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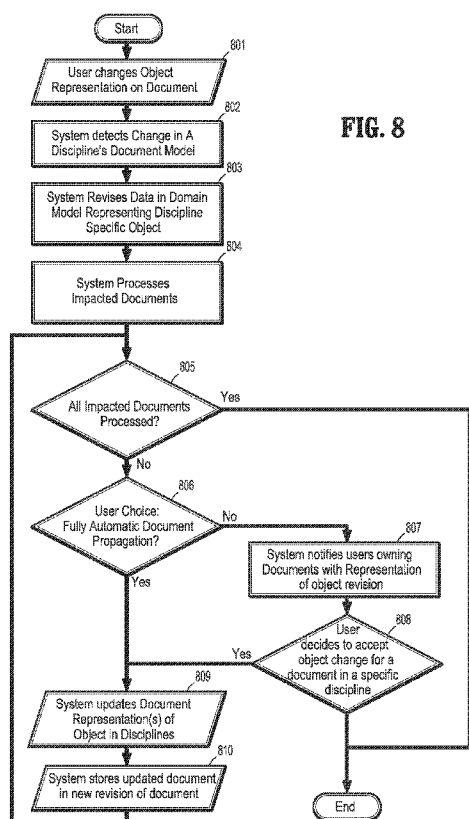
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(54) Title: METHOD AND SYSTEM FOR MULTI-DISCIPLINARY ENGINEERING WITH A SYNCHRONIZED DOCUMENTS INTERFACE



(57) Abstract: A method of synchronization in a multi-disciplinary engineering environment includes detecting (802) a change made to a document in a document-based portion of a domain in a multi-disciplinary engineering system, wherein the multi-disciplinary engineering system comprises a plurality of domains including the domain, updating (803) data in a model-based portion of the domain in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document, and updating (809) at least one other document in the document-based portion of the domain in response to updating the data in the model-based portion of the domain, wherein the at least one other document is impacted by the change made to the document



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METHOD AND SYSTEM FOR MULTI-DISCIPLINARY ENGINEERING WITH A SYNCHRONIZED DOCUMENTS INTERFACE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and the benefit of Provisional Application Serial No. 61/766,183, filed on February 19, 2013, the disclosure of which is herein incorporated by reference in its entirety.

BACKGROUND

1. Technical Field

Exemplary embodiments of the present invention relate to a method and system for multi-disciplinary engineering with a synchronized documents interface.

2. Discussion of Related Art

A multi-disciplinary engineering system is a system that allows engineers from multiple disciplines to work on common or connected data. For example, in a factory setting, a factory planner can work together with a mechanical engineer, an electrical engineer and an automation engineer to plan a new production line for a car door assembly.

Typically, when working on common or connected data, the work of engineers from multiple disciplines is separated from a data point of view. As a result, manual synchronization of discipline specific data may be time consuming and error prone. Referring to the example above, when the automation engineer introduces a new programmable logic controller (PLC) to a project, this information should be shared with the electrical engineer so that the electrical engineer can place the newly added programmable logic controller into the correct electrical cabinet and plan for the wiring of the newly added programmable logic controller. If the information is not shared between disciplines, or if the information is distorted when shared between disciplines, the work of the engineers may be impacted.

SUMMARY

According to an exemplary embodiment of the present invention, a method of synchronization in a multi-disciplinary engineering environment includes detecting a change made to a document in a document-based portion of a domain in a multi-disciplinary engineering system, wherein the multi-disciplinary engineering system comprises a plurality

of domains including the domain, updating data in a model-based portion of the domain in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document, and updating at least one other document in the document-based portion of the domain in response to updating the data in the model-based portion of the domain, wherein the at least one other document is impacted by the change made to the document.

The method may further include updating data in a model-based portion of at least one other domain from among the plurality of domains in response to updating the data in the model-based portion of the domain.

The method may further include transmitting a notification to at least one other domain from among the plurality of domains indicating that the data in the model-based portion of the domain has been updated subsequent to updating the data in the model-based portion of the domain.

The method may further include transmitting a notification to at least one user associated with the at least one other document upon updating the data in the model-based portion of the domain, wherein the notification indicates that a change impacting the at least one other document has occurred in the model-based portion of the domain.

The method may further include transmitting a query to a user upon detecting the change to the document in the document-based portion of the domain to determine whether the data in the model-based portion relates to the change made to the document, wherein the data in the model-based portion of the domain is updated based on a user response to the query provided by the user.

In an exemplary embodiment, the model-based portion of the domain includes a single common data model.

In an exemplary embodiment, the data in the model-based portion of the domain is updated at predefined time intervals.

In an exemplary embodiment, the data in the model-based portion of the domain is updated immediately upon detecting the change made to the document in the document-based portion of the domain.

According to an exemplary embodiment of the present invention, a method of synchronization in a multi-disciplinary engineering environment includes detecting a change made to a document in a document-based portion of a domain in a multi-disciplinary engineering system, wherein the multi-disciplinary engineering system comprises a plurality

of domains including the domain, updating data in a model-based portion of the domain in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document, and updating data in a model-based portion of at least one other domain from among the plurality of domains in response to updating the data in the model-based portion of the domain.

According to an exemplary embodiment of the present invention, a computer program product for a method of synchronization in a multi-disciplinary engineering environment includes a computer readable storage medium having program instructions embodied therewith, the program instructions being executable by a processor to cause the processor to detect, by the processor, a change made to a document in a document-based portion of a domain in a multi-disciplinary engineering system, wherein the multi-disciplinary engineering system comprises a plurality of domains including the domain, update, by the processor, data in a model-based portion of the domain in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document, and update, by the processor, at least one other document in the document-based portion of the domain in response to updating the data in the model-based portion of the domain, wherein the at least one other document is impacted by the change made to the document.

According to an exemplary embodiment of the present invention, an apparatus for performing a method of synchronization in a multi-disciplinary engineering environment includes a computer server including a plurality of storage databases corresponding to a plurality of domains, wherein each of the plurality of domains is accessible to a plurality of users via a corresponding application interfacing with the computer server via a network, a synchronization application of the computer server is configured to detect a change made to a document in a document-based portion of one of the storage databases, update data in a model-based portion of the one of the storage databases in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document, and update at least one other document in the document-based portion of the one of the storage databases in response to updating the data in the model-based portion of the one of the storage databases, wherein the at least one other document is impacted by the change made to the document.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the accompanying drawings, in which:

FIG. 1 shows a general overview of a multi-disciplinary engineering system.

FIG. 2 shows an overview of a document based engineering system.

FIG. 3 shows an overview of a model based engineering system.

FIG. 4 shows a multi-disciplinary engineering system application topology according to an exemplary embodiment of the present invention.

FIG. 5 shows a hardware implementation of a multi-disciplinary engineering system according to an exemplary embodiment of the present invention.

FIG. 6 shows an overview of user-defined automatic change propagation implemented to synchronize a document-based portion and a model-based portion of a domain in a multi-disciplinary engineering system, according to an exemplary embodiment of the present invention.

FIG. 7 shows an overview of fully automatic change propagation implemented to synchronize a document-based portion and a model-based portion of a domain in a multi-disciplinary engineering system, according to an exemplary embodiment of the present invention.

FIG. 8 is a flowchart describing a method of synchronizing the document-based portion and the model-based portion of the multi-disciplinary engineering systems of FIGs. 6 and 7, according to an exemplary embodiment of the present invention.

FIG. 9 shows an overview of semi-automatic synchronization between different domains of a multi-disciplinary engineering system, according to an exemplary embodiment of the present invention.

FIG. 10 shows an overview of fully automatic synchronization between different domains of a multi-disciplinary engineering system, according to an exemplary embodiment of the present invention.

FIG. 11 is a flowchart describing a method of synchronization between different domains of the multi-disciplinary engineering systems of FIGs. 9 and 10, according to an exemplary embodiment of the present invention.

FIG. 12 shows a multi-disciplinary engineering system application topology according to an exemplary embodiment of the present invention.

FIG. 13 is a block diagram of an exemplary computer system for implementing a method for multi-disciplinary engineering with a synchronized documents interface, according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Exemplary embodiments of the present invention will be described more fully hereinafter with reference to the accompanying drawings. Like reference numerals may refer to like elements throughout the accompanying drawings.

FIG. 1 shows a general overview of a multi-disciplinary engineering system **100**. In the example shown in FIG. 1, the engineering system **100** refers to a production line in a factory, and workers in different disciplines include factory designers, management employees, automation engineers, mechanical engineers, and electrical engineers. For convenience of explanation, exemplary embodiments described herein may refer to the engineering system **100** and disciplines (and corresponding workers) shown in FIG. 1, however, it is to be understood that exemplary embodiments are not limited thereto. That is, exemplary embodiments may be utilized in a variety of engineering systems. Herein, the terms workers, engineers, and users may be used interchangeably, and the terms disciplines and domains may be used interchangeably.

Different methods may be utilized in a multi-disciplinary engineering system. For example, an engineering system may utilize a document based engineering method or a model based engineering method.

FIG. 2 shows an overview of a document based engineering system.

Referring to a document based engineering system, workers create and manage documents, which may be in different formats and may be created and managed using different tools, during an engineering process. The tools used may be standard tools (e.g., Microsoft® Excel®, Microsoft® Visio®, etc.) or specialized tools (e.g., EPlan, Factory CAD, etc.). When a document based engineering method is used, efficiency and accuracy may be limited in regards to maintaining consistency between documents since documents each have their own separate format and data. A versioning scheme may be used to indicate changes made to documents, and the corresponding times of the changes.

For example, referring to FIG. 2, an automation engineer may introduce a new programmable logic controller (PLC) (e.g., PLC A) **201** in a document based engineering system **200**. When PLC A is added, all documents **202** (e.g., wiring diagrams, connection

lists, bills of material, cabinet diagrams, etc.) impacted by PLC A 201 are separately created and/or updated. Database or repository software may be utilized to administer and revise documents in a document based engineering system 200. Manual change propagation, in which engineers from one discipline alert engineers of another discipline that a change to a document has been made, may be utilized. Manual change propagation is described in further detail below.

FIG. 3 shows an overview of a model based engineering system.

Referring to a model based engineering system 300, engineering data is stored in a format that is structured in one common data model 301. In a model based system 300, the engineering data is not document specific. Thus, referring to the example above, when a new PLC (e.g., PLC A) is added in a model based engineering system 300, the PLC, and all of its associated data, is only represented once in the system 300, rather than being duplicated across different documents as done in a document based engineering system 200. That is, when a new PLC is added in a model based system 300, only the data model 301 of the system 300 is updated.

Since documents are typically needed by workers at some point during an engineering process, at certain points, the data model 301 in the model based engineering system 300 is converted and exported into document form for use by the workers. For example, in FIG. 3, the data model 301 is converted and exported into documents 302. Compared to a document based engineering system 200, in which data is always stored in document form, a model based engineering system 300 may result in increased productivity and efficiency of the engineering process. However, because generated documents 302 are decoupled from the data model 301 (e.g., since documents 302 are only generated periodically based on the data model 301), changes are not automatically synchronized between documents 302 and other documents 302, or between documents 302 and the data model 301.

