Library Coverage. Part I: 1D tensors

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***Abstract*—We formalize the following problem: We observe a function execution during a benchmark and we collect problem sizes and call numbers. Now, if we can choose a subset of calls to be done in HW (accelerators) what is the best selection to cover all function calls.**

I. Problem Statement

We observe the execution of one function during a benchmark. We can summarize the benchmark observation by a list

$$A = \{[s_i, n_i, c_i] \text{ with } i \in [0, N-1]\} \tag{1}$$

We consider all inputs and outputs as one dimensional array. The cardinality of the list is $\|A\| = N$. Where s_i is the size of the input problem, n_i is the number of time we call the function for this problem size, and c_i is the cost. In practice, we give a cost as the number of padding we need to introduce to execute this function in HW. We initialize the cost by a large number say 10^9.

We want to find a set $P \subset A$, where we can execute the function on such input in HW and thus with cost 0. Then, $\forall [s_i, n_i, c_i] \in A, \exists [p_j, n_j, 0] \in P^*$ such that $c_i = n_i(p_j - s_i)$. We imply that there is an extension p_j that is larger than s_i and we shall explain in the next section.

II. Solution Formulation

Here, we assume that all sets have indices and we imply an increasing order by size of the problem.

$$P \subset A \rightarrow \{p_i = [s_i, n_i, 0]\}, \forall s_i \leq s_{N-1} \tag{2}$$

We do not really need to choose elements of A, but it is reasonable to start with functions that are used.

Take a $p_i = [s_i, n_i, 0]$ and create the following extension:

$$\begin{aligned} p_i^* \rightarrow \{ & p_i = [ks_i, 0, 0], \\ & \forall k \in [1, M] \text{ s.t. } s_i(M-1) < s_{N-1} < s_i M \\ & \text{ and } [s_i * k, *, *] \notin P \\ & \} \end{aligned} \tag{3}$$

Thus the full extension of the HW calls is:

$$P^* = \cup_i p_i^* \tag{4}$$

We are going to merge A and P^* and sort them by size to create A^*. We artificially increased the number of entries. We can now define the cost of using P hardware function in calling all function calls in A.

Cost is $\sum_i c_i, a_i = [s_i, n_i, c_i] \in A^*$

$$c_i = \begin{cases} 0, & \text{if } c_i == 0 \\ n_i * (s_j - s_i), & \text{where } j = min_{k>0}(i+k) \text{ s.t. } c_j == 0 \end{cases} \tag{5}$$