PSLP: Padded SLP Automatic Vectorization

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University of Edinburgh[‡]

CGO 2015

SLP Straight-Line Code Vectorizer

- Superword Level Parallelism [Larsen PLDI'00]

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  - Unroll loop and vectorize with SLP
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- In practice it is missing features present in the Loop vectorizer (Interleaved Loads, Predication)

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Scalar Code

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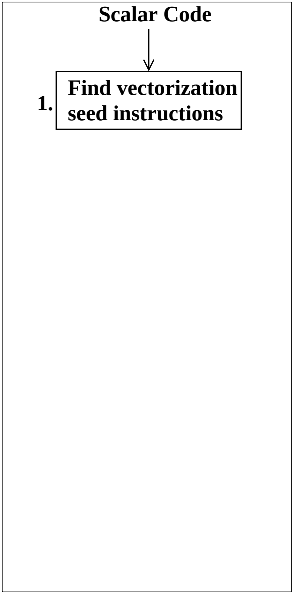

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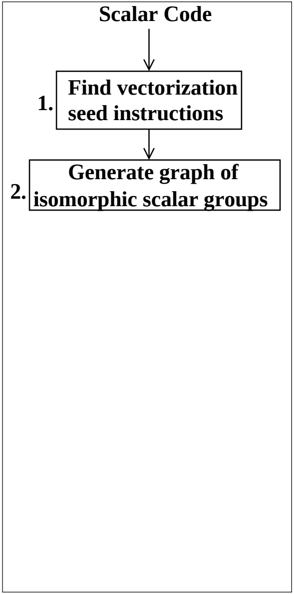

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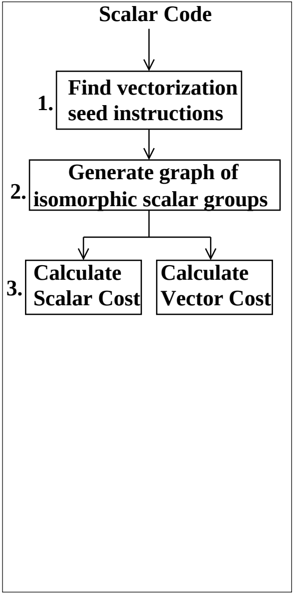

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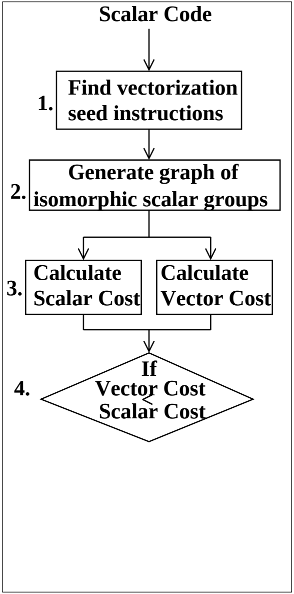

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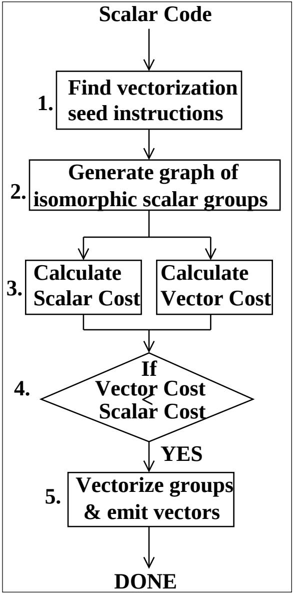

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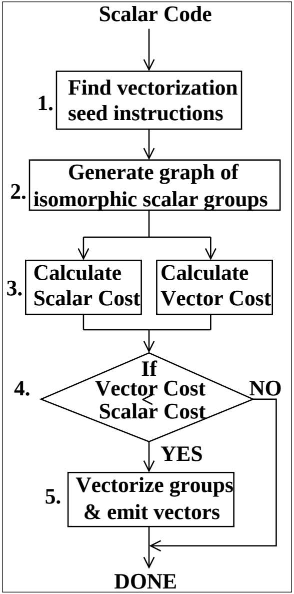

SLP Fails due to non-isomorphism

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B[i]  = A[i]  * 7.0 + 1.0;
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a. Input C code

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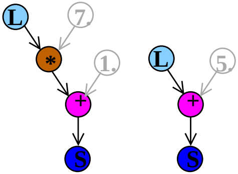

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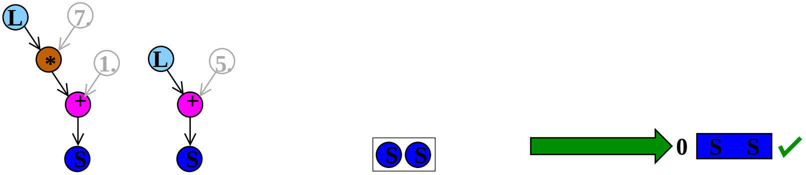

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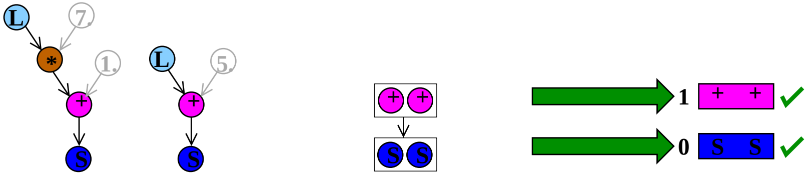

