent. In these embodiments, the graph query engine 326 may include a query 426 component, a translate 427 component, a bridge 428 component, and one or more bridging agents 429.

[0088] In various embodiments, the query 426 component is implemented to support natural language queries. In these and other embodiments, the query 426 component receives queries, processes them (e.g., using NLP processes), and then maps the processed query to a target cognitive graph. In various embodiments, the translate 427 component is implemented to convert the processed queries provided by the query 426 component into a form that can be used to query a target cognitive graph. To further differentiate the distinction between the functionality respectively provided by the query 426 and translate 427 components, the query 426 component is oriented toward understanding a query from a user. In contrast, the translate 427 component is oriented to translating a query that is understood into a form that can be used to query a cognitive graph.

[0089] In various embodiments, the bridge 428 component is implemented to generate an answer to a query provided by the translate 427 component. In certain embodiments, the bridge 428 component is implemented to provide domain-specific responses when bridges a translated query to a cognitive graph. For example, the same query bridged to a target cognitive graph by the bridge 428 component may result in
different answers for different domains, dependent upon domain-specific bridging operations performed by the bridge 428 component.

[0090] To further differentiate the distinction between the translate 427 component and the bridging 428 component, the translate 427 component relates to a general domain translation of a question. In contrast, the bridging 428 component allows the question to be asked in the context of a specific domain (e.g., healthcare, travel, etc.), given what is known about the data. In certain embodiments, the bridging 428 component is implemented to process what is known about the translated query, in the context of the user, to provide an answer that is relevant to a specific domain.

[0091] As an example, a user may ask, “Where should I eat today?” If the user has been prescribed a particular health regimen, the bridging 428 component may suggest a restaurant with a “healthy” menu. However, if the user is a business traveler, the bridging 428 component may suggest the nearest restaurant that has the user’s favorite food. In various embodiments, the bridging 428 component may provide answers, or suggestions, that are composed and ranked according to a specific domain of use. In various embodiments, the bridging agent 429 is implemented to interact with the bridging component 428 to perform bridging operations described in greater detail herein. In these embodiments, the bridging agent interprets a translated query generated by the query 426 component within a predetermined user context, and then maps it to predetermined nodes and links within a target cognitive graph.

[0092] In various embodiments, the insight/learning engine 330 is implemented to encapsulate a predetermined algorithm, which is then applied to a target cognitive graph to generate a result, such as a cognitive insight or a recommendation. In certain embodiments, one or more such algorithms may contribute to answering a specific question and provide additional cognitive insights or recommendations. In these and other embodiments, the insight/learning engine 330 is implemented to perform insight/learning operations, described in greater detail herein. In various embodiments, the insight/learning engine 330 may include a discover/visibility 430 component, a predict 431 component, a rank/recommend 432 component, and one or more insight 433 agents.

[0093] In various embodiments, the discover/visibility 430 component is implemented to provide detailed information related to a predetermined topic, such as a subject or an event, along with associated historical information. In certain embodiments, the predict 431 component is implemented to perform predictive operations to provide insight into what may next occur for a predetermined topic. In various embodiments, the rank/recommend 432 component is implemented to perform ranking and recommendation operations to provide a user prioritized recommendations associated with a provided cognitive insight.

[0094] In certain embodiments, the insight/learning engine 330 may include additional components. For example, the additional components may include classification algorithms, clustering algorithms, and so forth. Skilled practitioners of the art will realize that many such additional components are possible and that the foregoing is not intended to limit the spirit, scope or intent of the invention. In various embodiments, the insights agents 433 are implemented to create a visual data story, highlighting user-specific insights, relationships and recommendations. As a result, it can share, operationalize, or track business insights in various embodiments. In various embodiments, the learning agent 434 work in the background to continually update the cognitive graph, as described in greater detail herein, from each unique interaction with data and users.

[0095] In various embodiments, the destination agents 336 are implemented to publish cognitive insights to a consumer of cognitive insight data. Examples of such consumers of cognitive insight data include target databases, business intelligence applications, and mobile applications. In various embodiments, the destination agents 336 may include a Hypertext Transfer Protocol (HTTP) stream 440 agent, an API connectors 441 agent, a databases 442 agent, a message engines 443 agent, a mobile push notification 444 agent, and one or more custom destination 446 agents. Skilled practitioners of the art will realize that other types of destination agents 318 may be used in various embodiments and the foregoing is not intended to limit the spirit, scope or intent of the invention. In certain embodiments, each of the destination agents 318 has a corresponding API.

[0096] In various embodiments, the HTTP stream 440 agent is implemented for providing various HTTP streams of cognitive insight data to a predetermined cognitive data consumer. In these embodiments, the provided HTTP streams may include various HTTP data elements familiar to those of skill in the art. In certain embodiments, the HTTP streams of data are provided in real-time. In various embodiments, the API connectors 441 agent is implemented to manage interactions with one or more predetermined APIs that are external to the cognitive platform 310. As an example, various target databases, business intelligence applications, and mobile applications may each have their own unique API.

[0097] In various embodiments, the databases 442 agent is implemented for provision of cognitive insight data to one or more target databases familiar to those of skill in the art. For example, the target database may include a SQL, NoSQL, delimited flat file, or other form of database. In these embodiments, the provided cognitive insight data may include a single data element, a single data record or file, or a plurality of data records or files. In certain embodiments, the data may be provided to more than one cognitive data consumer and the provided data may be in a homogenous or heterogeneous form. In various embodiments, the message engines 443 agent is implemented to provide cognitive insight data to one or more message engines, such as a message queue (MQ) system, a message bus, a message broker, an enterprise service bus (ESB), and so forth. Skilled practitioners of the art will realize that there are many such examples of message engines with which the message engines 443 agent may interact and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0098] In various embodiments, the custom destination agents 420, which are purpose-built, are developed through the use of the development environment 314, described in greater detail herein. Examples of custom destination agents 420 include destination agents for various electronic medical record (EMR) systems at various healthcare facilities. Such EMR systems typically collect a variety of healthcare information, much of it the same, yet it may be collected, stored and provided in different ways. In this example, the custom destination agents 420 allow such EMR systems to receive cognitive insight data in a form they can use.

[0099] In various embodiments, data that has been cleansed, normalized and enriched by the dataset engine, as
described in greater detail herein, is provided by a destination agent 336 to a predetermined destination, likewise described in greater detail herein. In these embodiments, neither the graph query engine 326 nor the insight/learning engine 330 are implemented to perform their respective functions.

In various embodiments, the foundation components 334 are implemented to enable the dataset engine 322, the graph query engine 326, and the insight/learning engine 330 to perform their respective operations and processes. In these and other embodiments, the foundation components 334 may include an NLP core 436 component, an NLP services 437 component, and a dynamic pipeline engine 438. In various embodiments, the NLP core 436 component is implemented to provide a set of predetermined NLP components for performing various NLP operations described in greater detail herein.

In these embodiments, certain of these NLP core components are surfaced through the NLP services 437 component, while some are used as libraries. Examples of operations that are performed with such components include dependency parsing, parts-of-speech tagging, sentence pattern detection, and so forth. In various embodiments, the NLP services 437 component is implemented to provide various internal NLP services, which are used to perform entity detection, summarization, and other operations, likewise described in greater detail herein. In these embodiments, the NLP services 437 component is implemented to interact with the NLP core 436 component to provide predetermined NLP services, such as summarizing a target paragraph.

In various embodiments, the dynamic pipeline engine 438 is implemented to interact with the dataset engine 322 to perform various operations related to receiving one or more sets of data from one or more sourcing agents, apply enrichment to the data, and then provide the enriched data to a predetermined destination. In these and other embodiments, the dynamic pipeline engine 438 manages the distribution of these various operations to a predetermined compute cluster and tracks versioning of the data as it is processed across various distributed computing resources. In certain embodiments, the dynamic pipeline engine 438 is implemented to perform data sovereignty management operations to maintain sovereignty of the data.

In various embodiments, the platform data 338 includes various data repositories, described in greater detail herein, that are accessed by the cognitive platform 310 to generate cognitive insights. In these embodiments, the platform data 338 repositories may include repositories of dataset metadata 456, cognitive graphs 457, models 459, crawl data 460, and management metadata 461. In various embodiments, the dataset metadata 456 is associated with curated data 458 contained in the repository of cognitive graphs 457. In these and other embodiments, the repository of dataset metadata 456 contains dataset metadata that supports operations performed by the storage 424 component of the dataset engine 322. For example, if a MongoDB® NoSQL database with ten million items is being processed, and the cognitive platform 310 fails after ingesting nine million of the items, then the dataset metadata 456 may be able to provide a checkpoint that allows ingestion to continue at the point of failure instead restarting the ingestion process.

