APPLICATION OF HIGH-LEVEL MEMORY SIZE ESTIMATION FOR GUIDANCE OF LOOP TRANSFORMATIONS IN MULTIMEDIA DESIGN

We demonstrate how a novel technique for high-level memory requirement estimation can be used in system level synthesis for data-dominated multimedia applications. Using a polyhedral description of partitioned arrays and their dependencies, guiding hints for the loop ordering are presented to the designer. Together with estimates on the upper and lower bounds of the memory size requirement with a partially fixed execution ordering they are used in the early system design trajectory to find an implementation with low memory requirement. The methodology is demonstrated using a representative multimedia application.

MOTIVATION AND CONTEXT

For data-dominated HW/SW systems:

- Data transfer and storage determine cost and performance parameters.
- Must be main focus of the designer to achieve cost-optimized end product [Catthoor98].

DEFINITIONS

Dependency Part (DP), see Figure 3.

\[
A[i][j][k] = f(\text{input});
\]

for i=0 to 5 {
  for j=0 to 5 {
    for k=0 to 2 {
      if (j>=2) & (i>=1)
        g( A[i-1][j-2][k] );
    }
  }
}

Dependency Vector (DV), see Figure 4.

Dependency Vector Polytope (DVP), see Figure 5.

Estimate with no execution ordering fixed:
Upper Bound (UB) = Size (DVP) - Overlap = 36
Lower Bound (LB) = Size (DVP) - Overlap = 5

\[
B[i][j][k] = f(\text{input});
\]

for i=0 to 5 {
  for j=0 to 5 {
    for k=0 to 2 {
      if (j>=2) & (i>=1)
        g( A[i-1][j-2][k] );
    }
  }
}

Estimate with ND k outermost:
DP reduced \rightarrow UB=12. DVP unchanged \rightarrow LB=5. See Figure 5.

Estimate with SD j innermost:
DP reduced \rightarrow UB=18. DVP extended \rightarrow LB=6. See Figure 6.

Estimate with SD i innermost:
DP reduced \rightarrow UB=33. DVP extended \rightarrow LB=11. See Figure 7.

GUIDING HINTS FOR LOOP ORDERING

Fix:
- Nonspanning Dimensions outermost
- Spanning Dimensions innermost
- Among Spanning Dimensions fix:
  - Dimensions with shortest distance between border of DVP and border of DP innermost

MPEG-4 MOTION ESTIMATION KERNEL

Figure 9: Total storage requirement a) Multiplication of array dimensions b) No ordering, c) y_p outermost, d) y_s outermost, e) x_s second outermost, f) y_p third outermost and x_p fourth outermost

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Figure 1: Data dominated embedded system

Figure 2: High-level code with complex multi-dimensional loop nests and arrays

Figure 3: Dependency Part

Figure 4: Dependency Vector and Dependency Vector Polytope

Figure 5: Nonspanning Dimension k fixed outermost

Figure 6: Spanning Dimension j fixed innermost

Figure 7: Spanning Dimension i fixed innermost

Figure 8: Ordering according to guiding hints; k outermost, j innermost and l second innermost