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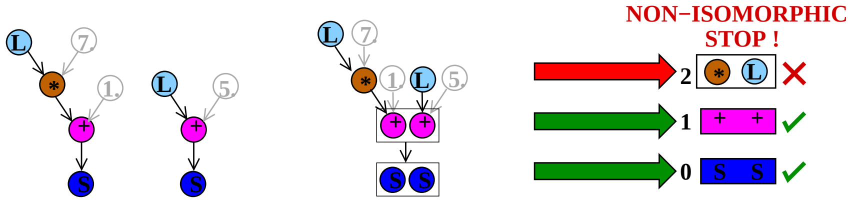

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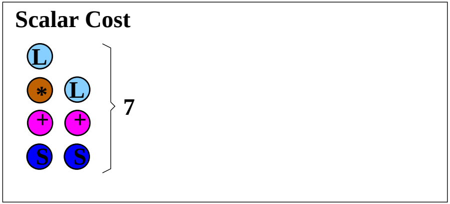

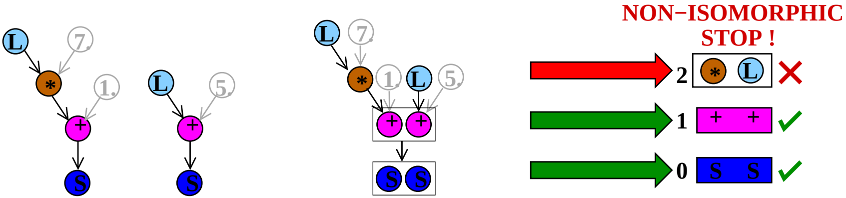

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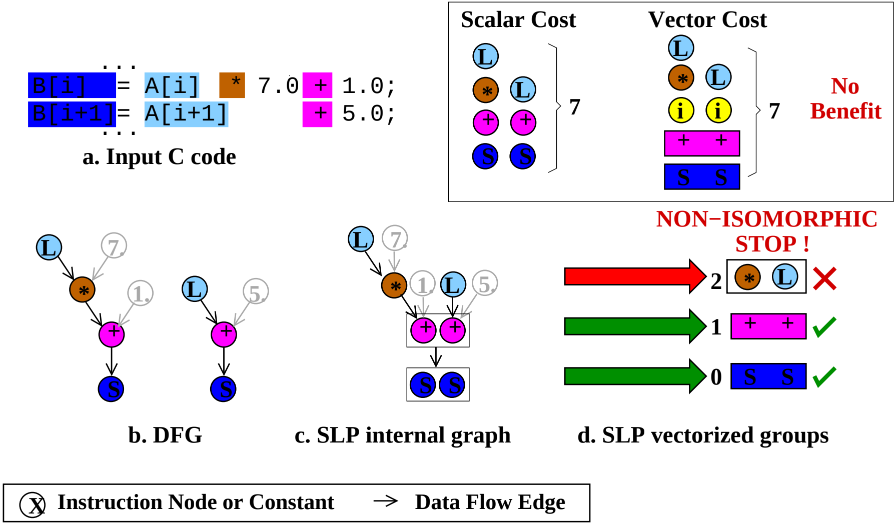
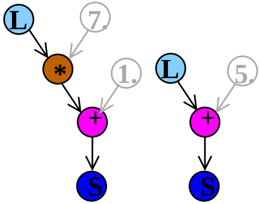


PSLP fixes Non-Isomorphism



a. PSLP graphs

X **Instruction or Constant** → **Data Flow Edge**

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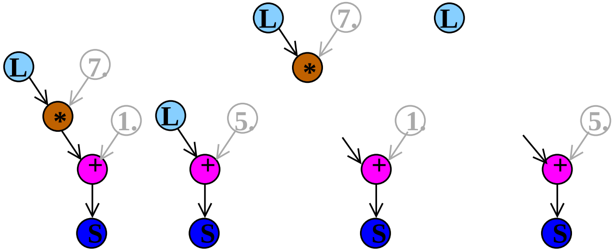

a. PSLP graphs

b. PSLP padded graphs

(X) Instruction or Constant	**→Data Flow Edge**

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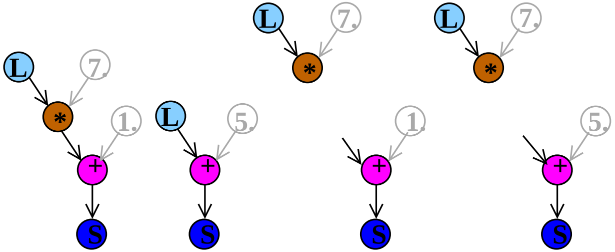

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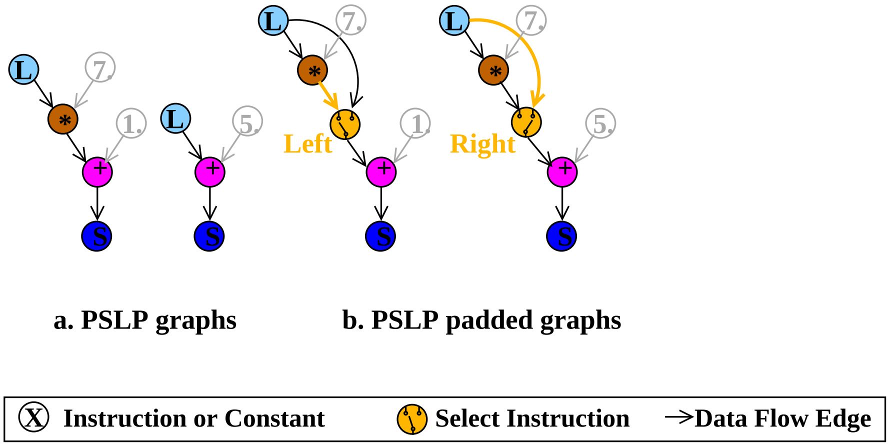

