Knowledge maps for managing Web-based business

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Abstract
Knowledge management has recently received considerable attention in the Web-based business community. This paper discusses the key concepts of human-computer interaction in knowledge development, and identifies new challenges of knowledge management for Web-based business. Based on theories of knowledge representations and semantic networks, this paper proposes a structure of knowledge maps for knowledge management in the Web-based business environment. An example of knowledge maps for online auctions is used to illustrate the application of the proposed structure of knowledge maps.

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Introduction

Knowledge management has become one of the important topics of management (Yen *et al.*, 2001). Knowledge management is a process that deals with the creation and utilization of high-level information within an organization to improve its business performance (Gupta *et al.*, 2000). After a period of proliferation of electronic commerce, knowledge management plays a crucial role in the globalization of Web-based business (McManis *et al.*, 2001).

There have been several new journals that entirely devote to research into knowledge management. In addition to this, many traditional information systems journals have recently published special issues on knowledge management. Information technology-based knowledge management involves many disciplines. It overlaps with information systems development (Sage and Rouse, 1999), information resource management (Nissen *et al.*, 2000), decision support systems (Ramesh and Tiwana, 1999), artificial intelligence (*Knowledge and Information Systems: An International Journal*, 2001), human resource management (Rastogi, 2000), and others.

Although knowledge management is viewed as one of the important issues for academic research and industrial practices (Wiig, 1999), the majority of senior executives have hardly perceived its real value yet (De Long and Fahey, 2000). On the managerial side, enterprises are seeking the support of information technology to catch the waves of business process reengineering and electronic commerce through knowledge management. On the scientific research side, artificial intelligence techniques for knowledge management (e.g. Quillian, 1968; Shapiro, 1990; Sowa, 2000) developed in the past decades need to make themselves in their general contours available for managers. On the technical side, generic knowledge management tools and software available at the present time have little powers beyond traditional information management (Ruggles, 1997) or groupware systems (Applied Learning Labs, 2001). Currently widely used keyword search engines and structured menu-driven user-computer interfaces do not meet the challenges of knowledge management. The mismatching between the expectations of enterprises and the realistic capability of information technology becomes the key issue of knowledge management, and raises new tasks for academic researchers and practitioners in knowledge management.

To support knowledge management for electronic commerce effectively, development of human-computer interaction-based knowledge management tools is imperative. Knowledge management tools are used by knowledge workers for the effective coordination of their actions in doing online business. Next, we discuss the characteristics of knowledge management for electronic commerce, and propose a knowledge management tool for online business.

Knowledge is coordination of actions

There have been many definitions of knowledge used in various disciplines (Liebowitz, 1999). In this study, we follow Zeleny's (2000) definition: knowledge is purposeful coordination of actions, and knowledge cannot be separated from the process of knowing. By this definition, individuals construct their own knowledge through experiencing and interacting with the surrounding world. Hence, given the capability of current information technology, any item stored in computer could be data, or information, or knowledge representation, but is not knowledge itself. Generally

speaking, documented experts' opinions (production rules), data mining results, and decision-making algorithms are high-level information. These pieces of information are only the inputs for human's actions. In this sense, human, not any computers, possesses knowledge, and knowledge management must emphasize human actions.

Due to the power of information technology, some information is quite useful for humans in coordinating actions, especially when the action is structured and simple enough. This gives an illusion that one can acquire knowledge from computers without doing. The pitfall of this misperception is over-emphasis on "knowledge discovery", and de-emphasis of the role of user-computer interaction in developing knowledge through performing unstructured actions. For example, a data mining process asserts that "supermarket customers who buy diapers are more likely to purchase beer". This observation is a piece of information, but is not knowledge in general. To develop his/her knowledge, the manager must take a specific action (e.g. re-order) based on this consumption pattern. The answer to whether this information is an input to the knowledge development depends upon the action. For instance, when the manager tries to determine whether diaper and beer should be put on the same shelf in order to increase sales, this diaper-beer consumption pattern might contribute little to the knowledge development in this case.

Human's knowledge is a complex organization of goals, beliefs, and concepts. Knowledge is coordination of actions, rather than detached pieces of information. Starting from this definition, we conceive that the human-computer aspects are crucial for knowledge management in the Web-based business environment. Specifically, it is important to investigate issues of how human-computer interaction can support the user to develop goals, beliefs, and concepts, and coordinate operations, learning, and decision making for the online business.