Those of skill in the art will realize that the use of such dataset metadata 456 in various embodiments allows the dataset engine 322 to be stateful. In certain embodiments, the dataset metadata 456 allows support of versioning. For example versioning may be used to track versions of modifications made to data, such as in data enrichment processes described in greater detail herein. As another example, geotagging information may have been applied to a set of data during a first enrichment process, which creates a first version of enriched data. Adding sentiment data to the same million records during a second enrichment process creates a second version of enriched data. In this example, the dataset metadata stored in the dataset metadata 456 provides tracking of the different versions of the enriched data and the differences between the two.

In various embodiments, the repository of cognitive graphs 457 is implemented to store cognitive graphs generated, accessed, and updated by the cognitive engine 320 in the process of generating cognitive insights. In various embodiments, the repository of cognitive graphs 457 may include one or more repositories of curated data 458, described in greater detail herein. In certain embodiments, the repositories of curated data 458 includes data that has been curated by one or more users, machine operations, or a combination of the two, by performing various sourcing, filtering, and enriching operations described in greater detail herein. In these and other embodiments, the curated data 458 is ingested by the cognitive platform 310 and then processed, as likewise described in greater detail herein, to generate cognitive insights. In various embodiments, the repository of models 459 is implemented to store models that are generated, accessed, and updated by the cognitive engine 320 in the process of generating cognitive insights. As used herein, models broadly refer to machine learning models. In certain embodiments, the models include one or more statistical models.

In various embodiments, the crawl framework 452 is implemented to support various crawlers 454 familiar to skilled practitioners of the art. In certain embodiments, the crawlers 454 are custom configured for various target domains. For example, different crawlers 454 may be used for various travel forums, travel blogs, travel news and other travel sites. In various embodiments, data collected by the crawlers 454 is provided by the crawl framework 452 to the repository of crawl data 460. In these embodiments, the collected crawl data is processed and then stored in a normalized form in the repository of crawl data 460. The normalized data is then provided to the SQL/NoSQL database 417 agent, which in turn provides it to the database engine 322. In one embodiment, the crawl database 460 is a NoSQL database, such as MongoDB®.

In various embodiments, the repository of management metadata 461 is implemented to store user-specific metadata used by the management console 312 to manage accounts (e.g., billing information) and projects. In certain embodiments, the user-specific metadata stored in the repository of management metadata 461 is used by the management console 312 to drive processes and operations within the cognitive platform 310 for a predetermined project. In various embodiments, the user-specific metadata stored in the repository of management metadata 461 is used to enforce data sovereignty. It will be appreciated that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

Referring now to FIG. 4c the cloud infrastructure 340 may include a cognitive cloud management 342 component and a cloud analytics infrastructure 344 component in various embodiments. Current examples of a cloud infra-
structure 340 include Amazon Web Services (AWS(R)), available from Amazon.com(R) of Seattle, Wash., IBM(R) Softlayer, available from International Business Machines of Armonk, N.Y., and Nebula/Openstack, a joint project between Rackspace Hosting(R), of Windcrest, Tex., and the National Aeronautics and Space Administration (NASA). In these embodiments, the cognitive cloud management 342 component may include a management playbooks 468 sub-component, a cognitive cloud management console 469 sub-component, a data console 470 sub-component, and an asset repository 471 sub-component. In certain embodiments, the cognitive cloud management 342 component may include various other sub-components.

[0109] In various embodiments, the management playbooks 468 sub-component is implemented to automate the creation and management of the cloud analytics infrastructure 344 component along with various other operations and processes related to the cloud infrastructure 340. As used herein, “management playbooks” broadly refers to any set of instructions or data, such as scripts and configuration data, that is implemented by the management playbooks 468 sub-component to perform its associated operations and processes.

[0110] In various embodiments, the cognitive cloud management console 469 sub-component is implemented to provide a user visibility and management controls related to the cloud analytics infrastructure 344 component along with various other operations and processes related to the cloud infrastructure 340. In various embodiments, the data console 470 sub-component is implemented to manage platform data 338, described in greater detail herein. In various embodiments, the asset repository 471 sub-component is implemented to provide access to various cognitive cloud infrastructure assets, such as asset configurations, machine images, and cognitive insight stack configurations.

[0111] In various embodiments, the cloud analytics infrastructure 344 component may include a data grid 472 sub-component, a distributed compute engine 474 sub-component, and a compute cluster management 476 sub-component. In these embodiments, the cloud analytics infrastructure 344 component may also include a distributed object storage 478 sub-component, a distributed full text search 480 sub-component, a document database 482 sub-component, a graph database 484 sub-component, and various other sub-components. In various embodiments, the data grid 472 sub-component is implemented to provide distributed and shared memory that allows the sharing of objects across various data structures. One example of a data grid 472 sub-component is Redis, an open-source, networked, in-memory, key-value data store, with optional durability, written in ANSI C. In various embodiments, the distributed compute engine 474 sub-component is implemented to allow the cognitive platform 310 to perform various cognitive insight operations and processes in a distributed computing environment. Examples of such cognitive insight operations and processes include batch operations and streaming analytics processes.

[0112] In various embodiments, the compute cluster management 476 sub-component is implemented to manage various computing resources as a compute cluster. One such example of such a compute cluster management 476 sub-component is Mesos/Nimbus, a cluster management platform that manages distributed hardware resources into a single pool of resources that can be used by application frameworks to efficiently manage workload distribution for both batch jobs and long-running services. In various embodiments, the distributed object storage 478 sub-component is implemented to manage the physical storage and retrieval of distributed objects (e.g., binary file, image, text, etc.) in a cloud environment. Examples of a distributed object storage 478 sub-component include Amazon S3(R), available from Amazon.com(R) of Seattle, Wash., and Swift, an open source, scalable and redundant storage system.

[0113] In various embodiments, the distributed full text search 480 sub-component is implemented to perform various full text search operations familiar to those of skill in the art within a cloud environment. In various embodiments, the document database 482 sub-component is implemented to manage the physical storage and retrieval of structured data in a cloud environment. Examples of such structured data include social, public, private, and device data, as described in greater detail herein. In certain embodiments, the structured data includes data that is implemented in the JavaScript Object Notation (JSON) format. One example of a document database 482 sub-component is Mongo, an open source cross-platform document-oriented database. In various embodiments, the graph database 484 sub-component is implemented to manage the physical storage and retrieval of cognitive graphs. One example of a graph database 484 sub-component is GraphDB, an open source graph database familiar to those of skill in the art.

[0114] FIG. 5 is a simplified process diagram of cognitive inference 340. In various embodiments, the CILS operations performed in accordance with an embodiment of the invention. In various embodiments, these CILS operations may include a perceive 506 phase, a relate 508 phase, an operate 510 phase, a process and execute 512 phase, and a learn 514 phase. In these and other embodiments, the CILS 118 shown in FIG. 2 is implemented to mimic cognitive processes associated with the human brain. In various embodiments, the CILS operations are performed through the implementation of a cognitive platform 310, described in greater detail herein. In these and other embodiments, the cognitive platform 310 may be implemented within a cloud analytics infrastructure 344, which in turn is implemented within a cloud infrastructure 340, likewise described in greater detail herein.

[0115] In various embodiments, multi-site, multi-structured source streams 504 are provided by sourcing agents, as described in greater detail herein. In these embodiments, the source streams 504 are dynamically ingested in real-time during the perceive 506 phase, and based upon a predetermined context, extraction, parsing, and tagging operations are performed on language, text and images contained in the source streams 504. Automatic feature extraction and modeling operations are then performed with the previously processed source streams 504 during the relate 508 phase to generate queries to identify related data (i.e., corpus expansion).

[0116] In various embodiments, operations are performed during the operate 510 phase to discover, summarize and prioritize various concepts, which are in turn used to generate actionable recommendations and notifications associated with predetermined plan-based optimization goals. The resulting actionable recommendations and notifications are then processed during the process and execute 512 phase to provide cognitive insights, such as recommendations, to various predetermined destinations and associated application programming interfaces (APIs) 524.
In various embodiments, features from newly-observed data are automatically extracted from user feedback during the learn 514 phase to improve various analytical models. In these embodiments, the learn 514 phase includes feedback on observations generated during the relate 508 phase, which is provided to the perceive 506 phase. Likewise, feedback on decisions resulting from operations performed during the operate 510 phase, and feedback on results resulting from operations performed during the process and execute 512 phase, are also provided to the perceive 506 phase.

