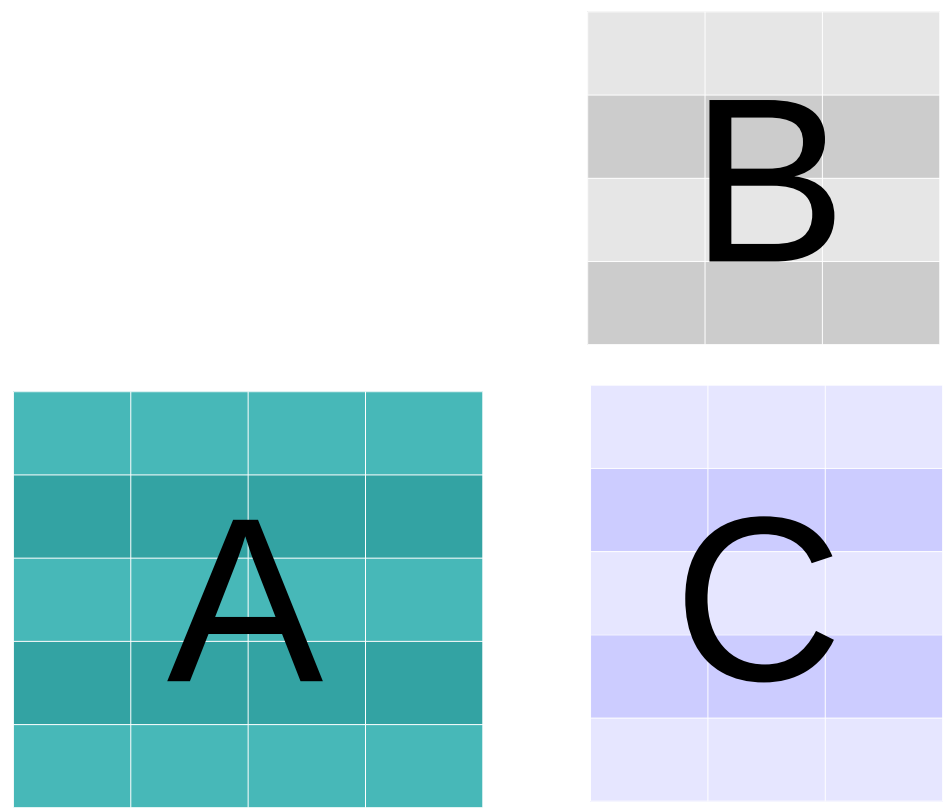


PaRSEC PTG DSL Local Iterators



Running Example: GEMM



Parameterized Task Graph

```
GEMM(m, n, k)
```

```
  m = 0 .. C.mt-1
```

```
  n = 0 .. C.nt-1
```

```
  k = 0 .. A.nt-1
```

```
READ A <- A READ_A(m, k)
```

```
READ B <- B READ_B(k, n)
```

```
RW  C <- k == 0 ? C READ_C(m, n)
      : C GEMM(m, n, k-1)
      -> k == A.nt-1 ? C WRITE_C(m, n)
      : C GEMM(m, n, k+1)
```

```
BODY
```

```
  blas_gemm(A, B, C);
```

```
END
```

```
READ_A(m, k)
```

```
  m = 0 .. A.mt-1
```

```
  k = 0 .. A.nt-1
```

```
  :A(m, k)
```

```
READ A <- A(m, k)
```

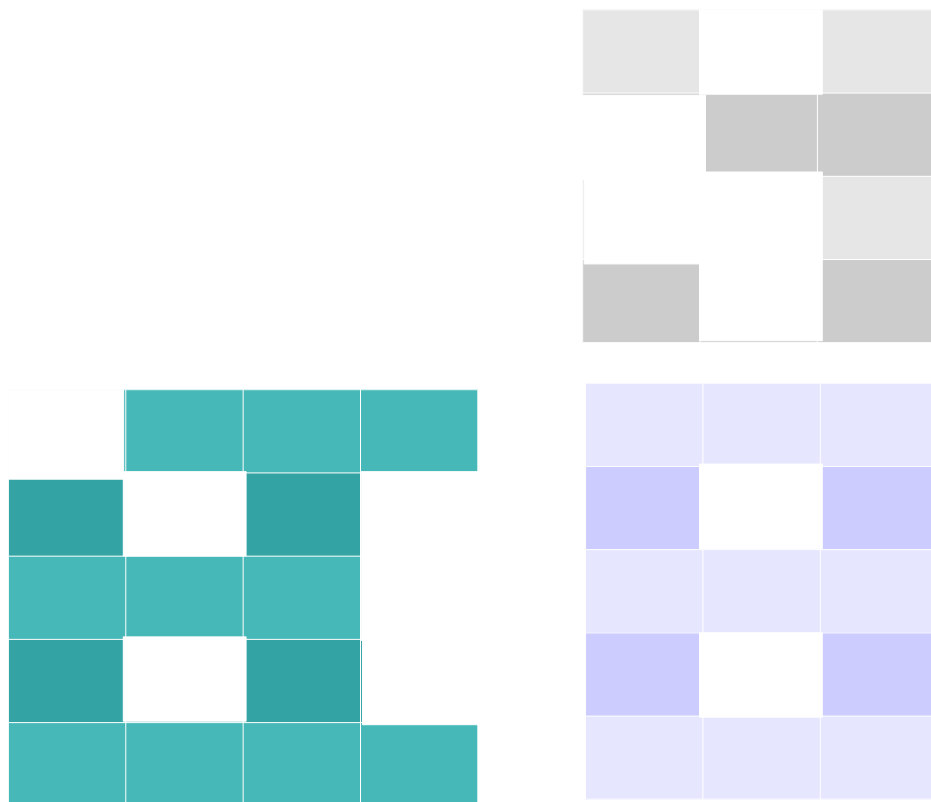
```
  -> A GEMM(m, 0..A.nt-1, k)
```

```
BODY
```

```
  /* nothing */
```

```
END
```

