# Compaan: Deriving Process Networks from Matlab for Embedded Signal Processing Architectures

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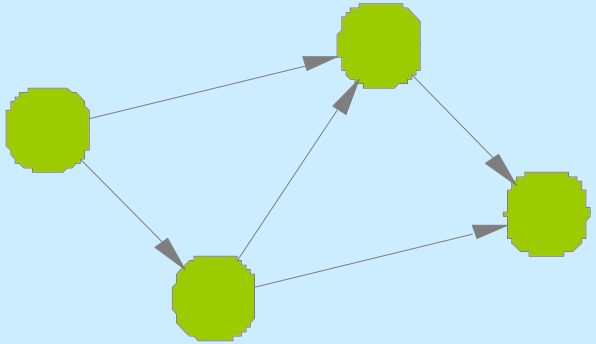
# Problem

Application

```
for k = 1:1:K,
  for j = 1:1:N,
    [r(j,j), x(k,j), t] = Vec( r(j,j), x(k,j) );
    for i = j+1:1:N,
      [r(j,i), x(k,i), t] = Rot( r(j,i), x(k,i), t );
    end
  end
end
```

MatParser

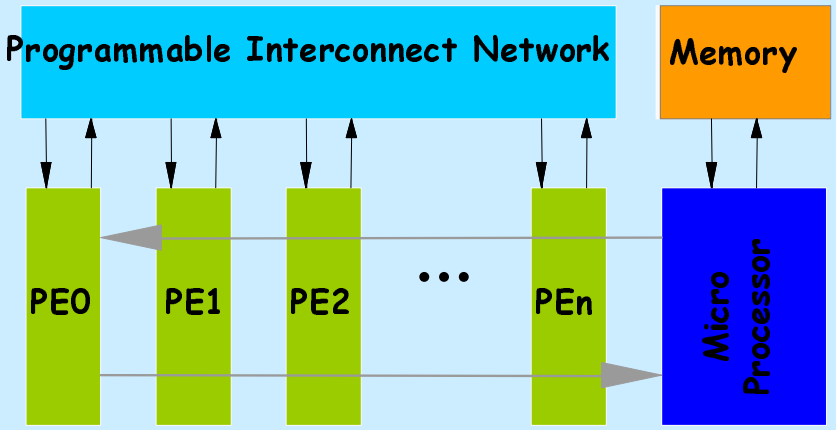
Polyhedra Reduced Dependence Graph

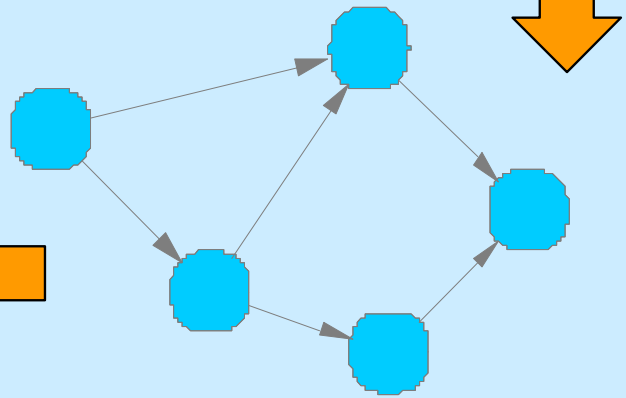


DGParser

Panda

Mapping ?



