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(57) Abstract:



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Time-centric Product Lifecycle Management (PLM) System and Method for Developing the Same

Field of the invention

The present invention relates to a time-centric Product Lifecycle
5 Management (PLM) system. The present invention further relates to a method
for the development of a time-centric PLM system.

Background of the invention

Product Lifecycle Management (PLM) is the process of managing the
entire lifecycle of a product, for example a manufactured product, from its
10 conception to its disposal, the main stages in-between being typically
development, design, production, selling and maintaining, for example.

In practice, different systems for managing different stages and/or for
managing different aspects of the same stage(s) are often combined in order to
achieve a complete management of the entire product lifecycle.

15 The visibility of information between different levels of abstraction in
different information and data management systems is not always available
and, if achieved, it requires a lot of effort due to the complexity of the systems
(the term "system" relates here and in the following to "information and data
systems"). These systems are either different from each other or they are under
20 the same commercial "PLM" system. In both cases, it is very difficult to
synchronise the data after the product exits its Beginning of Life (BOL) phase
(conception, development, design and production). Furthermore, data is
collected only for some pre-defined products and/or components. However,
experience shows that the data requirements change, depending on the use of
25 each part of the model and hence, data is missing and is impossible to recover
when needed in later stages. This leads into having stored information, which is
for use as input in decision making, with incomplete or without data and
therefore support is unsatisfactory. There is thus a need to change the

philosophy of the systems and simplify them, especially in the ever more competitive global market.

Summary of the invention

5 An aim of the present invention is thus to provide a Product Lifecycle Management System that allows for a better visibility, integration, coherence and recoverability of data during the entire lifecycle of a product.

Another aim of the present invention is to provide a Product Lifecycle Management System preserving data integration when a plurality of PLM systems according to the invention work together.

10 An aim of the present invention is also to provide a method for developing such a PLM system.

These aims are achieved by a PLM system and by a method for developing a PLM system comprising the features of the corresponding independent claims.

15 These aims are achieved in particular by an information and data management system comprising a semantic model with a plurality of classes for modelling the elements of the system, and a superclass comprising all time-related information and data characterizing the modelled elements of the system.

20 These aims are also achieved in particular by a method for the development of an information and data management system comprising the steps of defining a semantic model comprising a plurality of classes for modelling the elements of the system, defining a superclass comprising all time-related information and data of the system.

25 Many difficulties in the prior art information and data systems derive from the methodologies they are based on. In the prior art models, time is treated as a small part of the model and it is associated with a number of the models' entities, even though it is one of the very few common elements to all models.

According to the present invention, the system's complexity is reduced through a time-based method of modelling, i.e. by making time the main central and "moving" (variable) element of the model and the basis for all systems. This is achieved by having time in the logical centre-basis of the model and

5 developing the entire model around time. According to the invention, time is thus transformed into the main element of the model and everything else is described through it. All systems according to the invention at all levels of abstraction and their elements, or data, are thus "Duration of Time" elements.

This allows for a better compatibility and portability of data from one

10 system according to the invention to another one and/or between different levels of abstractions within a system according to the invention, since all of these elements are thus essentially defined with reference to time, which is common across all systems.

Furthermore, when data is integrated from a plurality of systems, all the

15 different parts of these systems are synchronized, which provides a first level of integration no matter the different vocabulary, definitions, semantics or language used in the different systems.

Brief description of the drawings

The present invention is explained in more details below with the help of

20 the figures, where:

Figure 1 is a schematic representation of an example of the Duration of Time modelling according to the invention;

Figure 2 is a schematic representation of the Pyramid of Abstraction;

Figure 3 is a schematic representation of the Tree of Abstraction

25 Figure 4 is a representation of a multi-system according to the invention;

Figure 5 illustrates a PDKM SOM as it is in a Time-Centric PLM according to the invention;

Figure 6 illustrates the PDKM SOM of Figure 5 extended with additional classes;

Figure 7 illustrates a first example of a system according to the invention as seen from the “duration of time” point of view;

5 Figure 8 illustrates the example of Figure 7 with queries;

Figure 9 illustrates the example of Figure 7 along time;

Figure 10a shows an example of “which” queries;

Figure 10b shows an example of “availability in given times” queries;

Figure 10c shows an example of “document availability” queries;

10 Figure 10d shows an example of “MOL-phase availability” queries;

Figure 10e shows the result of the “MOL-phase availability” query exported to excel;

Figure 11 illustrates a PDKM SOM extended with additional classes;

15 Figure 12 illustrates a second example of a system according to the invention as seen from the “duration of time” point of view;

Figure 13 illustrates the example of Figure 12 with queries;

Figure 14a shows an example of “which book is available, when and for how long” queries;

Figure 14b shows an example of “availability on given days” queries;

20 Figure 14c shows an example of “book availability” queries;

Figure 14d shows an example of “which user borrowed which book, when and for how long” queries.

Detailed description of the invention

25 In a PLM system, a managed product, its properties, data and documentation relating to the product, as well as any other aspect of interest

related to the product and/or within the product's environment, are represented and categorized in a data model as elements of corresponding classes.

According to the Duration of Time concept of the invention, all aspects and elements of the model are seen as parts of time, i.e. all parts of the model are time. Therefore, when two or more time-based systems of the invention are combined together, mapping is achieved through time. Figure 1 illustrates a schematic example relating the classes Field Data, Property, Activity, Process, Event, Physical Product, File, Document, Field Data Source, Information Provider, Condition, Resource, etc. with a Duration of Time class. The corresponding source code is listed in Appendix A.

According to the invention, all classes except for the Duration of Time class either have no time attributes or any local time attributes of the classes are deleted. Therefore, there are no time attributes in the classes of the model, except for the Duration of Time class. Furthermore, the Duration of Time class, which contains the time related attributes such as for example start and end date, start and end time, duration, etc., is set as the superclass of the model.

Accordingly, when applying the method of the invention to a system that is already functioning and that already contains data, the following steps have to be performed: the Duration of Time class is set as the superclass of the model, the already existing time related data of the model are copied from the local attributes of the subclasses to the new attributes defined by the Duration of Time class, and the local time attributes of the subclasses are removed from the model.

Depending on the actual implementation of the PLM system of the invention, for example the computer language used for implementing it as a computer program, parts of the above steps can be performed automatically by the available software tools. Similarly, some standard terms can vary, while the concept of the invention remains the same. For example, when implementing the system of the invention in Java or C++, the Duration of Time class which has been set as superclass can become the domain for all the already existing

time related attributes and then the subclasses are removed as domain of these attributes. In this way, there is no need to copy the data itself. This is managed automatically by the software tools.

Thus, in both cases above the attributes of the Duration of Time class
5 are all time related attributes existing in the model. In information systems (i.e. databases, ontologies) subclasses are extending the concepts described by their superclasses and they inherit all the attributes and the other characteristics of their superclasses. Thus, in Figure 1 all subclasses are extending the
10 concept of the Duration of Time and they inherit all the time attributes of the Duration of Time class. Therefore, all subclasses of Figure 1 have the same time attributes as each other and as the Duration of Time class. This means that all parts of the model are time and time expresses all parts of the model in a unique way, i.e. as defined by the time attributes of the Duration of Time class.

15 The list of values, or classes, in Figure 1 is not exhaustive, and is only an example of possible values for illustrating the Duration of Time concept of the invention. For the model shown in Figure 1, an instance, or element, of the Resource class is the time that this resource is available or is being used in the model. An instance of Human Agent is the time that a workforce is employed to
20 work in the model. An instance of the Process class is the time during which the process represented by this instance is being executed in the model. A more detailed example is presented later in this description.

As illustrated in Figures 2 and 3, having all systems of all levels of abstraction based on time provides the important advantage of a common
25 language/platform among the systems at all levels. This is because time exists in all systems and at all levels, and because all elements are described by it. As a result, this provides the benefit of vertical (multi-level) and horizontal (on the same level) transparency/visibility of the systems and an administrator of the PLM system of the invention, or whoever has the right access rights, can "drill"
30 the desired detailed information; for example, one can obtain all desired information related to a given time, as shown in Figure 4. Describing the entire

multi-level system through time can be seen as putting the question of “when” before “who”, “where”, “how”, “what”, “why” and combines them with each other.

In the illustrative, but not limitative example of Figure 2, the Pyramid of Abstraction illustrates the following:

- 5 • Each PLM system controls or manages more than one OEM (Original Equipment Manufacturer).
- Each OEM controls or manages more than one Decision Making System, for example its own structure and/or that of subcontracting or sister entities, that correspond to the Organisation (or Execution) level
- 10 of the system.
- Each Decision Making System’s action controls more than one Component and/or Part and includes all the artefacts involved in decision making. This Decision Making System level links the Organisation level with the Component/Part level.
- 15 • Each (type of) Component/Part belongs to/is used in more than one product.

The advantages of the Duration of Time concept of the invention stem from the fact that the model is based on time and therefore allows seeing the model from the time point of view. The system of the invention implementing the

20 Duration of Time concept allows seeing all aspects and elements of a model as parts of time and provides flexibility, application independence and simplicity. Moreover, time characteristics are objective and can be used as a guideline basis for achieving data integration and system interoperability. Advantages of the PLM system of the invention are deriving from the model structure. These

25 are:

1. Simple models.
2. Describe entire model by Duration of Time.
3. Track system/data changes through time.

4. Time data on all system parts, which allows vertical visibility of the system, as illustrated for example in Figure 4.
5. Thanks to its visibility, the PLM system of the invention supports System interoperability and Data Integration (over time).

5 According to the invention, the method for the development of a time-centric PLM model/system comprises:

- Making Duration of Time as the superclass of the model.
- Developing a time framework for the ontology of the PLM system.
10 This framework only has the “time” properties of the ontology. Thus, all classes and subclasses of the ontology have this same time framework.
- Choosing a central reference time, for example GMT or CET, in order to avoid misunderstandings concerning time in communication between different agents that are for example scattered around the
15 globe.

 According to the invention, in case of implementing the invention in a system which is already functioning and contains data, the development of a time-centric PLM model/system comprises:

- Making the Duration of Time class as the superclass of the model.
- 20 • Developing a time framework for the ontology of the PLM system.
- Choosing a central reference time, for example GMT or CET, in order to avoid misunderstandings concerning time in communication between different agents that are for example scattered around the globe.
- 25 • Copying the already existing time related data of the model from the local attributes of the subclasses to the new attributes defined by the Duration of Time class.

