Epistemology Under Schematization:

Defining Knowledge

Sabah Al-Fedaghi
Computer Engineering Department, Kuwait University, Kuwait

***Abstract*—Many scientific fields have used diagrams to depict knowledge and to assist in understanding problems. This paper proposes to apply a schematization method in epistemology. The method is used in three examples that challenge the definition of propositional knowledge as justified true belief. The resultant drawings seem to contribute to increasing the comprehension of this issue. Initially, such a description can be used as a flowchart that facilitates discussion.**

Keywords—knowledge; justified true belief; diagrams; diagrammatic representation; Gettier problem

I. INTRODUCTION

Diagrams probably rank among the oldest forms of human communication. Natural sciences, physical sciences, and mathematics, as well as applied sciences such as engineering, have used diagrams to depict knowledge and to assist in understanding problems [1-4]. Traditional logic diagrams have been utilized as conceptual representations [5-6], and it has been claimed that these diagrammatic representations, in general, have advantages over linguistic ones [7-9].

> Diagrammatic inscriptions, …, are media that provide a point of linkage between thinking and intuiting, ... Today, images are recognized as a legitimized object of research in epistemology and philosophy of science. They are considered not merely a means to illustrate and popularize knowledge but rather a genuine component of the discovery, analysis and justification of scientific knowledge. [10]

Several well-known diagrammatic systems have been available as a heuristic tool. Euler circles [11] embrace circles to illustrate syllogistic reasoning. A drawback of these diagrams is a failure to represent certain pieces of information in a single diagram [5]. Venn diagrams [12] developed to produce an expressive power so that partial information could be represented. "The solution was [the] idea of 'primary diagrams'. A primary diagram represents all the possible set-theoretic relations between a number of sets, without making any existential commitments about them [5]. Peirce [13] introduced his diagrams to extend Venn's system in expressive power with respect to the existential and disjunctive statements [5].

Recently, many researchers have become increasingly aware of the importance of diagrammatic representation systems.

> Diagrams are usually adopted as a heuristic tool in exploring a proof, but not as part of a proof. It is a quite recent movement among philosophers, logicians, cognitive scientists and computer scientists to focus on different types of representation systems, and much research has been focused on diagrammatic representation systems in particular. [5]

In philosophy, images and diagrams are old subjects. Plato's allegory of the cave visualizes situations and pictures knowledge configurations. "The diagram functions as an instrument of making evident the structure of ontology and epistemology" [10]. Descartes made "two-dimensional geometric figures and linear algebraic equations mutually transferable" [10].

Nevertheless, the current state of diagrammatic representation of logical and philosophical problems is susceptible to propose new methodologies. Specifically, this paper explores the diagrammatic representation, called the Flowthing Model (FM), that has been utilized in representing fundamental structure logic [14-16]. This paper applies FM to some epistemic problems to provide models, where a model is to an abstract schematization that expresses ordered sequence flows and structured events in the problem. Schematization, here, refers to a diagrammatic description of events, actions, and operations that assists in conveying the embedded structure of the involved situation.

Advantages of the resultant diagrams for epistemic problems include providing an explicit depiction represented only implicitly in these problems, conveying a better understanding of the problems, especially in the environment of human/computer interactions (e.g., learning), and presenting some new variations of considering these problems and how to reflect about them.

For the sake of completeness, and because that FM is not a well-known methodology, the model will be briefly described in the next section. The example in the section is a new contribution.

II. FLOWTHING MODEL

A flow model is a uniform method for representing things that "flow," i.e., things that are created, processed, released, transferred, and received [17-18]. "Things that flow" include information, materials (e.g., goods), and money. They flow in *spheres*, i.e., their environments. A sphere is different from a set in the sense that a set is a static structure, whereas a sphere includes flowthings (current members) at different stages in a progression and possible directions (lines) of movement from one stage to another, or movement from/to the spheres of the flowthings. A sphere may have subspheres.

