The Definition of MOLQ Updating Problem

Po-Wei Harn[1], Ji Zhang[2], Min-Te Sun[3], and Wei-Shinn Ku[2]

[1]Institute for Information Industry, Taipei, Taiwan 106

[2]Department of Computer Science and Software Engineering, Auburn University, Auburn, AL 36849, USA

[3]Department of Computer Science and Information Engineering, National Central University, Taoyuan, Taiwan 320

poweiharn@iii.org.tw *jizhang@auburn.edu* *msun@csie.ncu.edu.tw* *weishinn@auburn.edu*

1. PROBLEM DEFINITION

The multi-criteria optimal location query (MOLQ) updating problem is defined based on MOLQ problem [1]. We first define the object insertion and deletion operations over object sets as two types of object updating operations over a set of object sets. Then, given a universal set of object sets, $\mathbb{E} = \{P_1, \ldots, P_n\}$, the query result $MOLQ(\mathbb{E}, f^t, \sigma)$, and a set of changes on $\mathbb{E}$, the MOLQ updating problem is defined as a process that finds the result of MOLQ after the changes have been applied to $\mathbb{E}$. The changes on $\mathbb{E}$ are abstracted by a set of object insertion or deletion operations on $\mathbb{E}$. The updates on a particular object (e.g., the changes in its location, type weight, or object weight) are equivalent to deleting the object from $\mathbb{E}$ and then adding it back with new attributes.

1.1 Object Updating to a Set of Object Sets

Object Insertion Operation. Given a set of object sets $\mathbb{E} = \{P_1, \ldots, P_n\}$ and an object q ($\nexists\ P_i \in \mathbb{E}$, $q \in P_i$), we assume there exists an object set $P_j \in \mathbb{E}$, in which the objects are in the same type with q. Then we define the process of inserting q to $\mathbb{E}$ as follows:

$$\mathbb{E}' = \mathbb{E} \boxplus \{q\} = \{P_1, \ldots, P_j \cup \{q\}, \ldots, P_n\} \tag{1}$$

If an object set $Q = \{q_1, \ldots, q_k\}$ is given to insert into $\mathbb{E}$, the insertion process is equivalent to sequentially inserting each object in Q to $\mathbb{E}$. Note that there must exist one and only one object set in $\mathbb{E}$, which contains objects in the same type with the newly inserted object. Objects in Q can be in different types. We define the process that inserts an object set Q to $\mathbb{E}$ as follows ($\boxplus$ is left associative):

$$\mathbb{E}' = \mathbb{E} \boxplus Q = \mathbb{E} \boxplus \{q_1\} \boxplus \ldots \boxplus \{q_k\} \tag{2}$$

Object Deletion Operation. The object deletion is an inverse operation of the object insertion $\boxplus$. Given a set of object sets $\mathbb{E} = \{P_1, \ldots, P_n\}$ and an object $p_i^k \in P_i$, the object deletion operation that removes p_i^k from $\mathbb{E}$ is defined as follows:

$$\mathbb{E}' = \mathbb{E} \boxminus \{p_i^k\} = \{P_1, \ldots, P_i \backslash \{p_i^k\}, \ldots, P_n\} \tag{3}$$

Deleting a set of objects $Q = \{q_1, \ldots, q_k\}$ from $\mathbb{E}$ can be completed by removing each object in Q from $\mathbb{E}$. Every objects in Q must be contained by an object set in $\mathbb{E}$. Objects in Q can be in different types. The formal definition of deleting Q from $\mathbb{E}$ can be presented as ($\boxminus$ is left associative):

$$\mathbb{E}' = \mathbb{E} \boxminus Q = \mathbb{E} \boxminus \{q_1\} \boxminus \ldots \boxminus \{q_k\} \tag{4}$$

1.2 Multi-criteria Optimal Location Query Updating Problem

In this subsection, we focus primarily on the definition of MOLQ updating problem. We assume that the MOLQ has been addressed over a set of object sets. Each object is assigned with object weight and type weight. However, for any reasons, there are changes applied to a small number of objects, and the MOLQ is required to be re-evaluated over the updated object sets. So, the MOLQ updating problem can be defined as follows: given a set of object sets $\mathbb{E} = \{P_1, \ldots, P_n\}$, a type weight function f^t, and object weight functions $\sigma = \{f_1^o, \ldots, f_n^o\}$, where f_i^o is applied to an object $p_i^u \in P_i$, let $l = MOLQ(\mathbb{E}, f^t, \sigma)$ be the answer to the MOLQ query, Q be a set of objects updated to $\mathbb{E}$, then the multi-criteria optimal location query updating problem is to find an optimal location l', which minimizes the total weighted distance from l' to one object in each type after updating Q to $\mathbb{E}$.

If Q is inserted into $\mathbb{E}$, then

$$\begin{aligned} &MOLQ(\mathbb{E} \boxplus Q,\ f^t,\ \sigma) = l', \quad \text{if } l' \text{ satisfies the condition} \\ &MinD_G^W(l', \mathbb{E} \boxplus Q,\ f^t,\ \sigma) = \\ &\qquad min(\{MinD_G^W(l'',\ \mathbb{E} \boxplus Q,\ f^t,\ \sigma) \mid l'' \in \mathbb{R}\}) \end{aligned} \tag{5}$$

If Q is deleted from $\mathbb{E}$, then

$$\begin{aligned} &MOLQ(\mathbb{E} \boxminus Q,\ f^t,\ \sigma) = l', \quad \text{if } l' \text{ satisfies the condition} \\ &MinD_G^W(l', \mathbb{E} \boxminus Q,\ f^t,\ \sigma) = \\ &\qquad min(\{MinD_G^W(l'',\ \mathbb{E} \boxminus Q,\ f^t,\ \sigma) \mid l'' \in \mathbb{R}\}) \end{aligned} \tag{6}$$

It is worth noting that any change on an object is equivalent to deleting the object from $\mathbb{E}$ and adding it back with new attributes. The object insertion operation only applies to Q if, $\forall q_i \in Q$, there must exist an object set $P_j \in \mathbb{E}$, which contains objects in the same type of q_i. The object deletion operation only applies to Q if every object in Q must be in an object set of $\mathbb{E}$. The query result over updated object sets could be l or a better location.

2. REFERENCES

[1] J. Zhang, W. Ku, M. Sun, X. Qin, and H. Lu. Multi-Criteria Optimal Location Query with Overlapping Voronoi Diagrams. In *EDBT*, pages 391–402, 2014.