Roles of knowledge management in Web-based business

Knowledge management in Web-based business is a significant organizational challenge. Knowledge management plays many key roles in Web-based business.

Transition from information to knowledge

In Web-based business, ubiquitous computing makes the organization easier to acquire, generate, and store information. The transition from information to human's knowledge is a major task of knowledge management to optimize the utility of information (Blumentritt and Johnston, 1999). Such a transition must rely on the active learning of the information user through actions. One of the roles of knowledge management in a Web-based business is to create a learning environment for the organization, and require individuals to develop their knowledge through business problem solving.

Translate knowledge into information

In Web-based business, much of the important work in organizations is accomplished by teams. Building the organizational memory that symbolizes the organizational knowledge structures is another key task of knowledge management (Cross and Baird, 2000). While knowledge always remains implicit in individual human's mind, we must model the structure of knowledge that symbolizes coordination of business actions. Those structures of knowledge are aggregated and synthesized to produce organizational learning. Therefore, an important role of knowledge management is to identify and collect the structures of knowledge, and transform the knowledge representation into information that can be digitized and shared by all individuals of the organization.

Implement Web-based learning and actions coordination

Knowledge management has been with us for a long time; however, the issue of knowledge management has not become so important until electronic commerce was introduced years ago. In fact, knowledge management and Web-based information technology can never be separated in exploration of modern successful business (Khalil and Wang, 2001). The unique aspect of knowledge management in the internet era is the application of Web-based information technology to knowledge development. The development of competent human-centered Web-based support systems beyond databases, information repository, and groupware systems for organizational learning and actions coordination is the key to effective electronic business.

Next, we propose a method of knowledge maps to support knowledge management for the above roles. We develop an instrument that can symbolize coordination of online business activities. As explained in the next section, the semantic association of human-perceived entities in cyberspace related to the online business is the central wisdom of the instrument.

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Knowledge maps

The concept of graphical representation of knowledge structures has been developed a long time ago (e.g. Quillian, 1968). A simple form of knowledge structure representation is box-link graphics. The term "knowledge maps" and a form of knowledge maps have been used in the literature of thinking and communication a decade ago (Evans and Dansereau, 1991; Hall *et al.*, 1992). Knowledge mapping is becoming an important research topic of knowledge management in the Internet era (Maule, 1997; Herl *et al.*, 1999). While no single form of knowledge maps can fit all knowledge domains, one of the crucial tasks of knowledge management is the conscious design of knowledge mapping for the specific domain (Wexler, 2001).

In the business field, research into business graphics has a relatively long history in the management information systems field (Montazemi and Wang, 1988). Historically, research in this area has been focussing on the cognitive effects of business graphics on the human reaction to a decision environment (DeSanctis, 1984). Time saving in decision making, precision of the perceived data, and ease for recalling are common concerns of the use of business graphics. Later, static cognitive maps were promoted as management tools (Fiol and Huff, 1992). More recently, multimedia presentation as a new variable has been investigated in this area (Lim and Benbasat, 2000). Despite the presence of an extensive number of studies dealing with business graphics, little research into the structure of knowledge maps for effective electronic commerce has been reported. Next, we propose the form of knowledge maps for knowledge management in Web-based business.

Knowledge maps for Web-based business

According to Beckman (1999) and the references in his article, including Alter (1996), Tobin (1996), and van der Spek and Spijkervet (1997), knowledge representations include data of facts, information of summarized data and cases, knowledge representations for procedures, rules, ideas that guide actions and decisions. All these entities are Web documents that are semantically linked into a network as a knowledge map. A knowledge map can show the paths of actions for the user to achieve a certain goal. A primitive knowledge map consists of a pair of Web document entities and a relational linkage. It is formalized as shown in Figure 1. A large knowledge map is a composition of a set of primitive knowledge maps.

A Web document could be a static Web site with its location (URL) and a dynamic Web page generated by a server and presented on the client side. The Web documents mapped by a knowledge map is organized into a structure. Physically, this structure is a network of these static Web sites and the dynamic Web pages.

