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Personalized Agent Modeling by Modified Spreading Neural Network

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Abstract

Generally, we want to be searched the newest as well as some appropriate personalized information from the internet resources. However, it is a complex and repeated procedure to search some appropriate information. Moreover, because the user's interests are changed as time goes, the real time modeling of a user's interests should be necessary. In this paper, I propose PREA system that can search and filter documents that users are interested from the World Wide Web. And then it constructs the user's interest model by a modified spreading neural network. Based on this network, PREA can easily produce some queries to search web documents, and it ranks them. The conventional spreading neural network does not have a visualization function, so that the users could not know how to be configured his or her interest model by the network. To solve this problem, PREA gives a visualization function being shown how to be made his interest user model to many users.

Key words : personalized agents, modified spreading neural network, web search engine

1. Introduction

A personalized agent system needs a user profile to compute and interpret the user's information requirements. So it uses a user profile that contains user's interests to search and filter information from WWW. The most important thing in construction of a user profile is how to learn intelligently about user's interests [1,2].

There are some applications trying to learn a user's interest. For example, WebWatcher[3], Krakatoa Chronicles[4], Fab[5], News Weeder[6] and so on. These applications use a vector space model to represent documents or user's interests. They also use a relevance feedback and a reinforcement learning to profile the learning algorithm. These approaches are well understood but they do not contain some semantic relations between terms and documents. Therefore, I tried to make a network based on a construction of a user profile and a learning algorithm that can be modeling concepts that are important for some users and reduce a feedback process.

Jennings and Hideyuki proposed a user model neural network for making a user profile for a personalized news service[7]. A user model neural network can be made by a simple model of activation spreading networks that have studied in information retrieval and semantic network area[8]. It consists of terms and their associated weights. Terms have their own energies that indicate their importance, and there are correlated weights that indicate some correlation among terms.

The conventional user model neural network by a spreading activation network is useful more than by other multi-layered neural network. Therefore, in this paper the modified user model neural network is used as a profile mechanism in PREA (Personalized Research Agent) system. And the network can be formulated by the energies and the weights among terms. However, in the previous studies it is ambiguous that how the network is learning mathematically. To make up for the problem, a visualization process of making a user model in real time is proposed here. Through the changes of the network, users can see how to be changed the energies of terms and weights and the configurations of their interest in PREA.

This paper is composed of 5 chapters. In chapter 2, I will explain the PREA structure and the modeling concept. In chapter 3, I will explain the implementation processes. In chapter 4, I will discuss some simulation results, and finally I will discuss conclusions and further studies of this paper.

2. Overview of PREA System

Figure 1 provides an overview of the whole PREA system. In PREA, a user must input lots of paper data that he or she wants to manage before the agent can process. The knowledge of paper data is a kind of terms such as titles, authors, journal and abstract and so on. Whenever a user uses the local paper database, PREA records queries, search results, selected records and printed or saved records. The paper data which a user contacts become features. The features are used to construct and adapt a user model neural network with web document features.

After the construction of a user model neural network by features of paper database, PREA prepares to search web documents. PREA makes a query which is suitable to AltaVista[11] engine from a user model neural network by selecting several high energy terms from the network. The

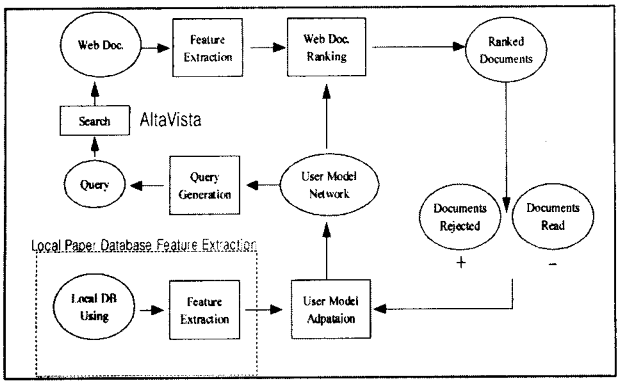

Figure 1. Overview of PREA System

search engine searches documents from the web based on a given query by PREA and returns the results. PREA ranks the retrieved web documents based on a user model neural network.

