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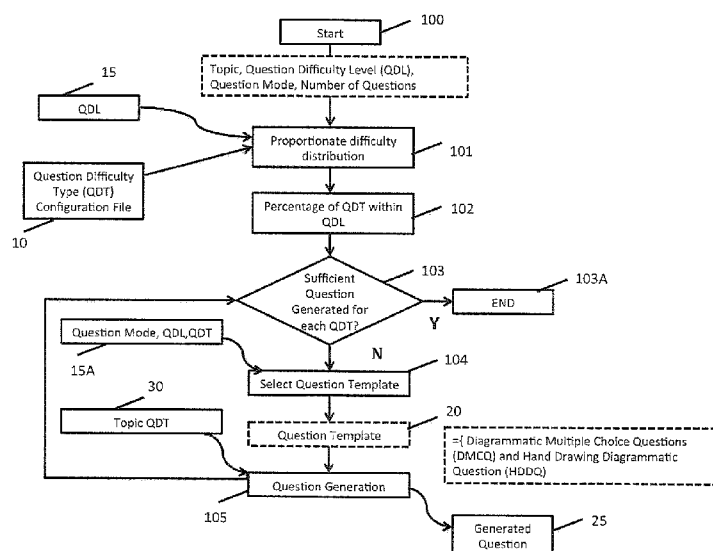


FIG. 1

(57) Abstract: Automated method for diagrammatic question generation and answer assessment. The method includes providing at least one topic and at least one question based on the topic (100), providing at least one range of a question difficulty level (QDL) (100) and a question mode, proportioning question difficulty type (QDT) based on the range of question difficulty level (101), selecting at least one question template based on the proportioned question difficulty type (QDT) and question difficulty level (QDL) (105), and generating a question based on the selected template (106). In one embodiment, the question mode includes questions in the form of diagrammatic multiple-choice type (DMCQ) and/or hand drawing diagrammatic type (HDDQ).

METHOD FOR AUTOMATIC DIAGRAMMATIC QUESTION GENERATION AND ANSWER ASSESSMENT

5

FIELD OF INVENTION

[0001] The present invention generally relates to generating question types, and more particularly to a method for automatically generating diagrammatical questions and answer assessment for various purposes.

10

BACKGROUND OF INVENTION

[0002] One of the countless ways for effective learning of the knowledge paradigms and schemes for various applications or purposes is to enquire and thus understand the relationship between the answers provided based on the enquiries made on a certain topic or subject matter. In this technique, at least a set of questions is provided to a participating individual to assess the individual's understanding of a certain topic based on the answers provided. Such method can be generally referred to as diagrammatic reasoning or diagrammatic learning.

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[0003] At present, apart from the arduous manually generated questions, the existing methods and techniques have partially evolved and are primarily focused on semi-automatic and automatic question assessments. Nevertheless, a great majority of the existing automatic methods suffer from several shortcomings including in many cases the diagrammatic questions and solutions still have to be created manually, thus can be ludicrously time consuming. In addition to this, the automatic answer assessment is performed based on one or more manually created solution diagrams. Other existing methods only offer limited question modalities thus may result to restricting the depth of assessment outcome and accuracy.

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[0004] US Patent Publication no. US20090280456 A1 discloses a system and method for generating family of question for a programming language. Specifically, the

system is adapted for generating conventional multiple choice question (MCQ). The system offers template questions having one or more variables, where the system generates a question by assigning fix values to the template questions, and automatically generates a correct answer corresponds the generated question and one or more incorrect answer. The system is limited to conventional MCQ only, it is not adapted to handle diagrammatic questions and answer rendering.

[0005] US Patent Publication no. US20130196305 A1 discloses a method and apparatus for generating question based on a generated graph. Based on the generated graph, the system and method synthesize a textual representation of the generated graph to render a question. The graph is used to render the textual question, the questions rendered by the system is not in diagrammatical form.

[0006] Hence it would be highly desirable to have a method and system that can automatically generate diagrammatic questions and with multiple modalities as well as difficulty levels of questions thereby providing a thorough assessment in learning or understanding a topic or subject matter.

SUMMARY

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[0007] In one aspect, there is disclosed an automated method for diagrammatic question and answer assessment. The method comprising of providing at least one topic and at least one question based on the topic, providing at least one range of a question difficulty level (QDL), providing at least one question mode, proportioning question difficulty type (QDT) based on the range of question difficulty level, selecting at least one question template based on the proportioned question difficulty type (QDT) and question difficulty level (QDL), generating a question based on the selected template, wherein the question mode includes questions in the form of diagrammatic multiple choice type (DMCQ) or hand drawing diagrammatic type (HDDQ).

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[0008] In one embodiment, proportioning question difficulty type (QDT) includes providing a predetermined percentage range of the QDT based on the question difficulty level (QDL).

5 [0009] In another embodiment, selecting at least one question template based on the proportioned question difficulty type (QDT) and question difficulty level (QDL) includes selecting the question template based on the question mode of DMCQ or HDDQ and selecting the question template based on mix mode being both DMCQ and HDDQ.

10 [0010] In a further embodiment, generating a question based on the selected template includes providing at least one topic, at least one question difficulty type (QDT) and at least one question template; retrieving at least one topic concept; retrieving a question generation strategy (QGS) based on at least one question mode; generating a question body; generating a question answer; generating a question distractor; and
15 aggregating the question body, answer and distractor.

[0011] In yet a further embodiment, generating a question further includes: generating drawing nodes and arcs; and aggregating the question body and drawing nodes
20 & arcs.

[0012] In a further embodiment, generating a question body further comprises providing at least one topic concept, a question template, and a question generation strategy (QGS); determining whether an instance is required to which if YES, randomly retrieving
25 an instance based on the topic concept and replacing the topic concept with the retrieved instance; if no instance is required; applying at least one type of question generation strategy (QGS) to generate the question body; wherein the question generation strategy (QGS) includes using label or definition or case strategy or a combination thereof; using a correct diagram strategy or filled-in-the-blank strategy or a combination thereof.

30

[0013] In yet another embodiment, using label or definition or case strategy includes: retrieving at least one label or definition or a case strategy or a combination thereof and aggregating the label or definition or use case with the question template.

[0014] In a further embodiment, using a correct diagram strategy includes: retrieving the conceptual structure (CS) based on the topic concept; and aggregating reference of the CS with the question template.

5

[0015] In yet another embodiment, using filled-in-the-blank strategy includes: retrieving the CS based on the topic concept; randomly selecting at least one node and one arc based on the CS; storing the selected node and arc in a vector list; and aggregating the reference of the CS and vector list with the question template.

10

[0016] In a further embodiment, generating a question answer includes: providing at least one topic concept, a vector list and at least one generation strategy (QGS); determining whether an instance is required; if YES to requiring an instance, randomly retrieving an instance of the topic concept and replacing the topic concept with the instance ; if NO to requiring an instance; determine whether to use definition or label strategy or correct diagram strategy or nodes or arc strategy in generating the question answer.

15

[0017] In another embodiment, using definition or label strategy in generating the question answer includes: retrieving at least one definition or a label based on the topic concept.

20

[0018] In yet a further embodiment, using correct diagram strategy in generating the question answer includes: retrieving the CS for the topic concept.

25 [0019] In another embodiment, using nodes or arcs strategy in generating the question answer includes: retrieving the CS for the topic concept and extracting the nodes or arcs from the CS.

30 [0020] In yet another embodiment, generating a question distractor includes: providing at least one topic concept, at least one QDT, at least one question generation strategy; determining whether an instance is required; if YES in requiring an instance, randomly retrieving an instance of the topic concept and replacing the topic concept with

the instance; if NO in requiring an instance, selecting a QGS; wherein selecting the QGS includes selecting anyone from the group comprising: a definition or label strategy; a nodes or arcs strategy; a diagram of topic concept distractor strategy; diagram with node and arc in wrong position strategy; and diagram with distractor node and arc strategy; or a
5 combination thereof.

[0021] In yet a further embodiment, using definition or label strategy includes: generating concept distractor based on topic concept or node or arc; retrieving the definition or label of the topic concept or node or arc; and saving the retrieved definition or label and
10 distractor into a distractor list.

[0022] In a further embodiment, using nodes or arc strategy includes: retrieving the CS of the topic concept; extracting at least one node and one arc from the retrieved CS; selecting at least one node and arc to generate a distractor; replacing the selected node and
15 arc with generated distractor; and grouping and saving the selected node and arc and distractor in the distractor list.

[0023] In yet a further embodiment, generating distractor with diagram of topic concept includes: generating a distractor concept; retrieving a CS based on the distractor concept; and saving the reference of the CS into the distractor list.
20

[0024] In another embodiment, generating distractor with diagram including node and arc in wrong position strategy includes: retrieving the CS for the topic concept; randomly switching position of the node and arc in the CS; and storing the distractor.
25

[0025] In yet a further embodiment, generating distractor with node and arc strategy includes: retrieving the CS for the topic concept; selecting nodes and arcs from the CS; generating distractor concept of the selected node and arc and replacing the selected node and arc with the respective distractor; and storing the distractor CS.
30

[0026] In another embodiment, generating the drawing nodes and arcs includes: providing at least one topic concept, and a question generation strategy (QGS); retrieving

the node and arc for the topic concept; randomly selecting the node and arc from the retrieved node and arc; generating the distractor for the selected node and arc; and aggregating the node and arc of the topic concept and their distractors.

5 **[0027]** In a further embodiment, generating a question distractor further includes
generating concept distractor which comprises: providing at least one concept, a question
difficulty type (QDT) and a question generation strategy; retrieving at least one type
hierarchy distance range (THDR); retrieving at least one result item within the THDR based
on the concept; filtering the result item which are instances or sub-classes of the concept in
10 the event that the concept type is a class; determining the type hierarchy distance between
the result items and the topic concept; ranking the result items; selecting a result item with
highest rank; and using the result item to generate a distractor concept.

[0028] In yet another embodiment, assessing of answers which comprises:
15 providing at least one question list; selecting at least one question; obtaining a correct
answer and user answer based on the question; and determining and evaluating the correct
answer and user answer.

[0029] In yet a further embodiment, assessing of answers further includes: selecting
20 user answer conceptual structure (CS) reference and retrieving the answer CS; selecting
topic concept and retrieving the CS for the topic concept; determining the similarity score
between the conceptual structures (CS); and accruing all scores and obtaining a total score.

