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Specifying Knowledge Graph with Data Graph, Information Graph, Knowledge Graph, and Wisdom Graph

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ABSTRACT

Knowledge graphs have been widely adopted, in large part owing to their schema-less nature. It enables knowledge graphs to grow seamlessly and allows for new relationships and entities as needed. A knowledge graph is a graph constructed by representing each item, entity and user as nodes, and linking those nodes that interact with each other via edges. Knowledge graphs have abundant natural semantics and can contain various and more complete information. It is an expression mechanism close to natural language. However, we still lack a unified definition and standard expression form of knowledge graph. The authors propose to clarify the expression of knowledge graph as a whole. They clarify the architecture of knowledge graph from data, information, knowledge, and wisdom aspects respectively. The authors also propose to specify knowledge graph in a progressive manner as four basic forms including data graph, information graph, knowledge graph and wisdom graph.

KEYWORDS

Graph, Information, Knowledge, Knowledge Data, Wisdom

1. INTRODUCTION

There are different kinds of discrete data in the real world we live in. The data cannot be used if they exist only in the discrete form. However, this is not worth worrying as we can simply make the data meaningful by giving a specific environment. Data are processed to be useful and presented to us in the form of information, then we can get a lot of fragmented expressions. With these fragmented expressions, that is, the conception "information" we mentioned above, we can combine multiple information to answer more complex questions about how to do it. By abstracting and converting information and data in a given context and the application of data and information (Bellinger & Castro, 2004), knowledge shows up. Furthermore, comprehensive knowledge of the same category can be use of making favorable judgments, precisely predicting, and smartly planning. Obviously, the utilization of vested knowledge is beyond its literal meaning of the category, which is what we say, "wisdom". Figure 1 shows the progressive relationship among data, information, knowledge and wisdom. Data existing as discrete elements have no semantics. Information is data after procession of conceptual mapping and relational connection. Users access to information after filtering valuable information and internalize those information into knowledge. When information is adequately assimilated, it produces knowledge which modifies an individual's mental store of information and benefits his/her development and that of the society in which he/she lives.

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In our previous work (Duan et al., 2017), we clarified the architecture of Knowledge Graph as a whole and extended the existing concept of Knowledge Graph into four aspects including Data Graph, Information Graph, Knowledge Graph and Wisdom Graph. Shao et al. (2017) proposed to answer the Five Ws problems through constructing the architecture of Data Graph, Information Graph and Knowledge Graph. We clarify the architecture of knowledge graph from $Data_{DIKW}$, $Information_{DIKW}$, $Knowledge_{DIKW}$ and $Wisdom_{DIKW}$ aspects respectively. Correspondingly, we propose to extend the existing expression of knowledge graph in a progressive manner as four basic forms including $DataGraph_{DIKW}$, $InformationGraph_{DIKW}$, $KnowledgeGraph_{DIKW}$ and $WisdomGraph_{DIKW}$. We propose a DIKW approach to support dynamic semantic modeling through a progressive hierarchy of $DataGraph_{DIKW}$, $InformationGraph_{DIKW}$, $KnowledgeGraph_{DIKW}$ and $WisdomGraph_{DIKW}$. We define the resources and the four graphs as follows:

Definition 1: Resource elements ($Elements_{DIKW}$).
$Elements_{DIKW}$: = <$Data_{DIKW}$, $Information_{DIKW}$, $Knowledge_{DIKW}$, $Wisdom_{DIKW}$ >;
Definition 2: $Graph_{DIKW}$. We extend the concept of existing knowledge graph into four parts: $DataGraph_{DIKW}$, $InformationGraph_{DIKW}$, $KnowledgeGraph_{DIKW}$ and $WisdomGraph_{DIKW}$.
$Graph_{DIKW}$: = ($DataGraph_{DIKW}$), ($InformationGraph_{DIKW}$), ($KnowledgeGraph_{DIKW}$), ($WisdomGraph_{DIKW}$).

We show the progressive forms of resources type in Table 1. $DataGraph_{DIKW}$ can be expressed through a variety of data structures including array, list, link and combination of multiple data structures. Semantic modeling of $Data_{DIKW}$, providing a platform-independent $Data_{DIKW}$ representation will be a major advantage in the cloud space. $InformationGraph_{DIKW}$ expresses the interaction between entities in the form of a directed graph. $KnowledgeGraph_{DIKW}$ is of free schema and expresses rich semantic relationships which is conductive to have a completing mapping towards requirements described in the form of natural language. $WisdomGraph_{DIKW}$ can be used to organize unknown resources inferred through existing known $Data_{DIKW}$, $Information_{DIKW}$ and $Knowledge_{DIKW}$.

In the rest of this paper, we firstly elaborate representations of $DataGraph_{DIKW}$, $InformationGraph_{DIKW}$, $KnowledgeGraph_{DIKW}$ and $WisdomGraph_{DIKW}$ in Section 2, 3, 4 and 5 respectively. Then we describe the progressive relationship among $Data_{DIKW}$, $Information_{DIKW}$, $Knowledge_{DIKW}$ and $Wisdom_{DIKW}$ in Section 6 and 7. The related works are elaborated in Section 8. And we conclude our work in Section 9.

2. REPRESENTATION OF $DATAGRAPH_{DIKW}$

$Data_{DIKW}$ is the symbolic representation of observable properties of the world. $Data_{DIKW}$ is obtained by observing basic individual item of numbers or other information, but on its own, without context, $Data_{DIKW}$ has no meaning. Storing of $Data_{DIKW}$ does not change $Data_{DIKW}$ itself, but it has many expression forms (Zins, 2010). As Figure 2 shows, $Data_{DIKW}$ can be organized in many different types of data structures, including arrays, stacks, list links and so on. $Data_{DIKW}$ can be of structured, semi-structured and unstructured, relational or non-relational form. Generally, $Data_{DIKW}$ is represented as many discrete elements originally (Johannessen & Fuglseth, 2014). Figure 3 shows a series of original

Figure 1. Progressive relationship among data, information, knowledge and wisdom