According to exemplary embodiments of the present invention, a multi-disciplinary engineering system may combine a document based engineering system and a model based engineering system. That is, according to exemplary embodiments, a multi-disciplinary engineering system is neither purely document based nor purely model based. The combined multi-disciplinary engineering system allows multiple workers from different disciplines to work together using a document based approach or a model based approach, as described above, while the multi-disciplinary system synchronizes both documents and models within the system.

FIG. 4 shows a multi-disciplinary engineering system application topology, according to an exemplary embodiment of the present invention.

According to an exemplary embodiment of the present invention, a multi-disciplinary engineering system includes a plurality of engineering applications coupled to a computer server via extension modules. Each engineering application corresponds to a different domain in the multi-disciplinary engineering system. The extension modules are configured to communicate with the computer server, which stores common data. The common data stored in the server may be in the form of an object-oriented engineering model that spans the multiple disciplines. The computer server may synchronize different connected applications, organize data, and transmit notifications regarding changes that are to be propagated.

For example, referring to FIG. 4, the plurality of engineering applications includes a mechanical CAD application **401**, an electrical application **402**, an automation application **403**, and an engineering application **404**. It is to be understood that exemplary embodiments of the present invention are not limited to the types and number of engineering applications shown in FIG. 4. Each engineering application includes an application interface **405** configured to communicate with a computer server interface **406** via a network **410** (e.g., a LAN, WAN, etc.). The computer server interface **406** and a storage database(s) **407** are part of a data repository application **408**. The storage database **407** may include a plurality of storage databases **407**, each storing data corresponding to the different domains (e.g., mechanical data, electrical data, layout data, automation data, etc.). Each storage database **407** may include a document-based portion and a model-based portion. A synchronization application of the computer server **406** may perform synchronization according to exemplary embodiments of the present invention (see, for example, FIGs. 8 and 11). The multi-disciplinary engineering system is extendable, allowing for additional engineering applications corresponding to different disciplines to be added to existing engineering projects. Extendibility may be implemented using, for example, well-defined extension interfaces provided by the applications (e.g., Application Programming Interfaces (APIs) for plugins or scripts), or an extendable meta-model based repository system for the server.

FIG. 5 shows a hardware implementation of a multi-disciplinary engineering system, according to an exemplary embodiment of the present invention.

As shown in FIG. 5, a multi-disciplinary engineering system **500** includes a client **501** connected to a computer server **502** via a network **512**. Exemplary embodiments may include multiple clients **501** and/or multiple servers **502**. The client **501** includes a memory

503, a central processing unit (CPU) 504, and a storage device 505. The computer server 502 similarly includes a memory 506, a CPU 507, and a storage device 508. The memory 506 may include a synchronization application for performing synchronization according to exemplary embodiments of the present invention (see, for example, FIGs. 8 and 11), and the storage device 508 may include a plurality of storage databases, each having a document-based portion and a model-based portion, corresponding to a domain of the system 500. The system 500 may further include, for example, automation hardware 509 (e.g., PLCs, I/O boards, etc.), sensors 510 (e.g., light barriers, proximity sensors, etc.), and/or actuators 511 (e.g., drives, robots, etc.), as well as various other peripheral devices. Engineers may interact with the multi-disciplinary engineering system via input/output (I/O) devices (e.g., a keyboard, mouse, monitor, etc.) 512 connected to the client 501, as well as the various peripheral devices of the system.

As described above, according to exemplary embodiments of the present invention, synchronization in a multi-disciplinary engineering system may be implemented between documents and models in a single system in which document based engineering methods are combined with model based engineering methods. That is, data in a document-based portion of a multi-disciplinary engineering system (e.g., a portion of a multi-disciplinary engineering system utilizing document based engineering as described, for example, with reference to FIG. 2) is synchronized with data in a model-based portion of the multi-disciplinary engineering system (e.g., a portion of the multi-disciplinary engineering system utilizing model based engineering as described, for example, with reference to FIG. 3). Workers in different disciplines may utilize the system via document based access (e.g., through layout plans, electrical schematics, etc.), as typically done in a document based engineering system (see FIG. 2), or via direct model access (e.g., through graph views, tree views, etc.), as typically done in a model based engineering system (see FIG. 3). Regardless of whether a worker accesses the system using document based access methods or direct model access methods, both the data model and data documents that form the engineering system are automatically synchronized by the system.

The visualization presented to the workers may include a modified visualization of the data model including additional document specific information such as, for example, page bounds, references, etc. The system may control the data model and its visualization either as a document or a model. The visualization may be an application/domain specific document presentation allowing documents to be viewed and opened. The visualization may also

display metadata and allow users to perform data management tasks and explore interdisciplinary connections between the documents and the data model, as well as between multiple documents. The visualization may allow additional metadata such as, for example, data sheets associated with documents or data, to be controlled. The visualization may further allow data management tasks such as, for example, revising and configuring data, to be performed.

Synchronization may be implemented in a variety of manners. For example, synchronization may be rule-based or notification-based, or synchronization may occur in real-time. When synchronization is rule-based, synchronization occurs at specific points in time (e.g., at predefined time intervals including, for example, user-defined points in time). When synchronization is notification-based, the multi-disciplinary engineering system notifies the user of potential synchronization steps, and the user decides which steps are to be executed. When synchronization occurs in real-time, changes are synchronized immediately. To allow for synchronization, the multi-disciplinary system may track the versions of objects and documents within the system.

Synchronization may be user-defined or fully automatic. FIG. 6 shows an overview of user-defined automatic change propagation implemented to synchronize a document-based portion and a model-based portion of a domain in a multi-disciplinary engineering system, according to an exemplary embodiment of the present invention. FIG. 7 shows an overview of fully automatic change propagation implemented to synchronize a document-based portion and a model-based portion of a domain in a multi-disciplinary engineering system, according to an exemplary embodiment of the present invention. FIG. 8 is a flowchart describing a method of synchronizing the document-based portion and the model-based portion of a domain in the multi-disciplinary engineering systems of FIGs. 6 and 7.

Referring to FIGs. 6 and 7, a multi-disciplinary system engineering system **600** according to an exemplary embodiment of the present invention includes a plurality of domains, each of which include both a model-based portion (e.g., the portion of the system **600** including the data model **601**) and a document-based portion (e.g., the portion of the system **600** including documents **602**). The model-based portion **601** and the document-based portion **602** described with reference to FIGs. 6 and 7 correspond to the automation domain utilized by automation engineers, as described in the example above. However, it is to be understood that the description of FIGs. 6 to 8 may apply to all of the domains **603** of the multi-disciplinary engineering system **600**. The domains, each of which may include a

model-based portion and a document-based portion, as described herein, may all be linked together as shown in FIGs. 6 and 7. Synchronization between these linked domains is described in detail with reference to FIGs. 9 to 11.

Referring to FIG. 8, a user changes an object representation in a document at block **801**. That is, at block **801**, a change occurs to a document in the document-based portion **602** of a domain (e.g., the automation domain) in the multi-disciplinary engineering system **600**. At block **802**, the system **600** detects the change of the document. That is, at block **802**, the change occurring in the document-based portion **602** is detected. At block **803**, data in the model-based portion **601** is updated based on the change that occurred in the document-based portion **602**. For example, if the change detected at block **802** corresponds to PLC A being changed in Document Z by Engineer C, PLC A is updated in the model-based portion **601**. At block **804**, the system **600** processes all impacted documents in the document-based portion **602** (e.g., all documents affected by the revision made to PLC A in the model-based portion **601**).

At block **805**, it is determined whether all impacted documents have been processed. If impacted documents remain, it is determined (e.g., by the user) whether propagation of the revision is user-defined or fully automatic at block **806**.

When propagation is user-defined (see FIG. 6), the system **600** transmits a notification to user(s) linked to the document at block **807**, informing the user(s) that a revision has occurred at the model-based portion **601** of the domain. A user may be linked to a document if the user is currently working on the document, has previously worked on the document, has indicated an intent to work on the document, has registered as an owner of the document, has indicated an interest in receiving updates regarding the document, etc. At block **808**, the user may accept or reject the revision.

When propagation is fully automatic (see FIG. 7), or when a user at block **808** accepts a revision, the system **600** updates the affected documents at block **809**, and stores a new revision of the document at block **810**. The data in the model-based portion **601** of the domain may be updated at predefined time intervals when propagation is fully automatic. Further, the data in the model-based portion **601** of the domain may be immediately updated upon detecting a change made to a document in the document-based portion **602** when propagation is fully automatic.

As shown in FIGs. 6 and 7, since all of the domains in the multi-disciplinary engineering system **600** are linked to each other, revisions are synchronized across all

domains in the system 600. Synchronization between different domains is described in further detail herein with reference to FIGs. 9 to 11.

In addition to providing synchronization between a model-based representation and a document-based representation within an engineering domain, as described above, the multi-disciplinary engineering system according to exemplary embodiments provides synchronization between different engineering domains within a multi-disciplinary engineering system. Synchronization between different domains may be semi-automatic (e.g., engineers may be permitted to provide input on potential changes to the system) or fully automatic. Synchronization between domains may utilize versioning of data in the systems, as well as notifications, as described in further detail below. Depending on the type of change occurring in the system (e.g., an addition of a new data object, the removal of an existing data object, a modification to an existing data object, etc.), different domains in the multi-disciplinary system may respond to the change differently. For example, depending on the type of change, a user notification may be provided requesting approval to create/remove/modify a data object, or a data object may be automatically created/removed/modified without further input from a user. In addition, user notifications may be utilized for all changes for which the multi-disciplinary system cannot automatically determine the appropriate action to take.

FIG. 9 shows an overview of semi-automatic synchronization between different domains, according to an exemplary embodiment of the present invention.

Referring to FIG. 9 and the example involving a production line in a factory, a mechanical engineer may change the belt speed specification of a conveyor belt from 10 mph to 15 mph. If the multi-disciplinary engineering system is unable to automatically detect whether this change affects a control program that controls the conveyor belt, and/or the manner in which the change affects the control program, user-defined automatic change propagation may be implemented. For example, a query may be generated and presented to the user to determine whether the specification change affects the control program, and/or in what manner the specification change affects the control program.

FIG. 10 shows an overview of fully automatic synchronization between different domains, according to an exemplary embodiment of the present invention.

Referring to FIG. 10 and the example involving a production line in a factory, an engineer may add a new data object (e.g., an input/output card to a PLC Station) in the automation domain. When fully automatic change propagation is implemented, addition of

the input/output card in the automation domain results in the automatic updating of the corresponding electrical representation in the electrical model, and the automatic connection of the new input/output ports of the new object to sensors/actuators of other objects already existing in the engineering system.