25 **BRIEF DESCRIPTION OF DRAWINGS**

[0030] The invention will be more understood by reference to the description below taken in conjunction with the accompanying drawings herein:

30 **[0031]** **FIG. 1** shows the overall process flow of the method for automated
diagrammatic question generation and answer assessment in accordance with an
embodiment of the present invention;

[0032] FIG. 2 shows the process flow for the question template selection in accordance with an embodiment of the present invention;

5 [0033] FIG. 3A shows the process flow for question generation for a type of question mode in accordance with an embodiment of the present invention;

[0034] FIG. 3B shows the detailed process flow for question generation for another type of question mode in accordance with an embodiment of the present invention;

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[0035] FIG. 4 shows the process flow for question body generation in accordance with an embodiment of the present invention;

[0036] FIG. 5 shows a process flow for answer generation with respect to a type of
15 question mode in accordance with an embodiment of the present invention;

[0037] FIG. 6 shows a process flow for distractor generation in accordance with an embodiment of the present invention;

20 [0038] FIG. 7 shows a process flow for another distractor generation in accordance with an embodiment of the present invention;

[0039] FIG. 8 shows an example of a question mode in accordance with an embodiment of the present invention;

25

[0040] FIG. 9 shows the drawing nodes and arcs generation process flow in accordance with an embodiment of the present invention;

[0041] FIG. 10 is an example of another question mode in accordance with an
30 embodiment of the present invention;

[0042] FIG. 11 shows the process flow for generating a distractor concept in accordance with an embodiment of the present invention;

[0043] FIG. 12 shows a type hierarchy tree as part of generating a distractor
5 concept in accordance with an embodiment of the present invention; and

[0044] FIG. 13 shows the process flow for assessing answers in accordance with an embodiment of the present invention.

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DETAILED DESCRIPTION

[0045] In line with the above summary, the following description of a number of specific and alternative embodiments is provided to understand the inventive features of the
15 present invention. It shall be apparent to one skilled in the art, however that this invention may be practiced without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals will be used throughout the figures when referring to the same or similar features common to the figures.

20

[0046] The present invention provides a method for automated diagrammatic question and answer assessment based on a knowledge base. Generally, the method in accordance with an embodiment of the present invention is adapted to provide effective proportionating question difficulty type distribution, the ability to select question template
25 based on the selected question mode, various question difficulty levels and types and then the ability to generate at least one question based on the selected template.

[0047] In accordance with an embodiment of the present invention, there are generally at least two basic components in generating the questions as part of the assessment
30 which are Question Difficulty Level (referred herein as QDL) and Question Difficulty Type (referred herein as QDT). Each of which will be described for the purpose of elucidating the objectives of the present invention.

Question Difficulty Level (QDL)

[0048] The commonly known Revised Bloom's Taxonomy is used for determining
5 QDL. The taxonomy is restructured into four (4) difficulty levels: Remembering – Level 1; Understanding – Level 2; Applying – Level 3; and Analysing, Evaluating and Creating – Level 4.

[0049] For Level 1, being the Remembering level, the Question template is generally
10 focused in testing the individual's memory capacity in a topic, whereby the questions can be in the form of Fill-in-blank, or the question can ask about all the involved parties in a process or the likes. The answers, distractors and drawing nodes and arcs in this level are restricted to concepts associated to a specific class type.

15 [0050] For Level 2, being the Understanding level, the Question template is generally focused in testing the individual's understanding capacity in a topic, whereby for example, the questions can provide a definition of an application process and asks the individual to select or draw the correct diagram. Similar to that of Level 1, the answers, distractors and drawing nodes and arcs in this level are restricted to concepts associated to a specific class type.

20

[0051] For Level 3, being the Applying level, the Question template is generally
focused for testing the individual's application of knowledge, whereby in one example the questions given may provide a definition of an application process and requires the individual to select or draw the correct diagram. The answers, distractors and drawing nodes
25 and arcs in this level can be instance type or class type.

[0052] For Level 4, being the Analysing, Evaluating and Creating level, the
Question template is generally focused on testing the individual's capabilities in analysing, evaluating and creating. The set of questions may give a use case of an application process
30 and the individual may need to select or draw the correct diagram. Answers, Distractors, Drawing Nodes and Arcs may include concepts with either instance or class type.

Question Difficulty Type (QDT)

[0053] In accordance with an embodiment of the present invention, Question difficulty type (QDT) is used to control the difficulty of distractor in questions. A distractor as generally known in the art and as used in the context of describing the embodiments of the present invention defines the incorrect alternatives for that of an accurate answer. For the method of the present invention, the distractor generation is based on the type hierarchy distance in knowledge base. In one embodiment, a distractor concept can be more difficult when it is semantically nearer or closer to the answer concept. Nevertheless, in another embodiment, a distractor concept can be easier when it is semantically further to the answer concept. One option, but not limiting to, which may be used to determine the distance between the distractor and answer is the type hierarchy similarity measure. Based on the distractor difficulty control methodology, generating questions with various difficulties within a specified question difficulty level can be performed. Question difficulty type (QDT) is used to classify question mode when question mode is "Mix" mode. The "Mix" mode will be further elaborated herein.

[0054] FIG. 1 provides an overall architecture on the operational process flow of the method in accordance with an embodiment of the present invention. The method starts at **100** with providing at least one topic, at least one question and at least one question difficulty type (QDT) configuration file **10** and question difficulty level (QDL) file **15**. In the next step **101**, the QDT configuration file **10** and question difficulty level (QDL) file **15** are used to proportionate the difficulty of at least one question distribution. Then, a percentage of QDT within the QDL is provided at **102**. In one embodiment, during this step in determining the question distribution, it can be within the range of easy, intermediate and difficult. For instance, a distribution of 30% can be "easy" types; 40% can be "intermediate" types and 50% can be "difficult" question types.

[0055] Further, for the Question Difficulty Level (QDL) in accordance with an embodiment of the present invention, the QDL will be initially specified where the value may be of QDL can be of Level 1, 2, 3 and 4 respectively where these values may be referred to the Revised Bloom's Taxonomy. At **103**, the method determines whether sufficient amount of questions has been generated for the QDT. In the event that a YES is obtained for step **103**, the

overall process thereby ends at **103A**. If **NO** is obtained for step **103**, the process continues to select a question template at **104** based on the Question Mode, QDL, and QDT **15A**. The selected question template **20** is then used for generating questions at **105**. In one embodiment, the generated question **25** can be either in the form of a Diagrammatic Multiple Choice Question (DMCQ) or Hand Drawing Diagrammatic Question (HDDQ) being the final the output. Topic and QDT containing input **30** can be further used to generate question.

[0056] The Question Template Selection of step **104** from **FIG. 1** process flow will now be described with reference to **FIG. 2**. Upon initiated at **200**, the question mode which can be of DMCQ or HDDQ, can be selected from a repository based on the Question Mode and QDL **24**. In the event that the Question Mode is a “mixed” mode, thus **YES** at **201** the process proceeds to classify the Question Mode at **202**. In addition, at **203** the Question Mode configuration file **35** will be used for classifying at **202**. Accordingly, the configuration file **35** will utilize a list of classification to specify a Question Mode based on the QDT **10**, whereby the output includes the value of DMCQ or HDDQ to be used in selecting the question template. In an example, the configuration file may have a classification provided below:

[0057] If *QDT* = “easy”, then *Question Mode* = “DMCQ”

[0058] Else *QDL* = “difficult”, then *Question Mode* = HDDQ”

[0059] In the event that at **201** a **NO** is obtained, the process proceeds to **203**, for selecting question template. During the step of **203** in selecting the question template, input to aid the selecting process can be retrieved from the Question Template Repository **250**, whereby further input may include question mode and QDL **24**. At **204**, the question template is obtained and the process ends at **205**.

[0060] The Question Generation of Diagrammatic Multiple Choice Question (DMCQ) being step **105** from **FIG. 1**. The process flow for question generation will now be described with reference to **FIG. 3A**, particularly when the Question Mode is Diagrammatic Multiple Choice Question (DMCQ). The process starts at **300**, whereby input, which

includes Topic **40**, Question Difficulty Type (QDT) and Question Template are subjected to a retrieving of Topic Concept step **301**. During this retrieving of Topic Concept step, source of input may include from Curriculum Knowledge Base **44**. As mentioned, in the event that the Question Mode chosen is Diagrammatic Multiple Choice Question (DMCQ) at **302**, the process proceeds to retrieve Question Generation Strategy (QGS) with input retrieved from Question Template Repository **250** and question template **20** to determine the Question Body, Answers and Distractors at **303**. Once when the question body and vector list **47**, question answer **48** and question distractors **49** are generated at **304**, **305** and **306** respectively, all of these are aggregated at **307** and the final output will be an aggregated question in the form of DMCQ at **308**. In one embodiment, the process utilizes topic concept, vector list, QDT and selected strategy input **43** to generate the question body, answer and distractors. The process ends at **309**. If the Question Mode is not DMCQ thus a NO at **302**, the process proceeds to the generation of HDDQ **302A**, which will be described herein.

[0061] Another process of the Question Generation of Hand Drawing Diagrammatic Question (HDDQ) being another question mode as part of step **105** from **FIG. 1** process flow will now be described with reference to **FIG. 3B**. The process starts at **310** (from **302A** in previous **FIG. 3A**), and proceeds to retrieving Question Generation Strategy (QGS) for Question Body and Drawing Nodes& Arcs at **311**. Upon selected the QGS, it is used for generating the Question Body **51** at **312**, and generating drawing nodes and Arcs **52** at **313**. During these steps **312** and **313**, input which includes Question Template **20**, Topic Concept, and QGS **25A**, **25B** may be utilized. At **314**, the Question Body and Drawing Nodes & Arcs **51**, **52** are aggregated prior to generating the HDDQ generation strategy at **315**. The process ends at **316**.

25

[0062] The Question Body generation being step **312** of **FIG. 3B** process flow in accordance with an embodiment of the present invention will now be described with reference to **FIG. 4**. The process is initiated at **401**, whereby the initial input parameter includes, but not limiting to, Topic Concept, question template and QGS for the question body. At **402**, a decision is made to determine whether an instance is required, whereby a YES response is received, the process proceeds to retrieving an Instance of the Topic Concept and replace Topic Concept with the Instance

at 402A. The Instance may be retrieved from a Domain Knowledge base 60. Examples of controlling and providing the question difficulties in accordance with an embodiment of the present invention are as shown in **EXAMPLE 1** and **EXAMPLE 2**.

5

EXAMPLE 1

[0063] Question Difficulty Level – 2

10 [0064] The selected topic concept is **Salam**;
 The selected HDDQ template is "Draw a correct diagram that represents <Topic Concept>;
 The selected QGS generates question body with the label of topic concept;
 The final output of the question body generation process will be "Draw a correct
 15 diagram that represents Salam."

