

## Manual Optimization Decisions

**Problem 1 (Physical Visualization Design Problem)** *Given an interface  $I$ , and a set of constraints, and a user interaction trace, identify the optimal placement policy  $P^*$  that will minimize the response time for the trace.*

Suppose we have a hierarchy of  $k$  different storages, ranging from small (fast) to large (slow):

$$S = \{S_1, S_2, \dots, S_k\}$$

Let:

$$x_{ij} = \begin{cases} 1 & \text{if place result of } query_i \text{ on } S_j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Suppose  $l(q, S)$  is the query latency placing the result of query  $q$  on storage  $S$  given by some cost model. We can minimize the total delay by solving for the matrix  $x$  using integer programming:

$$\text{Minimize } \sum_{i=1}^n \sum_{j=1}^k x_{ij} l(q_i, S_j)$$

subject to:

$$\sum_{j=1}^k x_{ij} = 1, (i = 1, 2, \dots, n) \quad - \text{ Placement is non-inclusive}$$

$$\sum_{i=1}^n x_{ij} s_i \leq S_j, (j = 1, 2, \dots, k) \quad - \text{ Placement need to fit for every storage device}$$