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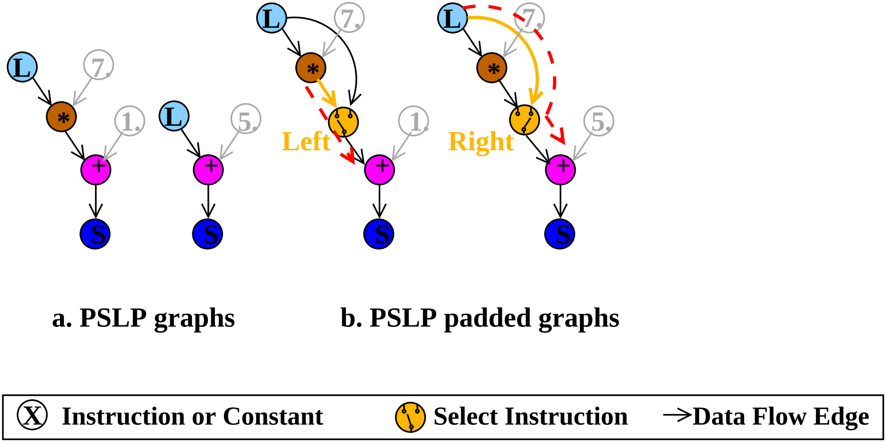

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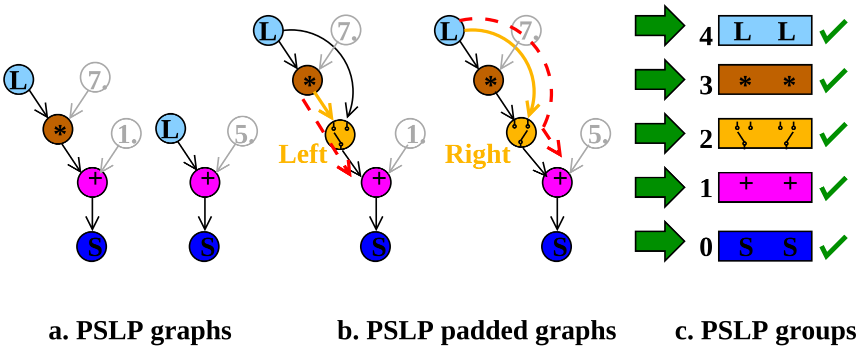

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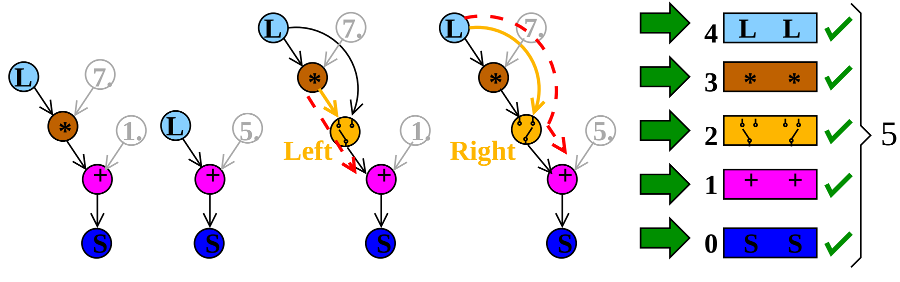

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c. PSLP groups

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1. Find vectorization seed instructions

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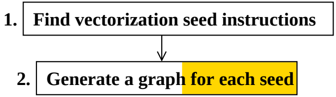

PSLP Algorithm

- Extension to SLP
- Generate multiple graphs (unlike SLP)
- Minimal Padding

1. **Find vectorization seed instructions**
2. **Generate a graph for each seed**
3. **Perform minimal Padding of graphs**

PSLP Algorithm

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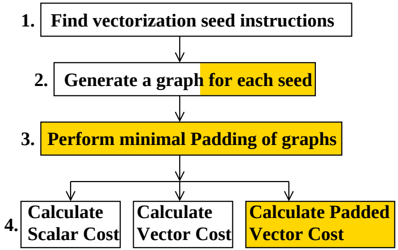
- Cost estimation



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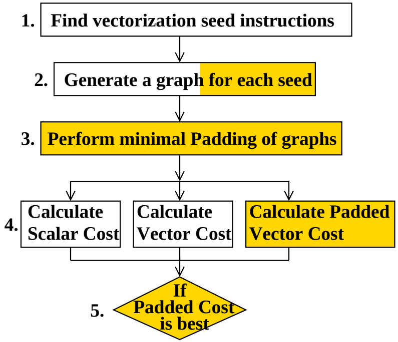