The ranked web documents are proposed to a user. If the user selects a URL web browser, it connects to the web site in PREA. The user can explore the links of the web sites and can reject them if they are not related with his or her interests. The selected and rejected web documents are used for constructing and adapting the network about the user model. As time goes by the network, it adapts to the user's interest very well.

3. User Model by Modified Spreading Neural Network

A user model neural network proposed in this paper is not a radically new model of neural network. However, it has somewhat different structures from the traditional neural network structure. Because a user model neural network is a simple form of spreading activation network that have studied in IR(Information Retrieval) and semantic network area. In this part I will consider how it is different from the traditional neural network models and why the network is appropriate for modeling of a user's interest.

3.1 Neural Network and Spreading Activation Network

Figure 2 shows the simple multi layer neural network and fully connected neural network. The multi layer neural network consists of an input layer, an output layer and more than one hidden layer. It is also fully connected by a hidden layer but not directly fully connected. The weights between layers have information about relations between inputs and outputs. As larger and more complex network, it generally offers greater computational capabilities. The multi layer network have been proven to have capabilities beyond those of single layer fully connected network directly connected between each nodes and each nodes' output affects again other's inputs. So the network can be considered as a recurrent one layered network.

A user model neural network is a kind of fully connected network. There are some reasons why a fully connected network is useful for modeling of a user's interests. Inputs are term's weight from paper database and web documents, and outputs are a value that indicates how much similar with user's interest.

In the user model neural network proposed by this paper, each input becomes terms in some documents. And I can train with some positive documents that a user is interested and some negative documents that a user is not interested. After training documents, if a new document comes to the network output which has a number between 0(not interested) and 1(interested). So PREA can classify new documents based on the network. But there is a problem in training new data. A user's interests can change in timely manner, so the network must train again by whole previous documents data and a new data, but it is a very heavy computation. It is also hard to adjust the number of units in hidden layers if the numbers of input units are changed. And it is not obvious the relations with each input units, so it can't change or adjust the correlated weights of units directly.

But if it is used a fully connected network that the relations between each unit are obvious, it can adjust them directly. A fully connected network is used in Hopfield network[9]. Hopfield network is very useful in associative memory and a traveling salesman problem. A user model neural network uses Hopfield network in structure and concept of energy, but it is quite different from Hopfield network in that the training algorithm and it's using.

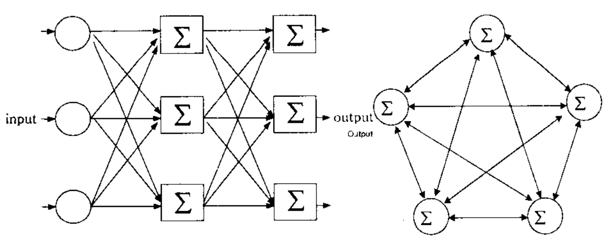

Figure 2. Multi layer neural network vs. fully connected neural network

A spreading activation network is an associative processing paradigm to be used in Information Retrieval [8]. It is made up of a conceptually simple processing technique on a network data structure. The network consists of nodes connected by links, as depicted in Figure 3. The nodes are modeling objects or features of the "real world" to be represented.

They are usually labeled with the name of the objects that are intended to represent. The links are modeling the relationships between nodes and weights. The connectivity pattern reflects the relationships between objects and features of objects of the "real world" to be represented. And the processing techniques are defined by sequences having many iterations, and each iterations are followed by another iteration until halted by a user or by triggering of some termination condition. This spreading phase consists of a number of passages of activation weaves from one node to all other nodes connected to it. There are many ways of spreading on the networks[10].

A user model neural network has a simple structure known as a spreading activation network. The idea of activation and learning each node is similar with neural network that Jennings has used before the user model neural network, but this thesis adjusts previous studies of a user model neural network. One is a formulation of term energy and weight between terms. In previous studies it was ambiguous how network is learning mathematically. The other problem is lack of a visualization process of a user model network in application. Even though network changes and evaluates during use of applications, a user couldn't see how much the value of energies and weights are and how network looks. However, in the course of the using of an application, a user can see how network change in PREA.