Referring to FIGs. 9 and 10, a multi-disciplinary engineering system **900** according to an exemplary embodiment of the present invention includes a plurality of domains, each of which include both a model-based portion and a document-based portion, as described in detail with reference to FIGs. 6 and 7. The domains described with reference to FIGs. 9 and 10 correspond to the automation domain **901** utilized by automation engineers and the electrical domain **902** utilized by electrical engineers, as described in the example above. However, it is to be understood that the description of FIGs. 9 and 10 applies to all of the domains **903** of the multi-disciplinary engineering system **900**. The domains **901** to **903**, each of which include a model-based portion and a document-based portion, are linked together and synchronized with each other as described herein.

For example, referring to FIG. 11 a user changes an object representation in a document at block **1101**. That is, at block **1101**, a change occurs to a document in the document-based portion of a domain in the multi-disciplinary engineering system **900** (e.g., the automation domain **901** in FIGs. 9 and 10). At block **1102**, the system **900** detects the change of the document. That is, at block **1102**, the change occurring in the document-based portion is detected. At block **1103**, data in the model-based portion of the same domain (e.g., the automation domain **901** in FIGs. 9 and 10) is updated based on the change that occurred in the document-based portion.

For example, if the change detected at block **1102** corresponds to PLC A being changed in a document by Engineer C in the automation domain **901**, PLC A is updated in the model-based portion of the automation domain **901**. At block **1104**, the system **900** notifies all other domains impacted by the change to PLC A (e.g., the electrical domain **902**, as shown in FIGs. 9 and 10). At block **1105**, it is determined whether all impacted domains have been notified. If all impacted domains have not yet been notified, it is determined (e.g., by the user) whether propagation of the data change is to be user-defined or fully automatic at block **1106**.

When propagation is user-defined (see FIG. 9), the system **900** transmits a notification to both the affected domain at block **1107** (e.g., the electrical domain **902** in FIGs. 9 and 10), and to user(s) working in the affected domain at block **1108** (e.g., Engineer B in FIGs. 9 and

10), informing the user(s) that a revision has occurred at the domain that the change originated from (e.g., the automation domain **901** in FIGs. 9 and 10). Alternatively, the user(s) may be notified by the affected domain rather than the domain that the change originated from. At block **1108**, the user may decide to accept or reject data change.

When propagation is fully automatic, or when a user at block **1108** accepts a revision, the system **900** updates the affected domains at block **1109**, and stores the updated data at block **1110**.

Combining the synchronization between the model-based portion and the document-based portion of a domain, as described with reference to FIGs. 6 to 8, and synchronization between multiple domains, as described with reference to FIGs. 9 to 11, allows for the realization of a multi-disciplinary engineering system in which engineers from multiple domains may more efficiently work on common or connected data.

FIG. 12 shows a multi-disciplinary engineering system application topology, according to an exemplary embodiment of the present invention.

Referring to FIG. 12, a multi-disciplinary engineering system **1200** includes an object-oriented repository system **1201** including a server **1202**. The server **1202** stores different domain specific data models **1203**. Each domain specific data model **1203** corresponds to a different domain, and the server **1202** provides multi-disciplinary access to the domain specific data models. In FIG. 12, the domain specific data models **1203** correspond to a mechanical domain, an electrical domain, a layout domain, and an automation domain, as described in the example above, however the data models **1203** are not limited thereto. For example, other data models **1203** may correspond to simulation data, factory planner data, etc.

As described above, according to exemplary embodiments, a plurality of engineering applications may be coupled to the server **1202**. Three examples of different applications coupled to the server **1202** are shown in FIG. 12, however, the type and number of applications are not limited thereto, and additional applications **1207** may be included.

Referring to FIG. 12, a first exemplary application **1204** interfaces with at least some of the plurality of domains. For example, in FIG. 12, the first application **1204** interfaces with the mechanical domain, the electrical domain, and the automation domain, each of which has its own user interface providing a user with both a model view and a document view. The first application **1204** may provide different types of graphical interfaces to the user to view and access the domains including, for example, a two-dimensional and a three-

dimensional work space. Exemplary work spaces include a factory layout editor, an electrical plan editor, mechanical drawings, schematic automation plans, etc. The second exemplary application **1205** in FIG. 12 is a mechanical simulation application allowing for the planning of robot behavior (e.g., welding plans) and human simulation (e.g., a factory worker). The third exemplary application **1206** in FIG. 12 is a portal application which serves as a development environment for automation & Human Machine Interface (HMI) hardware planning and programming. The third application **1206** includes graphical and textual interfaces for editing automation station configurations, and facilitates the compilation, configuration, and execution of code to be written on PLC devices.

FIG. 12 illustrates how data in an engineering environment (e.g., a factory in the present example) may be connected in a common model, allowing for an object to appear in multiple applications, and be synchronized across multiple applications via, for example, a network **1208**. For example, a robot may be mechanically constructed and electrically planned in the first application **1204**, the behavior of the robot may be planned in the second application **1205**, and the robot may be embedded in a production line process using automation software running on a PLC planned in the third application **1206**.

According to an exemplary embodiment of the present invention, a notification mechanism may be utilized to assist a user in an engineering domain with engineering tasks that may be impacted by changes in other engineering domains. In a multi-disciplinary engineering system utilizing user-defined automatic change propagation, the notification mechanism may be used to inform a user about new or changed data, and to offer the user an option to adopt his/her document/model views to the changed data. In a multi-disciplinary engineering system utilizing fully automatic change propagation, the notification mechanism may be used to inform a user of new versions of documents and models representing the changed objects. In scenarios in which there are multiple discipline specific data models, the notification mechanism may be used to notify different domains users about changes in data that has multiple discipline representations. The notification mechanism may be utilized to indicate changes regarding the creation of data objects, the deletion of data objects, and the modification of data objects, as well as other events occurring within the multi-disciplinary engineering system affecting data.

As described herein, according to exemplary embodiments of the present invention, providing data connections between different disciplines allows a system to support various functions. For example, the sharing of data connections allows for communication between

different disciplines, rule-based change propagation, the formalization of workflows, multi-disciplinary report generation, and usage of interdisciplinary common data structures.

Exemplary embodiments allow engineers from various domains to use document based engineering methods or model based engineering methods while the underlying data remains synchronized across multiple domains. Exemplary embodiments support engineers in the communication and adaptation of changes within an engineering project, thus, reducing error rate. Exemplary embodiments further allow for traditionally separate engineering domains to be combined and managed together in a controlled manner.

It is to be understood that exemplary embodiments of the present invention can be implemented in various forms of hardware, software, firmware, special purpose processes, or a combination thereof. In one exemplary embodiment, the present invention can be implemented in software as an application program tangibly embodied on a computer readable program storage device (e.g., a non-transitory tangible media). The application program can be uploaded to, and executed by, a machine comprising any suitable architecture.

FIG. 13 is a block diagram of an exemplary computer system for implementing a method for multi-disciplinary engineering with a synchronized documents interface, according to an exemplary embodiment of the invention. Referring to FIG. 13, a computer system **1351** for implementing the present invention can comprise, inter alia, a central processing unit (CPU) **1352**, a memory **1353** and an input/output (I/O) interface **1354**. The computer system **1351** is generally coupled through the I/O interface **1354** to a display **1355** and various input devices **1356** such as a mouse and a keyboard. The support circuits can include circuits such as cache, power supplies, clock circuits, and a communication bus. The memory **1353** can include random access memory (RAM), read only memory (ROM), disk drive, tape drive, etc., or a combination thereof. The present invention can be implemented as a routine **1357** that is stored in memory **1353** and executed by the CPU **1352** to process the signal from the signal source **1358**. As such, the computer system **1351** is a general purpose computer system that becomes a specific purpose computer system when executing the routine **1357** of the present invention.

The computer system **1351** also includes an operating system and micro instruction code. The various processes and functions described herein can either be part of the micro instruction code or part of the application program (or a combination thereof) which is executed via the operating system. In addition, various other peripheral devices can be

connected to the computer platform such as an additional data storage device and a printing device.

It is to be further understood that, because some of the constituent system components and method steps depicted in the accompanying figures can be implemented in software, the actual connections between the systems components (or the process steps) may differ depending upon the manner in which the present invention is programmed. Given the teachings of the present invention provided herein, one of ordinary skill in the related art will be able to contemplate these and similar implementations or configurations of the present invention.

Having described exemplary embodiments for a system and method for multi-disciplinary engineering with a synchronized documents interface, it is noted that modifications and variations can be made by persons skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in exemplary embodiments of the invention, which are within the scope and spirit of the invention as defined by the appended claims. Having thus described the invention with the details and particularity required by the patent laws, what is claimed and desired protected by Letters Patent is set forth in the appended claims.

What is claimed is:

1. A method of synchronization in a multi-disciplinary engineering environment, comprising:

detecting a change made to a document in a document-based portion of a domain in a multi-disciplinary engineering system, wherein the multi-disciplinary engineering system comprises a plurality of domains including the domain;

updating data in a model-based portion of the domain in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document; and

updating at least one other document in the document-based portion of the domain in response to updating the data in the model-based portion of the domain, wherein the at least one other document is impacted by the change made to the document.

2. The method of claim 1, further comprising:

updating data in a model-based portion of at least one other domain from among the plurality of domains in response to updating the data in the model-based portion of the domain.

3. The method of claim 1, further comprising:

transmitting a notification to at least one other domain from among the plurality of domains indicating that the data in the model-based portion of the domain has been updated subsequent to updating the data in the model-based portion of the domain.

4. The method of claim 1, further comprising:

transmitting a notification to at least one user associated with the at least one other document upon updating the data in the model-based portion of the domain,

wherein the notification indicates that a change impacting the at least one other document has occurred in the model-based portion of the domain.

5. The method of claim 1, further comprising:

transmitting a query to a user upon detecting the change to the document in the document-based portion of the domain to determine whether the data in the model-based portion relates to the change made to the document,

wherein the data in the model-based portion of the domain is updated based on a user response to the query provided by the user.

6. The method of claim 1, wherein the model-based portion of the domain comprises a single common data model.

7. The method of claim 1, wherein the data in the model-based portion of the domain is updated at predefined time intervals.

8. The method of claim 1, wherein the data in the model-based portion of the domain is updated immediately upon detecting the change made to the document in the document-based portion of the domain.

9. A computer program product for a method of synchronization in a multi-disciplinary engineering environment, the computer program product comprising a computer readable storage medium having program instructions embodied therewith, the program instructions executable by a processor to cause the processor to:

detect, by the processor, a change made to a document in a document-based portion of a domain in a multi-disciplinary engineering system, wherein the multi-disciplinary engineering system comprises a plurality of domains including the domain;

update, by the processor, data in a model-based portion of the domain in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document; and

update, by the processor, at least one other document in the document-based portion of the domain in response to updating the data in the model-based portion of the domain, wherein the at least one other document is impacted by the change made to the document.

10. The computer program product of claim 9, wherein the program instructions executable by the processor further cause the processor to:

update, by the processor, data in a model-based portion of at least one other domain from among the plurality of domains in response to updating the data in the model-based portion of the domain.