A knowledge map for a Web-based business is usually large. To make a large knowledge map visualized and manageable to the user, the entire map must be partitioned into parts. The partition is done through categorizing Web documents and developing the inheritance relationships pertinent to the domain. A formalized generic Web document category can help the organization in general aspects of knowledge map development. A generic Web document category for knowledge maps for the domain of Web-based business is proposed as follows:

- *Task*. Knowledge management for Web-based business is to provide online business task descriptions through the human-computer interaction. One of the most popular approaches to task descriptions is hierarchical task analysis (Annett and Duncan, 1967). A task is formally described as a hierarchical structure of its sub-tasks. However, in the knowledge management frame, the structure of a task is dynamic. That is, the user can assemble a task based on the business dynamics. The dynamic mode makes the representation of a task structure more flexible than the traditional static mode of designing the human-computer interaction (e.g. menus).
- *Procedure*. Knowledge development is the process of doing and learning. One of the major objectives of knowledge management is to support the user to conduct actions through decomposition of the unstructured actions into structured procedures, and execute these structured procedures.

  Each structural procedure is usually formalized by defining the protocols (e.g. when, where, and who) and instructions (e.g. how). The formal descriptions of procedures represent explicit expertise in the organization, while the selection and combination of the structured actions are the user's discretion.
- *Episode*. Knowledge management is designed toward the support of human cognitive activities. Human knowledge development is often story-based.

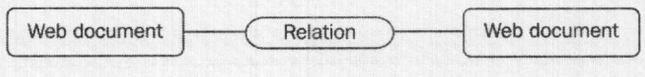
Therefore, the core competence of knowledge derives from episodic events. A recorded meeting and a live auction scene are examples of episodes for knowledge development. An episode can be played or replayed via the Internet.

- *Cognizance.* Cognizance concepts are powerful appliances to symbolize knowledge representations for knowledge management. In the fields of artificial intelligence and operation research, there has been abundant literature on cognizance concepts. Production rules, cognitive maps, and semantic networks have been used to represent human's expertise, rules of thumb, beliefs, and views of the real world. In fact, a knowledge map as we proposed in this study is a type of cognizance.
- *Instrument.* An elementary model that can be used for the user for operations, deriving conclusions, testing hypotheses, or discovering abnormal phenomena is called an instrument. An instrument could be a guideline, a statistical model, an operational research model (mathematical programming, networks, inventory model), a nondefinitional model (reasoning logic, simulation, inference engines, search engines), or an accounting/financial model.
- *Reference.* A free-format Web document other than the Web documents discussed above is called a reference document. A reference document may not be applied for business actions directly, but could be useful for learning.

Construction and maintenance of a knowledge map

A knowledge map for the Web-based business is a synthesis of the above six categories of Web documents based on the contingency of knowledge sharing in the organization. The first step of the development of a knowledge map is to identify the six independent categories of Web documents (task, procedure, episode, cognizance, instrument, and reference), and the second step of the development is to synthesize these six categories of Web documents and implement the construction. In this step, the relationships between the Web documents are constructed.

Figure 1
Primitive knowledge map



The relationships between the Web documents could be diversified. Yet, there are generic semantics that commonly exist among these Web documents and can be used for general purposes of knowledge management for Web-based business. For instance, in terms of inheritance relationships, a top-level Web document "has a" low-level Web document, and a low-level document "belongs to" a top-level Web document. A task "applies" a procedure(s). A procedure can "have its successive" procedure(s) "if a condition is true". The success of knowledge maps construction for knowledge management highly depends on those semantic relationships between the Web documents used for the Web-based business. Apparently, the commonly used techniques such as bookmarker, Web page site maps, menus, and hyperlinks can be integrated into knowledge maps in order to provide effective knowledge sharing for Web-based business.

The third step of the development of a knowledge map is to maintain the knowledge map through adding or deleting entities of Web documents on the map and modifying the relationships between the Web documents. The updated knowledge map reflects the current structure of knowledge for coordination of the business. Next, we present an illustrative case to demonstrate a prototype of the knowledge map model for online auctions.