In various embodiments, user interactions result from operations performed during the process and execute 512 phase. In these embodiments, data associated with the user interactions are provided to the perceive 506 phase as unfolding interactions 522, which include events that occur external to the CILS operations described in greater detail herein. As an example, a first query from a user may be submitted to the CILS system, which in turn generates a first cognitive insight, which is then provided to the user. In response, the user may respond by providing a first response, or perhaps a second query, either of which is provided in the same context as the first query. The CILS receives the first response or second query, performs various CILS operations, and provides the user a second cognitive insight. As before, the user may respond with a second response or a third query, again in the context of the first query. Once again, the CILS performs various CILS operations and provides the user a third cognitive insight, and so forth. In this example, the provision of cognitive insights to the user, and their various associated responses, results in unfolding interactions 522, which in turn result in a stateful dialog that evolves over time. Skilled practitioners of the art will likewise realize that such unfolding interactions 522, occur outside of the CILS operations performed by the cognitive platform 310.

FIG. 6 depicts the lifecycle of CILS agents implemented in accordance with an embodiment of the invention to perform CILS operations. In various embodiments, the CILS agents lifecycle 602 may include implementation of a sourcing 318 agent, an enrichment 425 agent, a bridging 429 agent, an insight 433 agent, a destination 336 agent, and a learning 434 agent. In these embodiments, the sourcing 318 agent is implemented to source a variety of multi-structured source streams of data described in greater detail herein. These sourced data streams are then provided to an enrichment 425 agent, which then invokes an enrichment component to perform enrichment operations to generate enriched data streams, likewise described in greater detail herein.

The enriched data streams are then provided to a bridging 429 agent, which is used to perform bridging operations described in greater detail herein. In turn, the results of the bridging operations are provided to an insight 433 agent, which is implemented as described in greater detail herein to create a visual data story, highlighting user-specific insights, relationships and recommendations. The resulting visual data story is then provided to a destination 336 agent, which is implemented to publish cognitive insights to a consumer of cognitive insight data, likewise as described in greater detail herein. In response, the consumer of cognitive insight data provides feedback to a learning 434 agent, which is implemented as described in greater detail herein to provide the feedback to the sourcing agent 318, at which point the CILS agents lifecycle 602 is continued. From the foregoing, skilled practitioners of the art will recognize that each iteration of the cognitive agents lifecycle 602 provides more informed cognitive insights.

FIG. 7 is a simplified block diagram of a plurality of cognitive platforms implemented in accordance with an embodiment of the invention within a hybrid cloud infrastructure. In this embodiment, the hybrid cloud infrastructure 740 includes a cognitive cloud management 342 component, a hosted 704 cognitive cloud environment, and a private 706 network environment. As shown in FIG. 7, the hosted 704 cognitive cloud environment includes a hosted 710 cognitive platform, such as the cognitive platform 310 shown in FIGS. 3, 4a, and 4b. In various embodiments, the hosted 704 cognitive cloud environment may also include a hosted 718 universal knowledge repository and one or more repositories of curated public data 714 and licensed data 716. Likewise, the hosted 710 cognitive platform may also include a hosted 712 analytics infrastructure, such as the cloud analytics infrastructure 344 shown in FIGS. 3 and 4c.

As likewise shown in FIG. 7, the private 706 network environment includes a private 720 cognitive platform, such as the cognitive platform 310 shown in FIGS. 3, 4a, and 4b. In various embodiments, the private 706 network cognitive cloud environment may also include a private 728 universal knowledge repository and one or more repositories of application data 724 and private data 726. Likewise, the private 720 cognitive platform may also include a private 722 analytics infrastructure, such as the cloud analytics infrastructure 344 shown in FIGS. 3 and 4c. In certain embodiments, the private 706 network environment may have one or more private 736 cognitive applications implemented to interact with the private 720 cognitive platform.

As used herein, a universal knowledge repository broadly refers to a collection of knowledge elements that can be used in various embodiments to generate one or more cognitive insights described in greater detail herein. In various embodiments, these knowledge elements may include facts (e.g., milk is a dairy product), information (e.g., an answer to a question), descriptions (e.g., the color of an automobile), skills (e.g., the ability to install plumbing fixtures), and other classes of knowledge familiar to those of skill in the art. In these embodiments, the knowledge elements may be explicit or implicit. As an example, the fact that water freezes at zero degrees centigrade would be an explicit knowledge element, while the fact that an automobile mechanic knows how to repair an automobile would be an implicit knowledge element.

In certain embodiments, the knowledge elements within a universal knowledge repository may also include statements, assertions, beliefs, perceptions, preferences, sentiments, attitudes or opinions associated with a person or a group. As an example, user 'A' may prefer the pizza served by a first restaurant, while user 'B' may prefer the pizza served by a second restaurant. Furthermore, both user 'A' and 'B' are firmly of the opinion that the first and second restaurants respectively serve the very best pizza available. In this example, the respective preferences and opinions of users 'A' and 'B' regarding the first and second restaurant may be included in the universal knowledge repository 880 as they are not contradictory. Instead, they are simply knowledge elements respectively associated with the two users and can be used in various embodiments for the generation of various cognitive insights, as described in greater detail herein.
In various embodiments, individual knowledge elements respectively associated with the hosted 718 and private 728 universal knowledge repositories may be distributed. In one embodiment, the distributed knowledge elements may be stored in a plurality of data stores familiar to skilled practitioners of the art. In this embodiment, the distributed knowledge elements may be logically unified for various implementations of the hosted 718 and private 728 universal knowledge repositories. In certain embodiments, the hosted 718 and private 728 universal knowledge repositories may be respectively implemented in the form of a hosted or private universal cognitive graph. In these embodiments, nodes within the hosted or private universal graph contain one or more knowledge elements.

In various embodiments, a secure tunnel 730, such as a virtual private network (VPN) tunnel, is implemented to allow the hosted 710 cognitive platform and the private 720 cognitive platform to communicate with one another. In these various embodiments, the ability to communicate with one another allows the hosted 710 and private 720 cognitive platforms to work collaboratively when generating cognitive insights described in greater detail herein. In various embodiments, the hosted 710 cognitive platform accesses knowledge elements stored in the hosted 718 universal knowledge repository and data stored in the repositories of curated public data 714 and licensed data 716 to generate various cognitive insights. In certain embodiments, the resulting cognitive insights are then provided to the private 720 cognitive platform, which in turn provides them to the one or more private cognitive applications 736.

In various embodiments, the private 720 cognitive platform accesses knowledge elements stored in the private 728 universal knowledge repository and data stored in the repositories of application data 724 and private data 726 to generate various cognitive insights. In turn, the resulting cognitive insights are then provided to the one or more private cognitive applications 736. In certain embodiments, the private 720 cognitive platform accesses knowledge elements stored in the hosted 718 and private 728 universal knowledge repositories and data stored in the repositories of curated public data 714, licensed data 716, application data 724 and private data 726 to generate various cognitive insights. In these embodiments, the resulting cognitive insights are in turn provided to the one or more private cognitive applications 736.

In various embodiments, the secure tunnel 730 is implemented for the hosted 710 cognitive platform to provide 732 predetermined data and knowledge elements to the private 720 cognitive platform. In one embodiment, the provision 732 of predetermined knowledge elements allows the hosted 718 universal knowledge repository to be replicated as the private 728 universal knowledge repository. In another embodiment, the provision 732 of predetermined knowledge elements allows the hosted 718 universal knowledge repository to provide updates 734 to the private 728 universal knowledge repository. In certain embodiments, the updates 734 to the private 728 universal knowledge repository do not overwrite other data. Instead, the updates 734 are simply added to the private 728 universal knowledge repository.

In one embodiment, knowledge elements that are added to the private 728 universal knowledge repository are not added to the hosted 718 universal knowledge repository. As an example, an airline may not wish to share private information related to its customer’s flights, the price paid for tickets, their awards program status, and so forth. In another embodiment, predetermined knowledge elements that are added to the private 728 universal knowledge repository may be provided to the hosted 718 universal knowledge repository. As an example, the operator of the private 720 cognitive platform may decide to license predetermined knowledge elements stored in the private 728 universal knowledge repository to the operator of the hosted 710 cognitive platform. To continue the example, certain knowledge elements stored in the private 728 universal knowledge repository may be anonymized prior to being provided for inclusion in the hosted 718 universal knowledge repository. In one embodiment, only private knowledge elements are stored in the private 728 universal knowledge repository. In this embodiment, the private 720 cognitive platform may use knowledge elements stored in both the hosted 718 and private 728 universal knowledge repositories to generate cognitive insights. Skilled practitioners of the art will recognize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

FIG. 8 depicts a travel-related cognitive persona defined in accordance with an embodiment of the invention by a first set of nodes in a travel-related cognitive graph. As used herein, a travel-related cognitive graph broadly refers to a representation of travel-related knowledge, associated with individuals and groups over a period of time, to depict relationships between people, places, and things using words, ideas, audio and images. As such, it is a machine-readable formalism for knowledge representation that provides a common framework allowing travel-related data and knowledge to be shared and reused across user, application, organization, and community boundaries.