EXAMPLE 2

[0065] Question Difficulty Level – 3

20

[0066] The selected topic concept is Salam;
 The selected HDDQ template is "Draw a correct diagram that represents
 <Topic Concept>;
 The Selected QGS generates question body with the **use case** of topic concept
 25 **instance**;

[0067] From the examples, the Question body process retrieves an instance of Salam that is salam_1 and subsequently retrieves the use case of the instance salam_1 and aggregate with the question template. An example of the final output of the question body generation
 30 process may be:

"Draw correct diagram that represents Framer Muhammad wants to purchase fertilizer from Hap Seng Consolidate Berhard for this farm with Maybank Islamic."

- 5 [0068] Based on the examples above, in one embodiment of the present invention, the same question template attached with various QGS can be used to generate question body for various difficulty levels.

- [0069] It should be noted that in accordance with an embodiment of the present invention,
10 there are three primary ways or types of the QGS being elucidated in **FIG. 4**. These are generating questions based on label, definition or use case; secondly generating question body with the correct diagram; and thirdly generating question body with a fill-in-the-blank diagram. Each of these types will be described herein below.

- 15 [0070] Still referring to **FIG. 4**, in the event that a **NO** in requiring the instance is received as a response at step **402**, the process proceeds to the next step of determining whether to retrieve and thus use any one or combination of properties such as, but not limiting to; label, definition or use case strategy based on the selected Topic Concept at **403**. If any one of the properties is used and thus a **YES** response is obtained at **403**, the selected property is retrieved at **403A** from the knowledge
20 base. Upon retrieved the selected property which can be of a label, definition or use case is aggregated with the Question Template at **403B**, to finally form a question body at **406**. The process ends at **407**.

- 25 [0071] In one embodiment, in the event that a **NO** is obtained at **403**, the process proceeds to determine whether to use the correct diagram strategy at **404**. If a **YES** is obtained at **404**, the process proceeds to retrieve the conceptual structures (CS) for Topic Concept at **404A**. And then the CS are aggregated based on reference of the CS with Question Template at **404B**. From here at least one question body is generated at **406** and the process ends at **407**.

30

- [0072] If a **NO** is obtained as a response at **404**, the process proceeds to determine whether a fill-in-the-blank diagram strategy can be used at **405**. If the fill-in-the-blank strategy is selected thus a **YES** is obtained at **405**, the CS for the Topic Concept are therefore accordingly

retrieved at **405A**. And then at **405B**, the system randomly selects at least one node; or arc from the CS. The selected node(s) or arc(s) are stored in a vector list at **405C**. From here at **405D**, the reference of the CS and vector list is accordingly aggregated with Question Template, and thus generating question body and vector list at **405E**. The process then ends at **407**. It should be
5 mentioned that in this fill-in-the-blank type the node(s) and arc(s) will be used to generate the answer and distractors.

[0073] **FIG.5** shows the process flow for Diagrammatic Multiple Choice Questions (DMCQ) answer generation being step **305** of **FIG. 3A** in accordance with an embodiment of the
10 present invention. In this process, the initial input parameter of the process includes, but not limiting to Topic Concept, Vector List and QGS. The process flow starts at **500**, whereby based on input, the process decides whether an instance is required at **501**. If a **YES** is obtained as a response at **501**, the process randomly retrieves at **502** at least one instance of the Topic Concept and replace the Topic Concept with the selected instance. The process may retrieve the instance from a Domain
15 Knowledge Base **60**.

[0074] In the event that a **NO** is obtained as a response at **501**, the process flow provides three types QGSs for DMCQ answer generation; firstly; based on definition/label strategy **503**; secondly based on correct diagram strategy **504** and finally the third being the nodes/arcs strategy
20 **505**. Each of these types will be described within the process flow herein below.

[0075] Still referring to **FIG.5**, in the event that the process decides with using definition or label for generating question answer at **503**, the process retrieves at **503A** label or definition of the Topic Concept from Domain Knowledge base **60** as the correct answer. In another embodiment,
25 label or definition of the node and arc may be retrieved as the correct answer as well. Upon completion of retrieving the said properties, the process proceeds to generate the question answer at **506** and the process ends at **507**.

[0076] In another embodiment, in the event that the process decides with using a correct
30 diagram strategy in generating question answer at **504**, the process therefore proceeds with retrieving

CS for Topic Concept from the Domain Knowledge Base **60** at **504A** and the reference of the CS will be used as part of generating the question answer at **506** and the process ends at **507**.

[0077] Further with reference to the process flow of **FIG.5**, in the event that the process decides with using node(s) or arc(s) strategy at **505**, the process proceeds to retrieve the CS for the Topic Concept at **505A** and then extracts at least one node and at least one arc from the CS at **505B**. Based on the retrieved properties, the question answer is generated at **506** and the process ends at
5 **507**.

[0078] In accordance with an embodiment of the present invention, there are two approaches in generating DMCQ distractors being step **306** of **FIG. 3A**. These are shown in the process flows depicted in **FIG.6** and **FIG.7**, respectively. With reference to **FIG.6**, the process flow
10 starts at **600**, whereby the input collected to be used for this process flow includes Topic Concept, QDT, Question Generation Strategies (QGS) in generating distractors. Next in **601**, the process determines whether an instance is required, to which if a **YES** is obtained as a response, the process proceeds to **601A**, for retrieval of at least one instance of the Topic Concept and then replacing the Topic Concept with the instance. In the event that there are not enough distractors at **602**, the process
15 proceeds with **602A**, whereby a question distractor list is generated and the process ends at **602B**.

[0079] There are five (5) types or approaches of QGS for the DMCQ distractors generation in accordance with an embodiment of the present invention. Each of them will be described herein with reference to **FIG. 6** and **FIG.7** as part of the process flows therein. Proceeding
20 from the above, at **602**, if there are enough distractors, the process proceeds with selecting a QGS at **603**. And then based on the selected QGS, the distractor is generated using several approaches. The process then determines at **604** whether a definition or label strategy may be initiated. If **YES**, the process proceeds to generate concept distractor at **604A** and then retrieving the definition and label of the Topic Concept at **604B**. All retrieved properties are saved into a list at **604C**. The concept
25 distractor may be retrieved or extracted from a Curriculum Knowledge Base **44**.

[0080] In the event that the process decides to proceed with node/arcs strategy at **605**, the retrieval of CS of the Topic Concept is therefore initiated at **605A**. And then the nodes/arcs are extracted from the retrieved CS at **605B**. At **605C**, at least one node and one arc are selected for
30 generating the distractors, to which at **605D**, the selected nodes and arcs are replaced with generated distractors. The distractors are then grouped and saved in a distractor list at **605E**.

[0081] The approach in generating distractors then continues to process flow **A** at **606**, which will be described with reference to **FIG.7**. The process continues with determining whether a

distractor concept diagram strategy can be initiated at **701**, whereby if a **YES** is obtained as a response, the process proceeds to generate distractor concept at **701A** and then retrieving the CS based on the distractor concept at **701B**. All reference to CS then saved to distractor list at **701C**.

5 [0082] If a diagram with node and arc in wrong position strategy is initiated at **702**, the process proceeds with retrieving the CS for the Topic Concept at **702A** and then randomly switching positions of the nodes and arcs in the CS at **702B**. The distractor CS is stored at **702C**. In another embodiment, if a diagram with distractor approach is initiated at **703**, the process proceeds with retrieving the CS for the Topic Concept at **703A**. Next, at least one node and one arc are selected
10 from the CS at **703B**. From the selected node and arc, the distractor concepts are generated at **703C** and then replace the selected nodes and arcs with the respective distractor. The distractor(s) CS are stored at **703D**, into a Question Generation Knowledge Base **80** and the reference of the CS stored in the distractor list. An example of a DMCQ is shown as **FIG. 8**.

15 [0083] **FIG. 9** depicts the process flow for generating HDDQ Drawing Nodes and Arcs being step **313** of **FIG. 3B** process flow in accordance with an embodiment of the present invention. The process starts at **900**, whereby the input parameter used includes Topic Concept and QGS. In the event that an instance is required at **901**, the process retrieves at least one instance of the Topic Concept and replaces the Topic Concept with the instance at **901A**. The instance may be retrieved
20 from the Domain Knowledge Base **60**. At **902**, the process proceeds to retrieve at least one node and arc of the Topic Concept. If a distractor is not needed at **903**, the process proceeds to aggregate the node(s) and arc(s) of the Topic Concept at **903A**. On the contrary, if a distractor is needed, the process then randomly selects at least one node and one arc from the retrieved node(s) and arc(s) at **904** and then generating at least one distractor for the selected node and arc at **905**. The node(s) and
25 arc(s) are aggregated at **906** and thus the drawing nodes and arcs are generated at **907**. The process ends at **908**. **FIG. 10** shows an example of the HDDQ with distractor Node and Arcs.

[0084] **FIG. 11** shows the process flow for generating a distractor concept in accordance with an embodiment of the present invention. For this process, the initial input
30 parameters includes, Concept, QDT and QGS. It should be noted that the concept in this context can either be referred to Topic Concept or concept of a node or arc in the knowledge base **60**. The process starts at **1100**, with the mentioned input parameters, the Type Hierarchy Distance Range (THDR) configuration file **65** will be utilized to retrieve THDR based on the QDT at **1101**. For

example, the THDR can be $1 < \text{range} < 3$, $2 < \text{range} < 5$, or $4 < \text{range}$, whereby it shows the distractor needs to be 1 to 2 nodes away from the concept. Suitable, the question difficulty will be more difficult when distractor is nearer to the concept, and will be easier when the distractors are further from the concept. Once the THDR is defined is retrieved, the process the result items **66** are
 5 retrieved at **1102**, which are within the THDR from the domain knowledge base **60**. The concept type is firstly checked at **1103**, before determining whether the concept is of class type at **1104**. And then if a **YES** is obtained at **1104**, the process then proceeds with filtering the instance of the concept, the subclasses and instance of the subclasses if the concept is class type at **1104A**. The process then proceeds with determining whether an instance is required at **1105**. If an instance is not required,
 10 the result items that are of instance type are filtered at **1105A**. On the other hand, in the event that the instance is required, the result items that are of class type are filtered at **1106**. It should further be noted that filtering plays a pivotal role in this process because the distractors and answers in the lower question difficulty levels are only limited to concepts that are of class type, while distractors and answer are limited to instance type. In this way sample question template can be used to create
 15 questions in various question difficulty level. Subsequently at **1107** the process proceeds with determining the semantic similarity between result items and the Topic Concept. Upon completion of determining the similarity, the result items are accordingly ranked based on hierarchy similarity at **1108**. And then from the ranking result, a result item is selected based on the highest rank at **1109**. A distractor concept is therefore generated based on the result item
 20 selected at **1110**. The process ends at **1111**.