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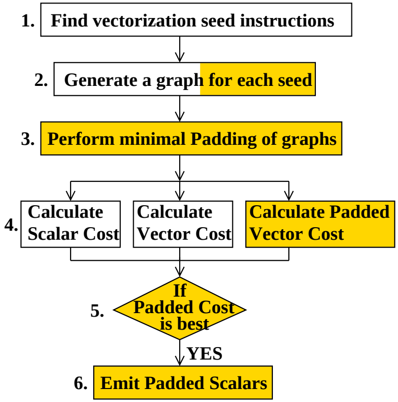

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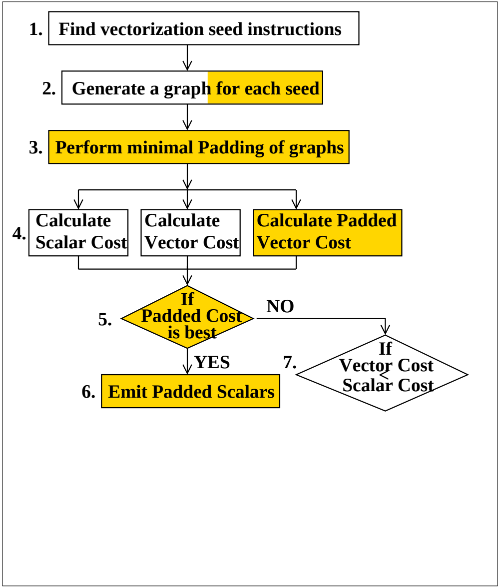

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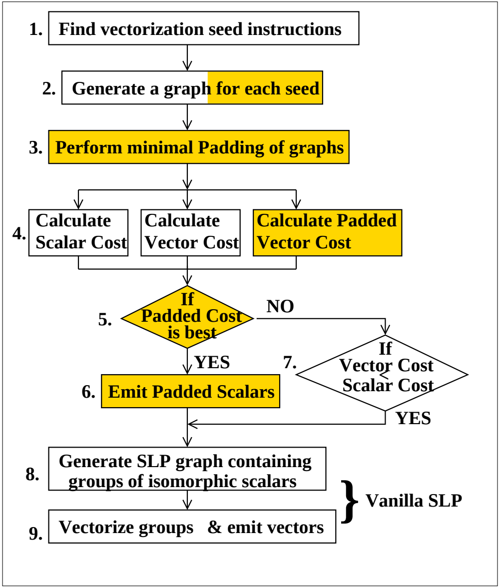

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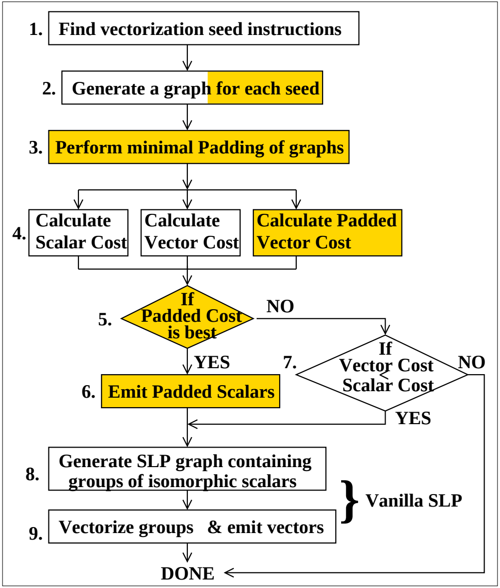

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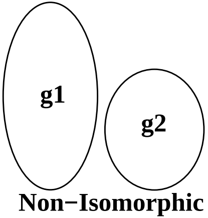

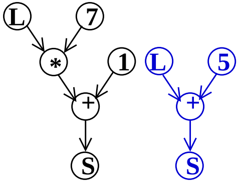

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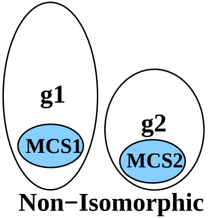

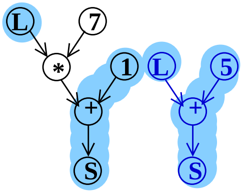

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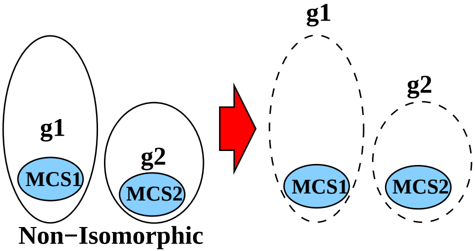

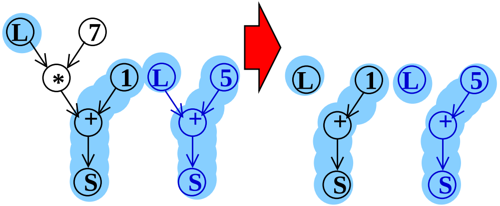

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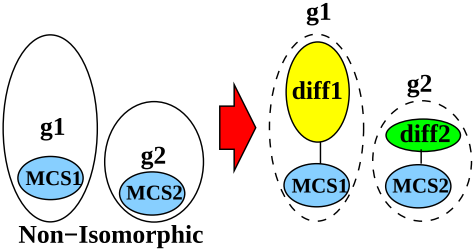