As likewise used herein, a travel-related cognitive persona broadly refers to an archetype user model that represents a common set of travel-related attributes associated with a hypothesized group of users. In various embodiments, the common set of travel-related attributes may be described through the use of demographic, geographic, psychographic, behavioral, travel-oriented, and other information. As an example, the demographic information may include age brackets (e.g., 25 to 34 years old), gender, marital status (e.g., single, married, divorced, etc.), family size, income brackets, occupational classifications, educational achievement, and so forth. Likewise, the geographic information may include the travel-related cognitive persona’s typical living and working locations (e.g., rural, semi-rural, suburban, urban, etc.), characteristics associated with individual locations (e.g., parochial, cosmopolitan, population density, etc.), and possible travel destinations.

The psychographic information may likewise include information related to social class (e.g., upper, middle, lower, etc.), lifestyle (e.g., active, healthy, sedentary, reclusive, etc.), interests (e.g., music, art, sports, etc.), and activities (e.g., hobbies, travel, going to movies or the theatre, etc.). Other psychographic information may be related to opinions, attitudes (e.g., conservative, liberal, etc.), preferences, motivations (e.g., living sustainably, exploring new locations, etc.), and personality characteristics (e.g., extroverted, introverted, etc.). Likewise, the behavioral information may include information related to knowledge and attitude towards various manufacturers or organizations and the products or services they may provide. To continue the example, the behavioral information may be related to
brand loyalty, interest in purchasing a travel-related product or using a travel-related service, associated usage rates, perceived benefits, and so forth.

Likewise, the travel-oriented information may include information related to various types of travel (e.g., budget, luxury, adventure, etc.), purpose of travel (e.g., business, pleasure, family vacation, etc.), and type of cuisine (e.g., fast food, gourmet, local, etc.). The travel-oriented information may likewise include information related to current location (e.g., a particular address or geographic coordinates), destination (e.g., city, state, region, country, etc.), method of transportation (e.g., plane, train, automobile, boat, etc.), and venues (e.g., restaurant, theater, museum, etc.). Other travel-oriented information may include information related to activities (e.g., snow skiing, hiking, etc.), performances (e.g., concert, play, etc.), seasons or dates (e.g., spring break, a scheduled professional conference, etc.), and times (e.g., morning, afternoon, evening, a particular time, etc.). Skilled practitioners of the art will recognize that many such travel-related attributes are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

In various embodiments, one or more travel-related cognitive personas may be associated with a predetermined user, such as a traveler. In certain embodiments, a predetermined travel-related cognitive persona is selected and then used by a cognitive inference and learning system (CILS) to generate one or more travel-related composite cognitive insights as described in greater detail herein. In these embodiments, the travel-related composite cognitive insights that are generated for a user as a result of using a first travel-related cognitive persona may be different from the travel-related composite cognitive insights that are generated as a result of using a second travel-related cognitive persona. In various embodiments, provision of the travel-related composite cognitive insights results in the CILS receiving feedback information from various individual users and other sources. In one embodiment, the feedback information is used to revise or modify the travel-related cognitive personas. In another embodiment, the feedback information is used to create a new travel-related cognitive persona. In yet another embodiment, the feedback information is used to create one or more associated travel-related cognitive personas, which inherit a common set of attributes from a source travel-related cognitive persona. In one embodiment, the feedback information is used to create a new travel-related cognitive persona that combines attributes from two or more source travel-related cognitive personas. In another embodiment, the feedback information is used to create a travel-related cognitive profile, described in greater detail herein, based upon the travel-related cognitive persona. Those of skill in the art will realize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

In this embodiment, a travel-related cognitive persona 802 is defined by travel-related attributes TRA, 804, TRA, 806, TRA, 808, TRA, 810, TRA, 812, TRA, 814, TRA, 816, which are respectively associated with a set of corresponding nodes in a travel-related cognitive graph 800. As shown in FIG. 8, the travel-related cognitive persona 802 is associated with travel-related attributes TRA, 804 and TRA, 810, which are in turn respectively associated with travel-related attributes TRA, 806, TRA, 808, TRA, 812, and TRA, 814. Likewise, travel-related attributes TRA, 804 and TRA, 810 are associated with each other as well as with travel-related attribute TRA, 816.

As an example, the travel-related cognitive persona 802 may represent a teacher of history who also has an interest in regional cuisines. In this example, travel-related attribute TRA, 804 may be a demographic attribute representing the profession of teaching history, while travel-related attribute TRA, 810 may be a psychographic attribute associated with an interest in regional cuisines. To continue the example, demographic travel-related attributes TRA, 806 and TRA, 808 may respectively be associated with teaching American and Texas history, while psychographic travel-related attributes TRA, 812 and TRA, 814 may respectively be associated with an interest in Southern and Mexican cuisines. Likewise, travel-related attribute TRA, 816 may be associated with historical regional cuisines, which relates to both teaching history and an interest in regional cuisines. In certain embodiments, a travel-related attribute may be associated with two or more classes of travel-related attributes. For example, travel-related attribute TRA, 816 may be a demographic attribute, a psychographic attribute, or both. In various embodiments, the travel-related cognitive persona 802 may be defined by additional travel-related attributes than those shown in FIG. 8. In certain embodiments, the travel-related cognitive persona 802 may be defined by fewer travel-related attributes than those shown in FIG. 8.

FIG. 9 depicts a travel-related cognitive profile defined in accordance with an embodiment of the invention by the addition of a second set of nodes to the first set of nodes in the cognitive graph shown in FIG. 8. As used herein, a travel-related cognitive profile refers to an instance of a travel-related cognitive persona that references personal data associated with a predetermined user, such as a traveler. In various embodiments, the personal data may include the user’s name, address, Social Security Number (SSN), age, gender, marital status, occupation, employer, income, education, skills, knowledge, interests, preferences, likes and dislikes, goals and plans, and so forth. In certain embodiments, the personal data may include data associated with the user’s interaction with a cognitive inference and learning system (CILS) and related travel-related composite cognitive insights that are generated and provided to the user. In various embodiments, the personal data may be distributed. In certain of these embodiments, predetermined subsets of the distributed personal data may be logically aggregated to generate one or more travel-related cognitive profiles, each of which is associated with the user. Skilled practitioners of the art will recognize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

In this embodiment, a cognitive profile 902 is defined by the addition of travel-related attributes TRA, 918, TRA, 920, TRA, 922, TRA, 924 to attributes TRA, 804, TRA, 806, TRA, 808, TRA, 810, TRA, 812, TRA, 814, TRA, 816, all of which are respectively associated with a set of corresponding nodes in a travel-related cognitive graph 900. As shown in FIG. 9, the travel-related cognitive profile 902 is associated with travel-related attributes TRA, 804 and TRA, 810, which are in turn respectively associated with attributes TRA, 806, TRA, 808, TRA, 812, and TRA, 814. Likewise, travel-related attributes TRA, 804 and TRA, 810 are associated with each other as well as with attribute TRA, 816. As shown in FIG. 9, travel-related attribute TRA, 816 is associated with travel-related attributes TRA, 920 and TRA, 924, both of which are associated with travel-related attribute TRA, 922. Likewise, travel-related attribute
TRA, 924 is associated with travel-related attribute TRA, 808, while travel-related attribute TRA, 918 is associated with travel-related attributes TRA, 814, TRA, 920 and TRA, 924.

[0139] To continue the example described in the descriptive text associated with FIG. 8, psychographic travel-related attributes TRA, 918, TRA, 920, and TRA, 922 may respectively be associated with the Tex-Mex cuisine, tamales, and enchiladas, Likewise, travel-related attribute TRA, 924 may be a travel-related attribute such as a venue, a location travel-related attribute, or both as it is associated with travel-related attribute TRA, 816, which may also be a demographic travel-related attribute, a psychographic travel-related attribute, or both. For example, TRA, 924 may be related to a restaurant located in San Antonio, Tex. that serves historical Tex-Mex cuisine, such as enchiladas. In various embodiments, the travel-related cognitive profile 902 may be defined by additional travel-related attributes than those shown in FIG. 9. In certain embodiments, the travel-related cognitive profile 902 may be defined by fewer travel-related attributes than those shown in FIG. 9.