Example: Block Sparse GEMM



PTG: Local iterators

```

READ_A(m, k)
  m = [mi = 0 .. %{ return nb_nnz_rows(A)-1;%}]
      %{ return nnz_row(A, mi);%}
  k = [ki = 0 .. %{ return nb_nnz_tile(A, m)-1; %}]
      %{ return nnz_col_tile(A, m, ki); %}

```

```
:A(m, k)
```

```

READ A <- A(m, k)
      -> A GEMM(m, ???, k)

```

```

BODY
  /* nothing */
END

```

```

nb_nnz_rows(A) = 4; nnz_row(A, i) = i
nb_nnz_tile(A, 0) = 3;
  nnz_col_tile(A, 0, 0) = 1; nnz_col_tile(A, 0, 1) = 2;
  nnz_col_tile(A, 0, 2) = 3;
nb_nnz_tile(A, 1) = 2;
  nnz_col_tile(A, 1, 0) = 0; nnz_col_tile(A, 1, 1) = 2;
nb_nnz_tile(A, 2) = 3;
  nnz_col_tile(A, 0, 0) = 0; nnz_col_tile(A, 0, 1) = 1;
  nnz_col_tile(A, 0, 2) = 2;

```

...

	(0,1)	(0,2)	(0,3)
(1,0)		(1,2)	
(2,0)	(1,1)	(2,2)	
(3,0)		(3,2)	
(4,0)	(4,1)	(4,2)	(4,3)

PTG: Local iterators

```

READ_A(m, k)
  m = [mi = 0 .. %{ return nb_nnz_rows(A)-1;%}]
      %{ return nnz_row(A, mi);%}
  k = [ki = 0 .. %{ return nb_nnz_tile(A, m)-1; %}]
      %{ return nnz_col_tile(A, m, ki); %}

  :A(m, k)

READ A <- A(m, k)
  -> [ni = 0 .. %{ return nb_gemm_n(m, k); %}]
      A GEMM(m, %{ return gemm_n(m, k, ni); %}, n)

BODY
  /* nothing */
END

```

PTG: local iterators

```
GEMM(m, n, k)
  m = [mi = 0 .. %{ return nb_nnz_rows(C)-1; %}] %{ return nnz_row(C, mi) %}
  n = [ni = 0 .. %{ return nb_nnz_cols(C, m)-1; %}]
                                     %{ return nnz_tile(C, m, ni); %}
  k = [ki = 0 .. %{ return nb_gemm_k(m, n)-1; %} %{ return gemm_k(m, n, ki); %}
  ki = %{ return gemm_index_k(m, n, k); %}
  firstk = %{ return gemm_k(m, n, 0); %}
  lastk =  %{ return gemm_k(m, n, nb_gemm_k(m, n)-1); %}
  prevk =  %{ return gemm_k(m, n, ki-1); %}
  nextk =  %{ return gemm_k(m, n, ki+1); %}
```

```
READ A <- A READ_A(m, k)
READ B <- B READ_B(k, n)
RW   C <- k == firstk ? C READ_C(m, n)
                        : C GEMM(m, n, prevk)
      -> k == lastk ? C WRITE_C(m, n)
                    : C GEMM(m, n, nextk)
```

```
BODY
  blas_gemm(A, B, C);
END
```

PTG: local iterators

```
TASK(p1, p2)
  p1 = [pli = CST1 .. CST2,
        p2i = %{ return f1(pli); %} .. %{ return f2(pli); %}]
        %{ return f3(pli, p2i); %}
  p2 = [p2i = %{ return f4(p1); %} .. %{ return f5(p1); %}]
        %{ return f6(p1, p2i); %}

READ A <- [ki = A1 .. B3] test(p1, p2, ki) ?
  [li = A2 .. B3] X TASK(f1(p1, p2, ki, li), f2(p1, p2, ki, li)) :
  [ji = A3 .. B3] Y TASK(f1(p1, p2, ki, ji), f2(p1, p2, ki, li))
-> A TASK( [mi = A4 .. B4] %{return f(p1, p2, mi); %},
           [mi = A5 .. B5] %{return f(p1, p2, mi); %})
```

Local iterators can be used:

- in any execution space / range definition (e.g. , in front of an expression.
 - Scope of local named variables is the expression
 - Space defined is the set of values for the expression, for all possible values of the named variables
- In front of a guarded call
 - Scope is all tests and calls after the local iterator; this corresponds to doing a sparse broadcast
- In front of a call
 - Scope is the call only; this corresponds to doing a sparse broadcast

The left half of the image features a background of a circuit board with various components and traces. Overlaid on this is the ICL logo, which consists of the letters 'ICL' in a bold, sans-serif font. The 'I' and 'L' are black, while the 'C' is orange. Below the logo, the words 'INNOVATIVE' and 'COMPUTING LABORATORY' are stacked in a smaller, black, sans-serif font.

ICL
INNOVATIVE
COMPUTING LABORATORY

The right half of the image features a background of a large, multi-story brick building with a prominent clock tower. The building is partially obscured by trees and a street lamp in the foreground. A faint grid pattern is overlaid on the entire image. The text 'THE UNIVERSITY OF TENNESSEE' and 'KNOXVILLE' is positioned below the 'T' logo in a black, serif font.

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