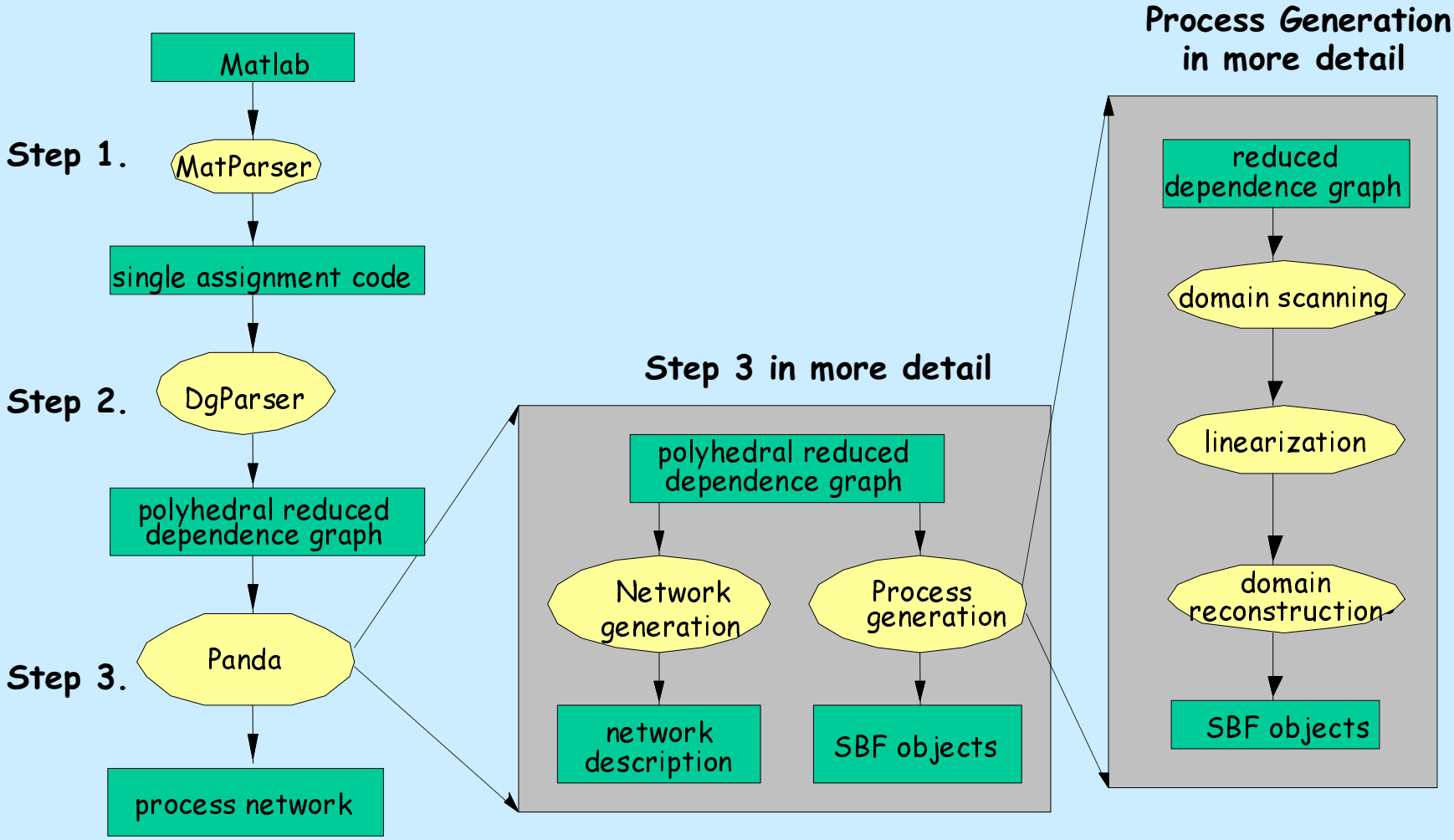



SPADE

Architecture

Process Network

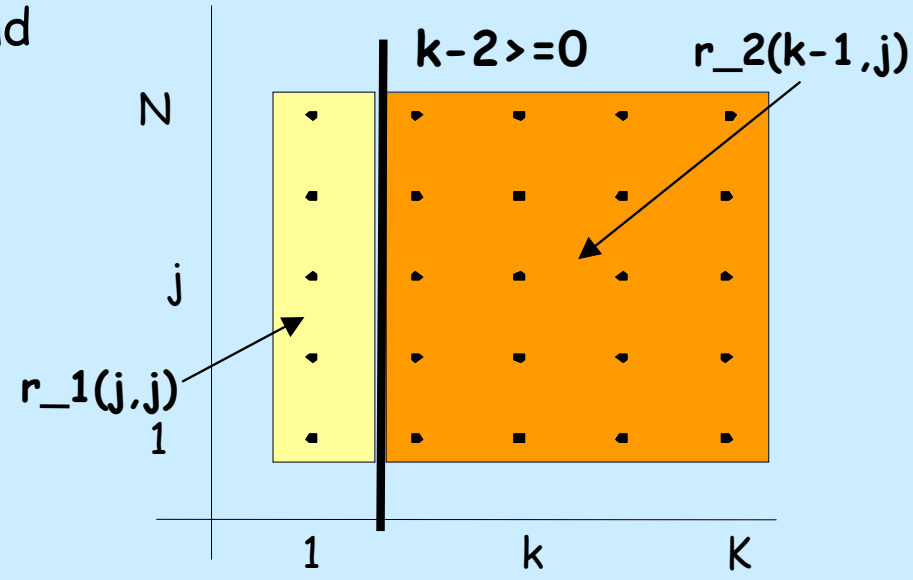
# Compaan


Matlab
Step 1.
MatParser
single assignment code
Step 2.
DgParser
polyhedral reduced dependence graph
Step 3.
Panda
process network
Step 3 in more detail
polyhedral reduced dependence graph
Network generation
Process generation
network description
SBF objects
Process Generation in more detail
reduced dependence graph
domain scanning
linearization
domain reconstruction
SBF objects