11. The computer program product of claim 9, wherein the program instructions executable by the processor further cause the processor to:

transmit, by the processor, a notification to at least one other domain from among the plurality of domains indicating that the data in the model-based portion of the domain has been updated subsequent to updating the data in the model-based portion of the domain.

12. The computer program product of claim 9, wherein the program instructions executable by the processor further cause the processor to:

transmit, by the processor, a notification to at least one user associated with the at least one other document upon updating the data in the model-based portion of the domain, wherein the notification indicates that a change impacting the at least one other document has occurred in the model-based portion of the domain.

13. The computer program product of claim 9, wherein the program instructions executable by the processor further cause the processor to:

transmit, by the processor, a query to a user upon detecting the change to the document in the document-based portion of the domain to determine whether the data in the model-based portion relates to the change made to the document,

wherein the data in the model-based portion of the domain is updated based on a user response to the query provided by the user.

14. The computer program product of claim 9, wherein the model-based portion of the domain comprises a single common data model.

15. The computer program product of claim 9, wherein the data in the model-based portion of the domain is updated at predefined time intervals.

16. The computer program product of claim 9, wherein the data in the model-based portion of the domain is updated immediately upon detecting the change made to the document in the document-based portion of the domain.

17. An apparatus for performing a method of synchronization in a multi-disciplinary engineering environment, comprising:

a computer server including a plurality of storage databases corresponding to a plurality of domains, wherein:

each of the plurality of domains is accessible to a plurality of users via a corresponding application interfacing with the computer server via a network;

a synchronization application of the computer server is configured to detect a change made to a document in a document-based portion of one of the storage databases;

the synchronization application of the computer server is configured to update data in a model-based portion of the one of the storage databases in response to detecting the change made to the document in the document-based portion, wherein the data relates to the change made to the document; and

the synchronization application of the computer server is configured to update at least one other document in the document-based portion of the one of the storage databases in response to updating the data in the model-based portion of the one of the storage databases, wherein the at least one other document is impacted by the change made to the document.

18. The apparatus of claim 17, wherein the synchronization application of the computer server is further configured to:

update data in a model-based portion of at least one other storage database from among the plurality of storage databases in response to updating the data in the model-based portion of the one of the storage databases.

19. The apparatus of claim 17, wherein the synchronization application of the computer server is further configured to:

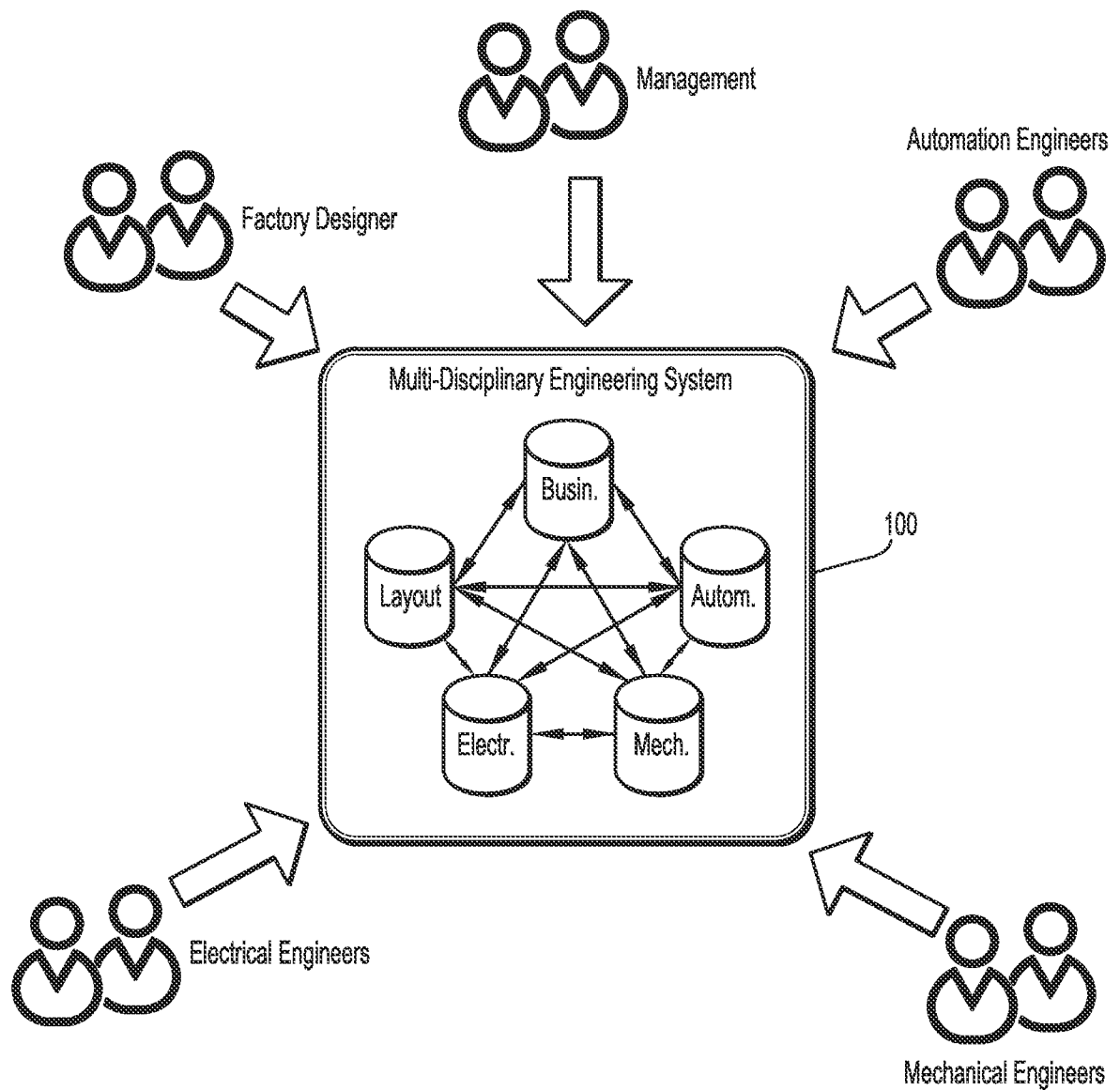
transmit a notification to at least one other storage database from among the plurality of storage databases indicating that the data in the model-based portion of the one of the storage databases has been updated subsequent to updating the data in the model-based portion of the one of the storage databases.

20. The apparatus of claim 17, wherein the synchronization application of the computer server is further configured to:

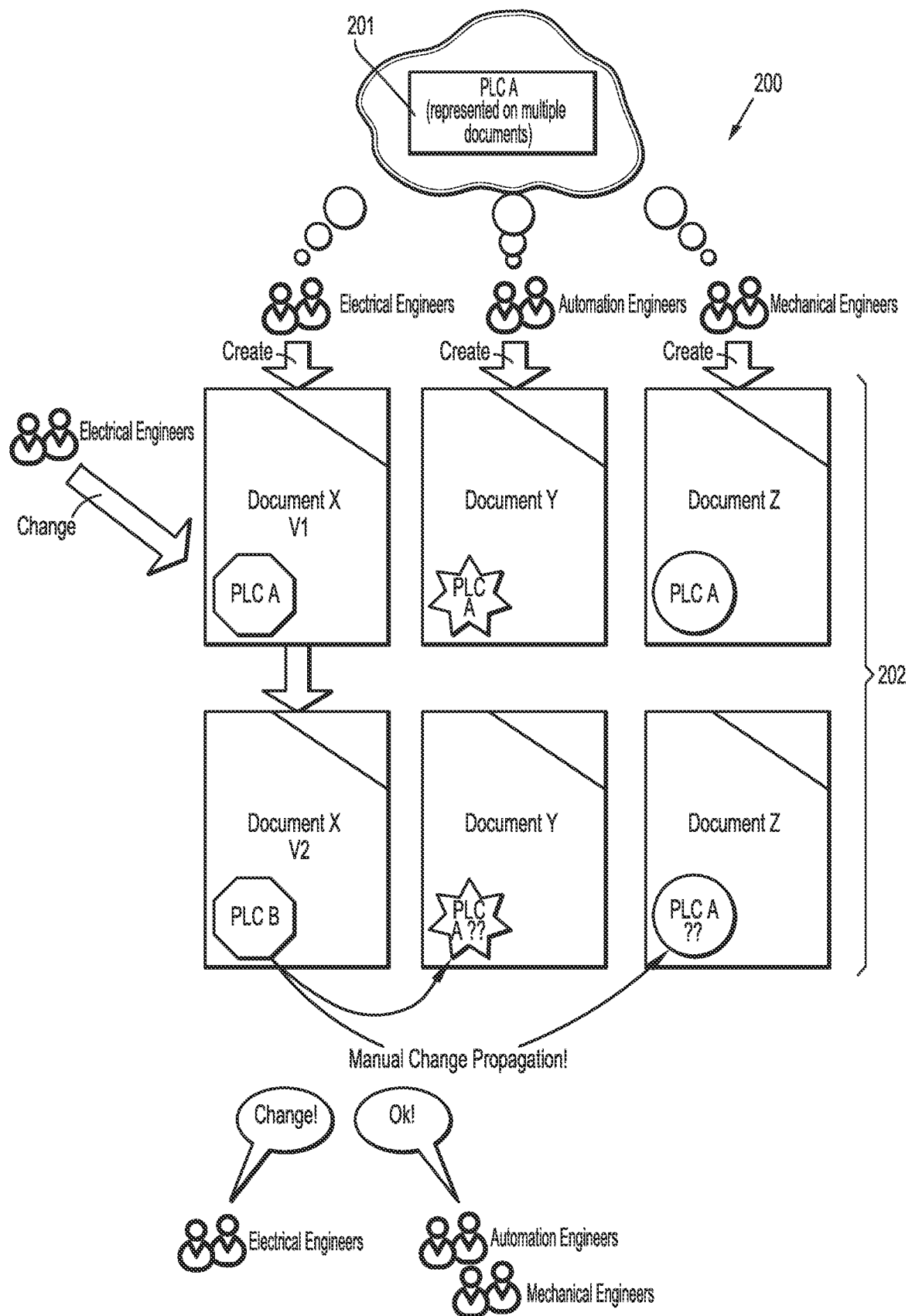
transmit a notification to at least one user associated with the at least one other document upon updating the data in the model-based portion of the one of the storage databases,

wherein the notification indicates that a change impacting the at least one other document has occurred in the model-based portion of the one of the storage databases.