- Removing the local time attributes of the subclasses from the model. Thus, the framework of the Duration of Time class defines the “time” properties of the ontology model and all classes and subclasses of the ontology have this same time framework.

5 According to the invention:

- All systems and parts of the system are based and/or developed on the Duration of Time.
- The Duration of time system as described has the Duration of Time class as root element.

10 • All abstraction levels of all systems are Duration of Time, and they are connected/related to each other through time.

- All individuals, parts, products, systems, activities, events are modelled as Duration of Time elements.
- All systems and parts of the system are Duration of Time elements.

15 Example A: MOL maintenance

A first example is a system according to the invention used for the maintenance of locomotives. The system includes some parts of the model such as documents that are usually not considered by engineers or other users from the time point of view. This example is based on the Product Data and Knowledge Management (PDKM) Semantic Object Model (SOM). As illustrated in Figure 5 and according to the invention, the SOM is a sub-class of time.

The method for developing the PLM system is:

- The class Duration of time is made the superclass of the model.
- A time framework for the ontology of the PLM system is developed. This framework only has the “time” properties of the ontology. Thus, all classes and subclasses of the ontology have the same “time” framework.

25

- A central reference time CET is chosen, in order to avoid misunderstandings concerning time in communication between different agents around the globe.
- Instances are stored in the classes of the ontology for every
5 necessary physical product, activity, event, process, resource etc.

This example describes the application of the model of the invention by an authorized locomotive maintenance provider (MP). For the sake of simplicity, the MP is specialized in one model/type of locomotives only. The MP has two maintenance platforms: Platform A and Platform B; each one has one machine
10 to aid maintenance: Machine A and Machine B; and one mechanic who performs the maintenance on the platform: Mechanic A and Mechanic B; each mechanic uses one toolbox: Tool-Box A and Tool-Box B; and there are 5 documents: Document 1, Document 2, Document 3, Document 4 and Document 5. Document 1 contains the field data from the locomotive and it is
15 updated each time the locomotive visits the garage (one per locomotive, for this reason there are Document 1a, Document 1b, etc.). Document 2 contains the maintenance history of the Locomotive and it is updated each time the locomotive enters the maintenance (one per locomotive having a, b, c and d, similarly to document 1). Document 3 contains the manufacturer's guidelines for
20 performing/operating maintenance according to the working hours of the locomotive or to the period of time lapsed since the last maintenance. Document 4 contains the manufacturer's instructions with schemas for removing/replacing parts. To facilitate and to better categorize the data for this application, the model was adapted accordingly, as illustrated in Figure 6.

25 In this scenario, locomotives are visiting the MP with an appointment. The duration of time for each resource, activity, etc. is shown in Figure 7. The different shades of gray in the rows are referring to Locomotive No. 1, No.2 and No.3 according to the legend below and show for which locomotive and for how long each resource is used. The time frame of this example can be referring to
30 the future (daily/weekly/monthly etc.) schedule according to appointments. In this example, the documents are represented as Time Duration elements

according to the invention. All the white cells of each row represent the time that the resource related to this row is in idle status. Each column represents for example 5 minutes. Other time intervals are however possible within the frame of the invention, such as years, months, days, hours, minutes, seconds, milliseconds, etc., depending in particular on the application of the PLM system of the invention.

As illustrated in Figure 7, Locomotive No.1 arrives and Mechanic A is responsible for it. He updates Document 1a with field data from the locomotive's on-board computer and he checks Document 2a which contains its maintenance history. Then, according to the status of the locomotive, he reads the manufacturer's guidelines for this type of locomotive to see the maintenance activities to be performed and for example decides to replace some parts. He checks document 5 to see if there is any in the local stock and document 4 for the replacement instructions. Similar are the activities for Locomotive No. 2 and No. 3 shown in Figure 7, except that for Locomotive No. 2, there is no need to remove/replace parts and Locomotive No. 3 arranges an appointment out of schedule. In case the MP provides multiple maintenance sites, locomotive No. 3 would have chosen the closest, soonest available maintenance site. The documents like all other resources are seen as duration of time elements that appear when they are used.

Using the Duration of Time approach according to the invention provides with all necessary information about the state of each resource at every moment. An example is shown in Figure 8. One can have information according to Which-queries such as "Which machines are available at this time slot?" which is equivalent to "Who is not working at this time?" and returns the non-active values at that duration of time, or according to Availability-queries such as "Is Mechanic A available at a given time?" which returns a Yes or No or "When and for how long is a given resource (machine or document, for example) available?" This information allows optimizing resource management. Moreover, the system also provides with the information of the time that a Locomotive is using resources, as illustrated in Figure 9.

In Figure 10a, an example of a Which-query is shown. The query is applied on the machine and describes "Which Machine(s) is (are) available right now (now = 8:40 AM) and for how long?" It returns either the idle instance of the available resources or nothing if the resources are not available.

5 Figure 10b shows an example of the query "Is Mechanic B available right now (now = 6:30 AM) and for how long from now?" This query applies only to the given resource instance (the query could be more generic like "who is available at this time?") and returns either the idle instance if the resource is available or nothing if the resource instance is not available.

10 Figure 10c shows an example of the query "When and for how long is Document 3 used?" This query applies to all instances and returns the result shown in Figure 10c.

15 Figure 10d shows an example of the query "When and for how long are any resources available?" This query applies to all instances and returns the result shown in Figure 10d. Figure 10d is only a snapshot and doesn't contain all the results, which are shown in Figure 10e in another format.

According to the invention:

- The PLM system provides a complete data visibility.
- The visibility exists under multi-system circumstances, i.e. when data
20 from two or more systems is combined.
- The PLM system allows optimal management of resources, activities, agents and processes thanks to a complete overview of the time slots.
- Documents like all other resources are seen as duration of time
25 elements that appear when they are used. Under this perspective, one can have an overview of all documents available in all systems.
- The system allows inter-OEMs/Suppliers co-operation for better resource exploitation.

- New classes, sub-classes of the tree, can be added to the ontology.

Example B: Public Library Book/Asset Management

5 This example illustrates the behaviour of an everyday “library management” system implementing the Duration of Time PLM system of the invention. This example is based on the Product Data and Knowledge Management (PDKM) Semantic Object Model (SOM). The SOM is a subclass of time, as illustrated in Figure 5.

10 According to the invention, the method for developing the corresponding PLM system is:

- A class Duration of Time is made the superclass of the ontology.
- A time framework for the ontology PLM is developed. This framework has the only “time” properties of the ontology. Thus all classes and subclasses of the system have the same “time” framework.
- 15 • A central reference time, for example CET, is chosen in order to avoid misunderstandings concerning time in communication between different agents around the globe.
- Instances are stored in the corresponding classes for every physical product (for example book), user and field data.

20 The public library is for example open to the public from 8:00 until 18:00. Each person who uses its services is a user and is allowed to borrow up to two books at a time. If he wants a third one, he must return one of the two previous ones first. Books can be borrowed up to one week and then they must be returned to the library’s return box. In this way, books can be returned even
25 when the library is closed. The box is opened by the personnel everyday at 7:30 and at 18:00 and the books are returned to the right shelves. To facilitate and to better categorise the data for this application, the ontology model was adapted accordingly with the classes User and User_Group and their necessary relationships, as illustrated in Figure 11.

In this scenario, users are borrowing books from the library. The duration of time representing each book according to the system of the invention is shown in Figure 12. According to the invention, a document like a book is seen as time by the library manager. The library manager looking for example at this data sees books as the duration of time for which they are borrowed and the duration of time during which they are on the shelves. An aim for the library is to be able to track the history of its books (previous users of the book) as well as to provide its users with the information of when and for how long the desired book will be available. The different shades of gray in the rows are referring to User No. 1, No. 2 and No. 3 according to the legend below and show by which user and for how long each book is used/borrowed. All the white cells of each row represent the time that the corresponding resource is in idle status. Each column represents for example 1 day. Other time periods such as years, months, days, hours, minutes, seconds, milliseconds, etc., are however possible within the frame of the invention, depending in particular on the specific application.

Using the duration of time approach of the invention provides with all the necessary information for the use of every book at every moment, as illustrated in Figure 13. One can have information according to which-queries such as “Which book is available on this day?”, which is equivalent to “which book is not used on this day?” and returns all the non-active values at that Duration of Time, or “When and for how long is a given book available?” This information helps tracking history or planning and can be used for an optimized management of the books, which could then be used for example in inter-library systems where all information synchronise through time.

In Figure 14a an example of a Which-query is shown. The query is applied on the books and describes “Which book(s) is (are) available on the 8th day and for how long?” It returns either the idle instance of the available books or nothing if they are not available.

Figure 14b shows an example of the query "Is Book 1 available on the 9th day and for how long from now?" It returns either the idle instance if the book is available or nothing if it is not available.

Figure 14c shows an example of the query "When and for how long are
5 any books available until the 30th day?" This query applies to all book instances and returns the result shown in Figure 14c.

Figure 14d shows an example of the query "When and for how long a book was borrowed and by which user?" This query applies to all book instances and returns the result shown in Figure 14d.

10 According to the invention:

- The PLM system provides a complete data visibility.
- This visibility exists under multi-system circumstances.
- Optimal management of Books or other resources is possible thanks to a complete overview of the time slots.
- 15 • Books like all other resources are seen as duration of time elements that appear when they are used. Under this perspective, one can have an overview of all documents of all systems.
- The library is able to track the history of its books.
- The library is able to provide its users with the information of when
20 and for how long the desired book(s) will be available.
- The system of the invention allows for Inter-library co-operation for a better resource exploitation.
- This ontology of the PLM system can be extended to facilitate the complete library management including books and resources
25 (personnel, software, facilities, etc.) according to the same duration of time system.