# Step 1: MatParser

## Array Dataflow Analysis

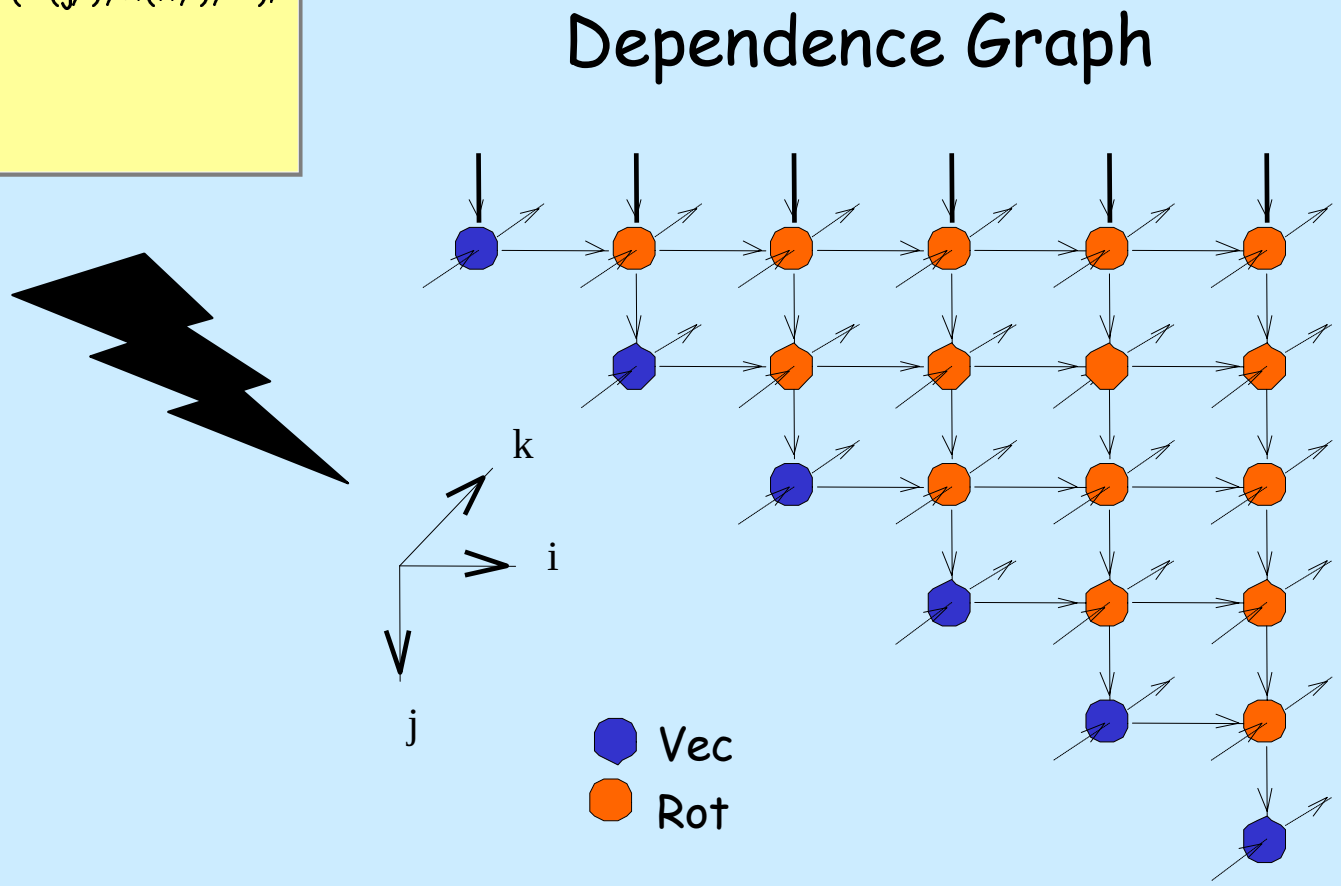
```
for k=1:1:K,
  for j=1:1:N,
    [r(j,j),x(k,j),t]=Vec(r(j,j),x(k,j));
    for i=j+1:1:N,
      [r(j,i),x(k,i),t]=Rot(r(j,i),x(k,i),t));
    end
  end
end
```