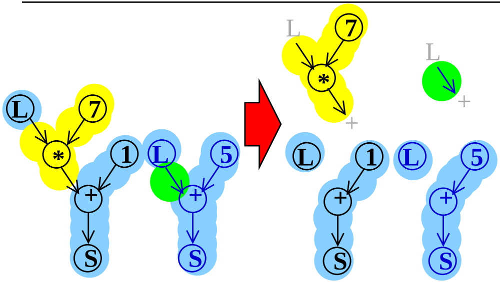

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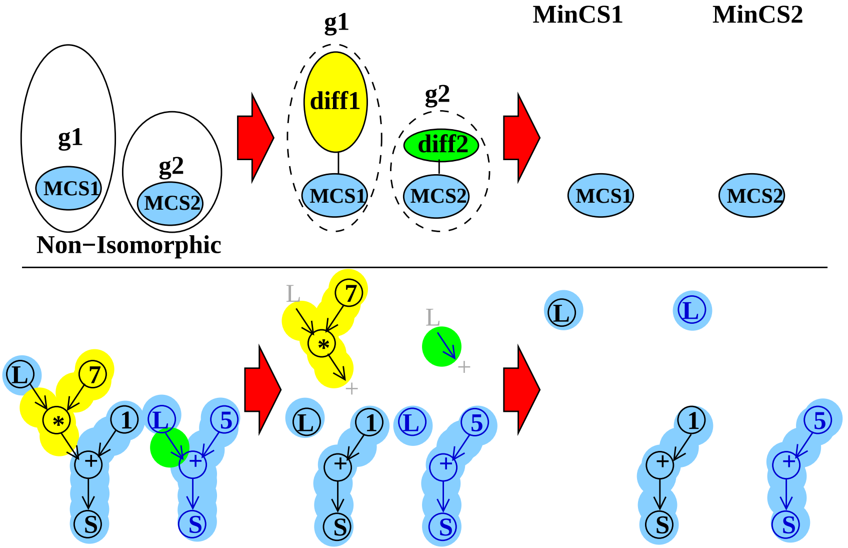

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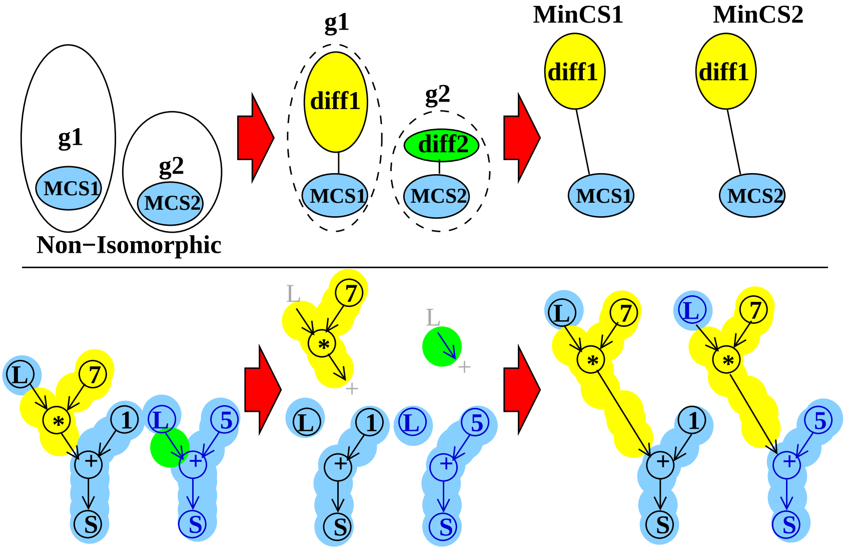

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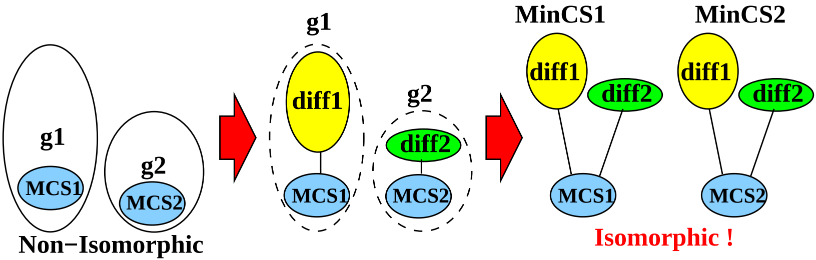

