

[USPTO PATENT FULL-TEXT AND IMAGE DATABASE](#)[Home](#)[Quick](#)[Advanced](#)[Pat Num](#)[Help](#)[Bottom](#)[View Cart](#)[Add to Cart](#)[Images](#)

( 1 of 1 )

**United States Patent**  
**Ivanov , et al.****10,621,234**  
**April 14, 2020**

Method for discovering a group of interdependent computing objects within undirected graph structure in a computing environment corresponding to a set of known conditions

**Abstract**

Various embodiments relate to a method and apparatus for discovering a group of interdependent computing objects within an undirected graph structure of objects in a computing environment, the method comprising the steps of performing object identification, performing relations identification, selecting objects by performing the steps comprising defining required properties, matching the required properties with the properties for each of the objects, dropping the objects which have at least one of the properties which do not match with the required properties, making a selection by performing object intersection on the objects by performing the steps of reading location and the relations for each of the objects, selecting a group including each of the objects in the sets of objects which are identical based on the relations for each of the objects, determining whether each of the objects in the group are related to each of the objects in each of the sets of objects, and determining whether at least one of the objects in each of the sets of objects is related to at least one of the objects in another set of the sets of objects.

**Inventors:** Ivanov; Konstantin (Brno, CZ), Duris; Marek (Brno, CZ), Sali; Aylin (Brno, CZ), Markov; Stanimir (Sliven, BG), Radu; Ionut (Sasar, RO)

**Applicant:**

Name	City	State	Country	Type
------	------	-------	---------	------

Runecast Solutions Limited	London	N/A	GB	
----------------------------	--------	-----	----	--

**Assignee:** RUNECAST SOLUTIONS LIMITED (London, GB)

**Family ID:** 68097215

**Appl. No.:** 15/947,485

**Filed:** April 6, 2018

**Prior Publication Data****Document Identifier**

US 20190311069 A1

**Publication Date**

Oct 10, 2019

**Current U.S. Class:****1/1****Current CPC Class:**

G06F 16/188 (20190101); G06F 16/284 (20190101); G06F 16/289 (20190101); G06F 16/2455 (20190101); G06F 16/9024 (20190101); G06F 16/90335 (20190101)

**Current International Class:**

G06F 16/901 (20190101); G06F 16/903 (20190101); G06F

---

**References Cited [Referenced By]**


---

**U.S. Patent Documents**

<a href="#">5717914</a>	February 1998	Husick et al.
<a href="#">7966291</a>	June 2011	Petrovic et al.
<a href="#">8775427</a>	July 2014	Birdwell
<a href="#">8788527</a>	July 2014	Nadel et al.
<a href="#">9135280</a>	September 2015	Milenova et al.
<a href="#">9165034</a>	October 2015	Edwards et al.
<a href="#">9652316</a>	May 2017	Gamage
<a href="#">2007/0273696</a>	November 2007	Cheng
<a href="#">2008/0016026</a>	January 2008	Farber et al.
<a href="#">2008/0208882</a>	August 2008	Zhang et al.
<a href="#">2010/0274815</a>	October 2010	Vanasco
<a href="#">2011/0154236</a>	June 2011	Stoeck
<a href="#">2011/0302168</a>	December 2011	Aggarwal
<a href="#">2012/0047149</a>	February 2012	Zhou et al.

**Other References**

Notification of Transmittal of the International Search Report and the Written Opinion, of the International Searching Authority, or the Declaration dated Aug. 28, 2019 for International Appl. No. PCT/2019/0026273. cited by applicant .

Blau, "A Visual Query Language for Relational Knowledge Discovery", University of Massachusetts-Amherst, Computer Science Department Faculty Publication Series, 2001, 17 pages. cited by applicant .

Curtis-Maury, "Online Power-Performance Adaptation of Multithreaded Programs using Event-Based Prediction", Queen's University Belfast, Published in Proceedings of the 20th ACM International Conference on Supercomputing (ICS), 2006, 11 pages. cited by applicant .

Jennings, "An Agent-Based Approach for Building Complex Software Systems", Communications of the ACM, Apr. 2001, vol. 44, No. 4, pp. 35-41. cited by applicant.