An example of knowledge maps for online auctions

Online auctions have been an important type of Web-based business to sell merchandise based on effective pricing approaches. Conventionally, auctions are commonly applied to sell unique and unusual items including celebrities' personal property and art. Since the Internet became the electronic commerce media, online auctions are virtually applied to all kinds of commodities ranging from low-price CDs to expensive real estate (eBay, 2001). Through the Internet, a bidder can also become an auctioneer, or vice versa. Since the Web documents of online auction sites are highly diversified, a crude navigation of online auction Web sites for business is ineffective. In this case, a knowledge map is able to help the user to conduct online auctions in an effective way. This would be especially useful for those people who make a living buying and selling goods through online auctions.

In this example, we show how knowledge maps can be used to support knowledge

development in auctions for the bidder. In Figure 2, the top-level knowledge map provides major actions that might be involved in auctions. Each entity on the map is actually a GIF image. It is clickable and is linked to a Web document. The icons shown on the entities indicate the categories of the six types of Web documents. From the top-level knowledge map, the user can scroll down to a detailed local knowledge map by clicking a task (e.g. "search auctions") or a relationship linkage (e.g. "use" between "search auctions" and "search engine"). For example, if the user clicks "bid", the local knowledge map will show up as Figure 3.

As shown in Figure 2, a procedure Web document (e.g. "registration procedures") is usually a menu that in turn provides hyperlinks to Web pages with forms to allow the user to input data or perform a procedure. An instrument Web document (e.g. "search engine") allows the user to use tools embedded in the Web page to solve a specific problem. An episode Web document (e.g. "live auctions") allows the user to view a multimedia presentation. A cognizance Web document (e.g. "bidding rules of thumb") shows high-level information or symbolized knowledge presentation. A reference Web document (e.g. "list of auctions") provides reference information and hyperlinks to other Web documents. Figure 4 shows the example that is displayed after the user clicks the entity "list of auctions" on the map. It indicates that the Web document has hyperlinks to the auction Web sites such as Amazon.com, eBay.com, and others.

Compared with the traditional site maps and menus, knowledge maps have the advantage in supporting the user to develop knowledge by coordinating unstructured actions. A knowledge map provides a guide for the user to view the knowledge structure for the Web-based business at the level of the task domain. The knowledge structure represented by the knowledge map facilitates task-related decision making and problem solving as well as task-related organizational learning. Technically, a knowledge map integrates naturally with individual site maps and hyperlinks to provide a network of information repository, tools, and procedures that is capable of supporting the user to transform unstructured actions to structured actions.

Clearly, the price for the above advantages of knowledge maps is the time-consuming elaboration process to build these maps for the Web-based business.