[0085] **FIG. 12** shows an example of the tree structure or hierarchy involved in distractor generation simulation in accordance with an embodiment of the present invention. With reference to **FIG. 12**, the aim of this tree structure is to generate the distractor concept
 25 of "Bank". Accordingly, from the knowledge base, the concepts that are not instances/subclasses of the concept "Bank" will therefore be distractors. The concepts that are outside of the red box will be the distractors of the concept "Bank". In this example, based on the type hierarchy distance, those concepts that are 4 nodes and not 7 nodes away will be selected. Example of selected concepts will be Cash, Capital, Cash_BBA, Cash_Istisna, Capital_Inan and
 30 Capital_kafalah. A type hierarchy similarity measure approach will be used to determine the type hierarchy similarity between "Bank" and selected concepts and then filter out the selected concept, which are instance type based on question difficulty level 1.

[0086] Still referring to **FIG. 12**, there are two concepts remaining, which are “Cash” and “Capital”. Accordingly a similar hierarchy measuring approach is used to determine the similarities between the 2 concepts and concept “Bank”. For example, in order to determine type
 5 hierarchy similarity between Cash and Bank, the following steps can be performed: Identifying a common ancestor of Cash and Bank, and then determine the distance between the common ancestors and the root of the hierarchy tree. In this example with reference to **FIG. 12**, the common ancestor is the root of the hierarchy tree therefore the distance should be 0. Upon identified the distance, the distance value is used to increase 1 in order to avoid 0 value that will
 10 result in calculation error later and then use the final value multiply with 2 (the common ancestor of two concepts); and finally the value A from above process is determined. Further in accordance with an embodiment of the present invention, the distance of the Cash to the common ancestor (CA) and Bank to the common ancestor (BA) is determined. (In this example they are 2 and 3). Once CA and BA value is determined, then determine the total value of the CA, BA and A,; and finally
 15 using of value A to normalize with the total value of the CA, BA and A to get the type hierarchy similarities. From here, the distractor with the highest type hierarchy similarity measure is selected as distractors. For this simulation, “Cash” is selected as the distractor of “Bank”.

[0087] **FIG. 13** shows the process flow for answer assessment in accordance with
 20 an embodiment of the present invention, to be described herein below. The process starts at **1301**, whereby the input parameter for this process includes a question list containing a list of question and user's answer. At **1302**, the process determines whether the question list is empty or otherwise. If **YES**, the process proceeds to calculate the total score with reference to the question score **91** at **1301A**. Next at **1301B** the total score is obtained and
 25 the process ends at **1301C**. If **NO**, the process proceeds to **1302** whereby at least one question is selected. If the question is DMCQ at **1303**, the process proceeds to retrieve the correct answer and the user's answer from the question at **1303A**, and subsequently evaluate the correct answer and user's answer to produce the answer score at **1303B**. The resultant selection and retrieved conceptual structure of the answer are used as input for
 30 converting a graph-based similarity result to question score – being the final step of the process at **1310**.

[0088] On the other hand, if the question is HDDQ thus not DMCQ at **1303**, the reference of the user answer's conceptual structure is selected and retrieves the conceptual structure of the answer at **1304**. Next the Topic Concept and CS are retrieved at **1305**, **1306**, **1307** and **1308**; these properties are then used in determining the similarity between the conceptual structures at **1309**, whereby a user semantic graph similarity matching method may be applied during this step for determining the similarity. It should be noted that in accordance with an embodiment of the present invention, in determining the similarity of the conceptual structures; nodes and arcs of two CS are matched and paired; whereby, the type hierarchy similarity measure will be determined for the paired nodes and arcs. The total value of the type hierarchy similarity measure of nodes and arcs are then normalized by the total number of the nodes and arcs in the CS to determine the similarity value between the two CSs. During the graph similarity matching process, a threshold value can be involved to determine the similarity results. For instance, the value 0.6 will be assigned as the threshold value; the similarity result will be 0 if it is lower than threshold.

15

[0089] Accordingly, a graph-based similarity result may be generated as an output. Finally at **1310**, the resulting graph is then used and thus converted into a question score. Suitably, both of the result of the semantic based graph similarity matching to the answer score and each of the answer scores are accrued by iterating each of the questions from the question list to produce the total score.

20

[0090] As would be apparent to a person having ordinary skilled in the art, the afore-described methods and components may be provided in many variations, modifications or alternatives to existing methods and systems. The principles and concepts disclosed herein may also be implemented in various manners which may not have been specifically described herein but which are to be understood as encompassed within the scope of the following claims.

25

CLAIMS

1. An automated method for diagrammatic question and answer assessment; the
5 method comprising:
- providing at least one topic and at least one question based on the topic (100);
providing at least one range of a question difficulty level (QDL) (100);
providing at least one question mode (100);
10 proportioning question difficulty type (QDT) based on the range of question
difficulty level (101);
selecting at least one question template based on the proportioned question
difficulty type (QDT) and question difficulty level (QDL) (104); and
generating a question based on the selected template (105);
15 wherein the question mode includes questions in the form of diagrammatic
multiple choice type (DMCQ) or hand drawing diagrammatic type (HDDQ).
2. The method as claimed in Claim 1 wherein proportioning question difficulty type
(QDT) includes providing a predetermined percentage range of the QDT based on the
20 question difficulty level (QDL) (102).
3. The method as claimed in Claim 1 wherein selecting at least one question template
based on the proportioned question difficulty type (QDT) and question difficulty level
(QDL) further includes:
25 selecting the question template based on the question mode of DMCQ or HDDQ
(203) and;
selecting the question template based on mix mode being both DMCQ and HDDQ
(201, 202, 203).
- 30 4. The method as claimed in Claim 1 wherein generating a question based on the
selected template (105) includes:
providing at least one topic, at least one question difficulty type (QDT) and
at least one question template (300);
retrieving at least one topic concept (301);

retrieving a question generation strategy (QGS) (302,303) based on at least one question mode;

generating a question body (304);

generating a question answer (305);

5 generating a question distractor (306);

aggregating the question body, answer and distractor (307)

generating drawing nodes and arcs (313); and

aggregating the question body and drawing nodes & arcs (314).

10 5. The method as claimed in Claim 4 wherein generating a question body (304) further comprises:

providing at least one topic concept, a question template, and a question generation strategy (QGS) (401);

15 determining whether an instance is required to which if YES, randomly retrieving an instance based on the topic concept and replacing the topic concept with the retrieved instance (402A);

if no instance is required, applying at least one type of question generation strategy (QGS) to generate the question body (403, 403A);

20 wherein the question generation strategy (QGS) includes using label or definition or case strategy or a combination thereof; using a correct diagram strategy or filled-in-the-blank strategy or a combination thereof.

6. The method as claimed in Claim 5, wherein in using label or definition or case strategy or a combination thereof; using a correct diagram strategy or filled-in-the-blank strategy or a combination thereof; at least one CS is retrieved based on the topic concept and the CS is aggregated with the question template.

7. The method as claimed in Claim 4, wherein generating a question answer (305) includes:

30 providing at least one topic concept, a vector list and at least one generation strategy (QGS) (500);

determining whether an instance is required (501);

if YES to requiring an instance, randomly retrieving an instance of the topic concept and replacing the topic concept with the instance (502);

if NO to requiring an instance, determine whether to use definition or label strategy or correct diagram strategy or nodes or arc strategy in generating the question answer (503,504,505).

5 8. The method as claimed in Claim 7, wherein using definition or label strategy in generating the question answer (503) include retrieving at least one definition or a label based on the topic concept (503A).

9. The method as claimed in Claim 7, wherein using correct diagram strategy in
10 generating the question answer (504) includes retrieving the CS for the topic concept (504A).

10. The method as claimed in Claim 7, wherein using nodes or arcs strategy in
generating the question answer (505) includes retrieving the CS for the topic concept
15 (505A) and extracting the nodes or arcs from the CS (505B).

11. The method as claimed in Claim 4 wherein generating a question distractor (306) includes:

20 providing at least one topic concept, at least one QDT, at least one question generation strategy (600);

determining whether an instance is required (601);

if YES in requiring an instance, randomly retrieving an instance of the topic concept and replacing the topic concept with the instance (601A);

25 if NO in requiring an instance (602), selecting a QGS (603);

wherein selecting the QGS includes selecting anyone from the group comprising a definition or label strategy, a nodes or arcs strategy, a diagram of topic concept distractor strategy, diagram with node and arc in wrong position strategy, and diagram with distractor node and arc strategy, or a combination thereof.

30

12. The method as claimed in Claim 4, wherein generating the drawing nodes and arcs (313) includes:

providing at least one topic concept, and a question generation strategy (QGS)
35 (900);

- determining whether instance is required (901);
if YES in requiring an instance, randomly retrieving an instance of the topic concept and replacing the topic concept with the instance (901A);
if NO in requiring an instance, retrieving the node and arc for the topic concept
5 (902);
randomly selecting the node and arc from the retrieved node and arc (904);
generating the distractor for the selected node and arc (905); and
aggregating the node and arc of the topic concept and their distractors (906).
- 10 13. The method as claimed in Claim 4 wherein generating a question distractor (306) further includes generating concept distractor which comprises:
- providing at least one concept, a question difficulty type (QDT) and a question generation strategy (1100);
15 retrieving at least one type hierarchy distance range (THDR) (1101);
retrieving at least one result item within the THDR based on the concept (1102);
filtering the result item which are instances or sub-classes of the concept in the event that the concept type is a class (1104A);
determining the type hierarchy distance between the result items and the topic
20 concept (1107);
ranking the result items (1108);
selecting a result item with highest rank (1109); and
using the result item to generate a distractor concept (1110).
- 25
14. The method as claimed in Claim 1 wherein the method further includes assessing of answers which comprises:
- providing at least one question list (1300);
30 selecting at least one question (1302,1303),
wherein,
when the question is a diagrammatical question,
obtaining a correct answer and user answer based on the question
(1303A); and

determining and evaluating the correct answer and user answer (1303B);

or

when the question is not a diagrammatical question,

5 selecting user answer conceptual structure (CS) reference and retrieving
the answer CS (1304);

selecting topic concept and retrieving the CS for the topic concept (1305,
1306,1307,1308);

determining the similarity score between the conceptual structures (CS)
(1309); and;

10 accruing all scores and obtaining a total score (1310).