[0140] FIG. 10 depicts a travel-related cognitive persona defined in accordance with an embodiment of the invention by a first set of nodes in a weighted cognitive graph. In this embodiment, a travel-related cognitive persona 1002 is defined by travel-related attributes TRA, 804, TRA, 806, TRA, 808, TRA, 810, TRA, 812, TRA, 814, TRA, 816, which are respectively associated with a set of corresponding nodes in a travel-related weighted cognitive graph 1000. In various embodiments, an attribute weight (e.g., attribute weights AW, 1032, AW, 1034, AW, 1036, AW, 1038, AW, 1040, AW, 1042, AW, 1044, AW, 1046, and AW, 1048), is used to represent a relevance value between two travel-related attributes. For example, a higher numeric value (e.g., ‘5.0’) associated with an attribute weight may indicate a higher degree of relevance above two travel-related attributes, while a lower numeric value (e.g., ‘0.5’) may indicate a lower degree of relevance.

[0141] As shown in FIG. 10, the degree of relevance between the travel-related persona 1002 and travel-related attributes TRA, 804 and TRA, 810 is respectively indicated by attribute weights AW, 1032 and AW, 1038. Likewise, the degree of relevance between travel-related attribute TRA, 804 and travel-related attributes TRA, 806 and TRA, 808 is respectively indicated by attribute weights AW, 1034 and AW, 1036. As likewise show in FIG. 10, the degree of relevance between travel-related attribute TRA, 810 and travel-related attributes TRA, 812 and TRA, 814 is respectively indicated by attribute weights AW, 1040 and AW, 1042. Likewise, the degree of relevance between travel-related attributes TRA, 804 and TRA, 810 is represented by attribute weight AW, 1044, while the degree of relevance between travel-related attribute TRA, 816 and travel-related attributes TRA, 804 and TRA, 810 is respectively represented by attribute weights AW, 1046 and AW, 1048.

[0142] In various embodiments, the numeric value associated with predetermined attribute weights (e.g., attribute weights AW, 1032, AW, 1034, AW, 1036, AW, 1038, AW, 1040, AW, 1042, AW, 1044, AW, 1046, and AW, 1048) may change as a result of the performance of travel-related composite cognitive insight and feedback operations described in greater detail herein. In one embodiment, the changed numeric values associated with the predetermined attribute weights may be used to modify an existing travel-related cognitive persona. In another embodiment, the changed numeric values associated with the predetermined attribute weights may be used to generate a new travel-related cognitive persona. In yet another embodiment, the changed numeric values associated with the predetermined attribute weights may be used to generate a travel-related cognitive profile.

[0143] FIG. 11 depicts a travel-related cognitive profile defined in accordance with an embodiment of the invention by the addition of a second set of nodes to the first set of nodes shown in FIG. 10. In this embodiment, a travel-related cognitive profile 1102 is defined by the addition of travel-related attributes TRA, 918, TRA, 920, TRA, 1022, TRA, 924 to travel-related attributes TRA, 804, TRA, 806, TRA, 808, TRA, 810, TRA, 812, TRA, 814, TRA, 816, all of which are respectively associated with a set of corresponding nodes in a travel-related weighted cognitive graph 1100. As shown in FIG. 11, the travel-related cognitive profile 1102 is associated with travel-related attributes TRA, 804 and TRA, 810, which are in turn respectively associated with travel-related attributes TRA, 806, TRA, 808, TRA, 812, and TRA, 814. Likewise, travel-related attributes TRA, 804 and TRA, 810 are associated with each other as well as with travel-related attribute TRA, 816. As likewise shown in FIG. 11, travel-related attribute TRA, 816 is associated with travel-related attributes TRA, 920 and TRA, 924, both of which are associated with travel-related attribute TRA, 922. Likewise, travel-related attribute TRA, 924 is associated with travel-related attribute TRA, 808, while travel-related attribute TRA, 918 is associated with travel-related attributes TRA, 814, TRA, 920 and TRA, 924.

[0144] As shown in FIG. 11, the degree of relevance between travel-related attributes TRA, 814 and TRA, 918 is represented by attribute weight AW, 1150, while the degree of relevance between travel-related attribute TRA, 918 and travel-related attributes TRA, 920 and TRA, 922 is respectively indicated by attribute weights AW, 1152 and AW, 1154. Likewise, the degree of relevance between travel-related attribute TRA, 922 and travel-related attributes TRA, 920 and TRA, 924 is respectively indicated by attribute weights AW, 1156 and AW, 1160. As likewise shown in FIG. 11, the degree of relevance between travel-related attribute TRA, 816 and travel-related attributes TRA, 920 and TRA, 924 is respectively indicated by attribute weights AW, 1158 and AW, 1162, while the degree of relevance between travel-related attributes TRA, 924 and TRA, 808 is represented by attribute weight AW, 1164.

[0145] In various embodiments, the numeric value associated with predetermined attribute weights may change as a result of the performance of travel-related composite cognitive insight and feedback operations described in greater detail herein. In one embodiment, the changed numeric values associated with the predetermined attribute weights may be used to modify an existing travel-related cognitive profile. In another embodiment, the changed numeric values associated with the predetermined attribute weights may be used to generate a new travel-related cognitive insight. As used herein, a travel-related composite cognitive insight broadly refers to a set of travel-related cognitive insights generated as a result of orchestrat-
ing a predetermined set of independent cognitive agents, referred to herein as insight agents. In various embodiments, the insight agents use a cognitive graph, such as a travel-related cognitive graph 1282, as their data source to respectively generate individual travel-related cognitive insights. As used herein, a travel-related cognitive graph 1282 broadly refers to a representation of travel-related knowledge, associated with individuals and groups over a period of time, to depict relationships between people, places, and things using words, ideas, audio and images. In certain embodiments, different cognitive applications 304 may interact with different travel-related cognitive graphs 1282 to generate individual travel-related cognitive insights for a user, such as a traveler. In various embodiments, the resulting individual travel-related cognitive insights are then composed to generate a set of travel-related composite cognitive insights, which in turn is provided to a user in the form of a cognitive insight summary 1248.

[0147] In various embodiments, the orchestration of the selected insight agents is performed by the cognitive insight/learning engine 330 shown in FIGS. 3 and 4a. In certain embodiments, a predetermined subset of insight agents is selected to provide travel-related composite cognitive insights to satisfy a graph query 1244, a contextual situation, or some combination thereof. For example, it may be determined, as described in greater detail herein, that a particular subset of insight agents may be suited to provide a travel-related composite cognitive insight related to a particular user of a particular device, at a particular location, at a particular time, for a particular purpose.

[0148] In certain embodiments, the insight agents are selected for orchestration as a result of receiving direct or indirect input data 1242 from a user. In various embodiments, the direct user input data 1242 may be a natural language inquiry. In certain embodiments, the indirect user input data 1242 may include the location of a user’s device or the purpose for which it is being used. As an example, the Geographical Positioning System (GPS) coordinates of the location of a user’s mobile device may be received as indirect user input data 1242. As another example, a user may be using the integrated camera of their mobile device to take a photograph of a location, such as a restaurant, or an item, such as a food product. In certain embodiments, the direct or indirect user input data 1242 may include personal information that can be used to identify the user. Skilled practitioners of the art will recognize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0149] In various embodiments, travel-related composite cognitive insight generation and feedback operations may be performed in various phases. In this embodiment, these phases include a data lifecycle 1240 phase, a learning 1238 phase, and an application/insight composition 1240 phase. In the data lifecycle 1236 phase, a predefined instantiation of a cognitive platform 1210 sources social data 1212, public data 1214, licensed data 1216, and proprietary data 1218 from various sources as described in greater detail herein. In various embodiments, an example of a cognitive platform 1210 instantiation is the cognitive platform 310 shown in FIGS. 3, 4a, and 4b. In this embodiment, the instantiation of a cognitive platform 1210 includes a source 1206 component, a process 1208 component, a deliver 1210 component, a cleanse 1220 component, an enrich 1222 component, a filter/transform 1224 component, and a repair/reject 1226 component. Likewise, as shown in FIG. 12a, the process 1208 component includes a repository of models 1228, described in greater detail herein.

[0150] In various embodiments, the process 1208 component is implemented to perform various travel-related composite insight generation and other processing operations described in greater detail herein. In these embodiments, the process 1208 component is implemented to interact with the source 1208 component, which in turn is implemented to perform various data sourcing operations described in greater detail herein. In various embodiments, the sourcing operations are performed by one or more sourcing agents, as likewise described in greater detail herein. The resulting sourced data is then provided to the process 1208 component. In turn, the process 1208 component is implemented to interact with the cleanse 220 component, which is implemented to perform various data cleansing operations familiar to those of skill in the art. As an example, the cleanse 1220 component may perform data normalization or pruning operations, likewise known to skilled practitioners of the art. In certain embodiments, the cleanse 1220 component may be implemented to interact with the repair/reject 1226 component, which in turn is implemented to perform various data repair or data rejection operations known to those of skill in the art.