*Primary Examiner:* Leroux; Etienne P

*Attorney, Agent or Firm:* Kramer Amado, P.C.

---

**Claims**


---

What is claimed is:

1. A method for discovering a group of interdependent computing objects within an undirected graph structure of objects in a computing environment, the method comprising the steps of: performing object identification; performing relations identification; selecting objects by performing the steps comprising: defining required properties; matching the required properties with the properties for each of the objects; dropping the objects which have at least one of the properties which do not match with the required properties; making a selection by performing object intersection on the objects by performing the steps of: reading location and the relations for each of the objects; selecting a group including each of the objects in the sets of objects which are identical based on the relations for each of the objects; determining whether each of the objects in the group are related to each of the objects in each of the sets of objects, and determining whether at least one of the objects in each of the sets of objects is related to at least one of the

objects in another set of the sets of objects.

2. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 1, the method comprising the steps of: performing the object identification by performing the steps comprising: receiving a search query including objects and operators; selecting an organization area; isolating object types for the objects in the search query; grouping the objects into sets of objects, and recording properties for each of the objects.

3. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 1, the method comprising the steps of: performing the relations identification by performing the steps comprising: recording relatability for each of the object types for the objects, and recording relations for each of the objects.

4. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 1, the method comprising the steps of: making a selection by performing object intersection on the objects by performing the steps of: dropping all of the objects from the group when each of the objects in the group are not related to each of the objects in each of the sets of objects.

5. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 1, the method comprising the steps of: making a selection by performing object intersection on the objects by performing the steps of: dropping all of the objects from the group when each of the sets of objects is not related to at least one of the objects in another set of the sets of objects.

6. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 1, the method comprising the steps of: making a selection by performing object union on the objects by performing the steps of: reading location and the relations for each of the objects, and selecting each of the objects that are in each of the sets of objects.

7. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 6, the method comprising the steps of: making a selection by performing object union on the objects by performing the steps of: dropping each of the objects that are not in each of the sets of objects.

8. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 1, the method comprising the steps of: making a selection by performing object combination on the objects by performing the steps of: reading location and the relations for each of the objects; selecting each of the objects that are in each of the sets of objects, and determining whether each of the objects in a first set of objects is related to at least one the objects in a second set of objects.

9. The method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment of claim 8, the method comprising the steps of: making a selection by performing object combination on the objects by performing the steps of: dropping each of the objects in a first set of objects which is not related to at least one the objects in a second set of objects.

10. A non-transitory computer readable medium configured discovering a group of interdependent computing objects within an undirected graph structure in a computing environment, the device comprising: a memory; and a processor configured to: perform object identification by performing the steps comprising: perform relations identification by performing the steps comprising: make a selection by performing object intersection on the objects by performing the steps of: reading location and the relations for each of the objects; selecting a group including each of the objects in the sets of objects which are identical based on the relations for each of the objects; determining whether each of the objects in the group are related to each of the objects in each of the sets of objects, and determining whether at least one of the objects in each of the sets of objects is related to at least one of the objects in another set of the sets of objects.

11. The non-transitory computer readable medium of claim 10, the processor configured to: perform object

identification by performing the steps comprising: receiving a search query including objects and operators; selecting an organization area; isolating object types for the objects in the search query; grouping the objects into sets of objects, and recording properties for each of the objects.

12. The non-transitory computer readable medium of claim 10, the processor configured to: perform relations identification by performing the steps comprising: recording relatibility for each of the object types for the objects; recording relations for each of the objects.

13. The non-transitory computer readable medium of claim 10, the processor configured to: make a selection by performing object intersection on the objects by performing the steps of: dropping all of the objects from the group when each of the objects in the group are not related to each of the objects in each of the sets of objects.

14. The non-transitory computer readable medium of claim 10, the processor configured to: make a selection by performing object intersection on the objects by performing the steps of: dropping all of the objects from the group when each of the sets of objects is not related to at least one of the objects in another set of the sets of objects.