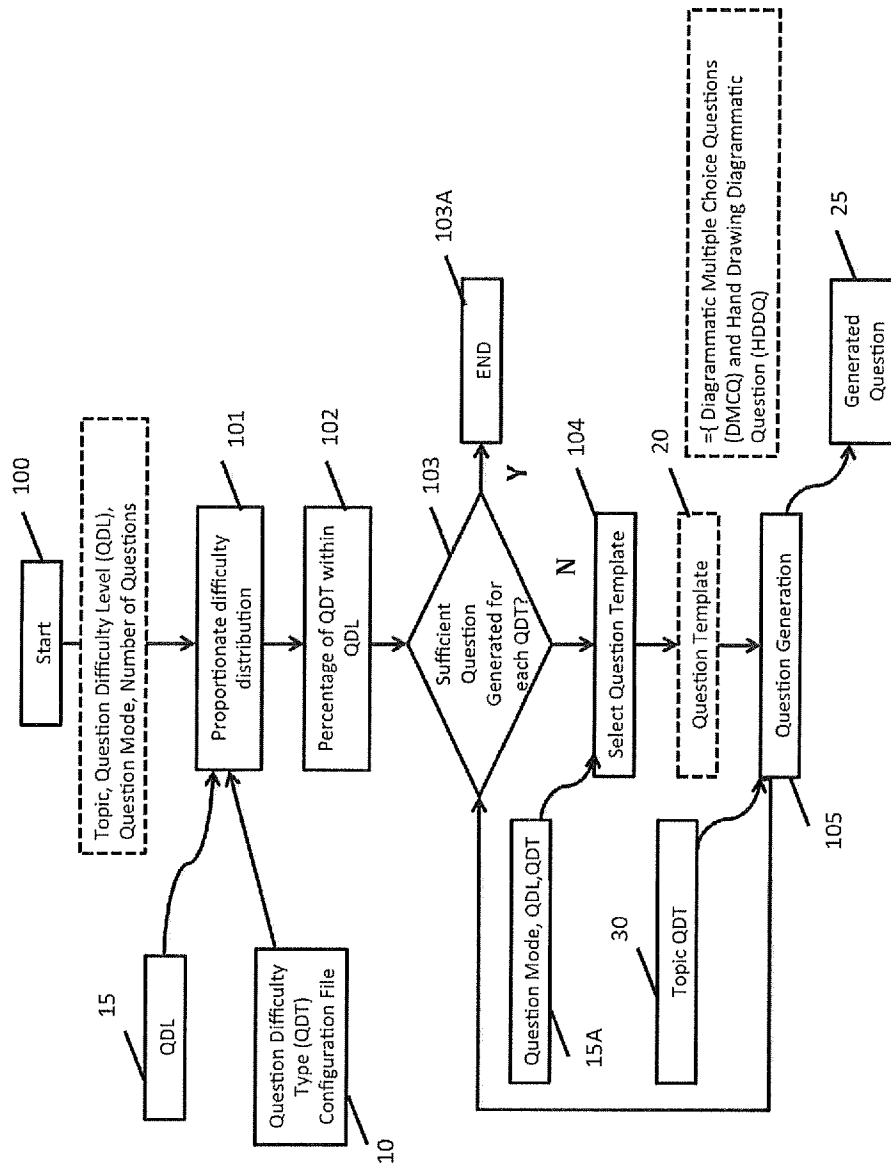


FIG. 1

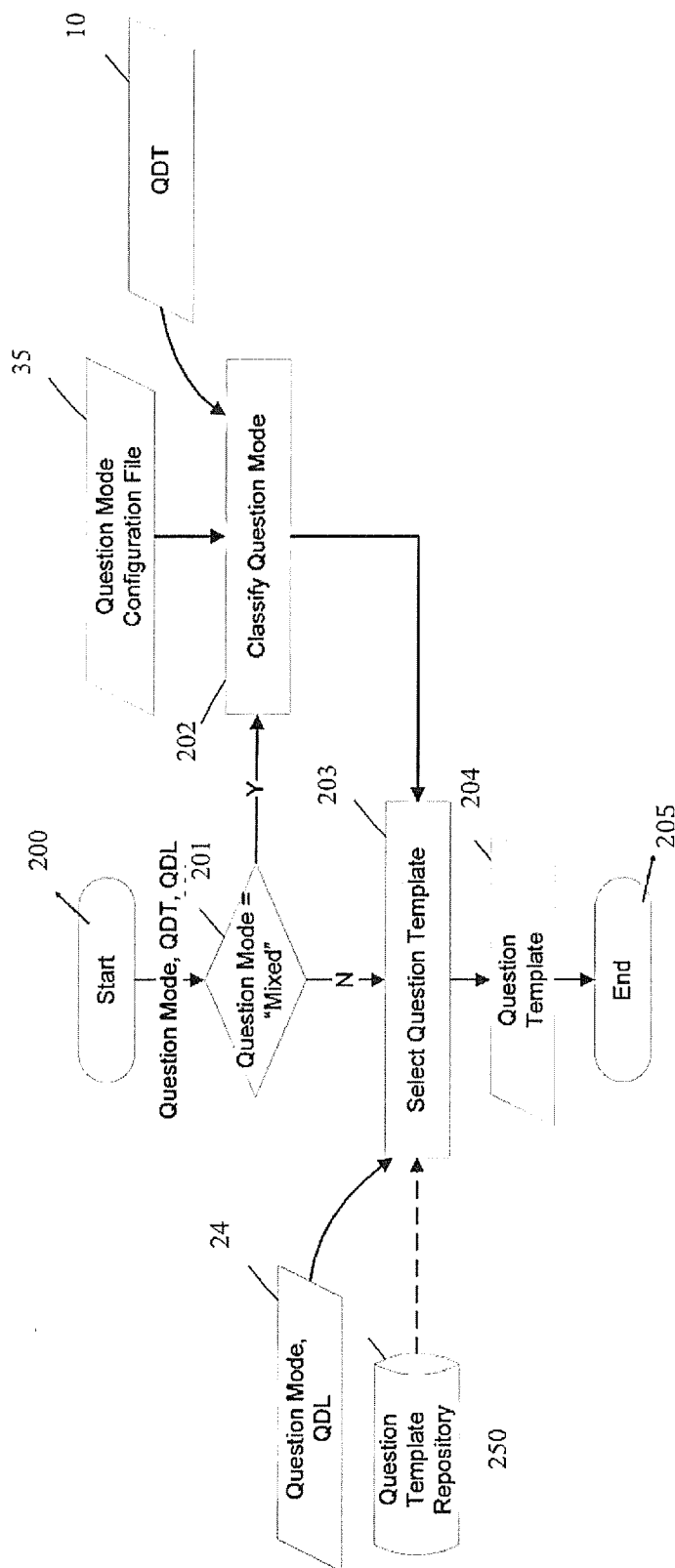


FIG. 2

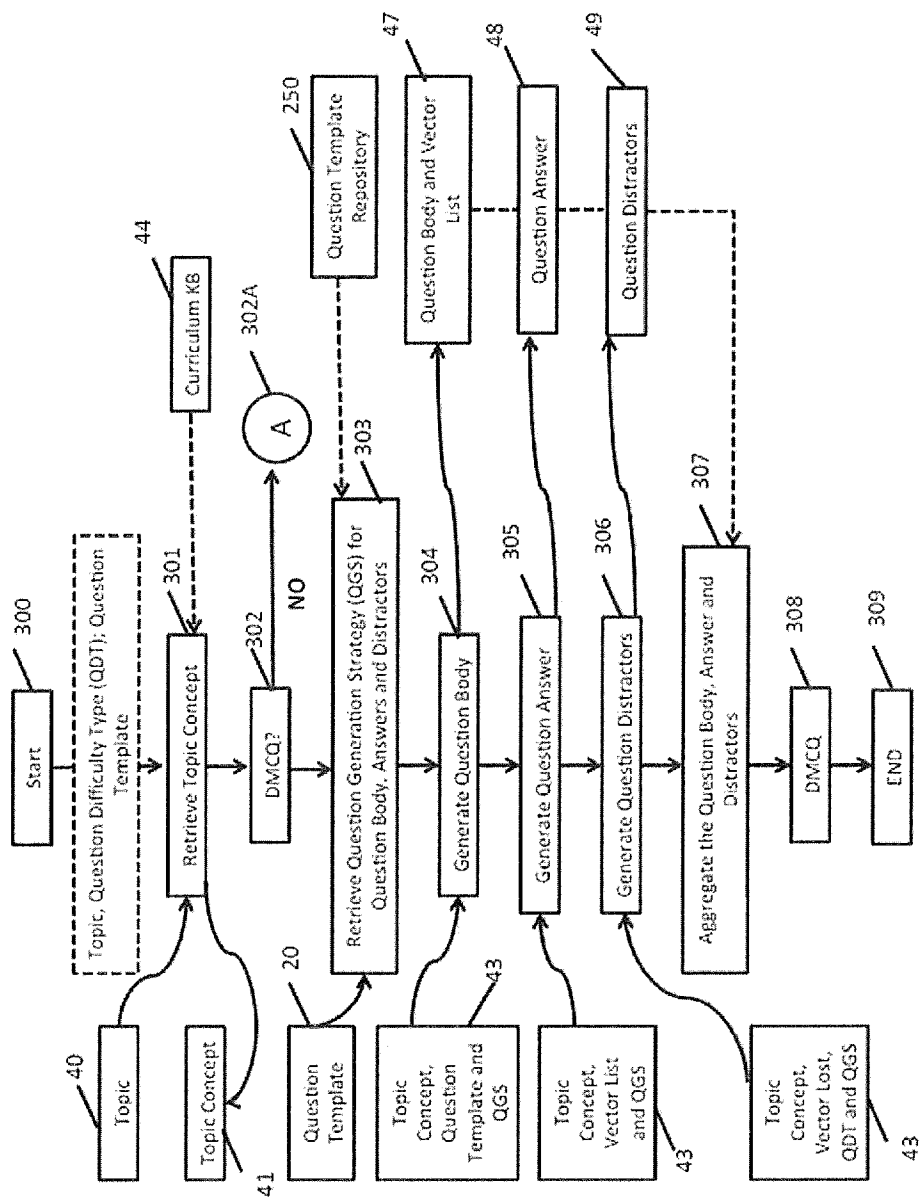


FIG. 3A

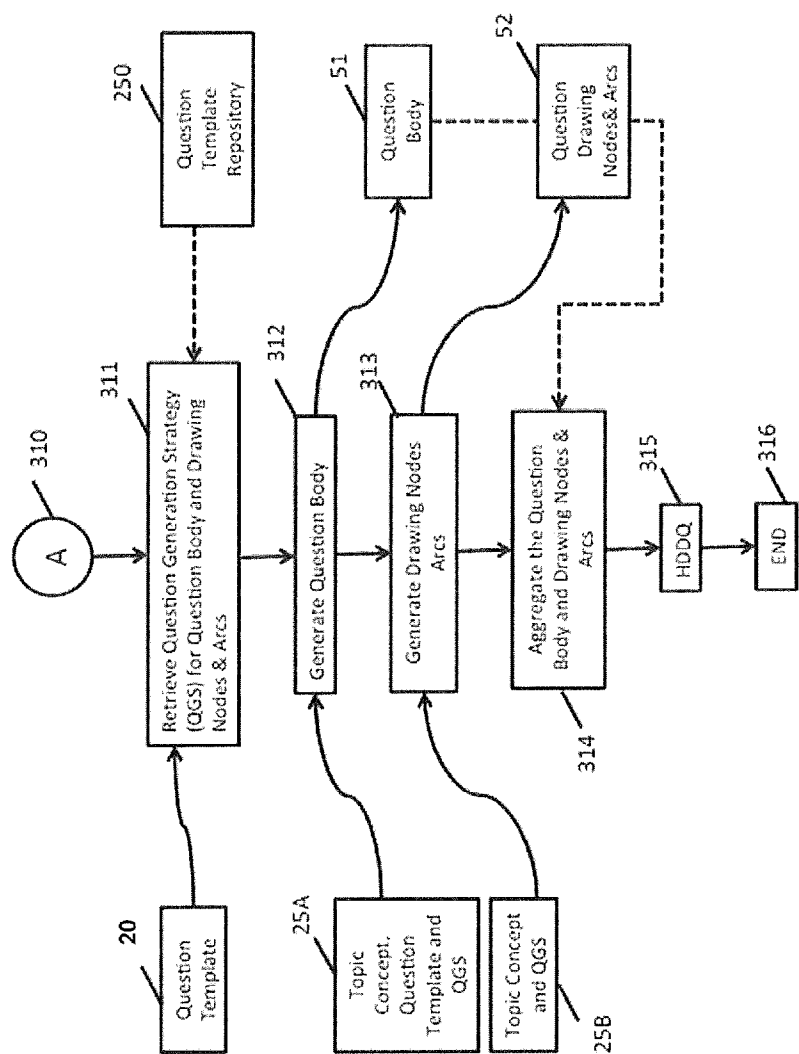


FIG. 3B

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