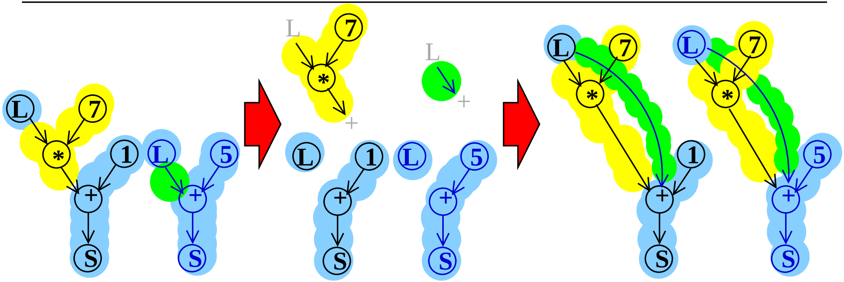

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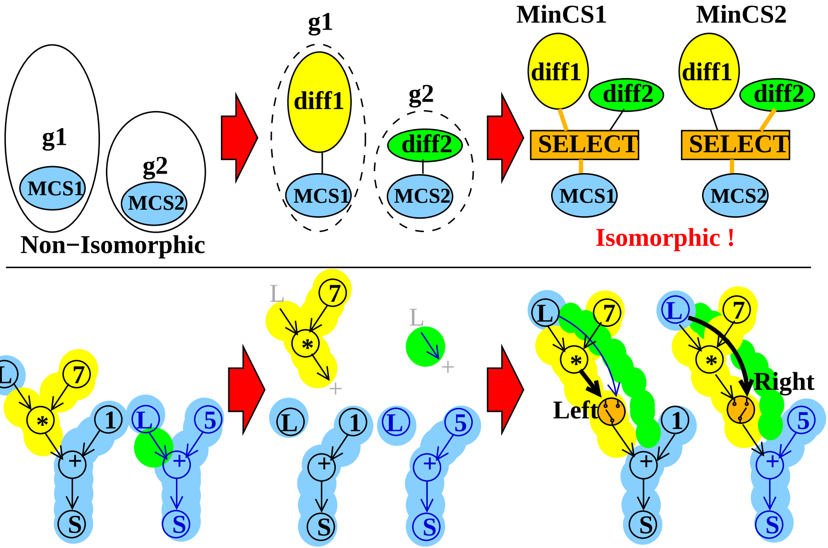
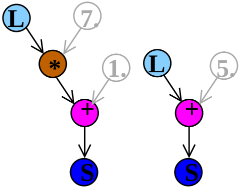


We can do better: Remove redundant Selects



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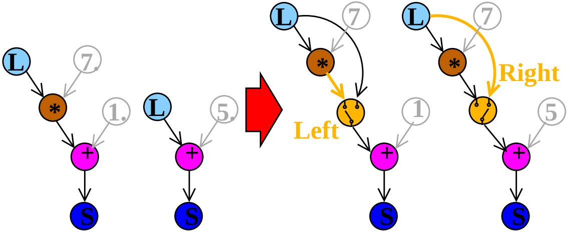

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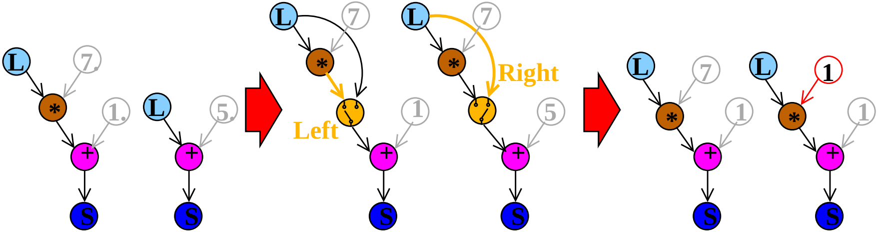

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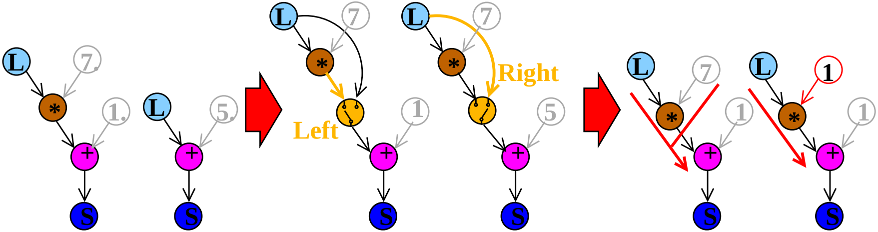

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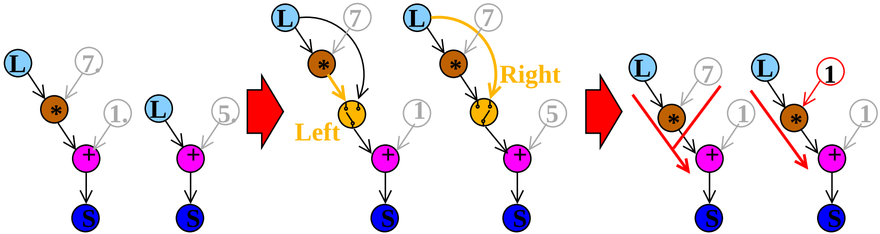

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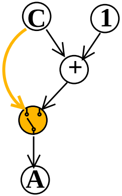

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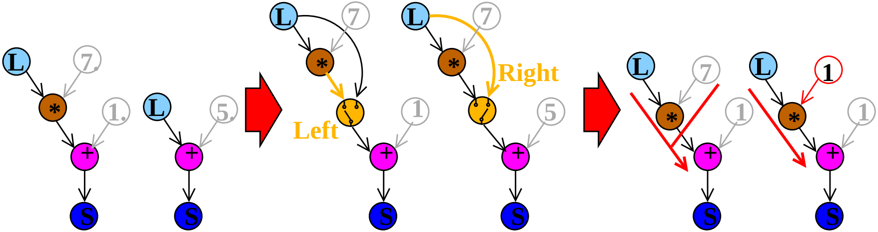

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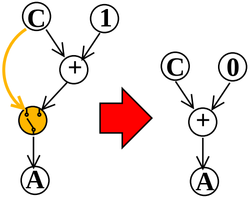

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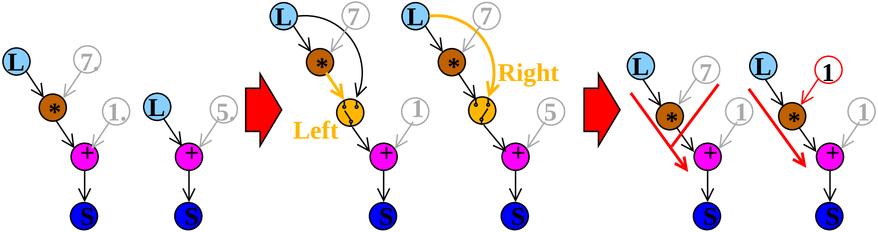