The system and method of the invention were described above with the help of two illustrating but not limiting examples. The system and method of the

invention can apply to very different technical fields. Time appears as a central parameter in healthcare, in Product Lifecycle Management (PLM), in Asset Lifecycle Management (ALM), in education, in data warehousing, in supply chain management, etc. Time is one of the few parameters common to all of

5 these domains. Similarly, time affects the entire PLM and is common for all different PLM elements. It affects Actors, Software and Human Agents, Processes, Resources, Events, Conditions, etc. Therefore, the Duration of Time model of the invention can be applied in various sectors of the society and science including, but not exclusively, healthcare and medicine, process

10 scheduling, field data tracking and tracing, etc. A use of this concept in PLM is possible for example, but not limited to, for processing data for prognostics, diagnostics, logistics, statistics and discovering valuable information.

Appendix A

The xml source code of the model of Figure 1.

```
<?xml version="1.0" ?>
  <!DOCTYPE rdf:RDF (View Source for full doctype...)>
  <rdf:RDF xmlns="http://www.owl-ontologies.com/Ontology1202459344.owl#" xml:base="http://www.owl-ontologies.com/Ontology1202459344.owl" xmlns:p1="http://www.owl-ontologies.com/assert.owl#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:xsp="http://www.owl-ontologies.com/2005/08/07/xsp.owl#"
    xmlns:swrl="http://www.w3.org/2003/11/swrl#"
    xmlns:swrlb="http://www.w3.org/2003/11/swrlb#"
    xmlns:protege="http://protege.stanford.edu/plugins/owl/protege#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:owl="http://www.w3.org/2002/07/owl#">
    <owl:Ontology rdf:about="" />
    <owl:AllDifferent>
      <owl:distinctMembers rdf:parseType="Collection" />
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    <owl:AllDifferent>
      <owl:distinctMembers rdf:parseType="Collection" />
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    </owl:Class>
    <owl:Class rdf:ID="Condition">
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    </owl:Class>
    <owl:Class rdf:ID="File">
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      <rdfs:subClassOf rdf:resource="#Duration_of_Time" />
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      <rdfs:subClassOf rdf:resource="#Duration_of_Time" />
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    <owl:Class rdf:ID="Process">
      <rdfs:subClassOf rdf:resource="#Duration_of_Time" />
    </owl:Class>
```

```
<owl:Class rdf:ID="Property">  
  <rdfs:subClassOf rdf:resource="#Duration_of_Time" />  
</owl:Class>  
<owl:Class rdf:ID="Resource">  
  <rdfs:subClassOf rdf:resource="#Duration_of_Time" />  
</owl:Class>  
</rdf:RDF>
```

Appendix B

Possible Case A:**The SWRL Query for Figure 10a**

```

Activity(?acx) ^
ActivityID(?acx, "Idle") ^
Maintenance_Machine(?mmx) ^
Activity2Resource(?acx, ?mmx) ^
Starting_Date_Time(?acx, ?zx) ^
Finishing_Date_Time(?acx, ?dx) ^
temporal:after(?dx, ?zx) ^
temporal:after(?dx, "2009-02-27T08:41:000") ^
temporal:before(?zx, "2009-02-27T08:41:000") ^
temporal:duration(?minute, ?zx, ?dx, temporal:Minutes)
  → sqwrl:select(?acx, ?mmx, ?zx, ?dx, ?minute) ^
sqwrl:orderBy(?acx) ^
sqwrl:columnNames("Instance", "Machine", "Birth Date ", "End Date", "Duration In
Minutes ")

```

The SWRL Query for Figure 10b

```

Activity(?acx) ^
ActivityID(?acx, "Idle") ^
Activity2Resource(?acx, Mechanic_B) ^
Starting_Date_Time(?acx, ?zx) ^
Finishing_Date_Time(?acx, ?dx) ^
temporal:after(?dx, ?zx) ^
temporal:after(?dx, "2009-02-27T06:31:000") ^
temporal:before(?zx, "2009-02-27T06:31:000") ^
temporal:duration(?minute, "2009-02-27T06:30:000", ?dx, temporal:Minutes)
  → sqwrl:select("Mechanic B", ?zx, ?dx, ?minute, ?acx, ?zx, ?dx, ?minute) ^
sqwrl:orderBy(?acx) ^
sqwrl:columnNames("Instance", "Birth Date ", "End Date", "Duration From Now In
Minutes ")

```

The SWRL Query for Figure 10c

```

Activity(?acx) ^
ActivityID(?acx, "Idle") ^
Activity2Resource(?acx, Document_Resource_3) ^
Starting_Date_Time(?acx, ?zx) ^
Finishing_Date_Time(?acx, ?dx) ^
temporal:after(?dx, ?zx) ^
temporal:duration(?minute, ?zx, ?dx, temporal:Minutes)
  → sqwrl:select(?acx, "Document_Resource_3", ?zx, ?dx, ?minute) ^

```

sqwrl:columnNames("Instance", "Resource", "Birth Date ", "End Date", "Duration In Minutes ")

The SWRL Query for Figure 10d

Activity(?acx) ^
 ActivityID(?acx, "Idle") ^
 Resource(?rex) ^
 Activity2Resource(?acx, ?rex) ^
 Starting_Date_Time(?acx, ?zx) ^
 Finishing_Date_Time(?acx, ?dx) ^
 temporal:after(?dx, ?zx) ^
 temporal:duration(?minute, ?zx, ?dx, temporal:Minutes)
 → sqwrl:select(?acx, ?rex, ?zx, ?dx, ?minute) ^
 sqwrl:orderBy(?rex) ^
 sqwrl:columnNames("Instance", "Resource", "Birth Date ", "End Date", "Duration In Minutes ")

Possible Case B:

The SWRL Query for Figure 14a

Field_Data(?fdx) ^
 Group_ID(?fdx, "Idle") ^
 Field_Data2Physical_Product(?fdx, ?ppx) ^
 Starting_Date_Time(?fdx, ?zx) ^
 Finishing_Date_Time(?fdx, ?dx) ^
 temporal:after(?dx, ?zx) ^
 temporal:after(?dx, "2009-03-08T08:01:00") ^
 temporal:before(?zx, "2009-03-08T08:01:00") ^
 temporal:duration(?day, "2009-03-08T08:00:00", ?dx, temporal:Days)
 → sqwrl:select(?ppx, ?zx, ?dx, ?day) ^
 sqwrl:orderBy(?ppx) ^
 sqwrl:columnNames("Instance", "Birth Date ", "End Date", "Duration From Now In Days ")

The SWRL Query for Figure 14b

Field_Data(?fdx) ^
 Group_ID(?fdx, "Idle") ^
 Field_Data2Physical_Product(?fdx, Book_1) ^
 Starting_Date_Time(?fdx, ?zx) ^
 Finishing_Date_Time(?fdx, ?dx) ^
 temporal:after(?dx, ?zx) ^
 temporal:after(?dx, "2009-03-9T08:01:00") ^
 temporal:before(?zx, "2009-03-09T08:01:00") ^
 temporal:duration(?day, "2009-03-09T08:00:00", ?dx, temporal:Days)
 → sqwrl:select("Book 1", ?zx, ?dx, ?day) ^

sqwrl:columnNames("Instance", "Birth Date ", "End Date", "Duration From Now In Days ")

The SWRL Query for Figure 14c

```
Field_Data(?fdx) ^
Group_ID(?fdx, "Idle") ^
Field_Data2Physical_Product(?fdx, ?ppx) ^
Starting_Date_Time(?fdx, ?zx) ^
Finishing_Date_Time(?fdx, ?dx) ^
temporal:after(?dx, ?zx) ^
temporal:after(?zx, "2009-03-01T07:01:000") ^
temporal:before(?zx, "2009-03-30T08:01:000") ^
temporal:duration(?day, ?zx, ?dx, temporal:Days)
→ sqwrl:select(?ppx, ?zx, ?dx, ?day) ^
sqwrl:orderBy(?ppx) ^
sqwrl:columnNames("Instance", "Birth Date ", "End Date", "Duration In Days ")
```

The SWRL Query for Figure 14d

```
Field_Data(?fdx) ^
Group_ID(?fdx, ?gidx) ^
swrlb:contains(?gidx, "User") ^
Field_Data2Physical_Product(?fdx, ?ppx) ^
Starting_Date_Time(?fdx, ?zx) ^
Finishing_Date_Time(?fdx, ?dx) ^
temporal:after(?dx, ?zx) ^
temporal:after(?zx, "2009-03-01T07:01:000") ^
temporal:before(?zx, "2009-03-30T08:01:000") ^
temporal:duration(?day, ?zx, ?dx, temporal:Days)
→ sqwrl:select(?ppx, ?gidx, ?zx, ?dx, ?day) ^
sqwrl:orderBy(?ppx) ^
sqwrl:columnNames("Instance", "User", "Birth Date ", "End Date", "Duration In Days ")
```

Claims

1. Information and data management system comprising:
a semantic model with a plurality of classes for modelling the
elements of the system, and
5 a superclass comprising all time-related information and data
characterizing the modelled elements of the system.
2. Information and data management system according to claim 1,
further comprising a normalized time framework.
3. Information and data management system according to claim 2,
10 wherein said normalized time framework is matched to a single international
time zone.
4. Information and data management system according to claim 1,
wherein said semantic model is an ontology.
5. Computer program implementing the information and data
15 management system of one of the preceding claim when run on a computer.
6. Method for the development of an information and data
management system comprising the steps of:
- defining a semantic model comprising a plurality of classes for
modelling the elements of the system;
20 - defining a superclass comprising all time-related information
and data of the system.
7. Method according to the preceding claim, further comprising the
step of developing a time framework for the ontology.
8. Method according to the preceding claim, wherein said time
25 framework is matched to a single international time zone.