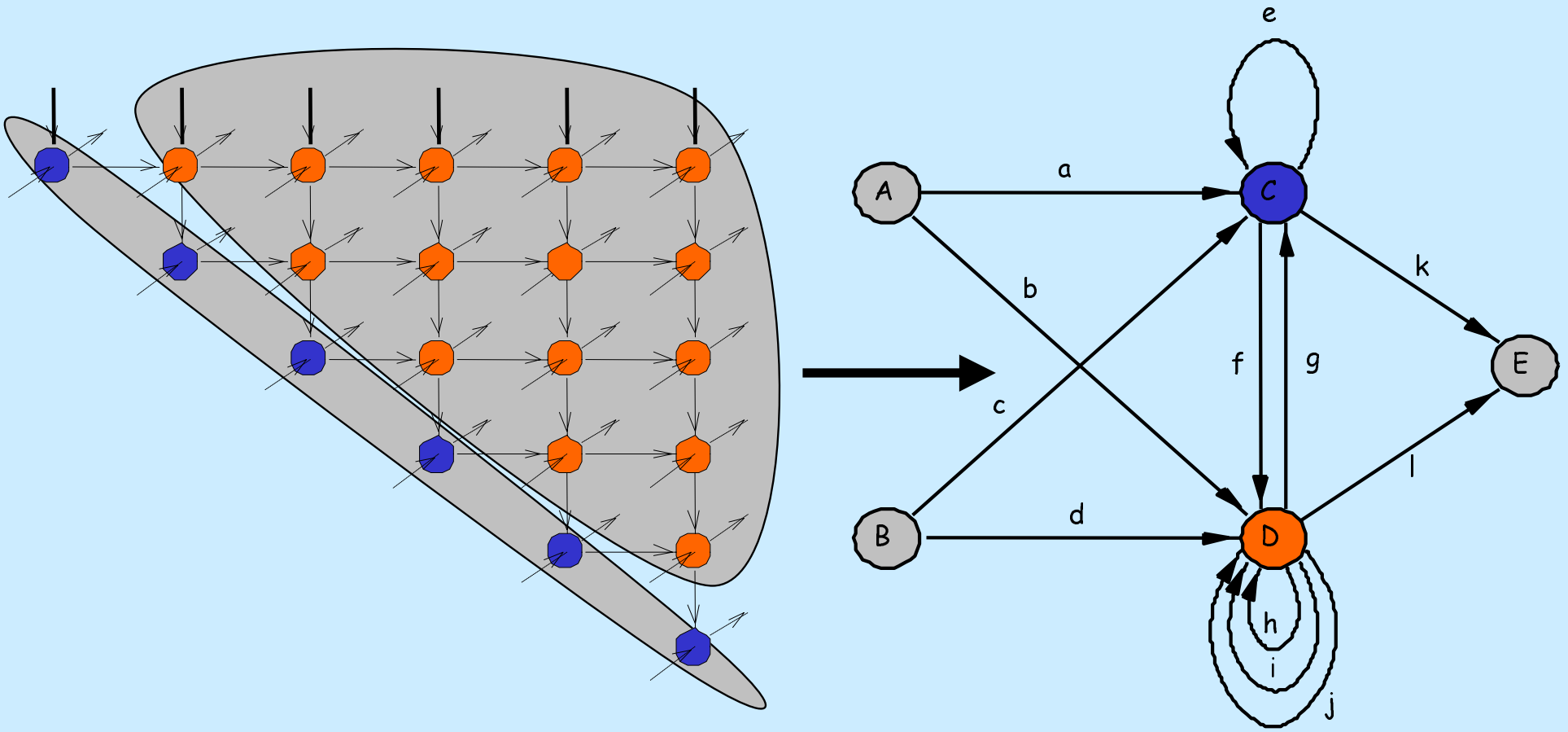

```
for k = 1 : 1 : K,
  for j = 1 : 1 : N,

    if k-2>= 0,
      [ in_0 ] = ipd( r_2( k-1, j ) );
    else %% if -k+1 >= 0
      [ in_0 ] = ipd( r_1( j, j ) );
    end

  [ out_0,out_1,out_2 ] = Vec( in_0, in_1 );

    [ r_1( k, j) ]  = opd( out_0 );
    [ x_1( k, j) ]  = opd( out_1 );
    [ t_1( k, j) ]  = opd( out_2 );
    for i=j+1:1:N,
```