An FM representation is a depiction of the structure of a scheme resembling a road map of components and conceptual flow. A *component* comprises *spheres* (e.g., those of a company, a robot, a human, an assembly line, a station) that enclose or intersect with other spheres (e.g., the sphere of a house contains rooms which in turn include walls, ceilings). Or, a sphere embeds flows (called *flowsystems*; e.g., walls encompass pipes of water flow and wires of electrical flow).

Things that flow in a flowsystem are referred to as *flowthings*. The life cycle of a flowthing is defined in terms of six mutually exclusive *stages*: creation, process, arrival, acceptance, release, and transfer.

Fig. 1 shows a flowsystem with its stages, where it is assumed that no released flowthing flows back to previous stages. The reflexive arrow in the figure indicates flow to the Transfer stage of another flowsystem. For simplicity's sake, the stages Arrive and Accept can be combined and termed *Receive*.

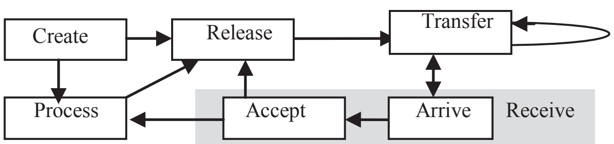

Fig. 1. Flowsystem

The *stages* of the life cycle of a flowthing are mutually exclusive (i.e., a flowthing can be in one and only one stage at a time). All other states or conditions of flowthings are not generic stages. For example, we can have *stored* created flowthings, *stored* processed flowthings, *stored* received flowthings, etc.; thus, *stored* is not a generic stage. In contrast, there are no such stages as, e.g., *created-processed, received-transferred*, or *processed-received* stages. Flowthings can be released but not transferred (e.g., the channel is down), or arrived but not accepted (wrong destination), …

In addition to flows, *triggering* is a transformation (denoted by a dashed arrow) from one flow to another, e.g., a flow of electricity triggers a flow of air.

Example: A proposition p indicates a *sphere* with two subsystems (Body (symbolic expression), and Truth value). Let p be the statement *Maria learns discrete mathematics* and q the statement *Maria will find a good job*. Consider expressing the statement p → q in FM (this example is based on a problem in [19]).

Fig. 2 shows the FM representation for p → q. Each formula p, q, and p → q (circles 1, 2, and 3, respectively) is represented by two flowsystems, body and truth value. If truth values are assigned (created) for p and q (4 and 5, respectively), then they flow to p → q (6 and 7, respectively). There, they are processed according to the truth table of p → q (8) to create a truth value (9).

Application of this method in logical proofs can be found in [14-16]. Note that the description in the body of the proposition can also be represented in FM See Fig 3).

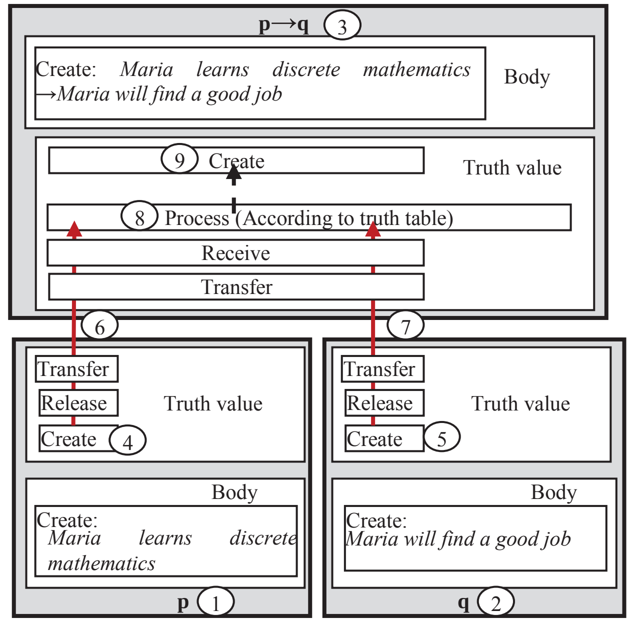

Fig. 2. FM representation of p → q

Fig. 3. FM representation of *Maria learns discrete* mathematics

III. APPLYING FM TO EPISTEMOLOGY

The so-called propositional knowledge refers to what is expressed by a proposition (roughly) sentence. In epistemology, *knowledge* is usually said to entail *true belief*; i.e., knowing a proposition, p, involves believing p, and p is true. Traditionally, to resolve what knowledge *is* (not just entails), a good *justification* is required. Accordingly, knowledge is said to be a justified true belief. There are three components to the traditional ("tripartite") analysis of knowledge. According to this analysis, justified, true belief is necessary and sufficient for knowledge. In the so-called *tripartite analysis of knowledge*, an agent S *knows* that proposition p iff

- S believes that p;
- p is true;
- S is justified in believing that p.