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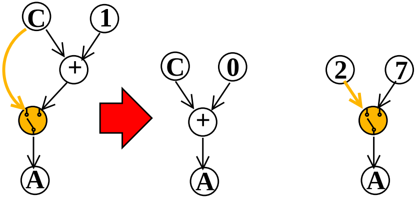
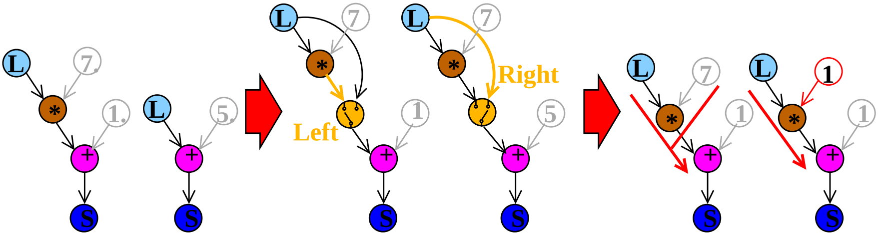


a. Instruction acting as Select **b. Select constants**

We can do better: Remove redundant Selects



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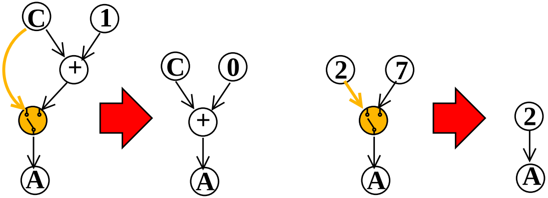

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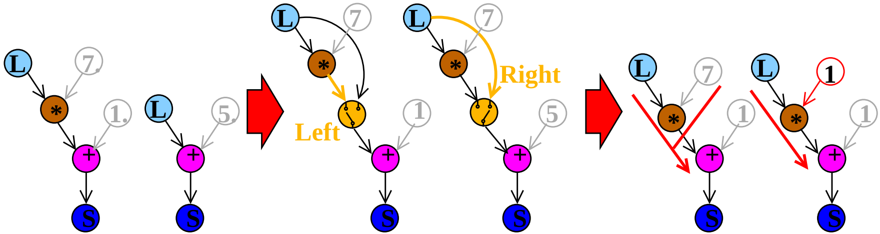

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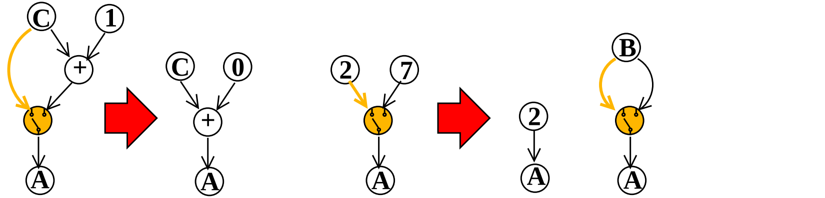

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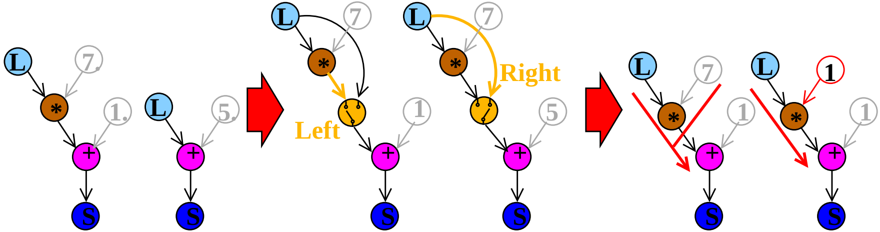
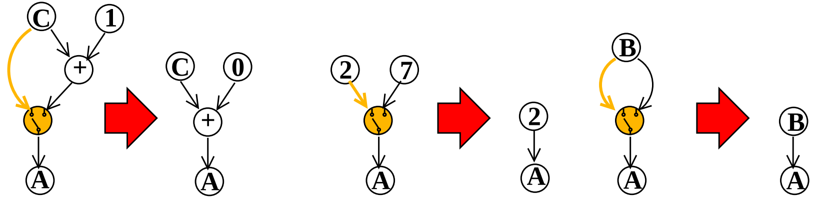
We can do better: Remove redundant Selects