# Dependence Graph

```
for k = 1:1:K,
  for j = 1:1:N,
    [r(j,j), x(k,j), t] = Vec( r(j,j), x(k,j) );
    for i = j+1:1:N,
      [r(j,i), x(k,i), t] = Rot( r(j,i), x(k,i), t);
    end
  end
end
```

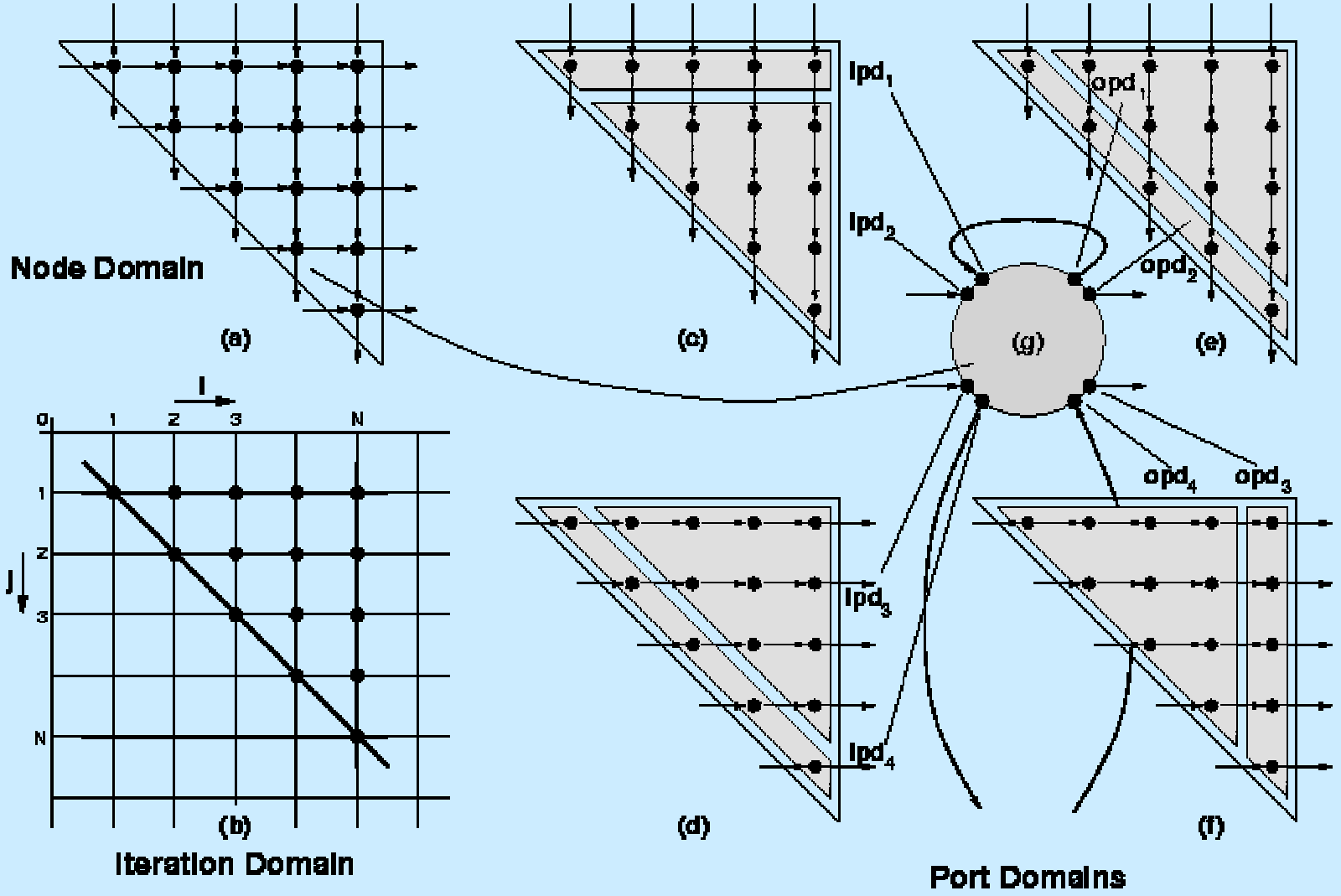


# Step 2: DgParser

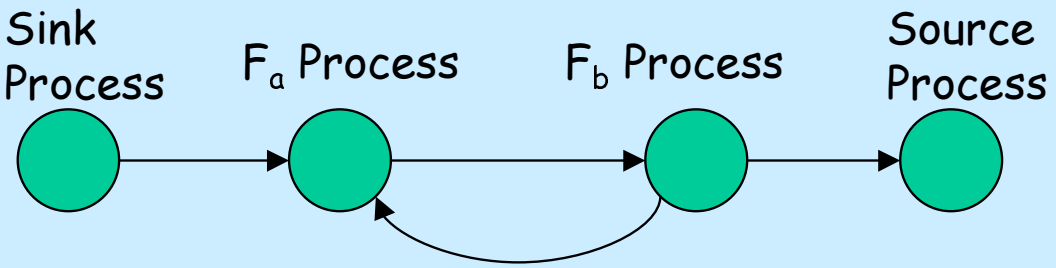