9. Method according to claim 6, wherein said semantic model is an ontology.

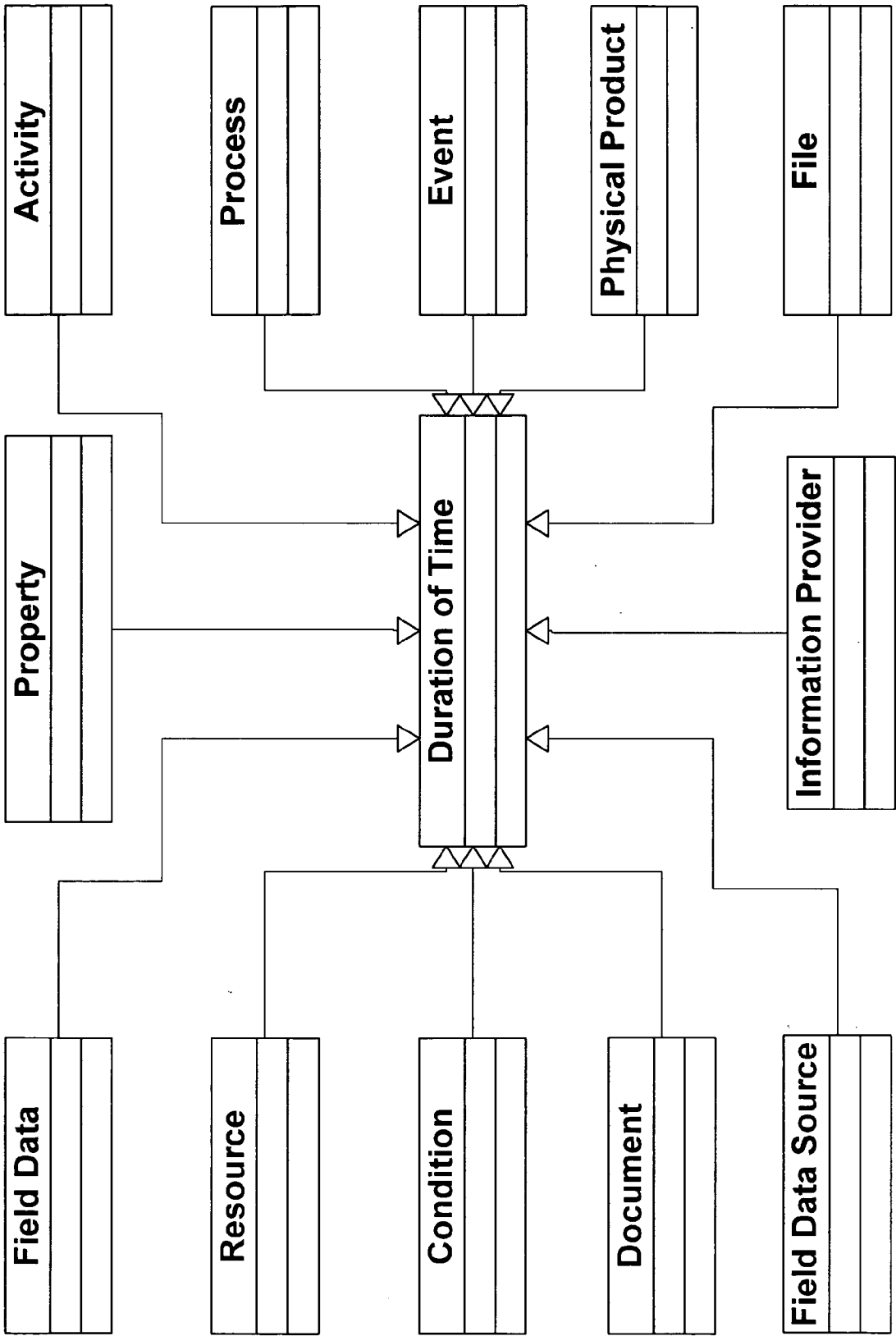


Figure 1

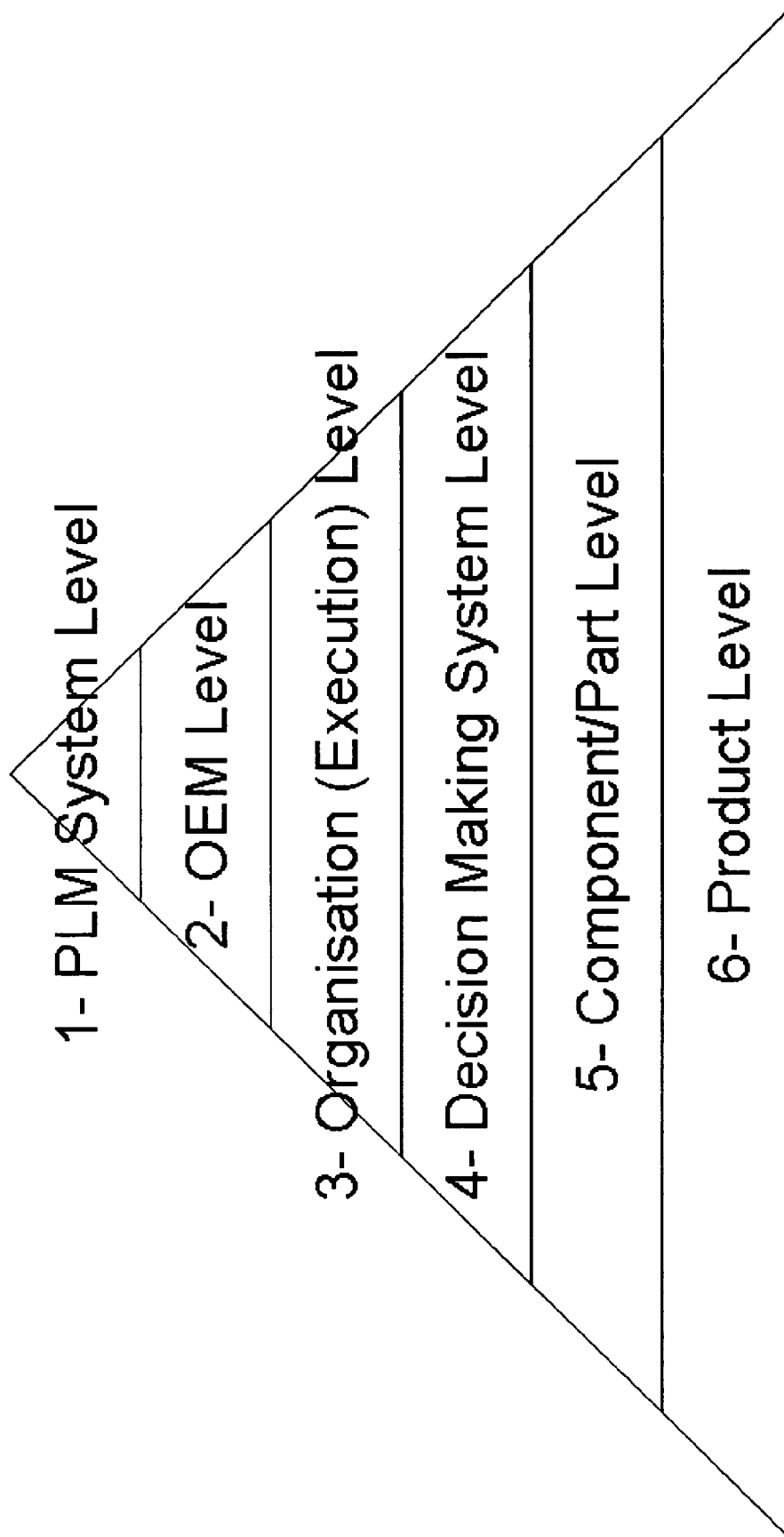


Figure 2

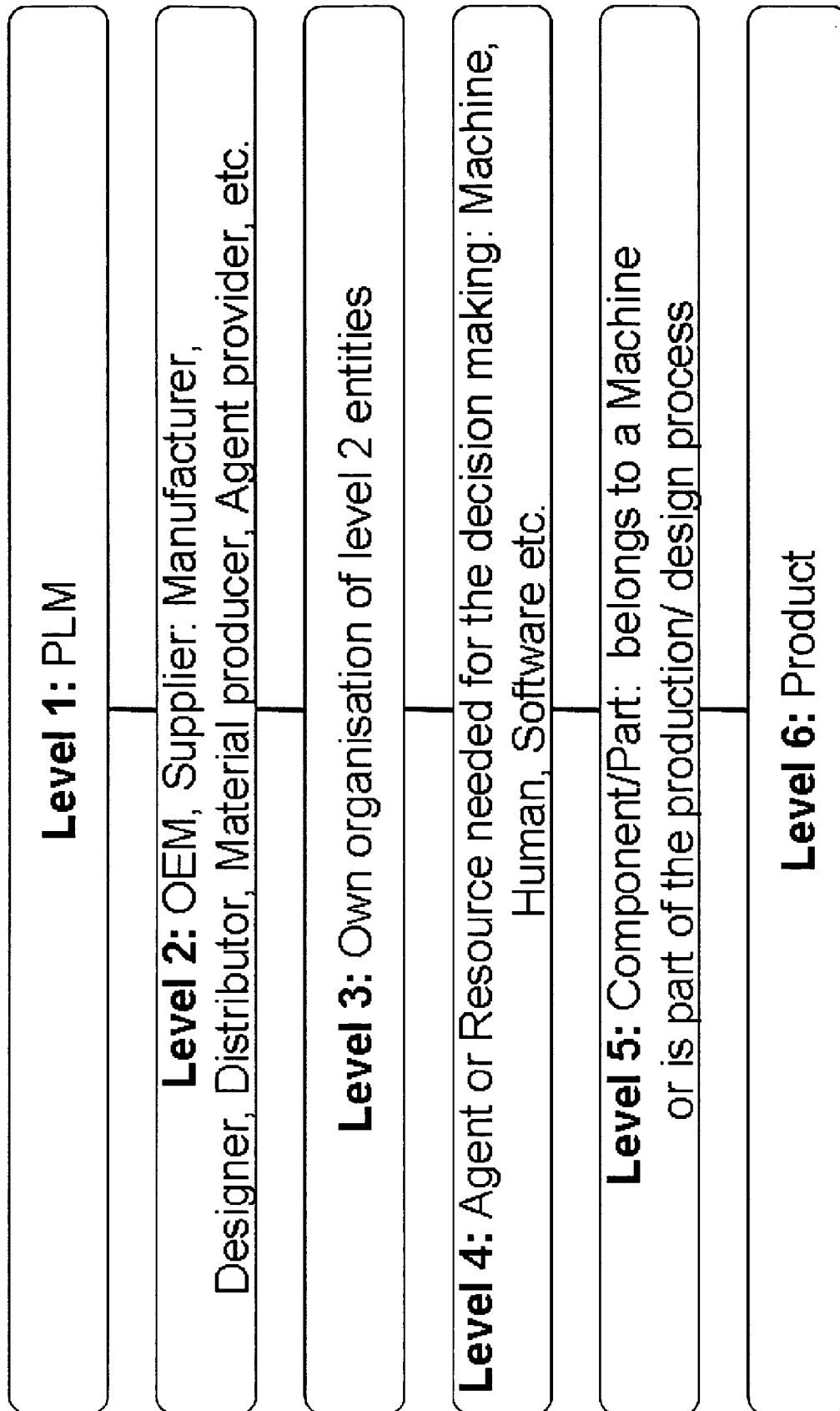


Figure 3

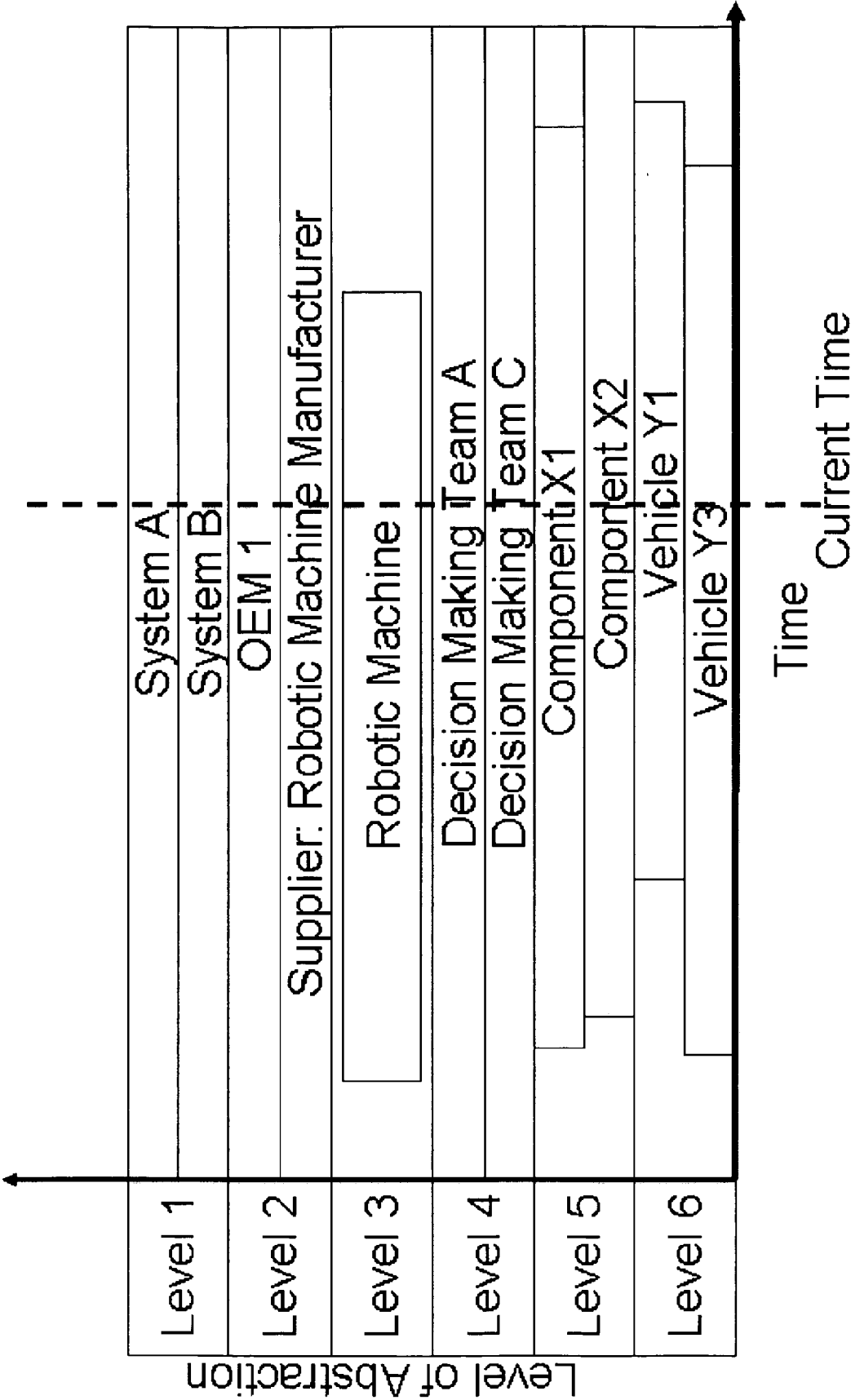


Figure 4

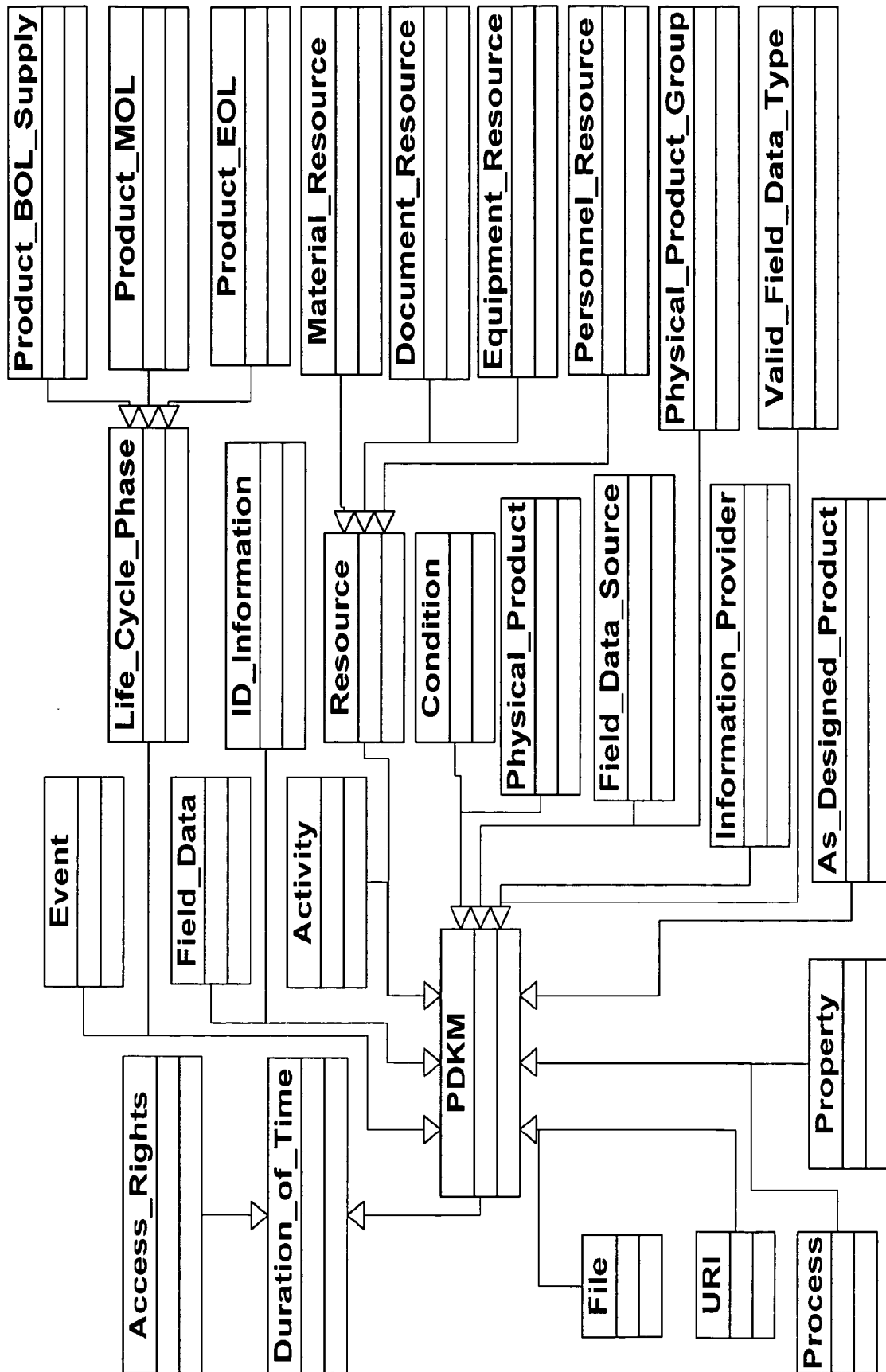


Figure 5

6/18

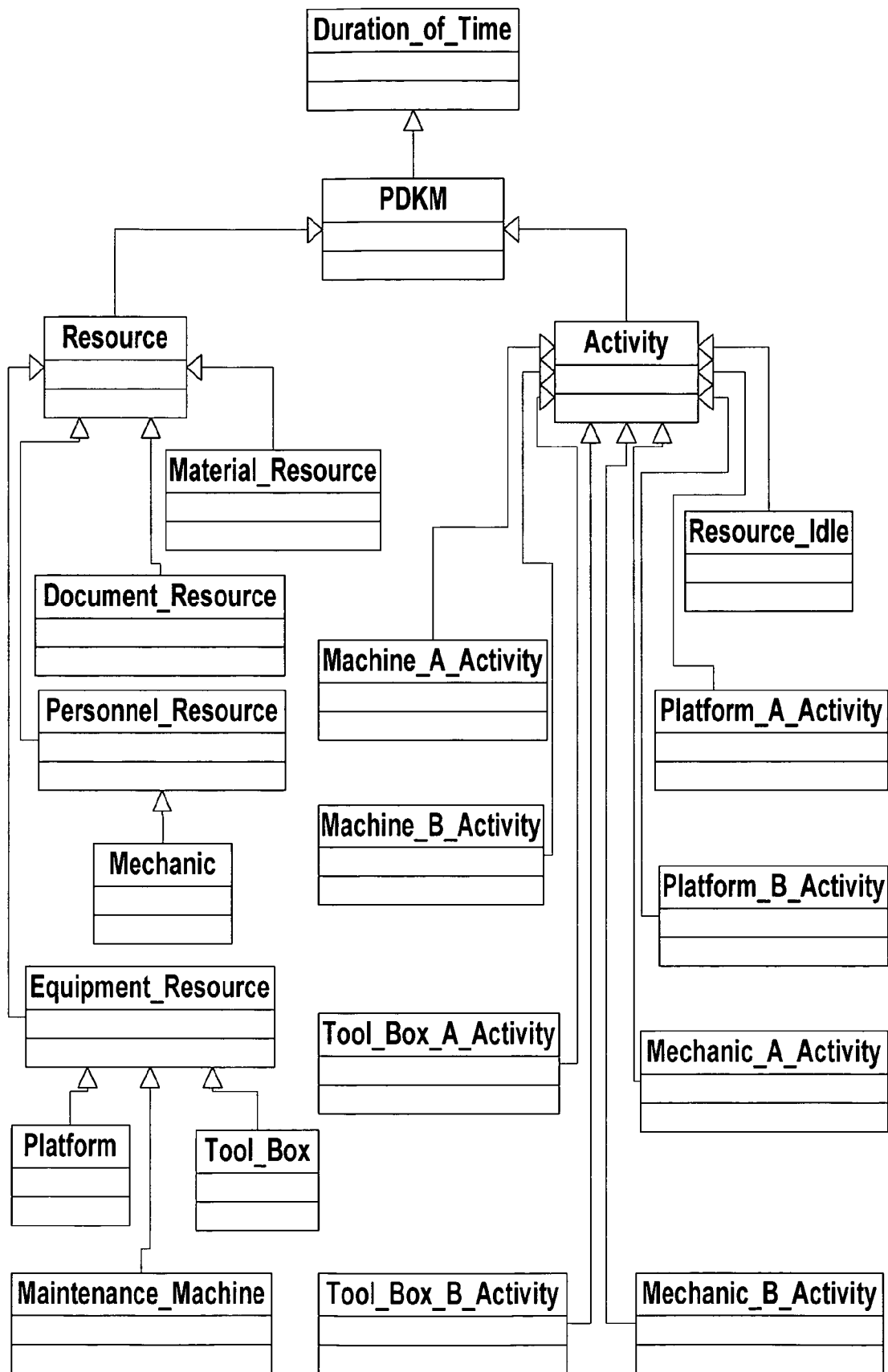


Figure 6

7/18

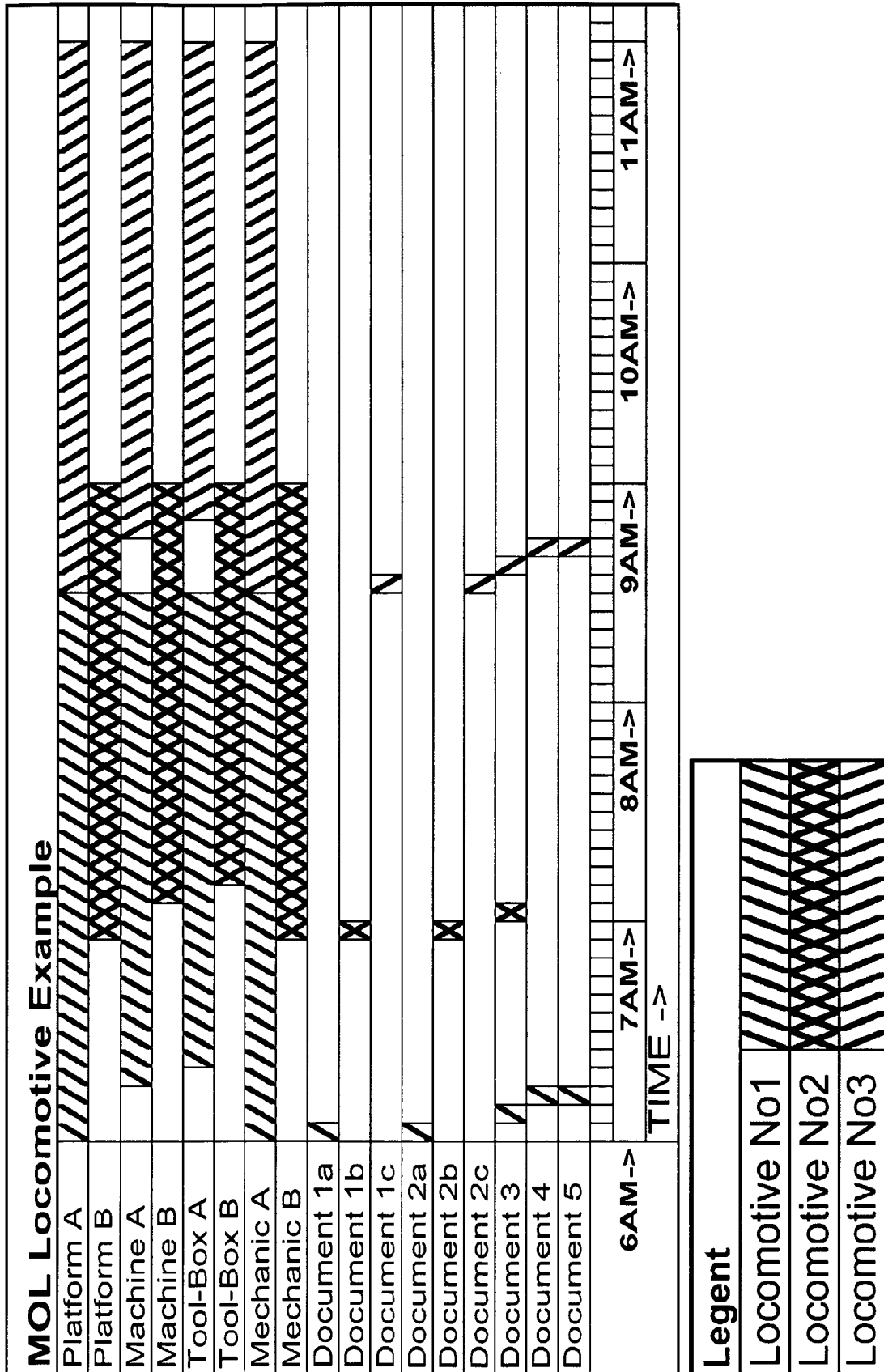


Figure 7

8/18

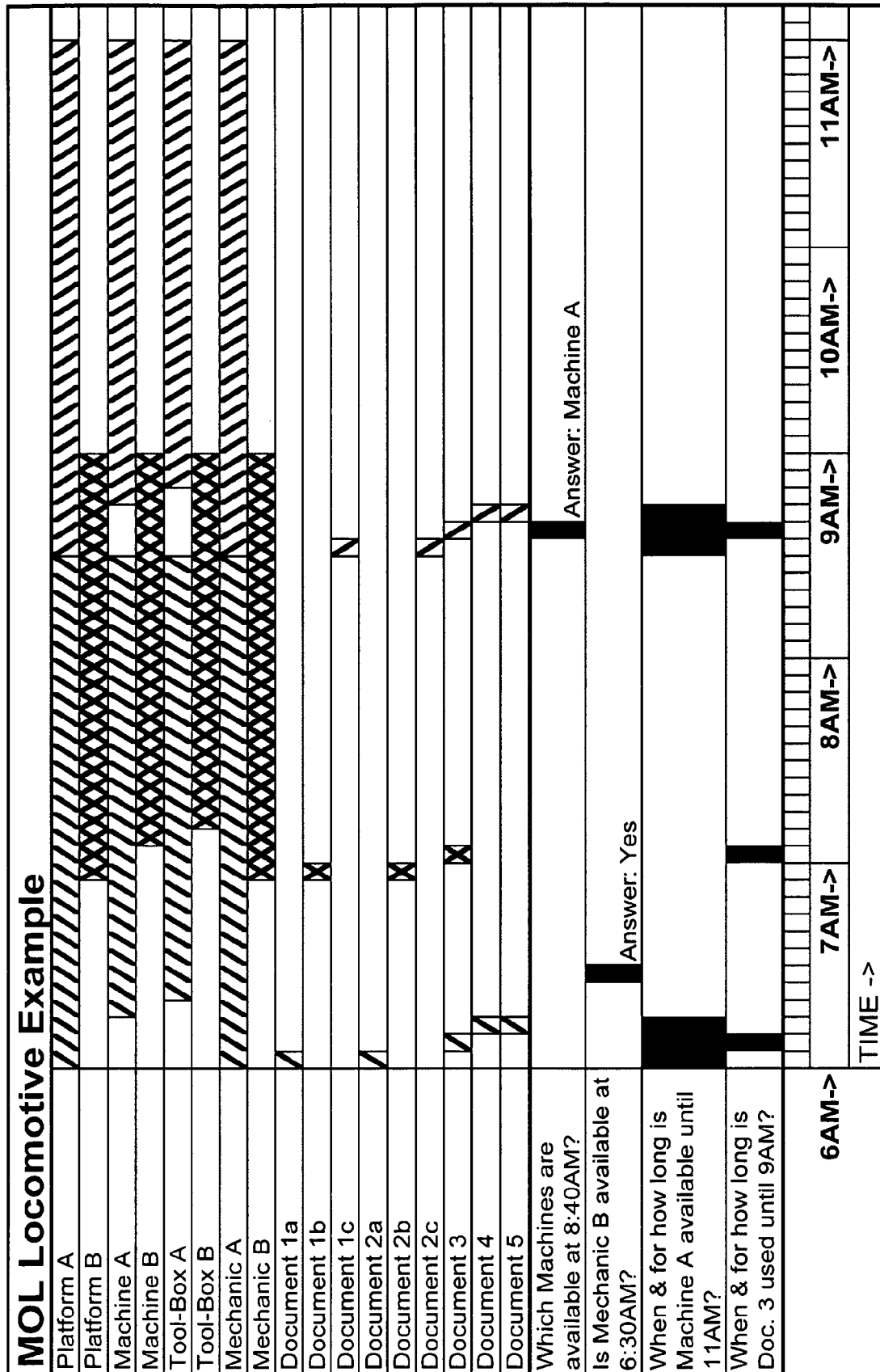


Figure 8

9/18

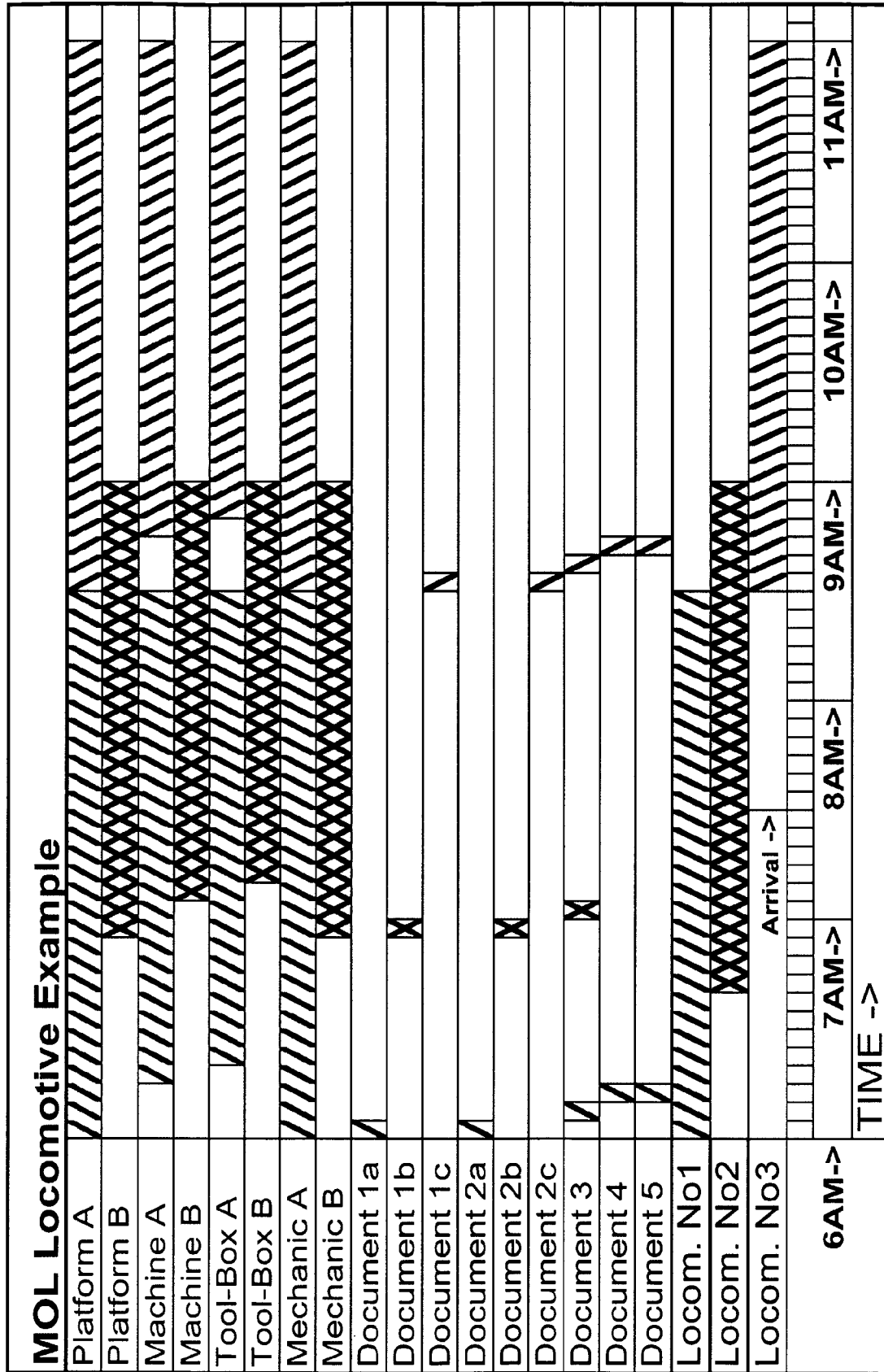


Figure 9

10/18

Which_Machine_is_Available_at_8_40AM			
Instance	Machine	Birth Date	End Date
Resource_Idle_73	Maintenance_Machine_A	2009-02-27T08:30	2009-02-27T08:45
			Duration In Minutes
			15

Figure 10a

Is_Mechanic_B_Available_at_6_30AM		
Instance	Birth Date	End Date
Mechanic B	2009-02-27T06:00:00	2009-02-27T06:55:00
		Duration From Now In Minutes
		25

Figure 10b

When_n_For_How_Long_Document_3			
Instance	Resource	Birth Date	End Date
Resource_Idle_97	Document_Resource_3	2009-02-27T07:05	2009-02-27T08:35
Resource_Idle_96	Document_Resource_3	2009-02-27T06:10	2009-02-27T07:00
Resource_Idle_95	Document_Resource_3	2009-02-27T06:00	2009-02-27T06:05
Resource_Idle_98	Document_Resource_3	2009-02-27T08:40	2009-02-27T16:00
			Duration in Minutes
			90
			50
			5
			440

Figure 10c

11/18

When_n_For_How_Long_Resources				
Instance	Resource	Birth Date	End Date	Duration In Minutes
Resource_Idle_85	Document_Resource_1a	2009-02-27T06:05	2009-02-27T16:00	595