[0151] Once data cleansing, repair and rejection operations are completed, the process 1208 component is implemented to interact with the enrich 1222 component, which is implemented in various embodiments to perform various data enrichment operations described in greater detail herein. Once data enrichment operations have been completed, the process 1208 component is likewise implemented to interact with the filter/transform 1224 component, which in turn is implemented to perform data filtering and transformation operations described in greater detail herein.

[0152] In various embodiments, the process 1208 component is implemented to generate various models, described in greater detail herein, which are stored in the repository of models 1228. The process 1208 component is likewise implemented in various embodiments to use the sourced data to generate one or more cognitive graphs, such as a travel-related cognitive graph 1282, as described in greater detail herein. In various embodiments, the process 1208 component is implemented to gain an understanding of the data sourced from the sources of data 1212, public data 1214, licensed data 1216, and proprietary data 1218, which assist in the automated generation of the travel-related cognitive graph 1282.

[0153] The process 1208 component is likewise implemented in various embodiments to perform bridging 1246 operations, described in greater detail herein, to access the travel-related cognitive graph 1282. In certain embodiments, the bridging 1246 operations are performed by bridging agents, likewise described in greater detail herein. In various embodiments, the travel-related cognitive graph 1282 is accessed by the process 1208 component during the learning 1236 phase of the travel-related composite cognitive insight generation operations.

[0154] In various embodiments, a cognitive application 304 is implemented to receive input data 1242 associated with an individual user or a group of users. In these embodiments, the input data 1242 may be direct, such as a user query or mouse click, or indirect, such as the current time or Geographical Positioning System (GPS) data received from a mobile device associated with a user. In various embodi-
ments, the indirect input data 1242 may include contextual data, described in greater detail herein. Once it is received, the input data 1242 is then submitted by the cognitive application 304 to a graph query engine 326 during the application/insight composition 1240 phase. In turn, the graph query engine 326 processes the submitted input data 1242 to generate a graph query 1244, as described in greater detail herein. The graph query 1244 is then used to query the travel-related cognitive graph 1282, which results in the generation of one or more travel-related composite cognitive insights, likewise described in greater detail herein. In certain embodiments, the graph query 1244 uses predetermined knowledge elements stored in the universal knowledge repository 1280 when querying the travel-related cognitive graph 1282 to generate the one or more travel-related composite cognitive insights.

[0155] In various embodiments, the graph query 1244 results in the selection of a predetermined travel-related cognitive persona, described in greater detail herein, from a repository of cognitive personas ‘1’ through ‘n’ 1272, according to a set of contextual information associated with a user. In certain embodiments, the universal knowledge repository 1280 includes the repository of personas ‘1’ through ‘n’ 1272. In various embodiments, individual nodes within predetermined travel-related cognitive personas stored in the repository of cognitive personas ‘1’ through ‘n’ 1272 are linked 954 to corresponding nodes in the universal knowledge repository 1280. In certain embodiments, predetermined nodes within the universal knowledge repository 1280 are likewise linked to predetermined nodes within the travel-related cognitive graph 1282.

[0156] As used herein, contextual information broadly refers to information associated with a location, a point in time, a user role, an activity, a circumstance, an interest, a desire, a perception, an objective, or a combination thereof. In certain embodiments, the contextual information is likewise used in combination with the selected travel-related cognitive persona to generate one or more travel-related composite cognitive insights for a user. In various embodiments, the travel-related composite cognitive insights that are generated for a user as a result of using a first set of contextual information may be different than the travel-related composite cognitive insights that are generated as a result of using a second set of contextual information.

[0157] As an example, a user may have two associated travel-related cognitive personas, “business traveler” and “vacation traveler,” which are respectively selected according to two sets of contextual information. In this example, the “business traveler” travel-related cognitive persona may be selected according to a first set of contextual information associated with the user performing travel planning activities in their office during business hours, with the objective of finding the best price for a particular hotel in a predetermined city on a specified weekday. Conversely, the “vacation traveler” travel-related cognitive persona may be selected according to a second set of contextual information associated with the user performing cognitive travel planning activities in their home over a weekend, with the objective of finding a family-oriented resort with predetermined amenities in a particular geographic region for a specified range of dates. As a result, the travel-related composite cognitive insights generated as a result of combining the first travel-related cognitive persona with the first set of contextual information will likely be different than the travel-related composite cognitive insights generated as a result of combining the second travel-related cognitive persona with the second set of contextual information.

[0158] In various embodiments, the graph query 1244 results in the selection of a predetermined travel-related cognitive profile, described in greater detail herein, from a repository of cognitive profiles ‘1’ through ‘n’ 1274 according to identification information associated with a user. The method by which the identification information is determined is a matter of design choice. In certain embodiments, a set of contextual information associated with a user is used to select the travel-related cognitive profile from the repository of cognitive profiles ‘1’ through ‘n’ 1274. In various embodiments, one or more travel-related cognitive profiles may be associated with a predetermined user. In these embodiments, a predetermined travel-related cognitive profile is selected and then used by a CILS to generate one or more travel-related composite cognitive insights for the user as described in greater detail herein. In certain of these embodiments, the selected travel-related cognitive profile provides a basis for adaptive changes to the CILS, and by extension, the travel-related composite cognitive insights it generates.

[0159] In various embodiments, provision of the travel-related composite cognitive insights results in the CILS receiving feedback 1262 information related to an individual user. In one embodiment, the feedback 1262 information is used to revise or modify a travel-related cognitive persona. In another embodiment, the feedback 1262 information is used to revise or modify the travel-related cognitive profile associated with a user. In yet another embodiment, the feedback 1262 information is used to create a new travel-related cognitive profile, which in turn is stored in the repository of cognitive profiles ‘1’ through ‘n’ 1274. In still yet another embodiment, the feedback 1262 information is used to create one or more associated travel-related cognitive profiles, which inherit a common set of attributes from a source travel-related cognitive profile. In another embodiment, the feedback 1262 information is used to create a new travel-related cognitive profile that combines attributes from two or more source travel-related cognitive profiles. In various embodiments, these persons and profile management operations 1276 are performed through interactions between the cognitive application 304, the repository of cognitive personas ‘1’ through ‘n’ 1272, the repository of cognitive profiles ‘1’ through ‘n’ 1274, and the universal knowledge repository 1280, or some combination thereof. Those of skill in the art will realize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0160] In various embodiments, a travel-related cognitive profile associated with a user may be either static or dynamic. As used herein, a static travel-related cognitive profile refers to a travel-related cognitive profile that contains identification information associated with a user that changes on an infrequent basis. As an example, a user’s name, Social Security Number (SSN), or passport number may not change, although their age, address or employer may change over time. To continue the example, the user may likewise have a variety of financial account identifiers and various travel awards program identifiers which change infrequently.

[0161] As likewise used herein, a dynamic travel-related cognitive profile refers to a travel-related cognitive profile that contains information associated with a user that changes on a dynamic basis. For example, a user’s travel-related interests and activities may evolve over time, which may be evi-
enced by associated interactions with the CILS. In various embodiments, these interactions result in the provision of associated travel-related composite cognitive insights to the user. In these embodiments, the user’s interactions with the CILS, and the resulting travel-related composite cognitive insights that are generated, are used to update the dynamic travel-related cognitive profile on an ongoing basis to provide an up-to-date representation of the user in the context of the travel-related cognitive profile used to generate the travel-related composite cognitive insights.

[0162] In various embodiments, a travel-related cognitive profile, whether static or dynamic, is selected according to a set of contextual information associated with a user. In certain embodiments, the contextual information is likewise used in combination with the selected travel-related cognitive profile to generate one or more travel-related composite cognitive insights for the user. In these embodiments, the travel-related composite cognitive insights that are generated as a result of using a first set of contextual information with the selected cognitive profile may be different than the travel-related composite cognitive insights that are generated as a result of using a second set of contextual information.

[0163] As an example, a user may have two associated travel-related cognitive profiles, “runner” and “foodie,” which are respectively selected according to two sets of contextual information. In this example, the “runner” travel-related cognitive profile may be selected according to a first set of contextual information associated with the user being out of town on business travel and wanting to find a convenient place to run close to where they are staying. To continue this example, two travel-related composite cognitive insights may be generated and provided to the user in the form of a cognitive insight summary 1248. The first may be suggesting a running trail the user has used before and liked, but needs directions to find again. The second may be suggesting a new running trail that is equally convenient, but wasn’t available the last time the user was in town.