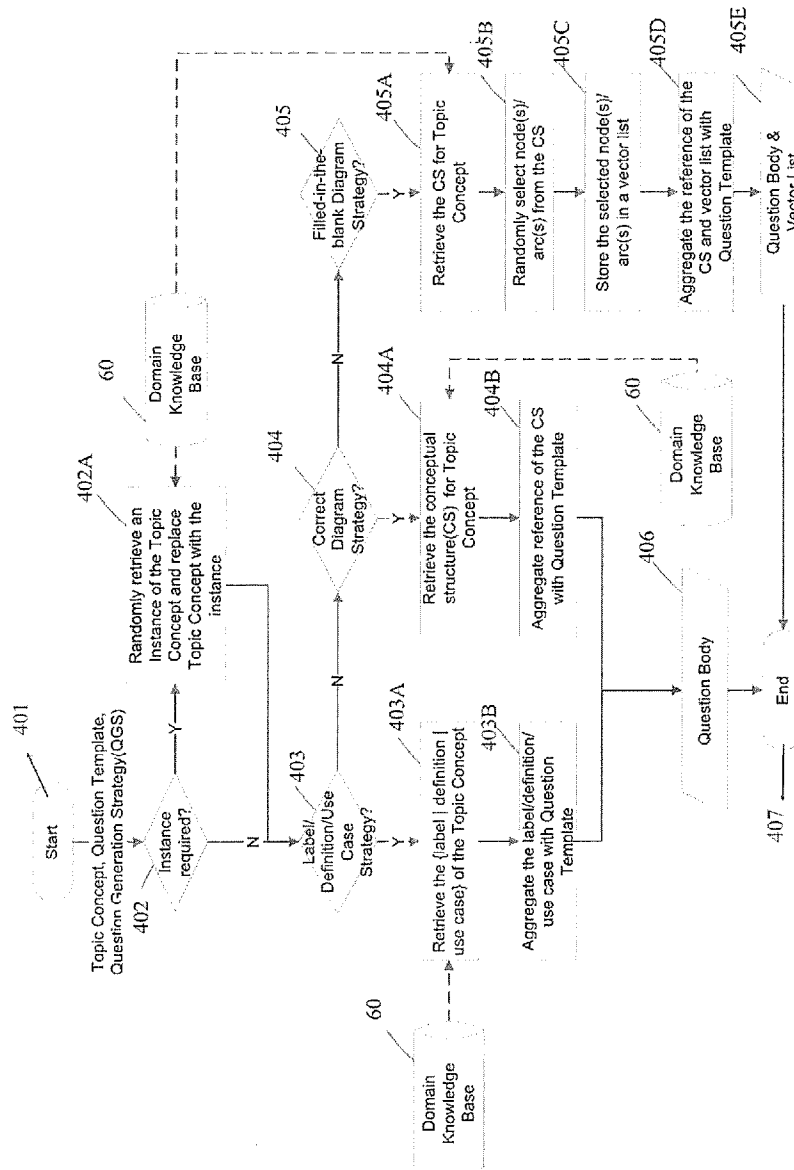


FIG. 4

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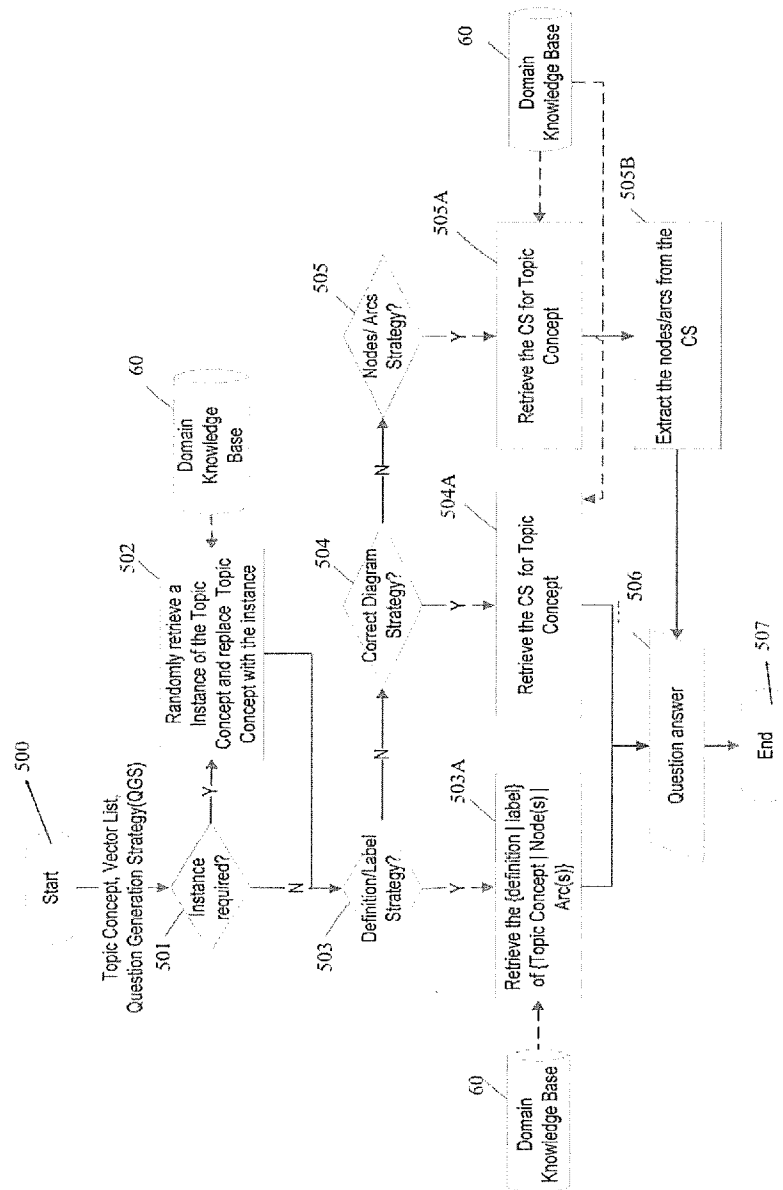


FIG. 5

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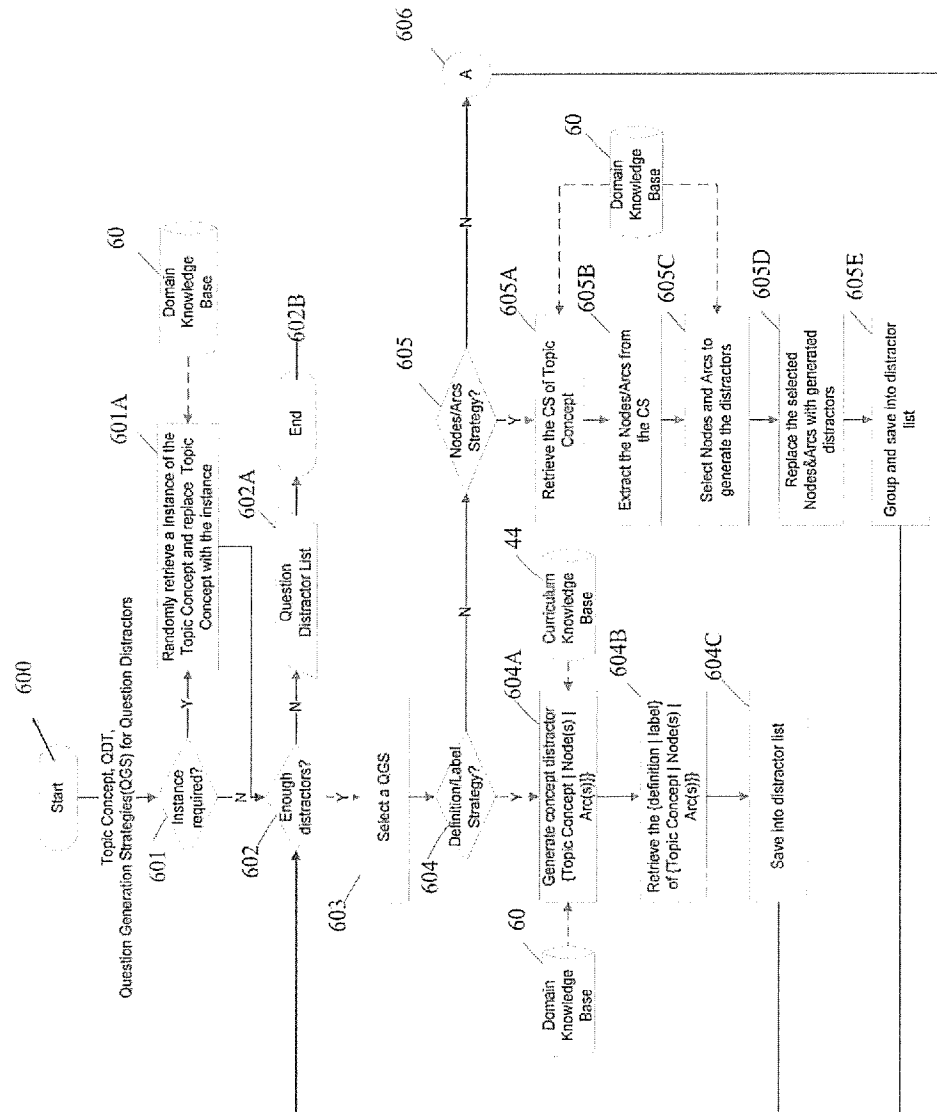