Resource_Idle_86	Document_Resource_1b	2009-02-27T06:00	2009-02-27T06:55	55
Resource_Idle_87	Document_Resource_1b	2009-02-27T07:00	2009-02-27T16:00	540
Resource_Idle_88	Document_Resource_1c	2009-02-27T06:00	2009-02-27T08:30	150
Resource_Idle_89	Document_Resource_1c	2009-02-27T08:35	2009-02-27T16:00	445
Resource_Idle_90	Document_Resource_2a	2009-02-27T06:05	2009-02-27T16:00	595
Resource_Idle_92	Document_Resource_2b	2009-02-27T07:00	2009-02-27T16:00	540
Resource_Idle_91	Document_Resource_2b	2009-02-27T06:00	2009-02-27T06:55	55
Resource_Idle_94	Document_Resource_2c	2009-02-27T08:35	2009-02-27T16:00	445
Resource_Idle_93	Document_Resource_2c	2009-02-27T06:00	2009-02-27T08:30	150
Resource_Idle_98	Document_Resource_3	2009-02-27T08:40	2009-02-27T16:00	440
Resource_Idle_97	Document_Resource_3	2009-02-27T07:05	2009-02-27T08:35	90
Resource_Idle_96	Document_Resource_3	2009-02-27T06:10	2009-02-27T07:00	50
Resource_Idle_95	Document_Resource_3	2009-02-27T06:00	2009-02-27T06:05	5
Resource_Idle_99	Document_Resource_4	2009-02-27T06:00	2009-02-27T06:10	10
Resource_Idle_100	Document_Resource_4	2009-02-27T06:15	2009-02-27T08:40	145
Resource_Idle_101	Document_Resource_4	2009-02-27T08:45	2009-02-27T16:00	435
Resource_Idle_103	Document_Resource_5	2009-02-27T06:15	2009-02-27T08:40	145
Resource_Idle_102	Document_Resource_5	2009-02-27T06:00	2009-02-27T06:10	10
Resource_Idle_104	Document_Resource_5	2009-02-27T08:45	2009-02-27T16:00	435
Resource_Idle_72	Maintenance_Machine_A	2009-02-27T06:00	2009-02-27T06:15	15