[0164] Conversely, the “foodie” travel-related cognitive profile may be selected according to a second set of contextual information associated with the user traveling to a destination city and expressing an interest in trying a restaurant known for serving innovative cuisine. To further continue this example, the user’s “foodie” travel-related cognitive profile may be processed by the CILS to determine which restaurants and cuisines the user has tried in the last eighteen months. As a result, two travel-related composite cognitive insights may be generated and provided to the user in the form of a cognitive insight summary 1248. The first may be a suggestion for a new restaurant that is serving an innovative cuisine the user has enjoyed in the past. The second may be a suggestion for a restaurant familiar to the user that is promoting a seasonal menu featuring Asian fusion dishes, which the user has not tried before. Those of skill in the art will realize that the travel-related composite cognitive insights generated as a result of combining the first travel-related cognitive profile with the first set of contextual information will likely be different than the travel-related composite cognitive insights generated as a result of combining the second travel-related cognitive profile with the second set of contextual information.

[0165] In various embodiments, a user’s travel-related cognitive profile, whether static or dynamic, may reference data that is proprietary to the user, an organization, or a combination thereof. As used herein, proprietary data broadly refers to data that is owned, controlled, or a combination thereof, by an individual user or an organization, which is deemed important enough that it gives competitive advantage to that individual or organization. In certain embodiments, the organization may be a governmental, non-profit, academic or social entity, a manufacturer, a wholesaler, a retailer, a service provider, an operator of a cognitive inference and learning system (CILS), and others.

[0166] In various embodiments, an organization may or may not grant a user the right to obtain a copy of certain proprietary information referenced by their travel-related cognitive profile. In certain embodiments, a first organization may or may not grant a user the right to obtain a copy of certain proprietary information referenced by their travel-related cognitive profile and provide it to a second organization. As an example, the user may not be granted the right to provide travel detail information (e.g., travel dates and destinations, etc.) associated with an awards program provided by a first travel services provider (e.g., an airline, a hotel chain, a cruise ship line, etc.) to a second travel services provider. In various embodiments, the user may or may not grant a first organization the right to provide a copy of certain proprietary information referenced by their travel-related cognitive profile to a second organization. Those of skill in the art will recognize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0167] In various embodiments, a set of contextually-related interactions between a cognitive application 304 and the travel-related cognitive graph 1282 are represented as a corresponding set of nodes in a predetermined travel-related cognitive session graph, which is then stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252. As used herein, a travel-related cognitive session graph broadly refers to a cognitive graph whose nodes are associated with a travel-related cognitive session. As used herein, a cognitive session broadly refers to a predetermined user, group of users, theme, topic, issue, question, intent, goal, objective, task, assignment, process, situation, requirement, condition, responsibility, location, period of time, or any combination thereof. As likewise used herein, a travel-related cognitive session broadly refers to a cognitive session related to various aspects of travel, as described in greater detail herein.

[0168] As an example, the travel-related cognitive graph 1282 may be unaware of a particular user’s preferences, which are likely stored in a corresponding user profile. To further the example, a user may typically choose a particular airline or chain of hotels when making travel arrangements. A record of each query regarding that airline or chain of hotels, or their selection, is iteratively stored in a predetermined travel-related cognitive session graph that is associated with the user and stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252. As a result, the preferences of that airline or chain of hotels is ranked higher, and is presented in response to contextually-related queries, even when the preferred brand of airline or chain of hotels are not explicitly referenced by the user. To continue the example, the user may make a number of queries over a period of days or weeks, yet the queries are all associated with the same travel-related cognitive session graph that is associated with the user and stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252, regardless of when each query is made.

[0169] As another example, a user queries a cognitive application 304 during business hours to locate an upscale
As a result, a first travel-related cognitive session graph stored in a repository of cognitive session graphs '1' through 'n' 1252 is associated with the user's query, which results in the provision of travel-related composite cognitive insights related to restaurants close to the user's headquarters office that are suitable for business meetings. To continue the example, the same user queries the same cognitive application 304 during the weekend to locate a family-friendly, casual restaurant located close to their hotel while on vacation travel. As a result, a second travel-related cognitive session graph stored in a repository of cognitive session graphs '1' through 'n' 1252 is associated with the user's query, which results in the provision of travel-related composite cognitive insights related to restaurants suitable for family meals. In these examples, the first and second travel-related cognitive session graphs are both associated with the same user, but for different purposes, which results in the provision of two different sets of travel-related composite cognitive insights.

As yet another example, a group of sales engineers travel extensively to conduct product demonstrations at a sales prospect's location as part of their responsibilities. In this example, the product demonstrations and the group of sales engineers are collectively associated with a predetermined travel-related cognitive session graph stored in a repository of cognitive session graphs '1' through 'n' 1252. To continue the example, individual sales engineers may submit queries related to the scheduling product demonstrations at a particular sales prospect's location to a cognitive application 304, such as a travel booking application. In response, a predetermined travel-related cognitive session graph stored in a repository of cognitive session graphs '1' through 'n' 1252 is used, along with the universal knowledge repository 880 and travel-related cognitive graph 1282, to generate individual or composite cognitive insights to provide travel booking information that will result in lowering the cost of travel to a given sales prospect's location. In this example, the cognitive application 304 may be queried by the individual sales engineers at different times during some predetermined time interval, yet the same travel-related cognitive session graph stored in a repository of cognitive session graphs '1' through 'n' 1252 is used to generate composite cognitive insights related to lowering the cost of their travel to a particular sales prospect's location.

In various embodiments, each travel-related cognitive session graph associated with a user and stored in a repository of cognitive session graphs '1' through 'n' 1252 includes one or more direct or indirect user queries represented as nodes, and the time at which they were asked, which are in turn linked 1254 to nodes that appear in the travel-related cognitive graph 1282. In certain embodiments, each individual travel-related cognitive session graph that is associated with the user and stored in a repository of cognitive session graphs '1' through 'n' 1252 establishes various relationships that the travel-related cognitive graph 1282 does not already have.

In various embodiments, individual travel-related cognitive profiles in the repository of profiles '1' through 'n' 1274 are respectively stored as travel-related cognitive session graphs in the repository of cognitive session graphs 1252. In these embodiments, predetermined nodes within each of the individual travel-related cognitive profiles are linked 1254 to predetermined nodes within corresponding travel-related cognitive session graphs stored in the repository of cognitive session graphs '1' through 'n' 1254. In certain embodiments, individual nodes within each of the travel-related cognitive profiles are likewise linked 1254 to corresponding nodes within various travel-related cognitive personas stored in the repository of cognitive personas '1' through 'n' 1272.

In various embodiments, individual graph queries 1244 associated with a predetermined travel-related cognitive session graph stored in a repository of cognitive session graphs '1' through 'n' 1252 are likewise provided to predetermined insight agents to perform various kinds of analyses. In certain embodiments, each insight agent performs a different kind of analysis. In various embodiments, different insight agents may perform the same, or similar, analyses. In certain embodiments, different agents performing the same or similar analyses may be competing between themselves.

For example, a user may be a young, upper middle-class, urban-oriented person that typically enjoys eating at trendy restaurants that are in walking distance of where they are staying while on vacation. As a result, the user may be interested in knowing about new or popular restaurants that are in walking distance of the hotel they are staying at. In this example, the user's queries may result in the assignment of predetermined insight agents to perform analysis of various social media interactions to identify such restaurants that have received favorable reviews. To continue the example, the resulting travel-related composite insights may be provided as a ranked list of candidate restaurants that match the user's preferences.

In various embodiments, the process 1208 component is implemented to provide these travel-related composite cognitive insights to the deliver 1210 component, which in turn is implemented to deliver the travel-related composite cognitive insights in the form of a cognitive insight summary 1248 to the cognitive application 304. In these embodiments, the cognitive platform 1210 is implemented to interact with an insight front-end 1256 component, which provides a composite insight and feedback interface with the cognitive application 304. In certain embodiments, the insight front-end 1256 component includes an insight Application Program Interface (API) 1258 and a feedback API 1260, described in greater detail herein. In these embodiments, the insight API 1258 is implemented to convey the cognitive insight summary 1248 to the cognitive application 304. Likewise, the feedback API 1260 is used to convey associated direct or indirect user feedback 1262 to the cognitive platform 1210. In certain embodiments, the feedback API 1260 provides the direct or indirect user feedback 1262 to the repository of models 1228 described in greater detail herein.

To continue the preceding example, the user may have received a list of candidate restaurants that may be suitable venues. However, the user has a pet that they like to take with them wherever they go. As a result, the user provides feedback 1262 that he is looking for a restaurant that is pet-friendly. The provided feedback 1262 is in turn provided to the insight agents to identify candidate restaurants that are also pet-friendly. In this example, the feedback 1262 is stored in the appropriate travel-related cognitive session graph
stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252 that is associated with the user and their original query.