15. The non-transitory computer readable medium of claim 10, the processor configured to: make a selection by performing object intersection on the objects by performing the steps of: reading location and the relations for each of the objects, and selecting each of the objects that are in each of the sets of objects.

16. The non-transitory computer readable medium of claim 15, the processor configured to: make a selection by performing object intersection on the objects by performing the steps of: dropping each of the objects that are not in each of the sets of objects.

17. The non-transitory computer readable medium of claim 10, the processor configured to: make a selection by performing object intersection on the objects by performing the steps of: reading location and the relations for each of the objects; selecting each of the objects that are in each of the sets of objects, and determining whether each of the objects in a first set of objects is related to at least one the objects in a second set of objects.

18. The non-transitory computer readable medium of claim 17, the processor configured to: make a selection by performing object intersection on the objects by performing the steps of: dropping each of the objects in a first set of objects which is not related to at least one the objects in a second set of objects.

---

### *Description*

---

#### TECHNICAL FIELD

This disclosure relates generally to getting and reading objects, object types, object relations and the values of their properties from systems such as for example computer systems that have a large configuration trees with many objects of different types and properties of those objects, and more specifically, but not exclusively, to an Organization Area ("OA") which is analyzed in the form of a graph where the vertices are defined by objects and the edges are defined by objects relations.

#### BACKGROUND

Modern systems such as computer systems have an extensive number of configuration parameters which are known to systems administrators. To optimize performance of computer systems, the methods of reading single values of known parameters and selections of multiple parameters with a high frequency must be optimized.

#### SUMMARY

A brief summary of various embodiments is presented below. Embodiments address a method and apparatus

for discovering a group of interdependent objects within an undirected graph structure of objects corresponding to a set of known conditions.

A brief summary of various example embodiments is presented. Some simplifications and omissions may be made in the following summary, which is intended to highlight and introduce some aspects of the various example embodiments, but not to limit the scope of the invention.

Detailed descriptions of example embodiments adequate to allow those of ordinary skill in the art to make and use the inventive concepts will follow in later sections.

Various embodiments described herein relate to a method for discovering a group of interdependent computing objects within an undirected graph structure of objects in a computing environment, the method comprising the steps of performing object identification, performing relations identification, selecting objects by performing the steps comprising defining required properties and matching the required properties with the properties for each of the objects, dropping the objects which have at least one of the properties which do not match with the required properties, making a selection by performing object intersection on the objects by performing the steps of reading location and the relations for each of the objects, selecting a group including each of the objects in the sets of objects which are identical based on the relations for each of the objects, determining whether each of the objects in the group are related to each of the objects in each of the sets of objects and determining whether at least one of the objects in each of the sets of objects is related to at least one of the objects in another set of the sets of objects.

In an embodiment of the present disclosure, the method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment, the method comprising the steps of performing the object identification by performing the steps comprising receiving a search query including objects and operators, selecting an organization area, isolating object types for the objects in the search query, grouping the objects into sets of objects and recording properties for each of the objects.

In an embodiment of the present disclosure, the method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment, the method comprising the steps of performing the relations identification by performing the steps comprising recording relatability for each of the object types for the objects, and recording relations for each of the objects.

In an embodiment of the present disclosure, the method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment, the method comprising the steps of making a selection by performing object intersection on the objects by performing the steps of dropping all of the objects from the group when each of the objects in the group are not related to each of the objects in each of the sets of objects.

In an embodiment of the present disclosure, the method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment, the method comprising the steps of making a selection by performing object intersection on the objects by performing the steps of dropping all of the objects from the group when each of the sets of objects is not related to at least one of the objects in another set of the sets of objects.

In an embodiment of the present disclosure, the method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment, the method comprising the steps of making a selection by performing object union on the objects by performing the steps of reading location and the relations for each of the objects and selecting each of the objects that are in each of the sets of objects.

In an embodiment of the present disclosure, the method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment, the method comprising the steps of making a selection by performing object union on the objects by performing the steps of dropping each of the objects that are not in each of the sets of objects.