A. Example 1

Consider the following example given by Pritchard [20]. Suppose that an agent called Edmund believes that it is 8:20 a.m. by looking at the clock in his hall. This clock has been very reliable in the past, and Edmund has grounds for believing that the time is 8.20 am (e.g., it's light outside). "Finally, let us stipulate that Edmund's belief is true, it is 8.20 am" [20]. Accordingly, Edmund has a true belief in this proposition, and he has excellent justification.

Suppose that the clock stopped working twenty-four hours previously and is stuck at the time 8.20 am. "The moral of the story is thus that whatever knowledge is, it is not justified true belief" [20].

Fig. 4 shows the FM schematization of this example. It has two time spheres (periods/frames):

- Time sphere 1, called *Twenty-four-hours-ago* (24h, for short, circle 1).
- Time sphere 2: called *Now* (circle 2)

Time sphere 1: Twenty-four-hours-ago (circle 1)

Twenty-four-hours-ago includes one sub-sphere: Clock. The clock receives time (3) that flows from the outside and is processed (4). Process, here, refers to "consuming" the time and triggering (5) the generation (creation) of its clock display (6). As the processing (4) indicates, the process stops at 8: 20 a.m., triggering the display "8:20." The displayed time flows to the *Now* sphere (7).

Time sphere 2: Now (circle 2)

Now includes two sub-spheres: *Edmund* and *(objective) Time* (9). *Edmund* contains three sub-spheres: *Clock display* (10), *Belief* (11) and *Perception* (used for justification, circle 12).

Accordingly, when *Edmund* processes (comprehends) the clock display (13) and is aided by perception (e.g., it's light outside), these trigger the creation of the proposition *It's 8:20* and its truth value (15). In reality, the time is also 8:20. *Reality*, here, means the total sphere that includes all spheres.

Because Edmond (i) believes that *it is 8:20*, (ii) the proposition *"It's 8:20" is true,* and (iii) there is reasonable justification for such a belief; then, does Edmond have *knowledge* about what time it is?

Analysis

Diagrammatic modeling techniques are hardly used in philosophical interpretation because such an act is inclined to be text based. Nevertheless, FM modelling form allows for analysis and hypothesis about the solution to the problem. Accordingly, in this sub-section, we present our interpretation of the cause of the problem involved: why Edmund does not have knowledge even though he seems to have a justified true belief. This is an attempt to demonstrate the capacity of FM to produce new understanding, not only to represent the problem in a graphical form. Of course, this analysis is open for refutation.

From the diagram, we can observe that there are two ways to originate that the proposition *"It's 8:20" is true*:

- Either, as shown in Fig. 4, where the proposition and its truth-value are triggered by the time on the clock (13) and perception (12)
- Or, as shown in Fig. 5, where the proposition and its truth-value is triggered by actual time in reality (e.g., seeing another clock, hearing the time on the radio, etc.).