Figure 10d

12/18

Instance	Resource	Birth Date	End Date	Duration In Minutes
Resource_Idle_85	Document_Resource_1a	"2009-02-27T06:05:00"	"2009-02-27T16:00:00"	595
Resource_Idle_86	Document_Resource_1b	"2009-02-27T06:00:00"	"2009-02-27T06:55:00"	55
Resource_Idle_87	Document_Resource_1b	"2009-02-27T07:00:00"	"2009-02-27T16:00:00"	540
Resource_Idle_88	Document_Resource_1c	"2009-02-27T06:00:00"	"2009-02-27T08:30:00"	150
Resource_Idle_89	Document_Resource_1c	"2009-02-27T08:35:00"	"2009-02-27T16:00:00"	445
Resource_Idle_90	Document_Resource_2a	"2009-02-27T06:05:00"	"2009-02-27T16:00:00"	595
Resource_Idle_92	Document_Resource_2b	"2009-02-27T07:00:00"	"2009-02-27T16:00:00"	540
Resource_Idle_91	Document_Resource_2b	"2009-02-27T06:00:00"	"2009-02-27T06:55:00"	55
Resource_Idle_94	Document_Resource_2c	"2009-02-27T08:35:00"	"2009-02-27T16:00:00"	445
Resource_Idle_93	Document_Resource_2c	"2009-02-27T06:00:00"	"2009-02-27T08:30:00"	150
Resource_Idle_98	Document_Resource_3	"2009-02-27T08:40:00"	"2009-02-27T16:00:00"	440
Resource_Idle_97	Document_Resource_3	"2009-02-27T07:05:00"	"2009-02-27T08:35:00"	90
Resource_Idle_96	Document_Resource_3	"2009-02-27T06:10:00"	"2009-02-27T07:00:00"	50
Resource_Idle_95	Document_Resource_3	"2009-02-27T06:00:00"	"2009-02-27T06:05:00"	5
Resource_Idle_99	Document_Resource_4	"2009-02-27T06:00:00"	"2009-02-27T06:10:00"	10
Resource_Idle_100	Document_Resource_4	"2009-02-27T06:15:00"	"2009-02-27T08:40:00"	145
Resource_Idle_101	Document_Resource_4	"2009-02-27T08:45:00"	"2009-02-27T16:00:00"	435