3.2 Structure of User Model Neural Network

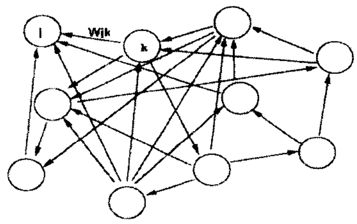

Figure 3. Spreading activation network

A user model neural network is constructed with nodes of terms and weights between nodes. The nodes of a network represent words that frequently appear in paper database or web documents that a user has read. It is similar with a spread activation network that has been used in IR. Figure 4 shows the modified user model neural network proposed in this paper. The formulation of terms weights and weights between terms are followings.

(1) Learning in paper DB

Eq.1 $W_{iNEW} = W_{iOLD} + tf_i \cdot \alpha^l \cdot F_k \cdot A_t$

W_{iNEW} is new weight in node *i*. W_{iOLD} is old weight in node *i*. This equation means that the weight is increased by term frequency tf_i, paper database constant α^l, field constant F_k and database contact constant A_t.

(2) Learning in web documents

Eq.2 $W_{iNEW} = W_{iOLD} + tf_i \cdot \alpha^g \cdot f \cdot H_k$

Equation 2 is similar with equation 2. But there are some different variables. α^g is web documents constant which makes difference terms in web documents feature lists with paper database feature lists. f is a feedback constant. If terms are web documents that a user selects f is +1, and user rejects f is −1. H_k is a hyper text field constant that varies along some hyper text tags.

(3) Learning between terms

Eq. 3. $W_{ijNEW} = W_{ijOLD} + \alpha C_{ij}$

W_{ijNEW} is new weight between node *i* and *j*, W_{ijOLD} is the old weight between node *i* and *j* and C_{ij} is co-occurrence of term *i* and *j* in feature lists and α is constant to determin onamont of increase at each co-occurrence.

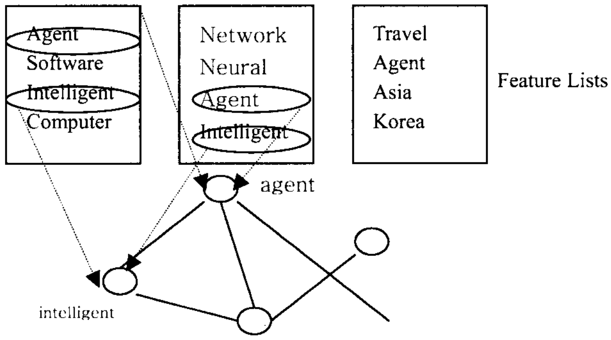

Figure 4. Modified spreading neural network of user model

The construction of a network is performed after each session of using the network browser is modified on the basis of the used web documents and paper database. So the computing time of a network is not excessive. As a network is intended to represent a user's interests, which will be changed over time, a mechanism of decay of node's energies is needed. PREA just set a fixed amount for decrease node's energy and connection strength.

3.3 Ranking of the Network

Assume that a network is already constructed by the method described in the previous section and there are feature lists of searched web documents. If the feature lists exist in the network, those terms can fire. And if the input to unfired terms is over the threshold, the terms can fire, too. The procedure is repeated for all nodes that are connected to active nodes. Until the network settles down to an equilibrium state, the procedure of node firing is continued for several times. Then PREA sums the all active node's energy, and it becomes a ranking score to measure how it is similar to the network.

The effect of a nonlinear measure is to bias the process of article ranking towards a deeper exploration of documents that are relevant to the current user interest. If there are a number of nodes with strong connections to a single feature in a web document, then that document will receive a high ranking.

4. Implementation and Simulations of PREA

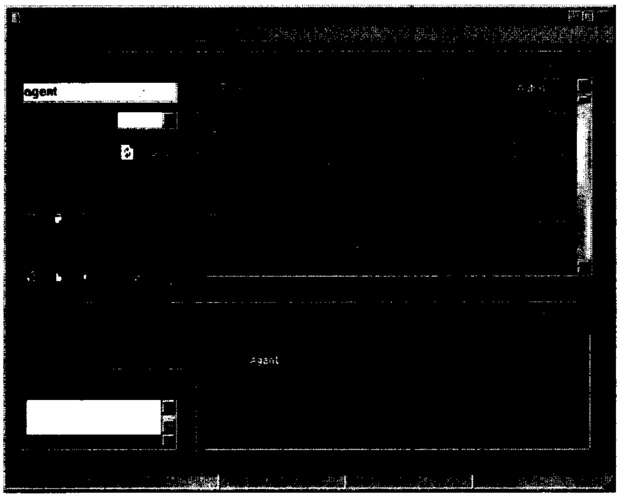

Figure 5. Main form of PREA

4.1 Initial Interface

Figure 5 shows PREA system as it appears to the user. The main form of PREA system is for a management of a paper database. The management of a paper database is also an important role of PREA. It organizes a paper database that a user had or is interested in. The use of paper database becomes basic information to construct and modify a network.