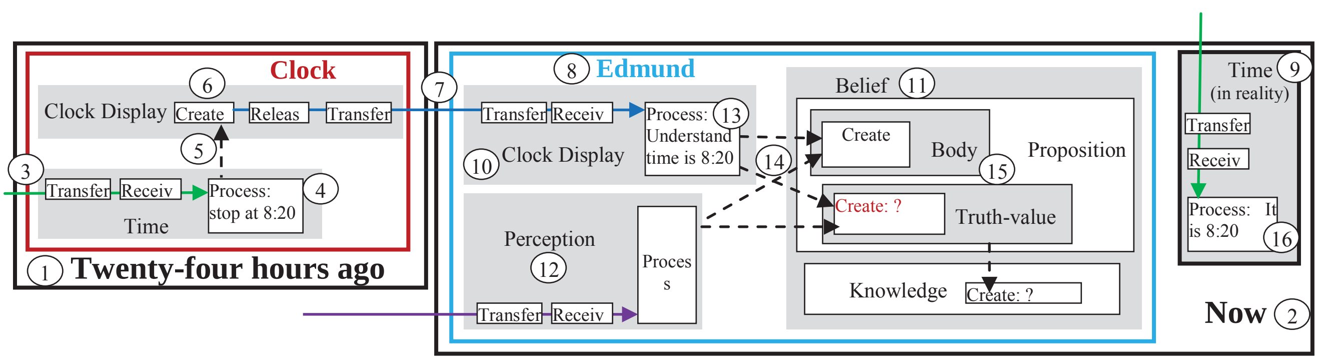

Fig. 4. In the *tripartite* account of knowledge (Triangles) the truthiness of the proposition is triggered by Clock and perception (justification)

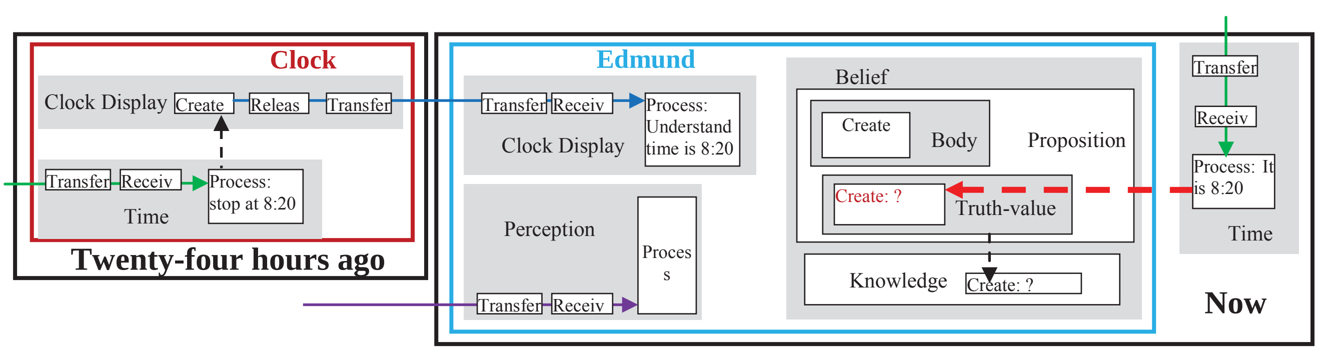

Fig. 5. In the *tripartite* account of knowledge (Triangles) the truthiness of the proposition is triggered by real time

If *"It's 8:20" is true* is based on the stopped clock (13) in Fig. 4) and perception (12 in Fig. 4), then clearly, *It's 8:20* is the product of wrong data. Thus, Edmund has no knowledge.

If *"It's 8:20"* is based on actual time in reality (9 in Fig. 4), then this is not possible because, according to the given account, he never looked at another source of timing.

We reach the conclusion that Edmond does not have *knowledge* about the time now.

Accordingly, to handle such an example, in the knowledge definition, we require that the truth of the proposition is based on the *objective* truth. Objective, here, refers to that the truth-value of the proposition in the *tripartite* account of knowledge (Fig. 6) should be triggered by "reality." In the example, even though the *truth value* that is assigned to *"It's 8:20"* in Edmund's mind coincides with the objective truth value, it has not been triggered by real time.

The moral of such analysis is that it is not enough that the truth value in *tripartite* account of knowledge is true, but also the method (triggering) of such an assignment of value should be originated in reality.