In an embodiment of the present disclosure, the method for discovering a group of interdependent computing objects within an undirected graph structure of objects in the computing environment, the method comprising



dropping each of the objects in a first set of objects which is not related to at least one the objects in a second set of objects.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate example embodiments of concepts found in the claims, and explain various principles and advantages of those embodiments.

These and other more detailed and specific features are more fully disclosed in the following specification, reference being had to the accompanying drawings, in which:

FIG. 1 illustrates a flowchart of the object identification process, the relations identification process and the making selection process of the current embodiment.

FIG. 2 illustrates the results of the object identification process, the relations identification process and the making selection process of the current embodiment.

FIG. 3 illustrates a flowchart for each of the three types of object selection, including object intersection, object union and object combination.

FIG. 4 illustrates the results of each of the three types of object selection, including object intersection, object union and object combination.

FIG. 5 illustrates a block diagram of the behavior of the object selection process.

FIG. 6 illustrates a block diagram of a real-time data processing system of the current embodiment.

## DETAILED DESCRIPTION

It should be understood that the figures are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the figures to indicate the same or similar parts.

The descriptions and drawings illustrate the principles of various example embodiments. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its scope. Furthermore, all examples recited herein are principally intended expressly to be for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Additionally, the term, "or," as used herein, refers to a non-exclusive or (i.e., and/or), unless otherwise indicated (e.g., "or else" or "or in the alternative"). Also, the various embodiments described herein are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments. Descriptors such as "first," "second," "third," etc., are not meant to limit the order of elements discussed, are used to distinguish one element from the next, and are generally interchangeable.

The embodiments described herein disclose the usage of set operations to define how to isolate and identify interconnected objects from an OA of a computer system. These objects may or may not share other objects of the OA, which may influence the search result. While, embodiments are described using a computer system, the methods disclosed in the embodiments may be applied to other complex systems that have interrelated objects of different types that need to be identified.

There are two types of operations which are used in the method, union and intersection. Both union and intersection are possible within one query, while within intersection, the current embodiment implements a variance to a standard set of mathematical operations to consider a broader set of objects of various types belonging to different logical sets.



The resulting set, after the query processing, is based on the mathematical operations of union (|) and intersection (&) of objects collections. The query addresses 2 . . . n objects of the OA and defines a logical structure to optimize the value search.

The resulting set is a set of objects sharing the same type or different types, which were used for the object identification.

Unlike standard mathematics operations, the intersection of an object resulting in a new set of resulting objects is not limited to a set of objects of the same type but may be altered to become a set of objects of different types and members of other sets, if they share logical interconnection. Therefore, a blend of objects of different types will be returned in case they form a logical entity within the OA that works in conjunction to provide a working item.

The operation (r-AND) of intersection to create resulting sets of objects that do not need to share the same type depending on whether logical links amongst those exist creates these resulting sets. The logical link is determined by the type of OA.

This embodiment may be applied to systems that have a large number of objects, a large number of properties of the objects with various values that can be assumed, a large number of relations among objects, a high change rate of number of objects, relations and values of objects properties and a low number of types or objects which are steady in time.

This embodiment uses two sets of operations: &.sub.R (operation r-AND) and .andgate. which is a standard set union operator.

For example, there are five sets of objects, of which three sets are of type A and two sets are of type B: A.sub.1, A.sub.2, A.sub.3, B.sub.1, B.sub.2 where the goal is to intersect the sets: A.sub.1 &.sub.R A.sub.2 &.sub.R B.sub.1 &.sub.R A.sub.3 &.sub.R B.sub.2 which would not be possible, because they are not of the same type and the result would not return the intersection. Therefore, a decomposition and relation must be performed before the standard intersection can be applied:

Below is an example of an evaluation of unrelated types (i.e., decomposition to objects of same types for standard set operations).