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**FIG. 1**

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**FIG. 2**

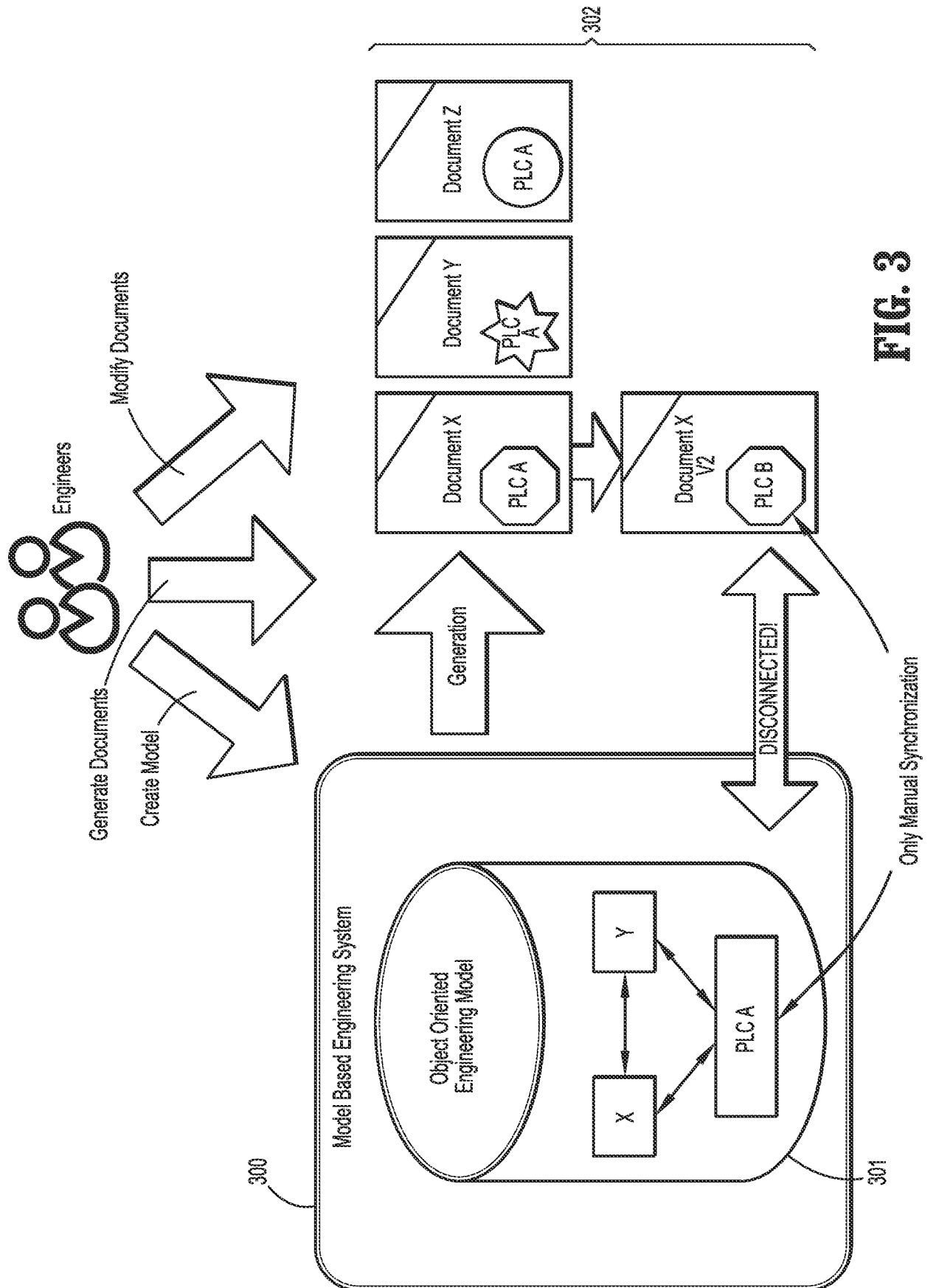
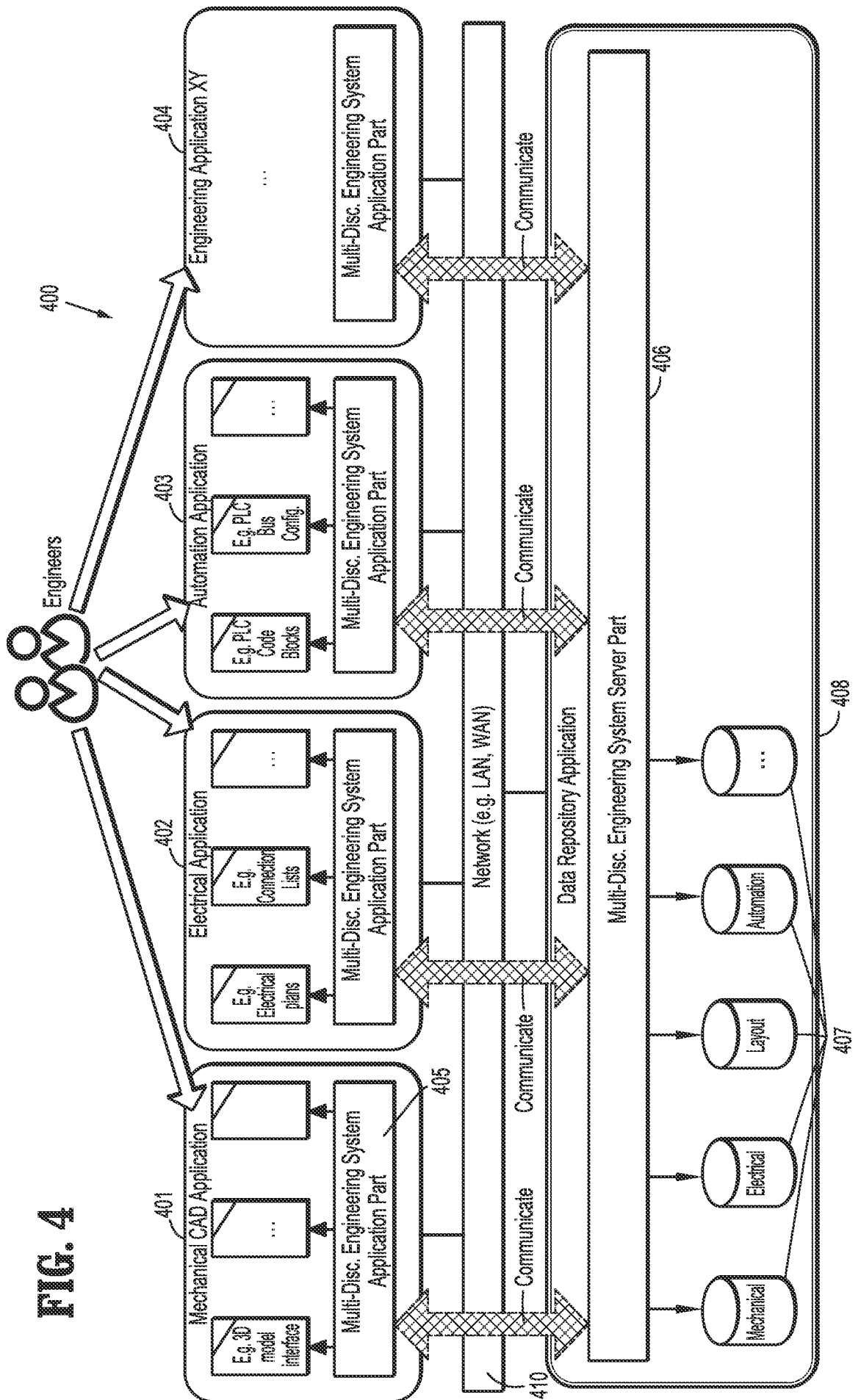
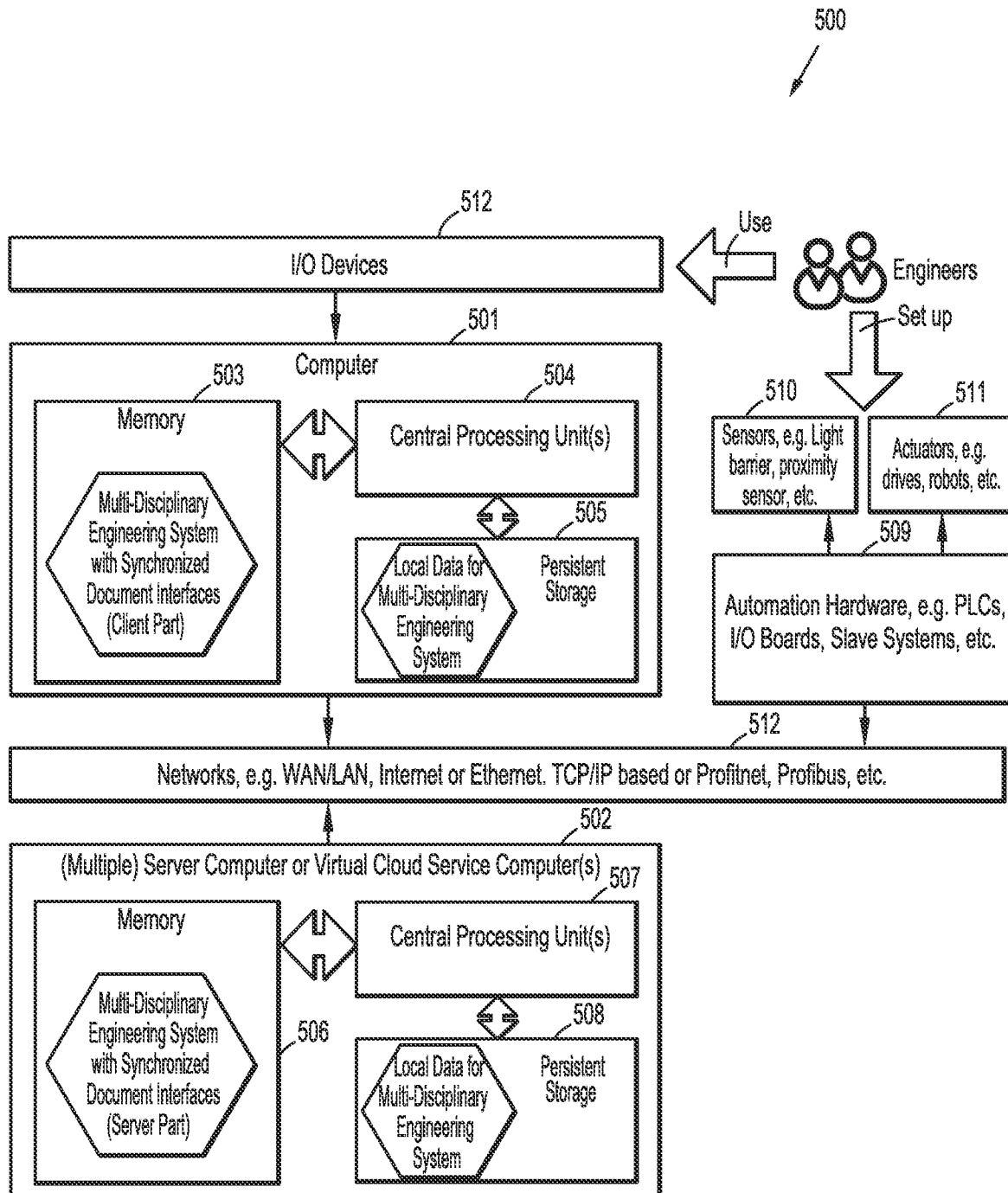