Accordingly, the FM schematization of this problem has provided the following:

- A non-verbose description of the involved situation that can be used in discussion and teaching.
- A possible tool for analysis

B. Example 2

Consider the following example given by Gettier [21]. Smith and Jones have applied for a certain job, and Smith has evidence that (d) *Jones is the man who will get the job, and Jones has ten coins in his pocket*. The president of the company assured him that Jones would be selected. Also, Smith counted the coins in Jones's pocket ten minutes ago. Proposition (d) entails (e) *The man who will get the job has ten coins in his pocket*. In this case, Smith is justified in believing that (e) is true. But suppose that unknown to Smith, he himself, not Jones, will get the job. And unknown to Smith, he himself has ten coins in his pocket. In this example, then, all of the following are true:

(i) (e) is true,
(ii) Smith believes that (e) is true, and
(iii) Smith is justified in believing that (e) is true. Gettier [21].

Fig. 7 shows the corresponding FM representation.

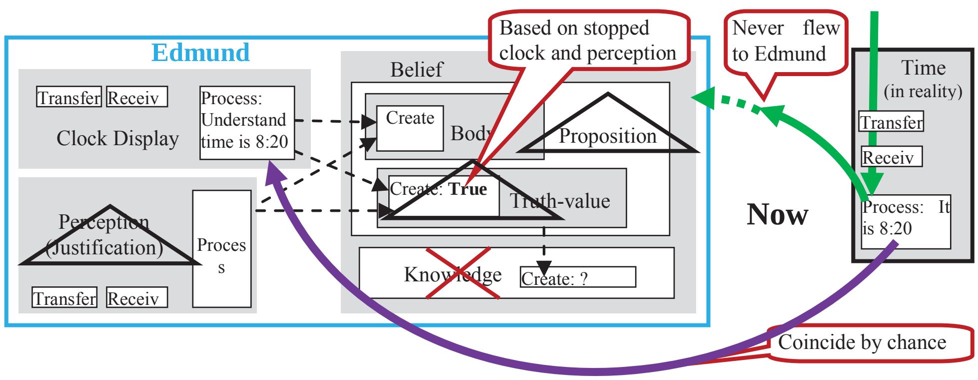

Fig. 6. In the *tripartite* account of knowledge (Triangles) the truthiness of the proposition is questionable

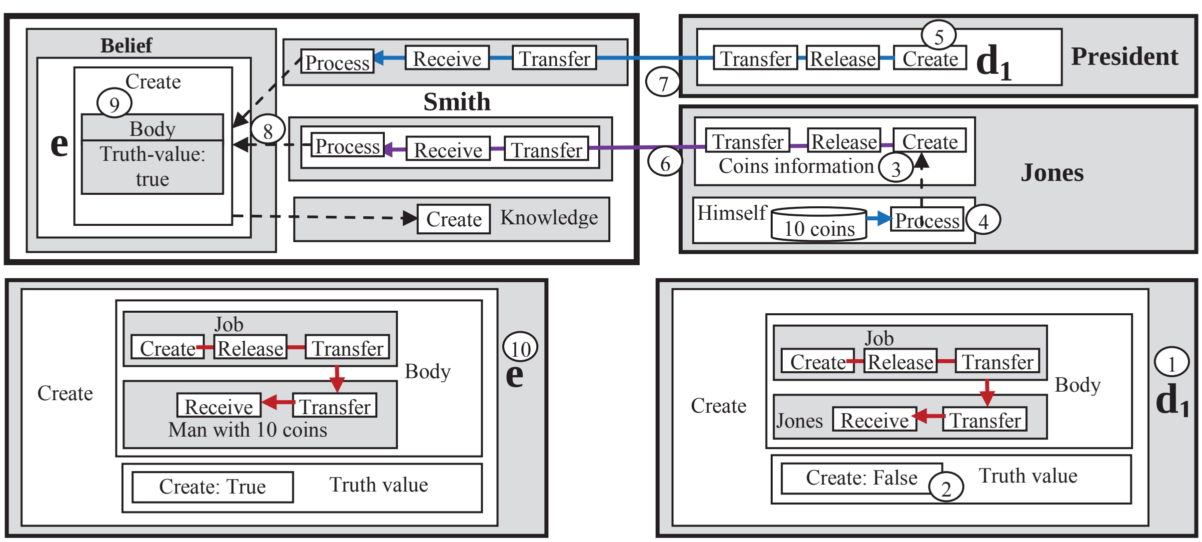

Fig. 7. The truth-value of proposition e is based on d1 from the president and coin information (circle 8).

