# Materialized View Selection for Data Warehouse Design

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## INTRODUCTION

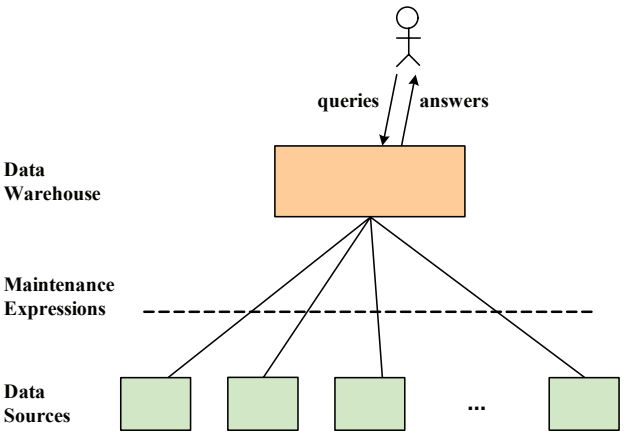
A Data Warehouse (DW) is a repository of information retrieved from multiple, possibly heterogeneous, autonomous, distributed databases and other information sources for the purpose of complex querying, analysis and decision support. Data in the DW are selectively collected from the sources, processed in order to resolve inconsistencies, and integrated in advance (at design time) before data loading. DW data are usually organized multidimensionally to support On-Line Analytical Processing (OLAP). A DW can be abstractly seen as a set of materialized views defined over the source relations. During the initial design of a DW, the DW designer faces the problem of deciding which views to materialize in the DW. This problem has been addressed in the literature for different classes of queries and views and with different design goals.

## BACKGROUND

Figure 1 shows a simplified DW architecture. The DW contains a set of materialized views. The users address their queries to the DW. The materialized views are used partially or completely for evaluating the user queries. This is achieved through partial or complete rewritings of the queries using the materialized views.

When the source relations change, the materialized views need to be updated. The materialized views are usually maintained using an incremental strategy. With such a strategy, the changes to the source relations are propagated to the DW. The changes to the materialized views are computed using the changes of the source relations, and are eventually applied to the materialized views. The expressions used to compute the view changes involve the changes of the source relations,

*Figure 1. A simplified DW architecture*



and are called maintenance expressions. Maintenance expressions are issued by the DW against the data sources and the answers are sent back to the DW. When the source relation changes affect more than one materialized view, multiple maintenance expressions need to be evaluated. The techniques of multiquery optimization can be used to detect ``common subexpressions'' among maintenance expressions in order to derive an efficient global evaluation plan for all the maintenance expressions.

## MAIN THRUST OF THE CHAPTER

When selecting views to materialize in a DW, one attempts to satisfy one or more design goals. A design goal is either the minimization of a cost function or a constraint. A constraint can be classified as user oriented or system oriented. Attempting to satisfy the constraints can result in no feasible solution to the view selection problem. The design goals determine the design of the algorithms that select views to materialize from the space of alternative view sets.

### Minimization of Cost Functions

Most approaches comprise in their design goals the minimization of a cost function. The following are examples of cost functions to be minimized:

- **Query evaluation cost.** Often, the queries that the DW has to satisfy are given as input to the view selection problem. The overall query evaluation cost is the sum of the cost of evaluating each input query rewritten (partially or completely) over the materialized views. This sum can also be weighted, each weight indicating the frequency or importance of the corresponding query. Several approaches aim at minimizing the query evaluation cost (Harinarayan et al., 1996; Shukla et al 1998; Gupta & Mumick, 1999).
- **View maintenance cost.** The view maintenance cost is the sum of the cost of propagating each source relation change to the materialized views. This sum can be weighted, each weight indicating the frequency of propagation of the changes of the corresponding source relation. The maintenance expressions can be evaluated more efficiently if they can be partially rewritten over views already materialized at the DW: the evaluation of parts of the maintenance expression is avoided since their materializations are present at the DW. Moreover, access of the remote data sources and expensive data transmissions are reduced. Materialized views that are added to the DW for reducing the view maintenance cost are called *auxiliary views* (Ross et al., 1996; Theodoratos & Sellis, 1999). The auxiliary views can be materialized permanently or transiently. Transiently materialized views are used during the maintenance process and discarded afterwards (Mistry et al., 2001). Obviously, maintaining the auxiliary views incurs additional maintenance cost. However, if this cost is less than the reduction to the maintenance cost of the initially materialized views, it is worth keeping the auxiliary views in the DW. Ross et al. (1996) derive auxiliary views to permanently materialize in order to minimize the view maintenance cost.
- **Operational cost.** Minimizing the query evaluation cost and the view maintenance cost are conflicting requirements. Low view maintenance cost can be obtained by replicating source relations at the DW. In this case, though, the query evaluation cost is high since queries need to be computed from the replicas of the source relations. Low query evaluation cost can be obtained by materializing at the DW all the input queries. In this case, all the input queries can be answered by a simple lookup but the view maintenance cost is high since complex maintenance expressions over the source relations need to be computed. The input queries may overlap, that is, they may share many common subexpressions. By materializing common subexpressions and other views over the source relations, it is possible, in general, to reduce the view maintenance cost. These savings must be balanced against higher query evaluation cost. For this reason, one can choose to minimize a linear combination of the query evaluation and view maintenance cost which is called *operational cost*. Most approaches endeavor to minimize the operational cost (Gupta, 1997; Baralis et al., 1997; Yang et al., 1997; Theodoratos & Sellis, 1999).
- **Total view size.** In a distributed DW where the materialized views are stored remotely, the performance bottleneck is usually the data transmission time over the network. In this case, the designer