Resource_Idle_103	Document_Resource_5	"2009-02-27T06:15:00"	"2009-02-27T08:40:00"	145
Resource_Idle_102	Document_Resource_5	"2009-02-27T06:00:00"	"2009-02-27T06:10:00"	10
Resource_Idle_104	Document_Resource_5	"2009-02-27T08:45:00"	"2009-02-27T16:00:00"	435
Resource_Idle_72	Maintenance_Machine_A	"2009-02-27T06:00:00"	"2009-02-27T06:15:00"	15
Resource_Idle_73	Maintenance_Machine_A	"2009-02-27T08:30:00"	"2009-02-27T08:45:00"	15
Resource_Idle_74	Maintenance_Machine_A	"2009-02-27T11:00:00"	"2009-02-27T16:00:00"	300
Resource_Idle_75	Maintenance_Machine_B	"2009-02-27T06:00:00"	"2009-02-27T06:55:00"	55
Resource_Idle_76	Maintenance_Machine_B	"2009-02-27T09:00:00"	"2009-02-27T16:00:00"	420
Resource_Idle_82	Mechanic_A	"2009-02-27T11:00:00"	"2009-02-27T16:00:00"	300
Resource_Idle_83	Mechanic_B	"2009-02-27T09:00:00"	"2009-02-27T16:00:00"	420
Resource_Idle_84	Mechanic_B	"2009-02-27T06:00:00"	"2009-02-27T06:55:00"	55
Resource_Idle_69	Platform_A	"2009-02-27T11:00:00"	"2009-02-27T16:00:00"	300
Resource_Idle_70	Platform_B	"2009-02-27T06:00:00"	"2009-02-27T06:55:00"	55
Resource_Idle_71	Platform_B	"2009-02-27T09:00:00"	"2009-02-27T16:00:00"	420
Resource_Idle_79	Tool_Box_A	"2009-02-27T11:00:00"	"2009-02-27T16:00:00"	300
Resource_Idle_78	Tool_Box_A	"2009-02-27T08:30:00"	"2009-02-27T08:50:00"	20
Resource_Idle_77	Tool_Box_A	"2009-02-27T06:00:00"	"2009-02-27T06:20:00"	20
Resource_Idle_80	Tool_Box_B	"2009-02-27T06:00:00"	"2009-02-27T07:10:00"	70
Resource_Idle_81	Tool_Box_B	"2009-02-27T09:00:00"	"2009-02-27T16:00:00"	420