In the figure, (d) *Jones is the man who will get the job, and Jones has ten coins in his pocket* is divided into two portions.

(1) d1: *Jones is the man who will get the job.*
It is shown (circle 1) as a sphere in the figure, which, in reality, is false (2). Note that the body in (1) is just a *description* of the proposition.

(2) d2*: Jones has ten coins in his pocket*.
This fact is produced as a piece of information (circle 3) by actual processing of Jones (physically counting the coins in his pocket — 4).

Accordingly, the coin information (3) d1, which is created by the president (5) flow to Smith (6 and 7, respectively, to be processed and triggers (8) the creation of proposition e (9) as a true belief. The description and the truth value in reality are shown in the e sphere (10). This sphere expresses that in reality there appears a proposition (sentence) *The man who will get the job has ten coins in his pocket,* and it is true.

We can see that the truth value of the proposition e in the tripartite account of knowledge can be based on the following:

- d1 from the president and coin information (circle 8 in Fig. 7), where d1 is false.
- The reality truth value of e (see Fig. 8)

Because Smith never accessed the truth value of e, he does not have knowledge.

C. Example 3

Consider the following example given, also, by Gettier [21].

Smith … has a justified belief that "Jones owns a Ford." Smith, therefore (justifiably), concludes (by the rule of disjunction introduction) that "Jones owns a Ford, or Brown is in Barcelona," even though Smith has no knowledge whatsoever about the location of Brown.

In fact, Jones does not own a Ford, but by sheer coincidence, Brown really is in Barcelona. (This description of Gettier [21]'s example is taken from Wikipedia [22].)

Fig. 9 shows the corresponding FM diagram. It includes the spheres of Smith, the two propositions (sentences/information) *Jones owns a Ford* and *Brown is in Barcelona,* and the OR logical operation. Smith includes a *Perception* sub-sphere (for justification, e.g., Jones has at all times in the past within Smith's memory owned a car — 5), and *beliefs* (6) regarding the two propositions and their OR.

In the *Jones owns a Ford* sphere (2), *create* means bringing into existence in the setting of situation under consideration. It is similar to a film script that lists the characters and their roles. This *Jones owns a Ford* is involved in the OR operation, thus, it flows to the sphere of OR to be processed. These spheres exist "outside" the sphere of Smith in "reality."

In Smith's belief sphere (6), *Jones owns a Ford* is assigned true (8) based on the perceived justification (5). The Or-ing of the two proposition is assigned *true* (9); however, this assignment is based on the triggering (11) and (12) in Smith's belief sphere, not on the truth value of OR in reality (12). Accordingly, it is not Knowledge.

IV. Conclusions

This paper proposes to use a flow-based representation as a base to facilitate understanding in epistemology. The paper demonstrates the viability of the proposed methodology by applying it in three examples that challenge the definition of propositional knowledge as justified true belief. The resultant representation of these three problems provides diagrammatic descriptions that can be used in teaching in artificial intelligence where students are not oriented toward philosophical explanations.