TABLE-US-00001 Sets of objects .fwdarw. Each set is a results of different queries Result Sentence A.sub.1 &.sub.R A.sub.2 &.sub.R B.sub.1 &.sub.R A.sub.3 &.sub.R B.sub.2 Types of objects .dwnarw. Each set from the row above contains objects of the type in the rows below A a.sub.1, a.sub.2 .andgate. a.sub.1, a.sub.3 .andgate. .sub.---- .andgate. a.sub.1, a.sub.2, a.sub.5 .andgate. .sub.---- a.sub.1 B .sub.---- .andgate. .sub.---- .andgate. b.sub.1, b.sub.2, b.sub.5 .andgate. .sub.---- .andgate. b.sub.1, b.sub.2 b.sub.1, b.sub.2

The sentence evaluation result is a1, b1, b2.

Below is an example of an evaluation of related types (i.e., substitution of missing objects by related objects of the other types).

TABLE-US-00002 Sets of objects .fwdarw. Each set is a results of different queries Result Sentence A.sub.1 &.sub.R A.sub.2 &.sub.R B.sub.1 &.sub.R A.sub.3 &.sub.R B.sub.2 Types of objects Since operations cannot contain objects of other types than its own, .dwnarw. relationships must be included to complete operations A a.sub.1, a.sub.2 .andgate. a.sub.1, a.sub.3 .andgate. a.sub.1, a.sub.2, a.sub.5 .andgate. a.sub.1, a.sub.2, a.sub.5 .andgate. a.sub.1, a.sub.2 a.sub.1 Implementing Relation of all objects of type A towards each related object of type relations B will be determined, and the other way round, filling the gaps in the other operation .uparw..dwnarw.. B b.sub.1, b.sub.2, b.sub.4 .andgate. b.sub.1 .andgate. b.sub.1, b.sub.2, b.sub.5 .andgate.b.sub.1, b.sub.2, b.sub.4, b.sub.5 .andgate. b.sub.1, b.sub.2 b.sub.1

The sentence evaluation result is a1, b1.

However, values of embedded systems' properties are not the only determinant of their state.







order to remain after final operation (I&II|N).

In the example above, all virtual servers and all data stores (regardless of whether they are mounted to any of virtual servers) are listed. All virtualization servers that host at least one virtual server and are connected to at least one data store remain; those that only host a virtual server but have no data store or have a data store mounted but do not host any virtual server, are dropped.

For example, assuming the persons are members of set I, houses are in set II and cars in set III. Firstly, all detached houses and all SUV cars (regardless whether they ever park in the houses) are listed. Secondly, all females that inhabit a detached house and drive a SUV car, without ever using that car for coming to that house, stay. All females who only inhabit a detached house but drive no SUV or drive an SUV but live in other estate but a detached house, are dropped.

FIG. 4 illustrates the results of each of the three types of object selection, including object intersection, object union and object combination.

FIG. 5 illustrates a block diagram of the behavior of the object selection process.

There are three OAs illustrated in FIG. 5 which show for all of them how the object selection changes for groups if the relation of the object is changed.

For example, in FIG. 5, OA I 132 has objects that are relatable in all the selected sets. Set I.2 includes two selected objects of the group, the other sets each have one. If the relation represented by the edge I.5 is lost, the condition of all the objects in all sets must be interconnected is not fulfilled for the object I.6 and the object is then dropped. The condition of having at least one object of the selected group in each set still exists and it is met. The result will return all the other objects except I.6.

For example, in FIG. 5, OA II 133 have objects that are relatable in all the selected sets. If the relation II.5 is lost, the condition of all the objects in all sets must be interconnected is not fulfilled for the object II.6. The set II.4 would be empty after the object II.6 is removed from the group. Since the condition of having at least 1 object of the selected group in each set still exist and it is not met, all object of the group are dropped and the result is an empty set for this query.

For example, in FIG. 5, OA III 134 have three relatable types of object in sets III.1, III.2 and III.3. The type of object in set III.4 is not relatable to the type of set III.1. If the relation III.5 is lost the condition of having at least one object of the selected group in each set still exist and it is not met. All object of the group are dropped and the result is an empty set for this query. That means that even though there is no relation between III.1 and III.4, as it technically cannot be, the other objects must still be interconnected among them whenever a connection is technically possible to keep in the group.

The operator may be used for all purposes when finding relationships among objects of different types is required within a described system. The system may be heterogeneous (i.e., consisting of member of different technical and logical types).