Figure 10e

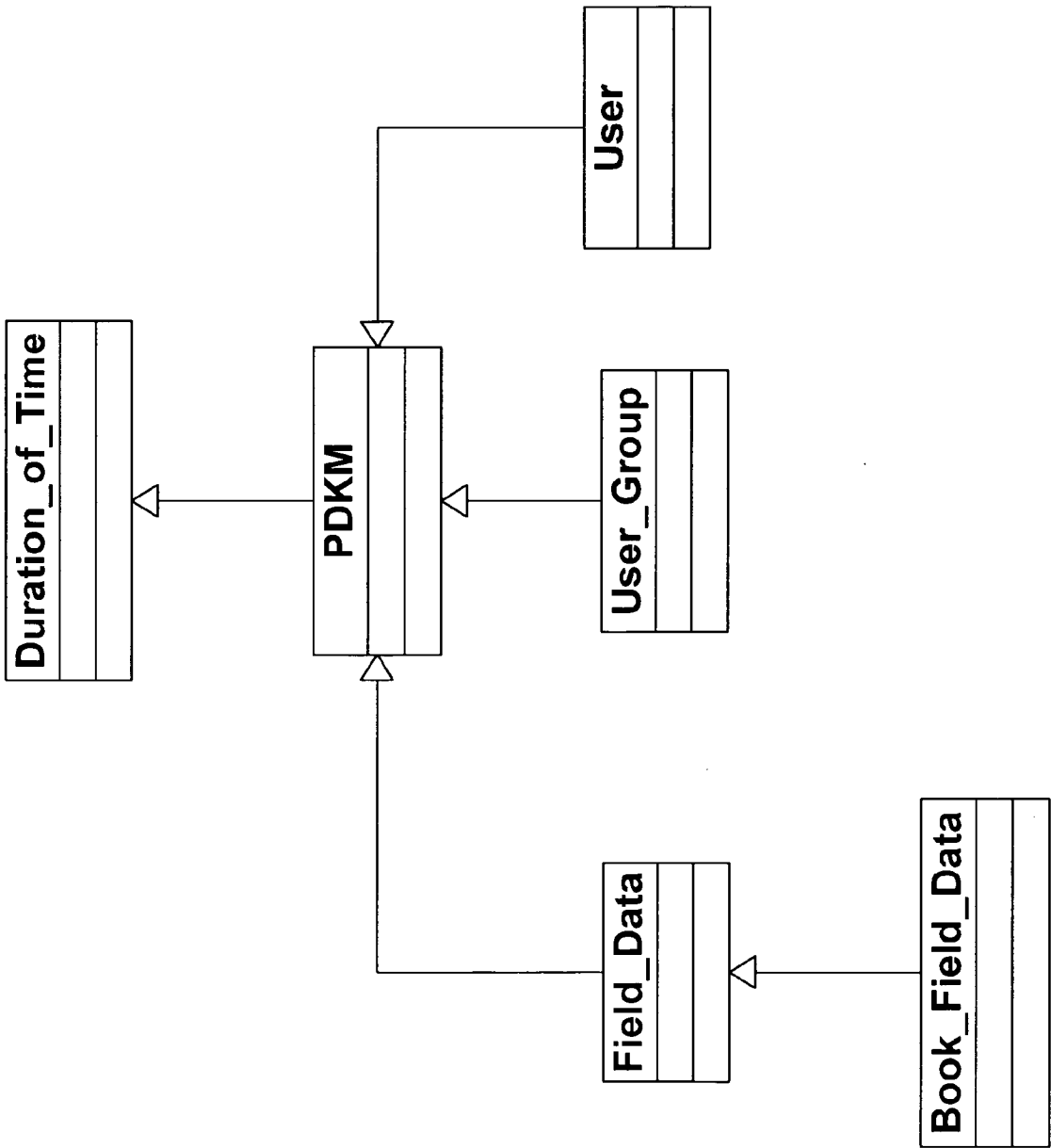


Figure 11

Library Management																									
Book 1																									
Book 2																									
Book 3																									
Book 4																									
Book 5																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Day ->																								

Legent	
User No1	
User No2	
User No3	

Figure 12

Library Management																																
Book 1																																
Book 2																																
Book 3																																
Book 4																																
Book 5																																
Query 1																																
Query 2																																
Query 3																																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
Day ->																																

List of Queries
Query 1: Which Books & for how long are available on the 8th day?
Query 2: Is Book 1 available at the 9th day?
Query 3: When & for how long is Book 2 available until the 30th day?

Figure 13

Library_Ex_Which_n_for_How_long_Available_on_8th_day			
Instance	Birth Date	End Date	Duration From Now In Days
Book_5	2009-03-01T08:00:00	2009-03-17T07:30:00	9

Figure 14a

Library_Ex_Is_Book_1_Av_on_9th_day			
Instance	Birth Date	End Date	Duration From Now In Days
Book1	2009-03-09T08:00:01	2009-03-13T07:30:00	4

Figure 14b

17/18

Library_Ex_Which_n_for_How_long_Available_30days			
Instance	Birth Date	End Date	Duration In Days
Book_1	2009-03-09T08:00:01	2009-03-13T07:30:00	4
Book_1	2009-03-01T08:00:01	2009-03-02T07:30:00	1
Book_1	2009-03-20T08:00:00	2009-03-31T07:30:00	11
Book_2	2009-03-19T08:00:00	2009-03-31T07:30:00	12
Book_2	2009-03-10T08:00:00	2009-03-12T07:30:00	2
Book_3	2009-03-17T08:00:00	2009-03-31T07:30:00	14
Book_3	2009-03-01T08:00:01	2009-03-02T07:30:00	1
Book_3	2009-03-09T08:00:00	2009-03-10T07:30:00	1
Book_4	2009-03-01T08:00:01	2009-03-02T07:30:00	1
Book_4	2009-03-23T08:00:00	2009-03-31T07:30:00	8
Book_4	2009-03-09T08:00:00	2009-03-14T07:30:00	5
Book_5	2009-03-24T08:00:00	2009-03-31T07:30:00	7
Book_5	2009-03-01T08:00:00	2009-03-17T07:30:00	16

Figure 14c

18/18

Library_Ex_Which_Users_30days				
Instance	User	Birth Date	End Date	Duration In Days
Book_1	User_No1	2009-03-02T08:00:00	2009-03-09T07:30:00	7
Book_1	User_No2	2009-03-13T08:00:00	2009-03-20T07:30:00	7
Book_2	User_No1	2009-03-03T08:00:00	2009-03-10T07:30:00	7
Book_2	User_No3	2009-03-12T08:00:00	2009-03-19T07:30:00	7
Book_3	User_No3	2009-03-10T08:00:00	2009-03-17T07:30:00	7
Book_3	User_No2	2009-03-02T08:00:00	2009-03-09T07:30:00	7
Book_4	User_No2	2009-03-16T08:00:00	2009-03-23T07:30:00	7
Book_4	User_No3	2009-03-02T08:00:00	2009-03-09T07:30:00	7
Book_5	User_No1	2009-03-17T08:00:00	2009-03-24T07:30:00	7

Figure 14d

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT

(PCT Article 17(2)(a), Rules 13ter.1(c) and Rule 39)

Applicant's or agent's file reference 17305/PCT	IMPORTANT DECLARATION	Date of mailing(day/month/year) 15/06/2010
International application No. PCT/EP2010/053238	International filing date(day/month/year) 13/03/2010	(Earliest) Priority date(day/month/year) 13/03/2009
International Patent Classification (IPC) or both national classification and IPC G06Q10/00		
Applicant ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE (EPFL)		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below

1. ☐ The subject matter of the international application relates to:

- a. ☐ scientific theories
- b. ☐ mathematical theories
- c. ☐ plant varieties
- d. ☐ animal varieties
- e. ☐ essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes
- f. ☐ schemes, rules or methods of doing business
- g. ☐ schemes, rules or methods of performing purely mental acts
- h. ☐ schemes, rules or methods of playing games
- i. ☐ methods for treatment of the human body by surgery or therapy
- j. ☐ methods for treatment of the animal body by surgery or therapy
- k. ☐ diagnostic methods practised on the human or animal body
- l. ☐ mere presentations of information
- m. ☐ computer programs for which this International Searching Authority is not equipped to search prior art

2. ☒ The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:

☐ the description ☒ the claims ☐ the drawings

3. ☐ A meaningful search could not be carried out without the sequence listing; the applicant did not, within the prescribed time limit:

- ☐ furnish a sequence listing on paper complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Searching Authority in a form and manner acceptable to it.
- ☐ furnish a sequence listing in electronic form complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Searching Authority in a form and manner acceptable to it.
- ☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rule 13ter.1(a) or (b).

4. Further comments:

Name and mailing address of the International Searching Authority  European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Katrin Sommermeyer
--	--

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 203

The subject-matter of the claims of the present application relates to software, i.e. to subject-matter referred to in rules 39.1(iii) and 67.1(iii) PCT, in combination with Articles 17(2)(a)(i) and 34(4)(a)(i) PCT. This software has no further technical effect. For such matter, this International Searching Authority does not carry out a search.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.