FIG. 3

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**FIG. 5**

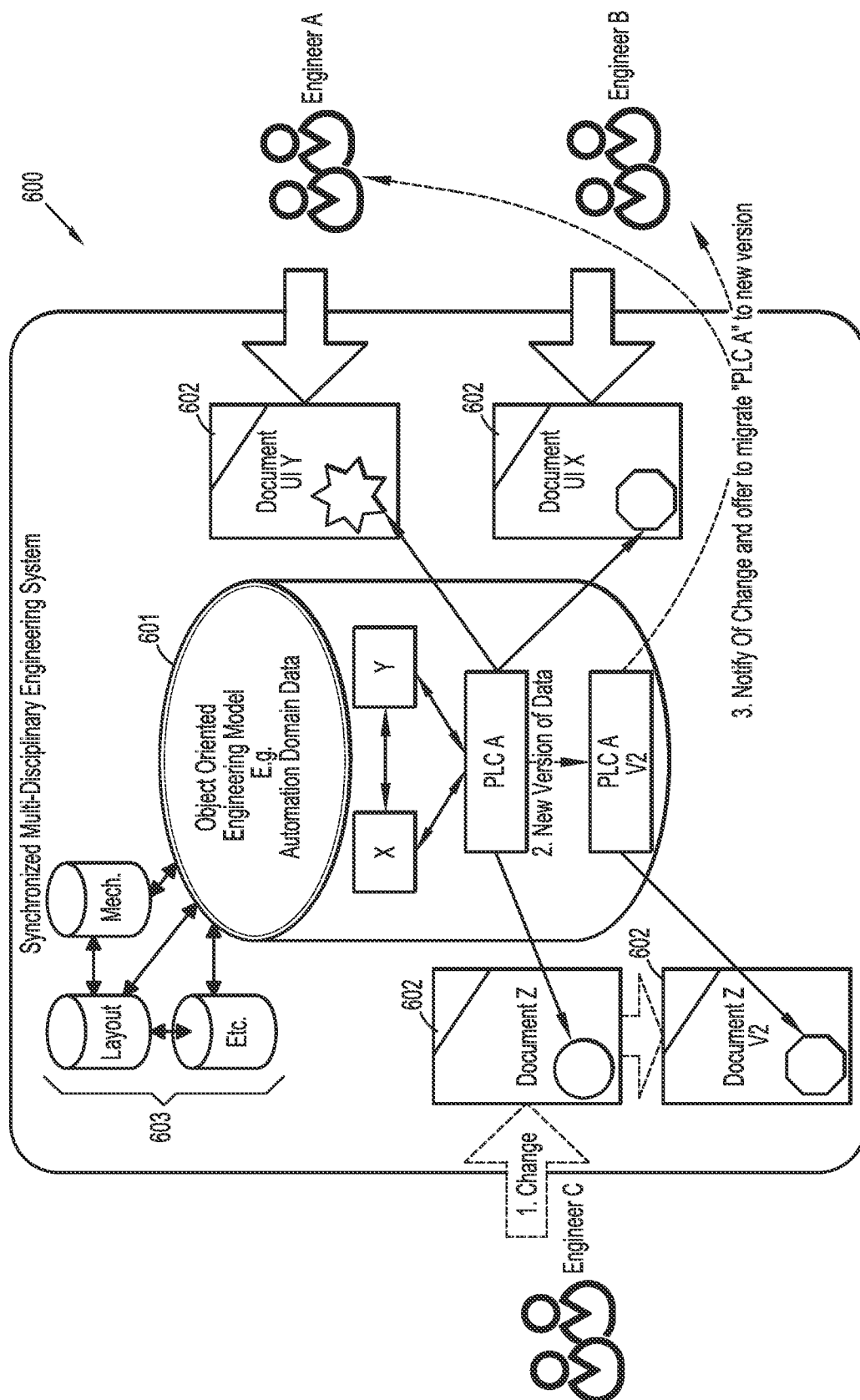


FIG. 6

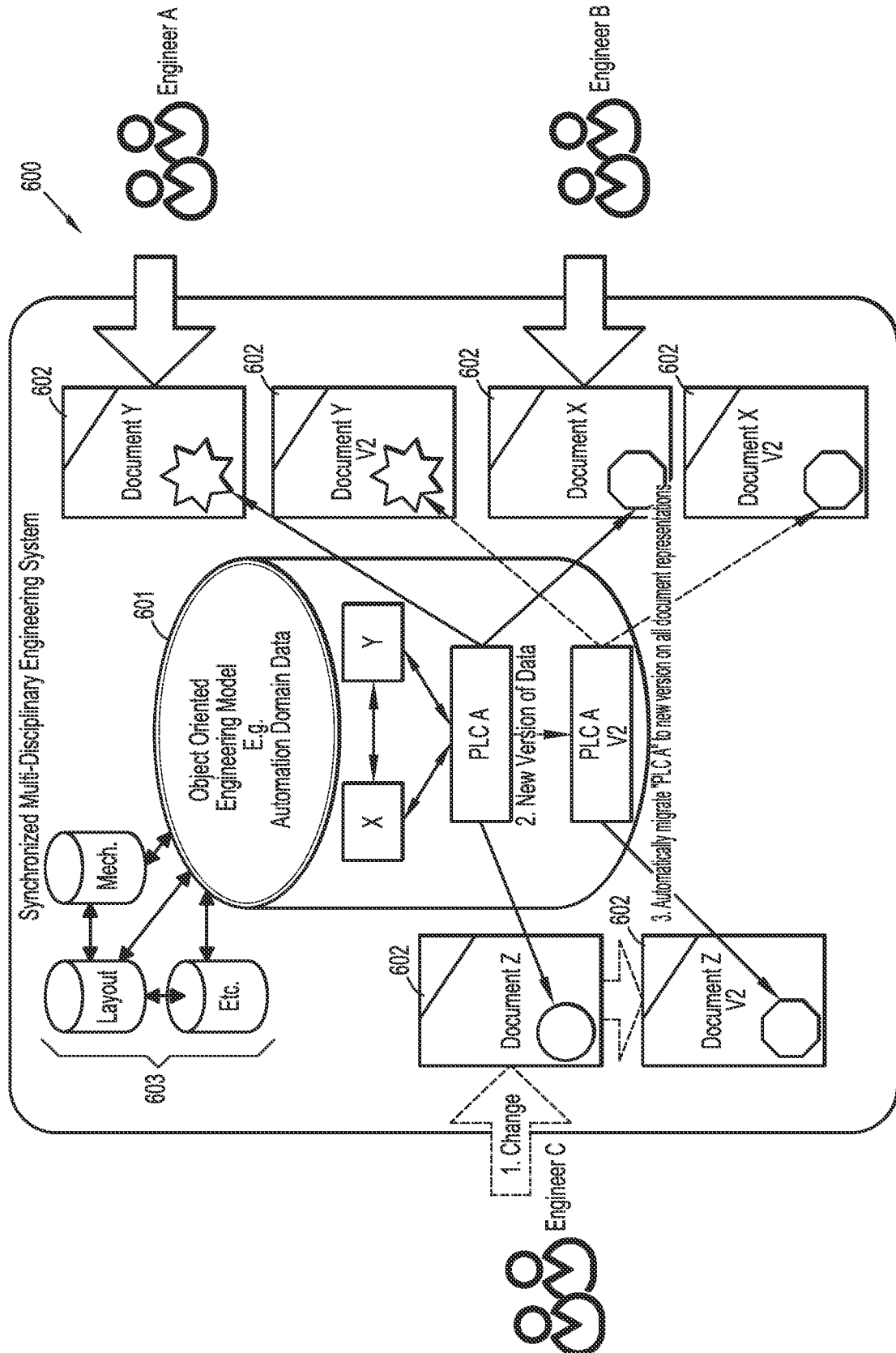
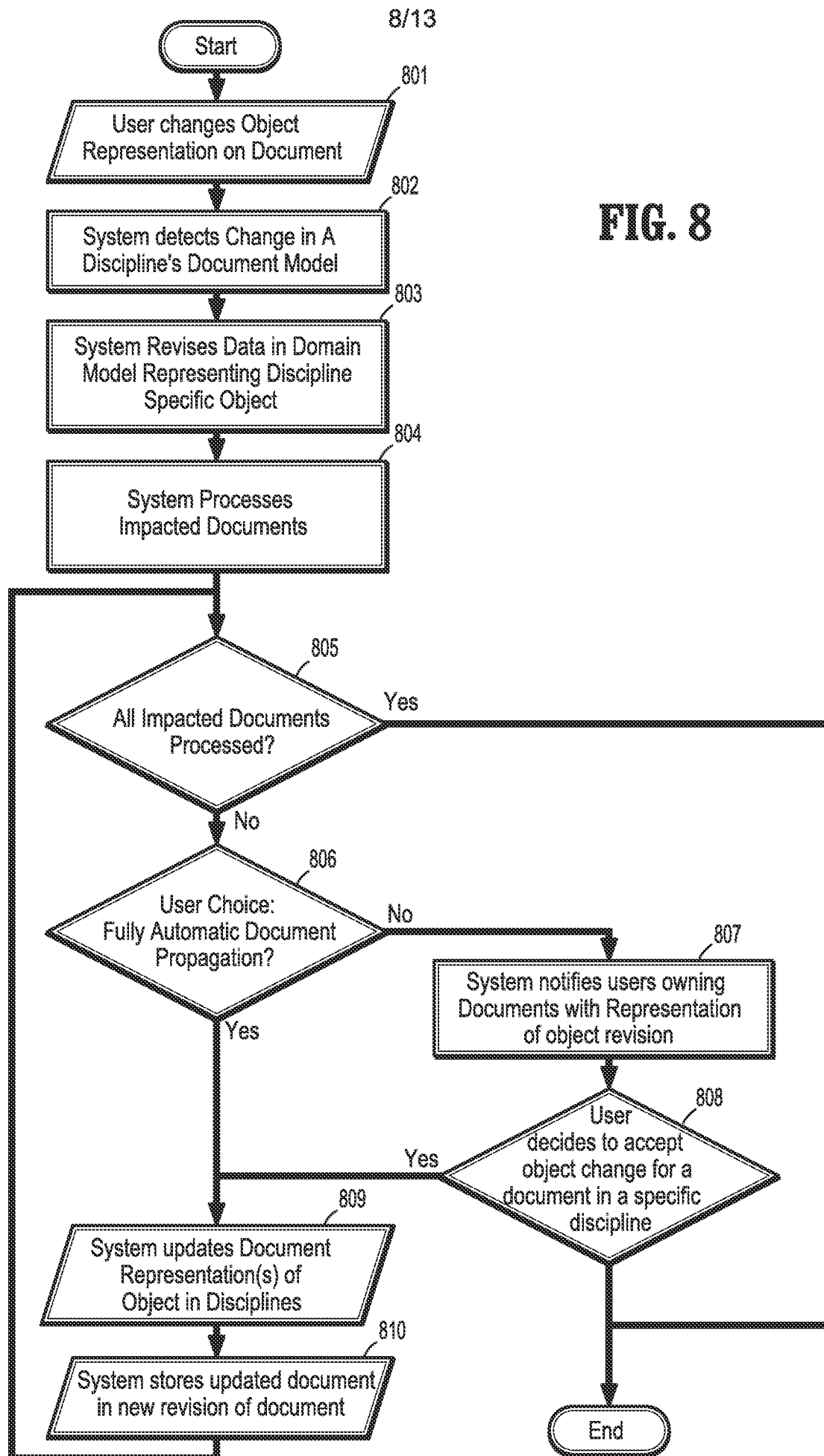