A topology of the system must be determinable (i.e., relations and characteristics of the members must be known or retrievable). This may be either through information in the configuration database ("CMDB") or must be available by inquiring the systems' parameters.

The &.sub.R operator may be used to retrieve objects of interest. This is useful when large number of queries must be made over large number of sets of impacted objects. Results can be then retrieved in an efficient and fast manner. This can be used for a network connecting servers and switches across several data centers, providing services to multiple clients. Server, business applications, network ports, data centers, clients, support personnel may be types of objects.

For example, to find relations for all impacted ports by intervention of support personnel, the &.sub.R or r-AND operators (which are different notations of the same operator) may be used (e.g., ports, staff members and changing relationships between those two types).

The power of the method is multiplied with a growing number of queries to fetch systems' objects of interests for various situations. The situation must be known (e.g., who of the support personnel did latest intervention on network ports with decreased speed of data transmission, so in a situation where no natural link between these two objects is obvious, the situation description will form the query that will be processed using the operator).

The use of an operator may not be limited to computer systems. It may be used for others, like a person's relation to other people, communities, services or places of presence. This must be, however, done through having all information in a digital format to be able to retrieve the topology of such a system, meaning that objects to be inquired may be of a technical or biological type, but must be represented by a digital model.

An example of pseudocode for the current embodiment is described below. A check defines a set of objects and a sentence is a combination of checks. The syntax of a sentence is as follows:

Sentence.fwdarw.Check

Sentence.fwdarw.Sentence|Sentence

Sentence.fwdarw.Sentence &.sub.R Sentence

Sentence.fwdarw.(Sentence)

A sentence is normalized if and only if it is in the form of a single check, or it is in the form of left operator right, where the operator is one of { |, &.sub.R } and both left and right parts are in the form of (Sentence).

That is, a sentence is normalized if it does not contain any operators, or if each argument of each operator contained in the sentence is explicitly delimited by parentheses.

Every sentence can be normalized. The semantics of the operators, together with the entire process of scanning and analyzing the configuration of an OA of the current embodiment, are described by the pseudocode below:

TABLE-US-00003 function ANALYZE: collect data from OA execute all checks from all sentences on the collected data for each normalized sentence s: EVALUATE(s) function EVALUATE(Sentence s): if (s consists of a single check) return s.check.result else resultLeft = EVALUATE(s.left) resultRight = EVALUATE (s.right) for (t in resultLeft.types .orgate. resultRight.types) if (s.operator = = | ) result[t] = resultLeft[t] .orgate. resultRight[t] if (s.operator = = &.sub.R) if (resultLeft.types contains t) if (resultRight.types contains t) result[t] = resultLeft[t] .andgate.resultRight[t] else result[t] = resultLeft[t] .andgate.RESTRICT\_BY\_RELATIONS(t, resultRight, resultLeft) else result[t] = RESTRICT\_BY\_RELATIONS(t, resultLeft, resultRight) .andgate. resultRight[t] return result function RESTRICT\_BY\_RELATIONS(Type t, Result resultToBeRestricted, Result resultOther): relatedTypes = GET\_RELATED\_TYPES(t, resultToBeRestricted.types) if (relatedTypes = = O) return resultOther[t] else result = resultOther[t] for (t' in relatedTypes \ t): result = result .andgate.resultToBeRestricted[t'] return result function GET\_RELATED\_TYPES(Type t, Set < Type > types): return those types t' from the supplied set of types that are related to t

This function is defined by the target domain, usually in the form of a simple lookup structure enumerating types related to each type.

The function ANALYZE performs collection of the input data and evaluates all sentences submitted for processing. The function EVALUATE analyzes and evaluates a single sentence and determines which objects from the environment are affected by definitions of a particular sentence. The function RESTRICT\_BY\_RELATIONS is a helping function used internally in the analysis to exclude objects from the analysis based on their relations to other objects. The function GET\_RELATED\_TYPES returns those types from the supplied set of types that are related to the one given type.

FIG. 6 illustrates a block diagram of a real-time data processing system of the current embodiment.