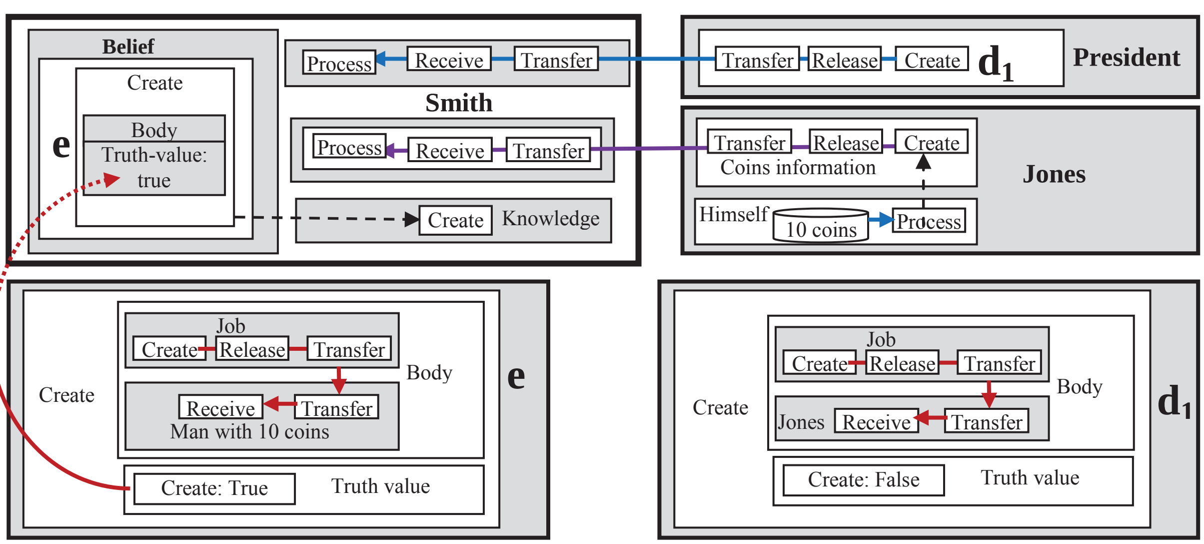

Fig. 8. The "reality" truth-value of proposition e never reaches Smith.

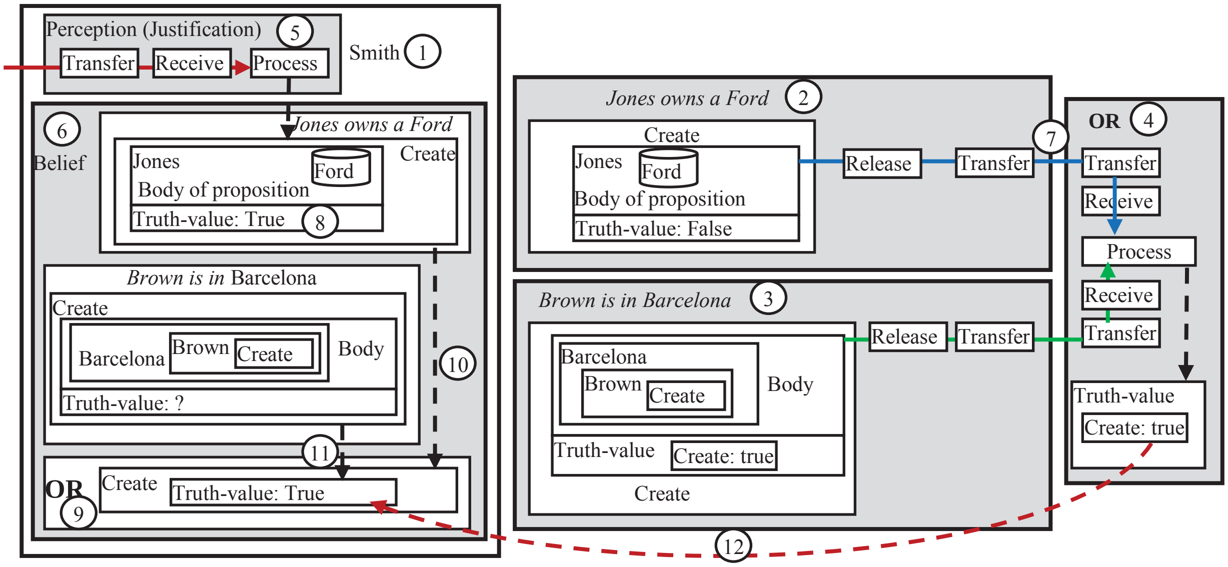

Fig. 9. FM representation of example 3

There is also, an attempt, in the paper to analyze the involved epistemic problems in terms of the structure of the diagram.

The study is exploratory in the sense that it aims at introducing the idea and demonstrating its feasibility. Future research can further develop the approach of FM representation in different epistemic problems.

V. References

[1] R. Arnheim, Visual Thinking, University of California Press, Berkeley, 1980.