EXAMPLE: Instruction acting as Select



a. Instruction acting as Select **b. Select constants** **c. Select same node**

Opportunities for PSLP in real-life applications

1. Non-isomorphic source code (e.g. computing conjugates in 433.milc)

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b[0].real =   a[0].real
b[0].imag = - a[0].imag
b[1].real =   a[1].real
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Memory
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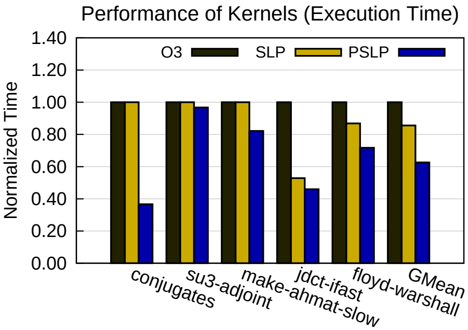
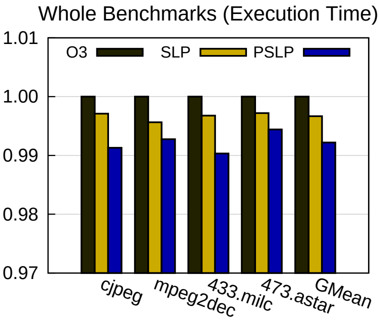
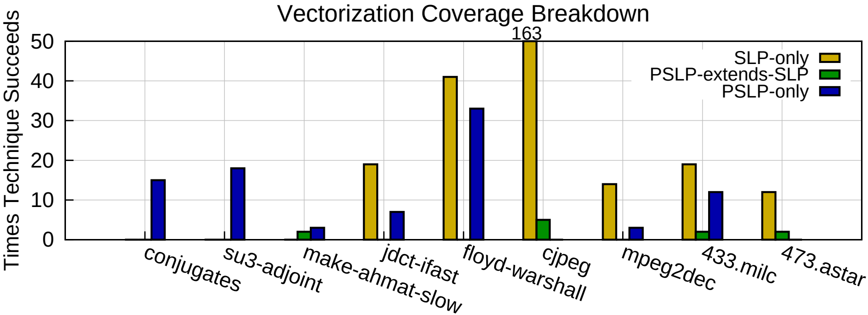
  3. O3 + PSLP enabled (PSLP)

PSLP increases performance





PSLP enables or extends vectorization



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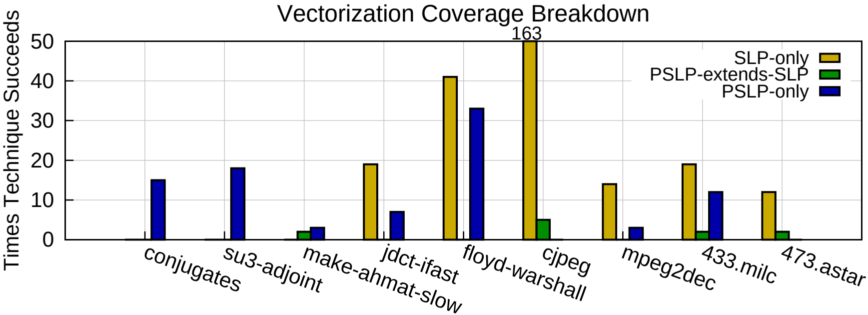

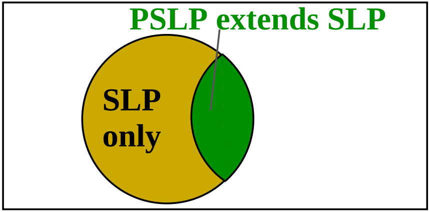

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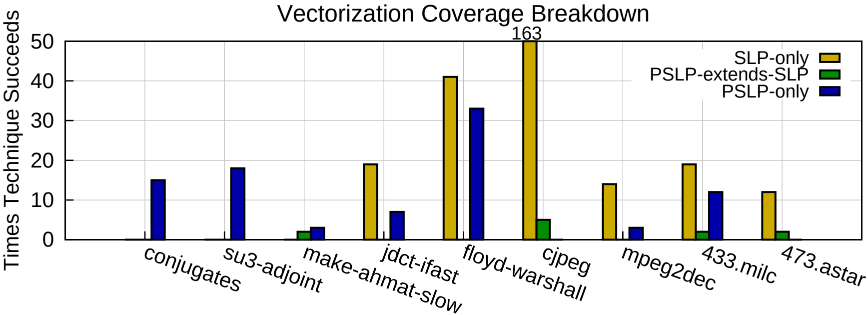

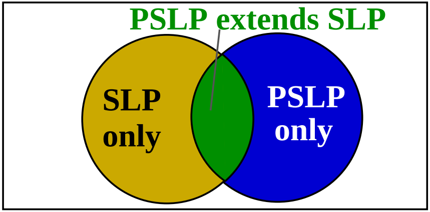

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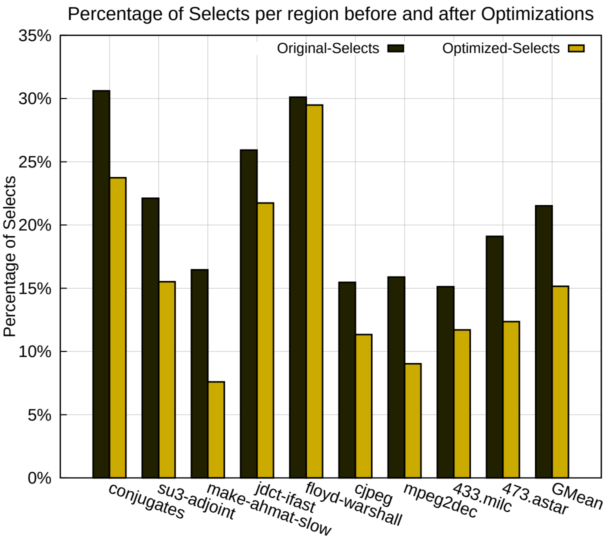
- SLP fails completely. PSLP succeeds.

Optimizing away redundant Selects

- Select-removal optimizations remove about 21% of the Selects



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- PSLP performs better compared to SLP on commodity SIMD-capable hardware