[0177] In various embodiments, as described in the descriptive text associated with FIG. 5, learning operations are iteratively performed during the learning 1238 phase to provide more accurate and useful travel-related composite cognitive insights. In certain of these embodiments, feedback 1262 received from the user is stored in a predetermined travel-related cognitive session graph that is associated with the user and stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252, which is then used to provide more accurate travel-related composite cognitive insights in response to subsequent contextually-relevant queries from the user.

[0178] As an example, travel-related composite cognitive insights provided by a particular insight agent related to a first subject may not be relevant or particularly useful to a user of the cognitive application 304. As a result, the user provides feedback 1262 to that effect, which in turn is stored in the appropriate travel-related cognitive session graph that is associated with the user and stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252. Accordingly, subsequent insights provided by the insight agent related to the first subject may be ranked lower, or not provided, within a cognitive insight summary 1248 provided to the user. Conversely, the same insight agent may provide excellent insights related to a second subject, resulting in positive feedback 1262 being received from the user. The positive feedback 1262 is likewise stored in the appropriate travel-related cognitive session graph that is associated with the user and stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252. As a result, subsequent insights provided by the insight agent related to the second subject may be ranked higher within a cognitive insight summary 1248 provided to the user.

[0179] In various embodiments, the travel-related composite insights provided in each cognitive insight summary 1248 to the cognitive application 304, and corresponding feedback 1262 received from a user in return, is provided in the form of one or more insight streams 1264 to an associated travel-related cognitive session graph stored in a repository of cognitive session graphs ‘1’ through ‘n’ 1252. In these and other embodiments, the insight streams 1264 may contain information related to the user of the cognitive application 304, the time and date of the provided travel-related composite cognitive insights and related feedback 1262, the location of the user, and the device used by the user.

[0180] As an example, a query related to upcoming activities that is received at 10:00 AM on a Saturday morning from a user’s hotel while on vacation may return travel-related composite cognitive insights related to entertainment performances scheduled for the weekend that are close to the hotel. Conversely, the same query received at the same time on a Monday morning from a user’s hotel while on business travel may return travel-related composite cognitive insights related to business (e.g., sponsored receptions at an industry conference), scheduled during the work week. In various embodiments, the information contained in the insight streams 1264 is used to rank the travel-related composite cognitive insights provided in the cognitive insight summary 1248. In certain embodiments, the travel-related composite cognitive insights are continually re-ranked as additional insight streams 1264 are received. Skilled practitioners of the art will recognize that many such embodiments are possible and the foregoing is not intended to limit the spirit, scope or intent of the invention.

[0181] FIGS. 13a and 13b are a generalized flowchart of travel-related cognitive persona and cognitive profile operations performed in accordance with an embodiment of the invention to generate travel-related composite cognitive insights. In this embodiment, travel-related cognitive persona and profile operations are begun in step 1302, followed by a cognitive application requesting an Application Programming Interface (API) key from a cognitive platform, described in greater detail herein, in step 1304. The method by which the API key is requested and verified is provided to the cognitive application is a matter of design choice. A cognitive session token is then issued to the cognitive application, which uses it in step 1306 to establish a travel-related composite cognitive session.

[0182] In various embodiments, the cognitive session may also include the receipt of feedback from the user, likewise described in greater detail herein. In one embodiment, the cognitive session token is used to establish a travel-related composite cognitive insight session that generates a new travel-related cognitive session graph. In another embodiment, the cognitive session token is used to establish a travel-related composite cognitive insight session that appends travel-related composite cognitive insights and user feedback to an existing travel-related cognitive session graph associated with the user.

[0183] In various embodiments, the cognitive session token enables the cognitive application to interact with a travel-related cognitive session graph associated with the cognitive session token. In these embodiments, the travel-related composite cognitive insight session is perpetuated. For example, a given travel-related composite cognitive insight session may last months or even years. In certain embodiments, the cognitive session token expires after a predetermined period of time. In these embodiments, the cognitive session token is no longer valid once the predetermined period of time expires. The method by which the period of time is determined and monitored, is a matter of design choice.

[0184] Direct and indirect user input data, as described in greater detail herein, is received in step 1308, followed by a determination being made in step 1310 whether or not the user is identified. As an example, the identity of the user may be determined from the direct and indirect user input data received in step 1308. If it is determined in step 1310 that the user has been identified, then a determination is made in step 1312 whether a relevant travel-related cognitive profile exists for the user. If not, or if the user was not identified in step 1310, then a relevant travel-related cognitive profile is selected for the user in step 1316. Otherwise, a relevant travel-related cognitive profile is retrieved for the user in step 1314.

[0185] Thereafter, or once a relevant travel-related cognitive persona has been selected for the user in step 1316, the direct and indirect user input data is used with the selected travel-related cognitive persona or retrieved travel-related cognitive profile to generate and present contextually-relevant travel-related composite cognitive insights to the user in step 1318. In various embodiments, travel-related composite cognitive insights presented to the user are stored in the travel-related cognitive session graph associated with the cognitive session token. A determination is then made in step 1320 whether a travel-related cognitive profile is currently in use. If so then it is updated, as described in greater detail herein, in step 1322. Thereafter, or if it is determined in step 1320 that a travel-related cognitive profile is not currently in use, a determination is then made in step 1324 whether to
convert the travel-related cognitive persona currently in use to a travel-related cognitive profile. If so, then the travel-related cognitive persona currently in use is converted to a travel-related cognitive profile in step 1326. The method by which the travel-related cognitive persona is converted to a travel-related cognitive profile is a matter of design choice.

[0186] However, if it was determined in step 1324 to not convert the travel-related cognitive persona currently in use to a travel-related cognitive profile, or once it has been converted in step 1326, a determination is then made in step 1328 whether feedback has been received from the user. If not, then a determination is made in step 1340 whether to end travel-related composite cognitive insights and feedback operations. If not, then a determination is made in step 1342 whether the cognitive session token for the target session has expired. If not, then the process is continued, proceeding with step 1310. Otherwise, the process is continued, proceeding with step 1304. However, if it is determined in step 1324 not to end travel-related composite cognitive insights and feedback operations, then travel-related composite cognitive insights and feedback operations are ended in step 1344.

[0187] However, if it was determined in step 1328 that feedback was received from the user, then the cognitive application provides the feedback, as described in greater detail herein, to the cognitive platform in step 1330. A determination is then made in step 1332 whether to use the provided feedback to generate contextually-relevant questions for provision to the user. If not, then the process is continued, proceeding with step 1340. Otherwise, the cognitive platform uses the provided feedback in step 1334 to generate contextually-relevant questions. Then, in step 1336, the cognitive platform provides the contextually-relevant questions, along with additional travel-related composite insights, to the cognitive application. In turn, the cognitive application provides the contextually-relevant questions and additional travel-related composite cognitive insights to the user in step 1334 and the process is continued, proceeding with step 1320.

[0188] Although the present invention has been described in detail, it should be understood that various changes, substitutions and alterations can be made hereto without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A computer-implementable method for performing cognitive computing operations comprising:
   receiving streams of data from a plurality of data sources;
   processing the streams of data from the plurality of data sources, the processing the streams of data from the plurality of data sources performing data enriching for incorporation into a cognitive graph;
   defining a travel-related cognitive persona within the cognitive graph, the travel-related cognitive persona corresponding to an archetype user model, the travel-related cognitive persona comprising a set of nodes in the cognitive graph, links among the set of nodes being weighted to provide a weighted cognitive graph;
   associating a user with the travel-related cognitive persona; and,
   performing a cognitive computing operation based upon the travel-related cognitive persona associated with the user.

2. The method of claim 1, wherein:
   the travel-related cognitive persona represents a set of attributes, each of the set of attributes corresponding to a node of the set of nodes; and,
   an amount of weighting between nodes of the set of nodes corresponds to a degree of relevance between the persona and the attributes.

3. The method of claim 2, wherein:
   the set of attributes comprise at least one of demographic attributes, geographic attributes, psychographic attributes, and behavioral attributes.

4. The method of claim 1, wherein:
   a link between a first node of the set of nodes and a second node of the set of nodes is represented by an attribute weight, the attribute weight indicating a degree of relevance between the attributes corresponding to the first node and the second node.

5. The method of claim 1, further comprising:
   receiving feedback from the user relating to the travel-related cognitive persona associated with the user; and,
   revising weighting of the links among the set of nodes of the weighted cognitive graph based upon the feedback.

6. The method of claim 5, further comprising:
   using the revised weighting to generate a second travel-related cognitive persona.

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