[2] A. Barr, and E. A. Feigenbaum, The Handbook of Artificial Intelligence, vol. 1, William Kaufmann, Los Altos, CA, 1981, pp. 200–206.

[3] A. Sloman, "Interactions between philosophy and A.I.: the role of intuition and non-logical reasoning in intelligence," Artificial Intelligence, vol. 2, 1971, pp. 209–225.

[4] A. Sloman, "Afterthoughts on analogical representations," in Proceeding of the 1st Workshop on Theoretical Issues in Natural Language Processing (TINLAP-1), Cambridge, MA, 1975, pp. 164–168.

[5] S–J. Shin, O. Lemon, and J. Mumma, "Diagrams," The Stanford Encyclopedia of Philosophy (Winter 2014 Edition), Edward N. Zalta (ed.). http://plato.stanford.edu/archives/win2014/entries/diagrams/.

[6] G. Allwein, & J. Barwise (Eds.), Logical Reasoning with Diagrams. New York: Oxford University Press, 1996.

[7] A. Shimojima, "The graphic linguistic distinction," Artif. Intell. Rev., vol. 13, 2001, pp. 313–335.

[8] K. Stenning, "Distinctions with differences: comparing criteria for distinguishing diagrammatic from sentential systems," in Diagrams 2000, M. Anderson, P. Cheng, and V. Haarslev, Eds. LNCS (LNAI), vol. 1889, 2000, pp. 132–148.

[9] "Diagrams," in Stanford Encyclopedia of Philosophy, 2012. www.science.uva.nl/~seop/archives/spr2012/entries/diagrams

[10] S. Krämer, "Epistemology of the line. Reflections on the diagrammatical mind," in Studies in Diagrammatology and Diagram Praxis, Alexander Gerner and Olga Pombo (Eds.), , London: College Publications, 2010, pp. 13–38.

[11] L. Euler, Lettres à une Princesse d'Allemagne, St. Petersburg; l'Academie Imperiale des Sciences, 1768.

[12] J. Venn, Symbolic Logic, London: Macmillan, 1881.

[13] D. Roberts, The Existential Graphs of Charles S. Peirce. The Hague: Mouton, 1973.

[14] S. Al-Fedaghi, "Schematizing proofs based on flow of truth values in logic," IEEE International Conference on Systems, Man, and Cybernetics (IEEE SMC 2013), Manchester, UK.

[15] S. Al-Fedaghi, Visualizing Logical Representation and Reasoning, The 15th International Conference on Artificial Intelligence (ICAI '13), July 22–25, 2013, Las Vegas, USA.

[16] S. Al-Fedaghi, "Enriched diagrammatic representation for resolution," The Asia Pacific Symposium of Intelligent and Evolutionary Systems, November 7–9, 2013, Seoul, Korea. This article also appears in Procedia Computer Science, Elsevier.

[17] S. Al-Fedaghi, "How to diagram your drama story," HCI International 2013, July 21–26, 2013, Mirage Hotel, Las Vegas, Nevada, USA. Lecture Notes in Computer Science/Artificial Intelligence, Springer. Extended version is published in the Communications in Computer and Information Science (CCIS) series, vol. 374, 2013, pp. 531–535.

[18] S. Al-Fedaghi, High-Level Representation of Time in Diagrammatic Specification, Procedia Computer Science Journal, This paper is from the 2015 International Conference on Soft Computing and Software Engineering (SCSE '15), University of California at Berkeley (UC Berkeley), USA, March 5-6, 2015.

[19] K. H. Rosen. Discrete Mathematics and Its Applications, 7th ed., 2011.

[20] D. Pritchard, "Knowledge," Central Issues of Philosophy, J. Shand, Ed., Blackwell, 2000, 24-36

[21] E. Gettier, "Is justified true belief knowledge?," Analysis, vol. 23, 1966, 121–123. http://philosophyfaculty.ucsd.edu/faculty/rarneson/courses/gettierphilreading.pdf

[22] Wikipedia, Gettier problem, Accessed May, 10, 2015.