FIG. 7



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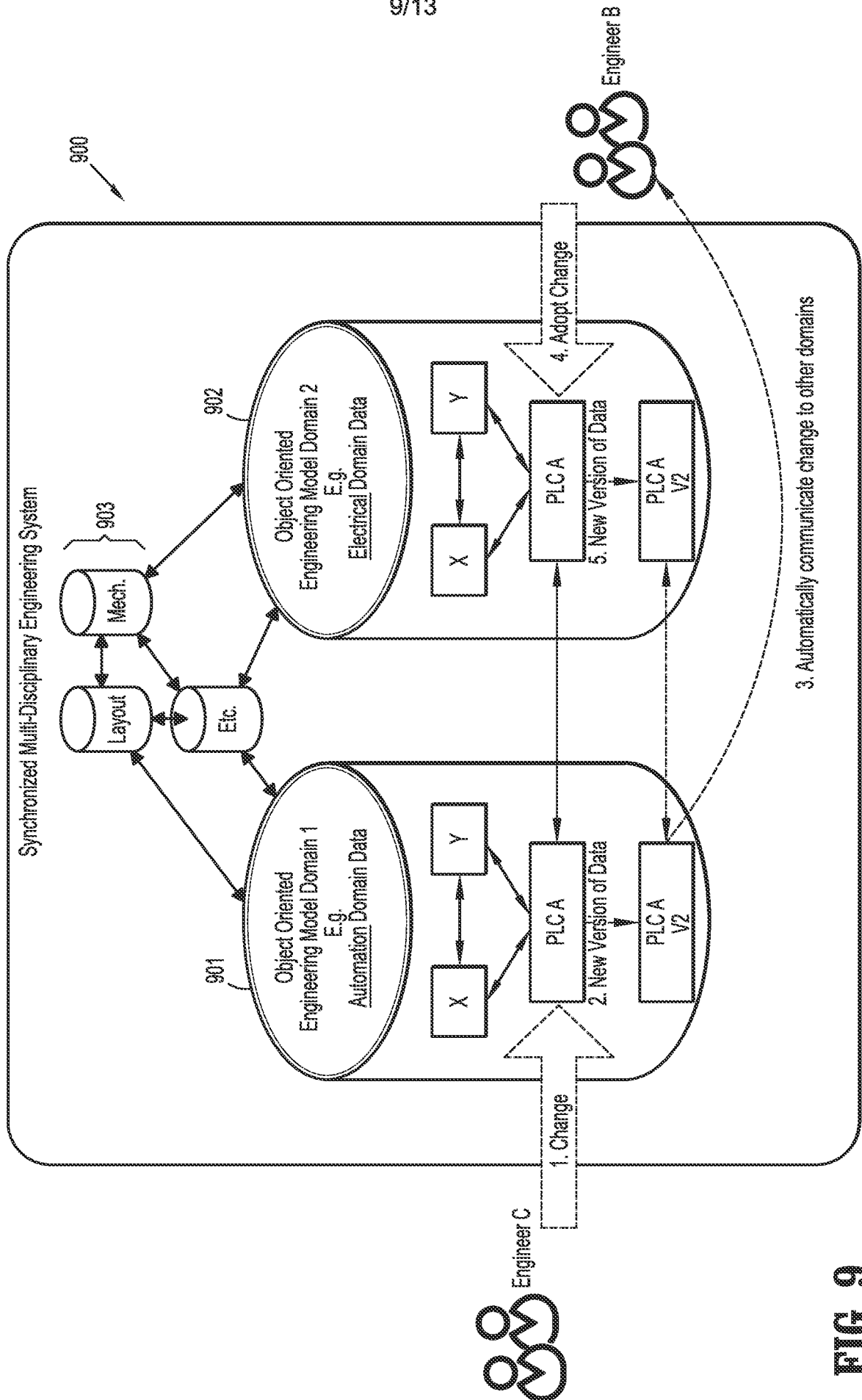


FIG. 9

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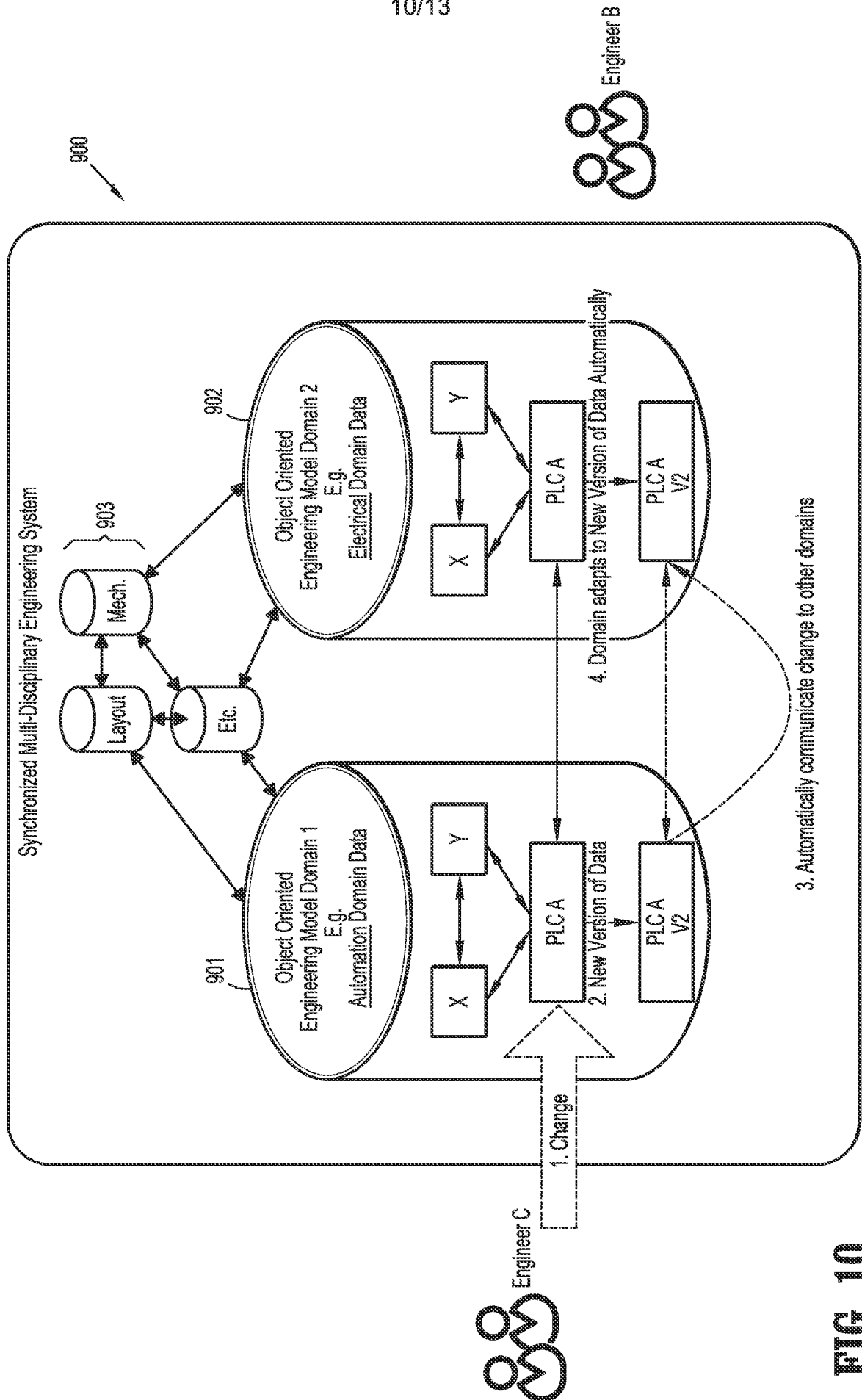
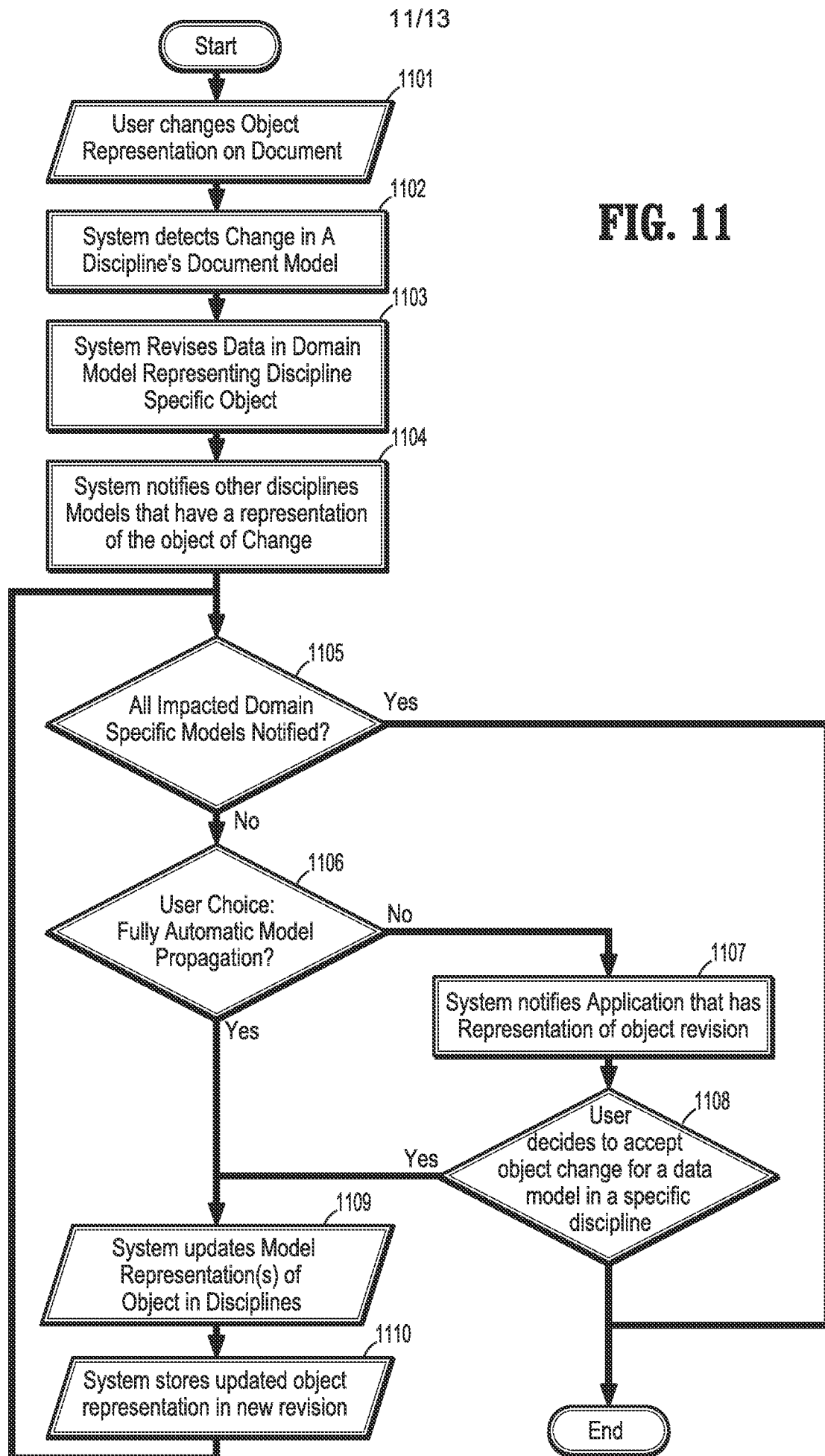