The left part of Figure 5 is a collection of tools to manage the paper database such as input, edit, print, lend, return and search. The right part is to search the results of paper data. For example, if a search query is the "agent", then the result is the whole paper data that include term "agent" in paper data field. The right below part shows that specific information of paper data that a user selects in search results.

After using the paper database, it can construct and adapt a network. The left part of the form shows terms in a profile by high weight order, and the right part shows the related terms and connection weights based on the selected terms from the left part. The size of the circle at each node means the node's weight and width of the connected line to each node refers to its correlation weight.

Therefore a user can see directly how a network is constructed and which terms are related to a specific term. Also a user can delete, edit and insert nodes and node's energies to the network. But a user must be cautious to edit the nodes directly because it affects the performance of the search and ranking. If a user clicks "Profile Update" button, the network is constructed an adapted based on user's paper database using. The process time depends on the number of terms in feature lists.

4.2 Web Document Ranking and Navigation

After the network is constructed, PREA searches web documents that a user is interested through the AltaVista search engine, and it ranks the search results based on the network.

The process is like the followings. A user can change the number of terms in query for AltaVista and the number of ranking web documents. If a user increases the number of terms in query, the number of results will be decreased. It means that precision will be increased but recall will be decreased in the searching. Even though AltaVista searches lots of web documents, it is needless to rank whole web documents. So a user can adjust the number of web documents to be ranked through the network. The initial number of ranking web documents is 30. The process time of web search and ranking depends on the number of web documents to be ranked. Because PREA visits each web site to be ranked, it extracts the main features. The traffic of some web site is usually high. So it takes a great deal of time to connect, and there is also the problem of disconnected web sites. In initial setup condition having 30 ranked web sites, it takes average 10~15 minutes to extract web documents feature and rank based on the network.

Figure 6 shows the result of ranking web documents based on the network. There are some information about the URL, title, site description, last updated date and language of ranking web site by high ranking order. Information about these web documents is from AltaVista. If a user does double clicks the URL, it connects to that web site using an internal web browser.

PREA's web browser includes Microsoft Internet Explore 5.0 and can observe user's browsing. If a user selects a web site for ranking results, the web browser will connect to that site. A user can explore another site that is linked from that site or check for unrelated site. PREA's web browser records this information from web sites that a user has visited or a user has rejected. After finishing the process a user can update a profile. If a user clicks "Update Profile" button as shown in Figure 6, and then the network starts an adaptation process, and its process time takes about 15~20 minutes.

The whole process is one session of network adaptation. It does not need to use a paper database at every session because the selected web documents also affect the adaptation of the network. But it is helpful to adapt quickly to a user interest at first stage. And PREA needs enough time to adapt to a user's interest.

4.3 Simulations Environments

The effectiveness of PREA system can be estimated by testing by many users. A user model neural network adapts to a user's interest when the user uses a paper database management and web document search and navigation. Before a real user test, PREA was tested for a network construction and web document ranking.

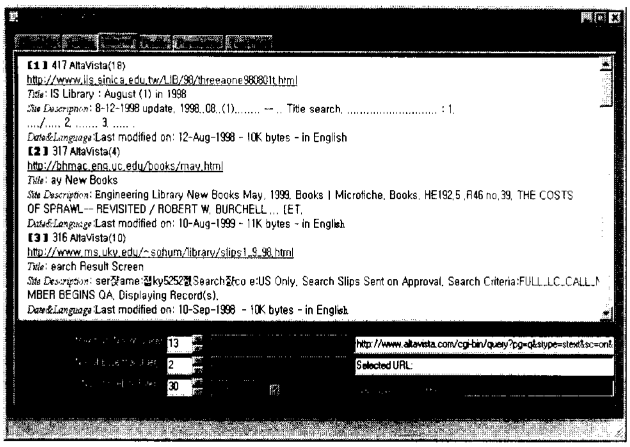

Figure 6. Ranking result of web documents

To see how well it works in network construction, the system was tested in 10 sessions. One session is a whole procedure of web document's searching, ranking and network adaptation. And 1, 2, 6, 7 sessions were only for local paper database features, and others were for the selected web document features. A user's interest was the "agent system", and about 800 local paper data were sampled at bibliography on software agents in the collection of computer science bibliographies[12] before simulation and saved to the paper database.