FIG. 6

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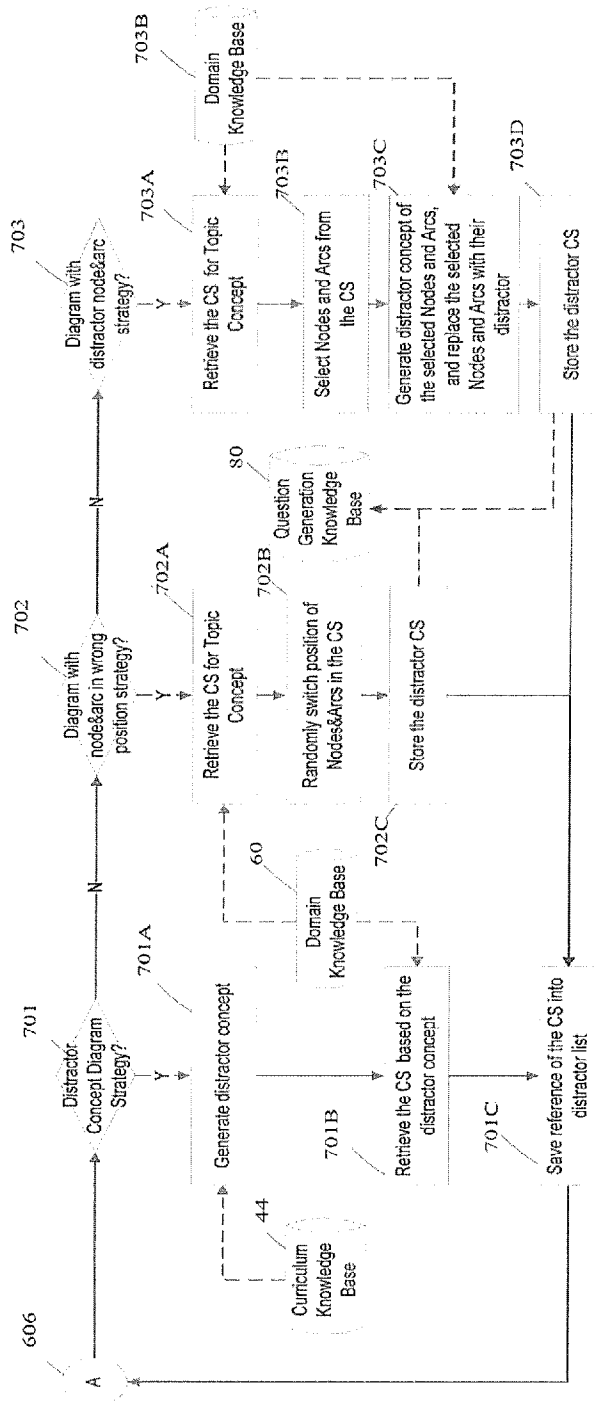


FIG. 7

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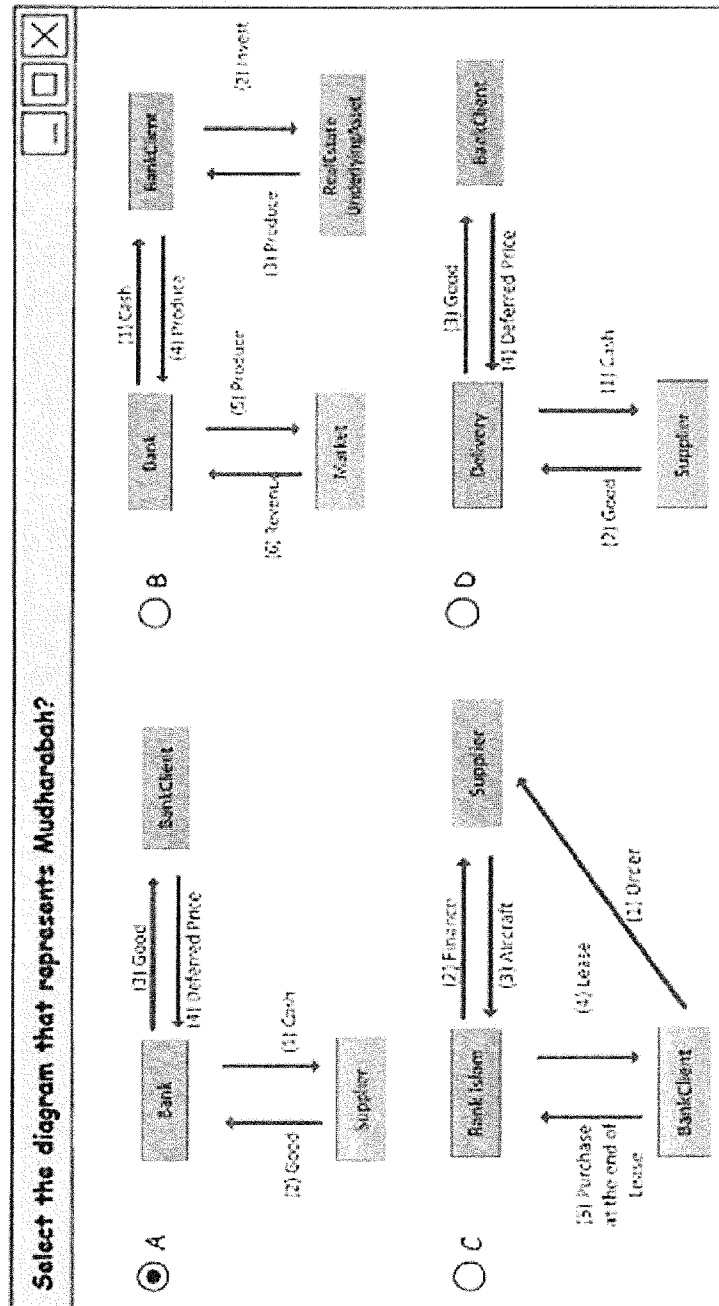


FIG. 8

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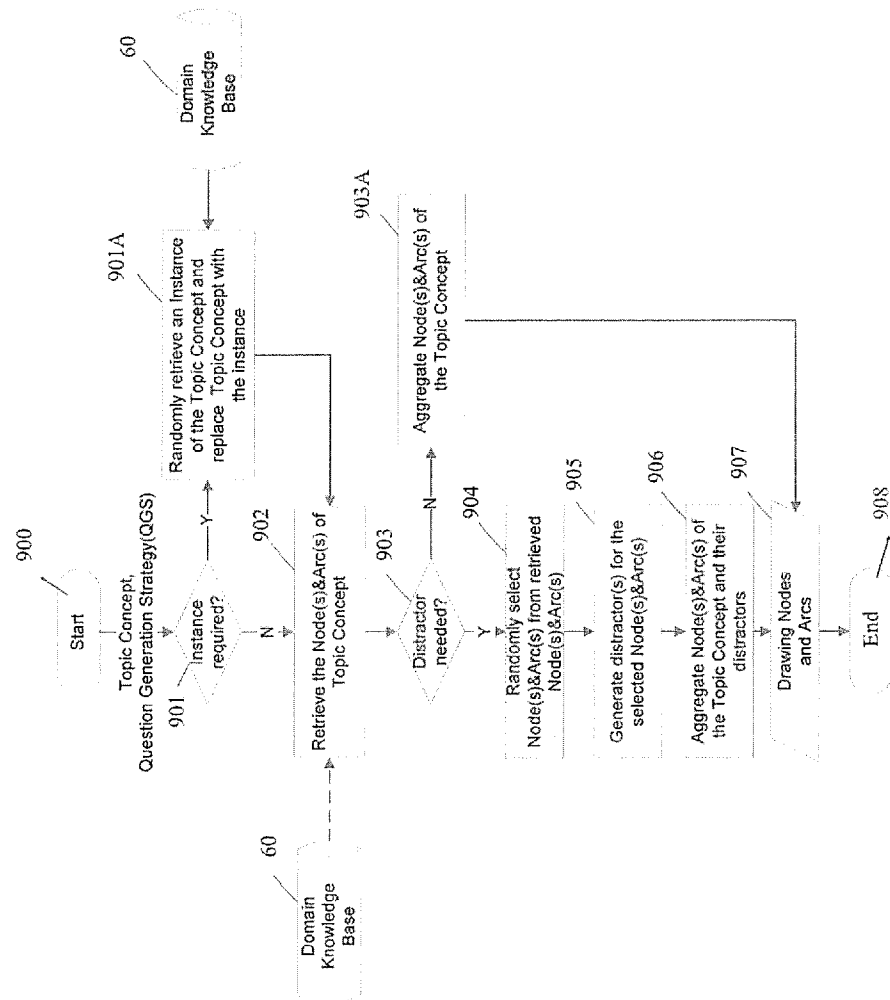


FIG. 9

Free Hand Drawing Diagram Question

Muhammad wants to purchase fertilizer from Hap Seng Consolidated Berhad for his crop with Maybank Islamic. Please draw out the correct contract process follow.