Figure 2
The top-level knowledge map for auctions

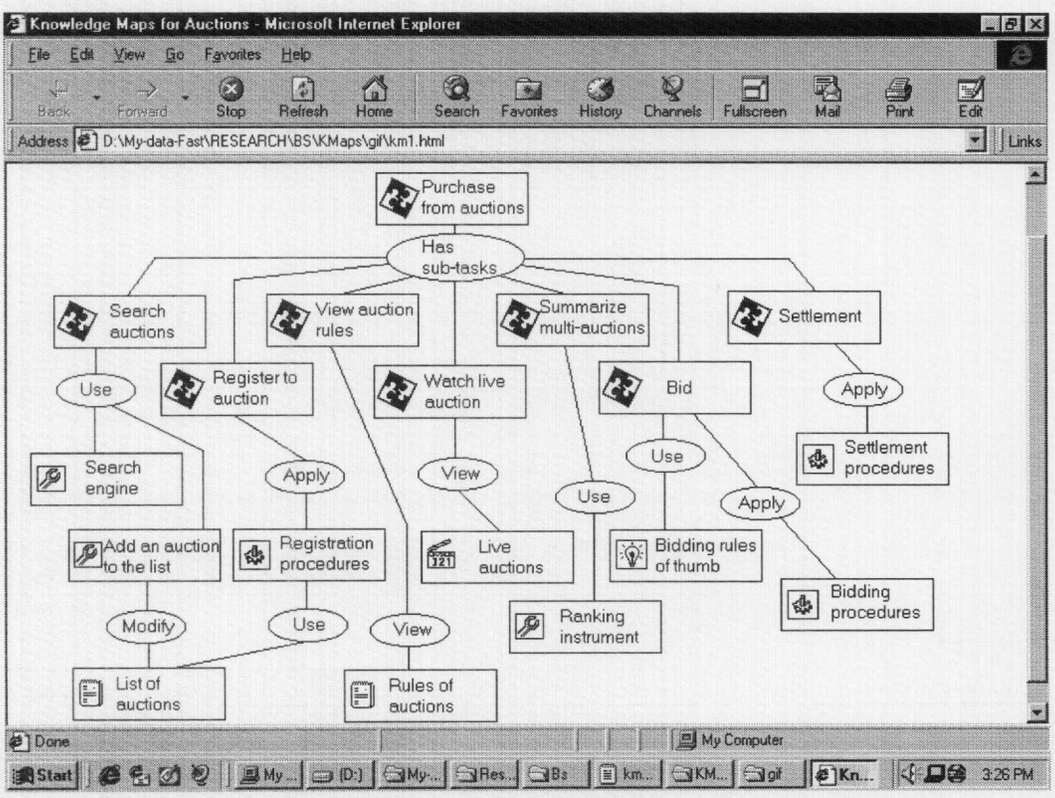


Figure 3
A detailed knowledge map

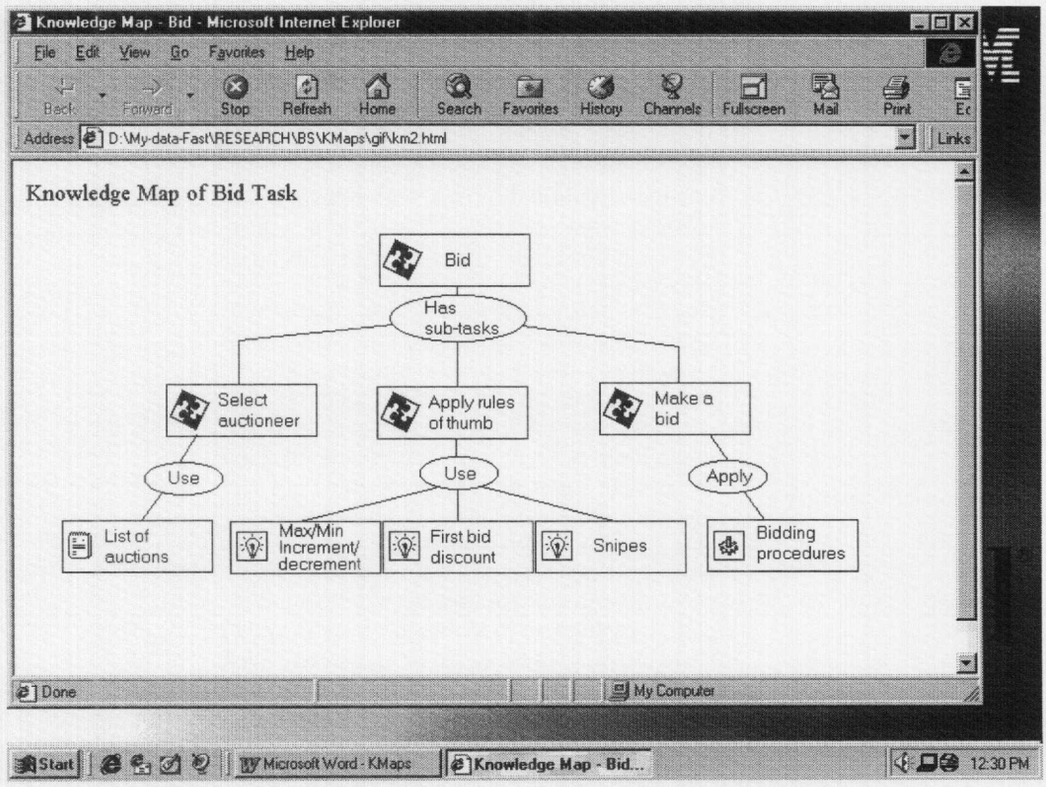
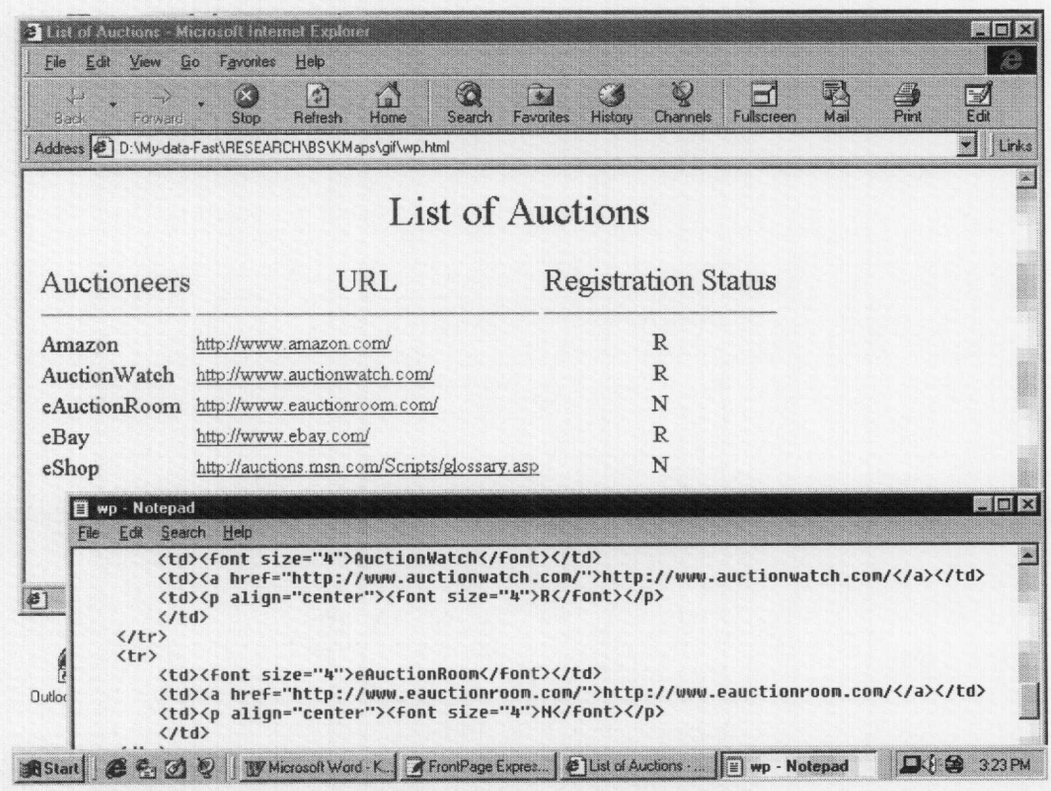