Figure 7 shows a network around sample terms "agents", "intelligence", "distributed", "reinforcement", "archit ecture" and "software". The first figure at top left shows that the related weight between "artificial" and "intelligence" is higher than other weights. So in ranking procedure it is more likely to fire "intelligence" than the term "artificial" fires. It is similar with the next figure, "artificial" and "distributed".

There are many parameters that may change a network status. In PREA, a user can directly change a network status, too.

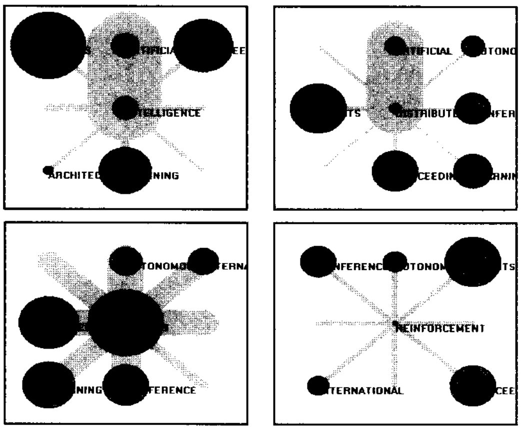

Figure 7. Network visualization process

4.4 Web Document Ranking

After confirming how well the network is constructed, in order to see how the network can filter and rank web documents quite well according to user's interest, I used the network in the previous session.

At first the system made queries for AltaVista search engine using the terms in the network. The number of query terms was restricted 13, and the number of essential query was 2. The system extracted the queries from the network. In the test, essential query terms were "agent" and "proceeding" and other 11 terms having high energy order were selected another query terms. Then the resulting number of documents by web searching was 335. And I set the number of web document to filter as 30, so the system visited 30 web sites and extracted features and began ranking web documents.

Table 1 shows the result of the ranking ordered by each score. The second column shows AltaVista search ranking. As it can be shown, it is somewhat different from PREA ranking. It is because AltaVista search engine only concerns statistical results of query but PREA concerns how it is similar with the network.

For example, the AltaVista ranking of the top PREA ranking document is only 18. But PREA ranking of the top AltaVista ranking document is 21. The reasons why the differences are happened is that the content of the top ranking documents in PREA is journal and conference list in the "artificial intelligent" and "agent" systems at Shinca University in Taiwan. Because in the documents there are many terms in the network it can be made to fire terms and related terms in the network, so the document can get high score. Even though AltaVista ranks top documents, it is just for the query. In top ranking document in AltaVista, there are so many documents almost having no relationship with "agent" area, even though it contains "agent" and "proceeding". The document is about House Bill list of State of Rhode Island, it is a very long list so many words in the query are contained even though they have no relation with software agent.

There are many parameters that can change the ranking. Among the firing parameters the firing threshold is the most important parameter in the network. Generally speaking, a wide range of network behaviors is possible with different settings. A low firing threshold gives a very active network that readily makes associations, giving a high article energy when several network nodes are present in the document. If it makes the threshold too low in PREA, it can be lost the ability to make high precision searches.