FIG. 10

FIG. 11

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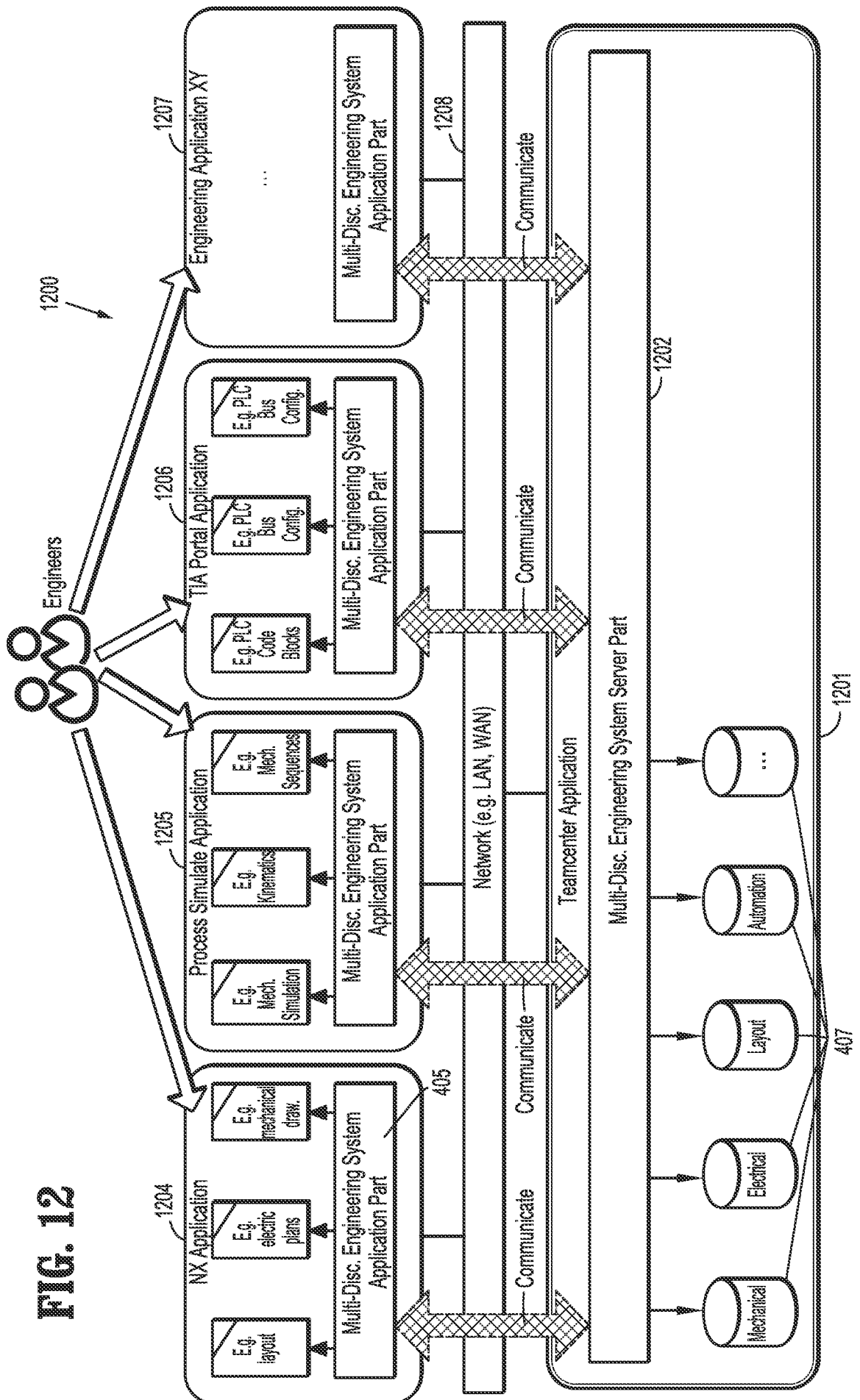
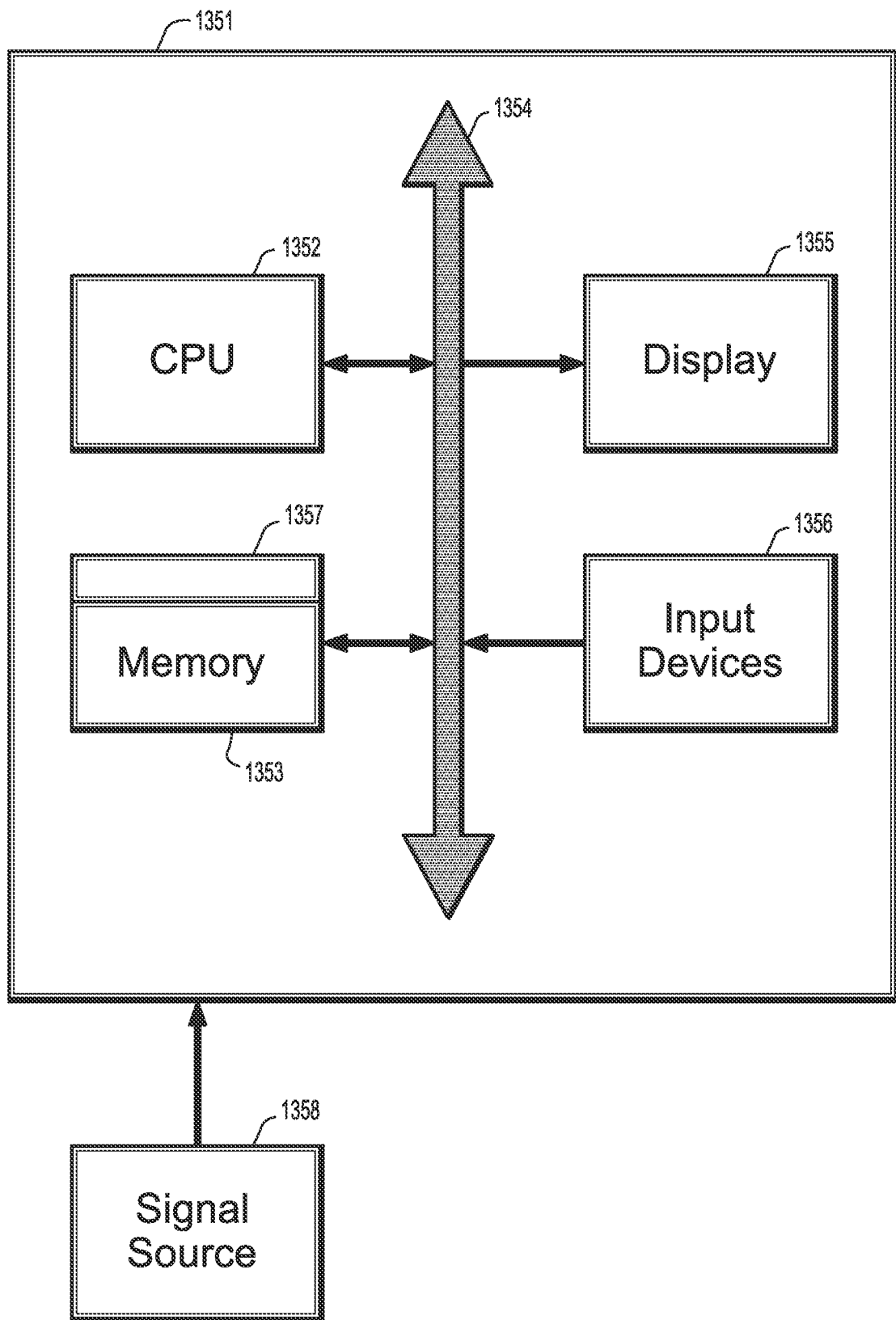


FIG. 12

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**FIG. 13**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/016808A. CLASSIFICATION OF SUBJECT MATTER
INV. G06Q10/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TRIP DENTON ET AL: "NAOMI â An Experimental Platform for Multiâ modeling", 28 September 2008 (2008-09-28), MODEL DRIVEN ENGINEERING LANGUAGES AND SYSTEMS; [LECTURE NOTES IN COMPUTER SCIENCE], SPRINGER BERLIN HEIDELBERG, BERLIN, HEIDELBERG, PAGE(S) 143 - 157, XP019107325, ISBN: 978-3-540-87874-2 abstract figure 1 page 4 - page 5 page 10 - page 11 ----- -/-	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

14 April 2014

Date of mailing of the international search report

24/04/2014

Name and mailing address of the ISA/

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Authorized officer

Moser, Raimund

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/016808

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ROMINA ERAMO ET AL: "A model-driven approach to automate the propagation of changes among Architecture Description Languages", SOFTWARE & SYSTEMS MODELING, SPRINGER, BERLIN, DE, vol. 11, no. 1, 31 July 2010 (2010-07-31), pages 29-53, XP035007591, ISSN: 1619-1374, DOI: 10.1007/S10270-010-0170-Z abstract page 32 - page 33 page 44 - page 45 -----	1-20
X	HOLGER GIESE ET AL: "Model Synchronization at Work: Keeping SysML and AUTOSAR Models Consistent", 1 November 2010 (2010-11-01), GRAPH TRANSFORMATIONS AND MODEL-DRIVEN ENGINEERING, SPRINGER BERLIN HEIDELBERG, BERLIN, HEIDELBERG, PAGE(S) 555 - 579, XP019158022, ISBN: 978-3-642-17321-9 abstract page 13 -----	1-20
X	WHITFIELD R I ET AL: "A collaborative platform for integrating and optimising Computational Fluid Dynamics analysis requests", COMPUTER AIDED DESIGN, vol. 44, no. 3, 2012, pages 224-240, XP028437800, ISSN: 0010-4485, DOI: 10.1016/J.CAD.2011.04.004 [retrieved on 2011-04-22] the whole document -----	1-20