Hap Seng Berhad

Muhammad

Farm

Maybank Islamic

Involved Party

Revenue

Asset

Produce

Cash

Installment

FIG. 10

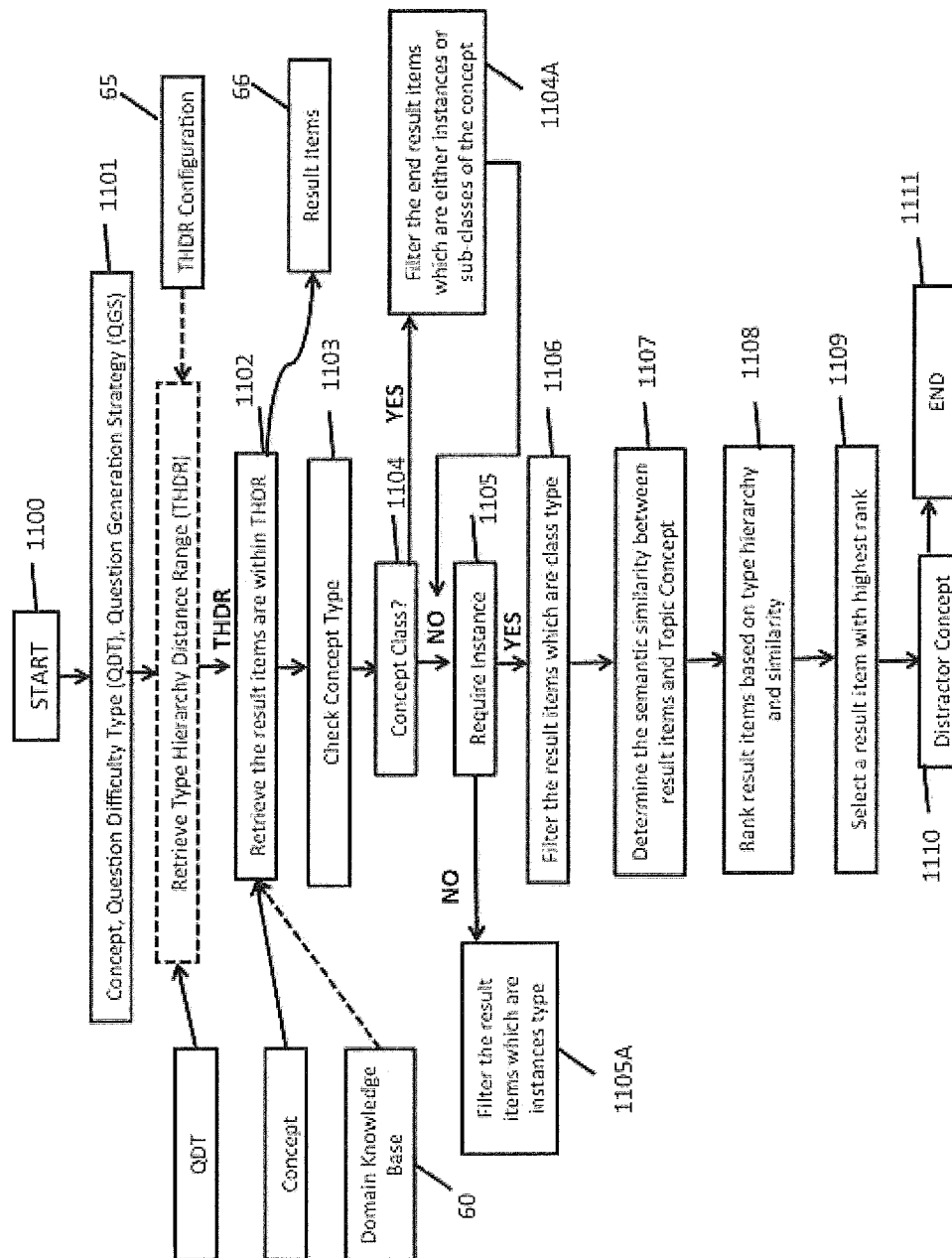


FIG. 11

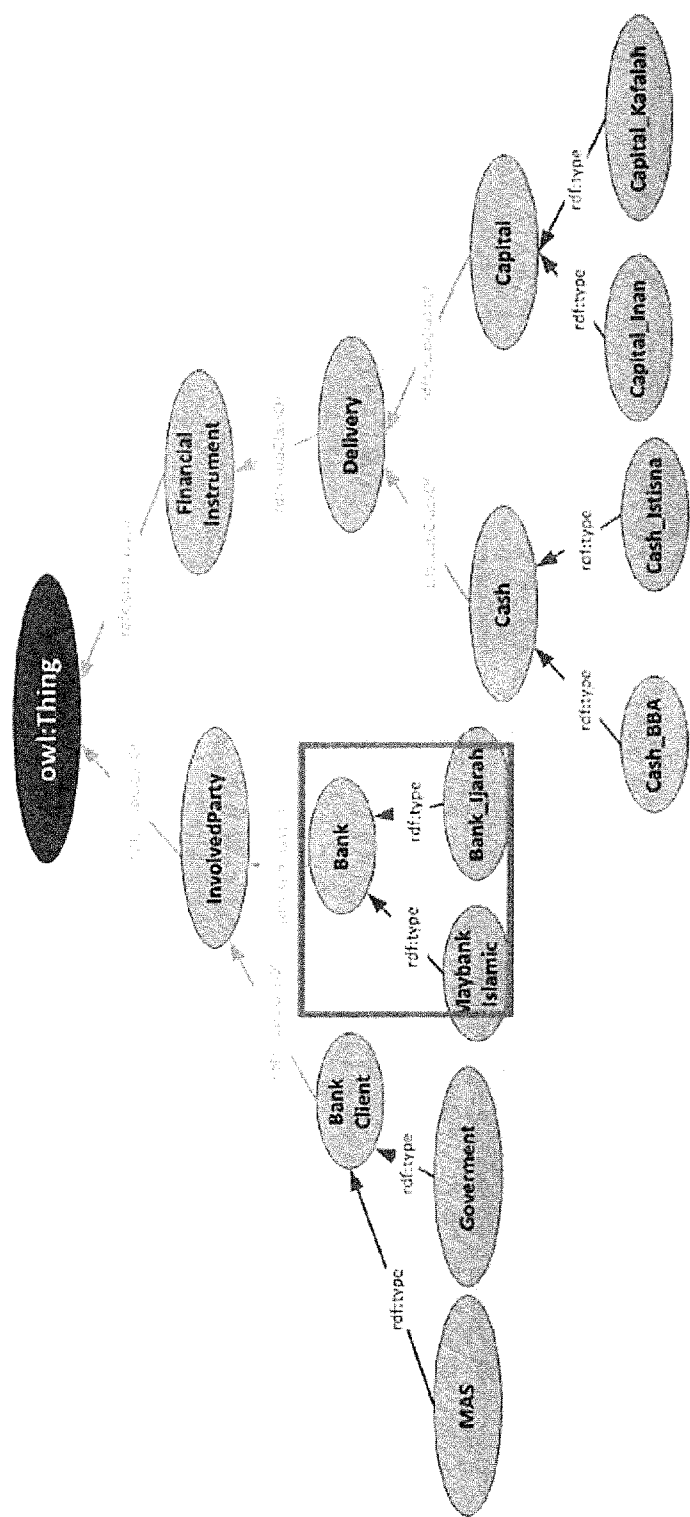


FIG. 12

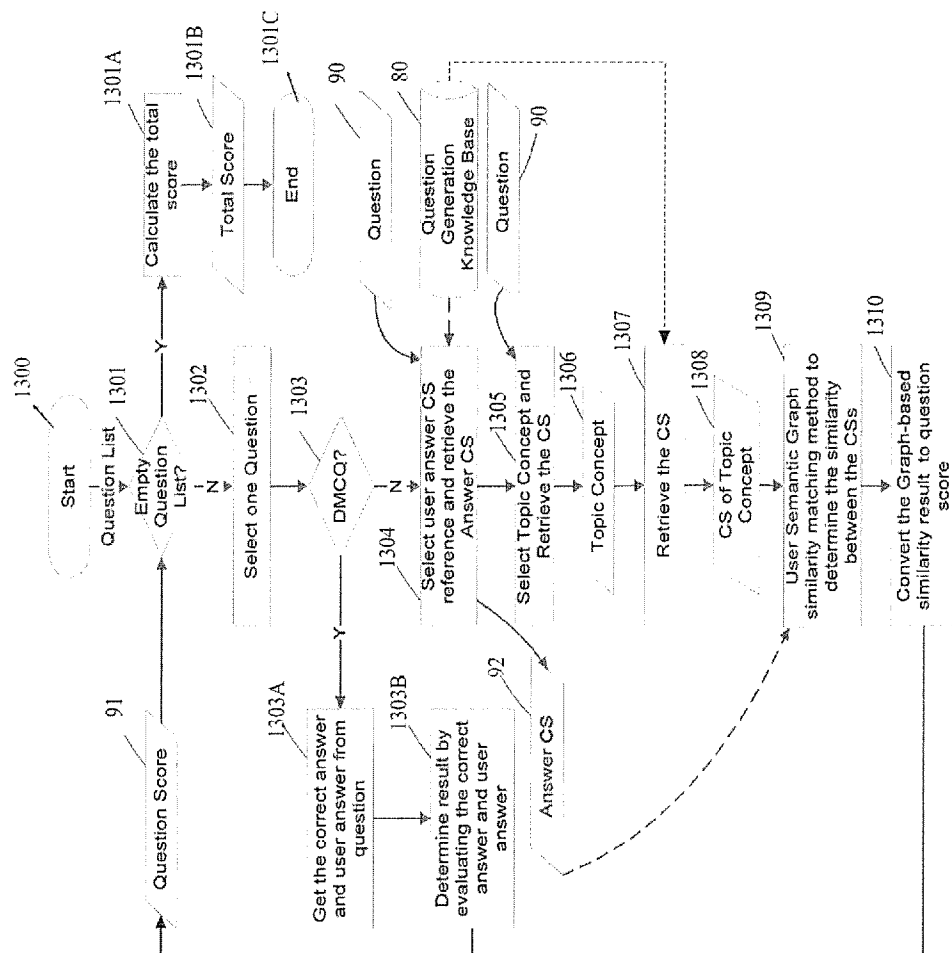


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/MY2015/050058

A. CLASSIFICATION OF SUBJECT MATTER
INV. G09B7/00
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)
G09B

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/196305 A1 (ADIR ALLON [IL] ET AL) 1 August 2013 (2013-08-01) cited in the application paragraph [0001]; figure 3 paragraph [0009] - paragraph [0011] -----	1-14
X	US 2009/280456 A1 (ISHAQ ALSAAD [IN] ET AL) 12 November 2009 (2009-11-12) cited in the application paragraph [0008] - paragraph [0011]; figure 1 -----	1-14
X	US 2005/255439 A1 (CODY PRESTON [US]) 17 November 2005 (2005-11-17) abstract; figure 13 -----	1-14



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

21 October 2015

Date of mailing of the international search report

29/10/2015

Name and mailing address of the ISA/

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Authorized officer

Kirchler, Dominik

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/MY2015/050058

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013196305 A1	01-08-2013	CN 103226562 A US 2013196305 A1	31-07-2013 01-08-2013
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