Table 1. Ranking result of PREA compare with AltaVista search

PREA	AltaVista	Score	URL
1	18	417.11	http://www.iis.sinica.edu.tw/LIB/98/threeaone980801t.html
2	4	317.03	http://bhmac.eng.uc.edu/books/may.html
3	10	316.23	http://www.ms.uky.edu/~sohum/library/slips1_9_98.html
4	17	259.95	http://regoc.srce.hr/iti/97proc.html
5	12	233.06	http://www.library.csuhayward.edu/acq/books/csi.htm
6	6	134.50	http://beta.bids.ac.uk/journallists/istpjournals.txt
7	21	126.92	http://www.library.ucg.ie/floors/ucgissns.txt
8	5	122.87	http://www.daimi.aau.dk/~brian/EDAIM26text
9	2	105.03	http://www.dbd.puc-rio.br/Tit_peri11.html
10	22	78.04	http://bioneer.kaist.ac.kr/~yshan/jif/sci_list.txt
11	14	74.72	http://www.bids.ac.uk/journallists/scijournals.txt
12	15	74.72	http://www.sissa.it/furio/journal.html
13	20	74.72	http://156.17.85.29/iflist94.htm
14	30	74.72	http://www.library.kaist.ac.kr/dlibrary/EXPANDED.txt
15	28	68.07	http://www.ifs.hr/ifs/ifs/biblioteka/cc/cc-i.html
16	29	68.07	http://library.kimm.re.kr/SCI/sci-i.html
17	23	67.59	http://icad.kaist.ac.kr/info/SCI_List/A.htm
18	25	62.65	http://www.nova.edu/cwis/hpdlibrary/nbk0698.html
19	3	49.04	http://www.state.ri.us/98session/WWWBILLH.HTM
20	19	41.69	http://www.ml.usoms.poznan.pl/journal/i.htm
21	1	17.47	http://204.17.96.10/WWWBILLH.HTM

4.5 Simulation Results

The final purpose of PREA is how the system can filter efficiently web documents that a user is interested. To measure it, real two users have used PREA for two weeks. They had different interests in research area. One is "Intelligent Agent", the other is "Digital Communication". Their interests were not clear but wide range of each area. To measure the system's efficiency, two measurements are presented in PREA.

a) Measurement 1:
Number of interesting documents in Top 10 ranking documents (ranking test)
b) Measurement 2:
Number of interesting documents in whole filtered documents (query test)

The measurement 1 can be a measurement for how PREA ranks interest web sites for a user, and measurement 2 can be a measurement for how PREA makes query well. Figure 8 shows the result of this test.

The condition of simulation is described the followings:

a) Number of documents to filter : 30
b) Number of terms in query : 10
c) Number of essential terms in query : 2
d) Network parameters, Featuring parameters which is determined by many trials

As it can be shown here, usually the average number of interest documents in PREA shown in top 10 ranking is much more than the results in AltaVista. This means that PREA can filter and rank of interest web documents for a user very well than other search engines.

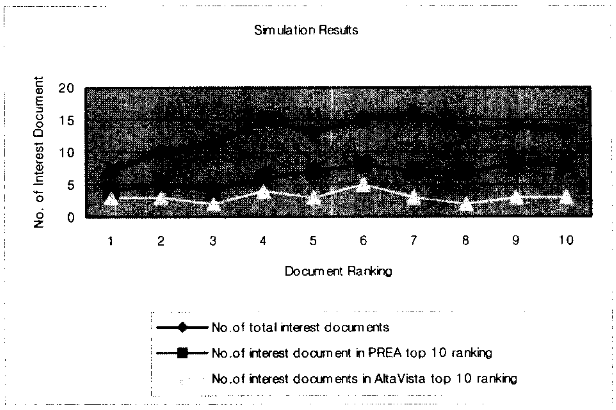

Figure 8. Simulation results

5. Conclusions

In this paper, I proposed a personalized research agent system, PREA, based on a modified user model neural network. PREA helps to manage and organize paper data and search out web documents for the research area that a user is interested in. To model the semantics of the entire information storage, a modified user model neural network is adapted in PREA.

The modified user model neural network is to overcome the computational cost associated with attempting to model the semantics of the entire information store, and overcome the vocabulary problem. It is the first application of a web filtering system using a user model neural network and there are lots of possibilities to modify the system.

In the course of searching web documents about user's interests, the conventional user model neural network does not give a visualization process making the user model, so that the user could not know how to make his model as well as how much correct the results. However, the modified user model neural network in PREA proposed in this paper shows a visualization process to the users very well, so that users can know the network mode about his interests.

In the future, PREA should make up for the following:

A computational cost that depends on network size should be reduced. Many other search engines should be adopted. Too many heuristic parameters are needed. The sufficient testing is needed.

Most of all, in order to probe PREA system, it is necessary to have so many tests about users who have different interests. Also, the visualization process of the network needs to be researched for refining, and the database of user's behaviors should be compensated in the future.

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