Figure 4
A Web document and its hyperlinks



Conclusion

This paper discusses the crucial concepts of knowledge management, and explains the distinction between knowledge and information. It also outlines the major roles of knowledge management in Web-based business. The competence of Web-based business depends not only on the abundance of information on the Internet, but also on the effectiveness of knowledge management based on human-computer interaction. To provide more tools for knowledge management in Web-based business, it proposes a specific model of the structure of knowledge maps. This model is based primarily on the premise of semantic networks and business graphics for human-computer interaction, and shift data/information management to knowledge management using the Web technology.

In the proposed structure, Web documents are semantically linked and mapped onto a map. To make a large knowledge map visualized and manageable to the user, the entire knowledge map must be partitioned into parts. The partition is done through categorizing Web documents. Task, procedure, episode, cognizance, instrument, and reference are the six typical categories of Web documents in knowledge management. For each Web document, there can be a local map that is closely related to this Web document. The user is allowed to navigate the entire knowledge map by exploring, searching, and viewing local maps.

A knowledge map does not replace the user's activities in determining actions. Rather, it will aid the user to better use the knowledge map to conduct unstructured actions and develop his/her own knowledge though doing business. As a result, the use of knowledge maps would allow the user to fully utilize the Internet in an effective way.

This study has shown the way of computer support for knowledge management in the Internet era. It raises new tasks for all parties involved in knowledge management. For business in electronic commerce, knowledge sharing through knowledge management techniques is crucial for the success of Web-based business. For software developers, new techniques and tools for knowledge management are imperative. Simple Web navigation tools and general search engines are no longer adequate for knowledge management. New knowledge management tools need to be fully integrated in the Web environment. For the users in Web-based business, new skills are required in the knowledge management era. They must better understand the structure of the Web-based business, and possess the ability of transforming unstructured actions to structured tasks through the use of knowledge maps.

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