Polyhedral Reduced Dependence Graph

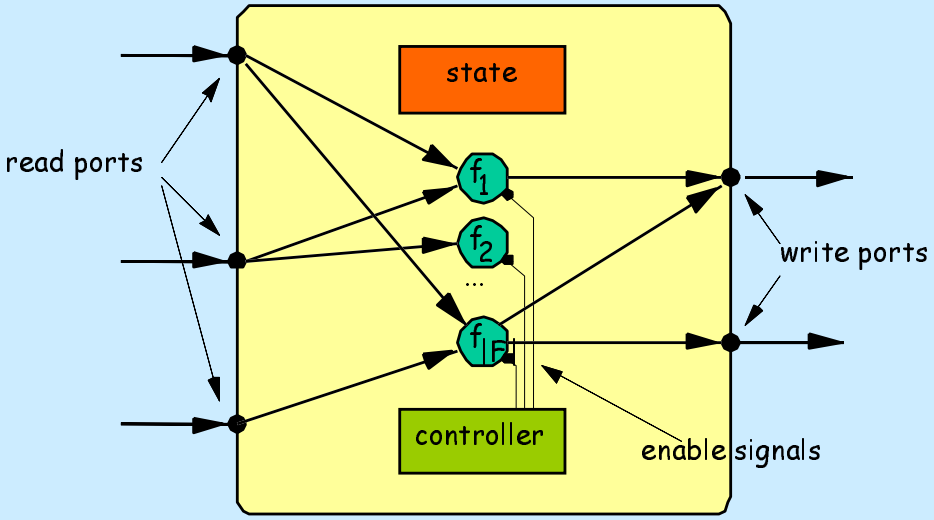
# Example of Node and Port Domains



# SBF Object and Network Generation



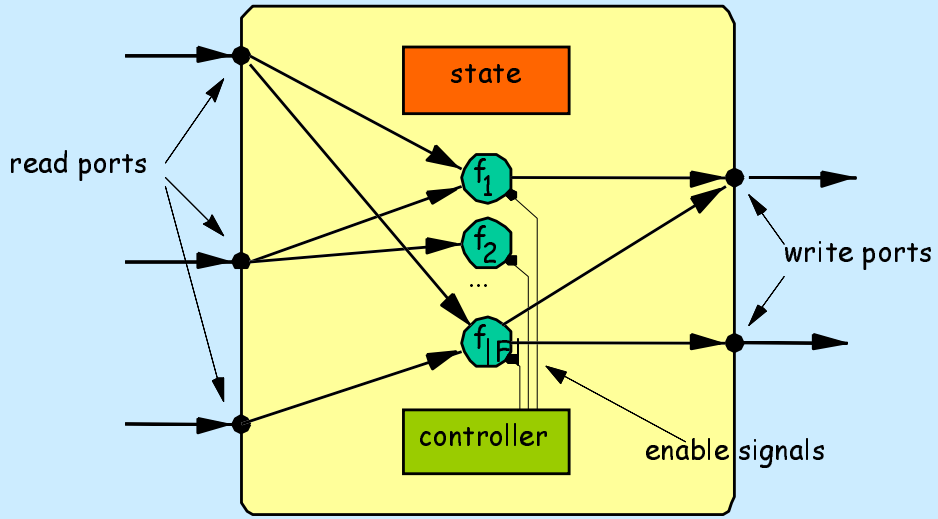

SBF Network (Parallel)




SBF Object (Sequential)

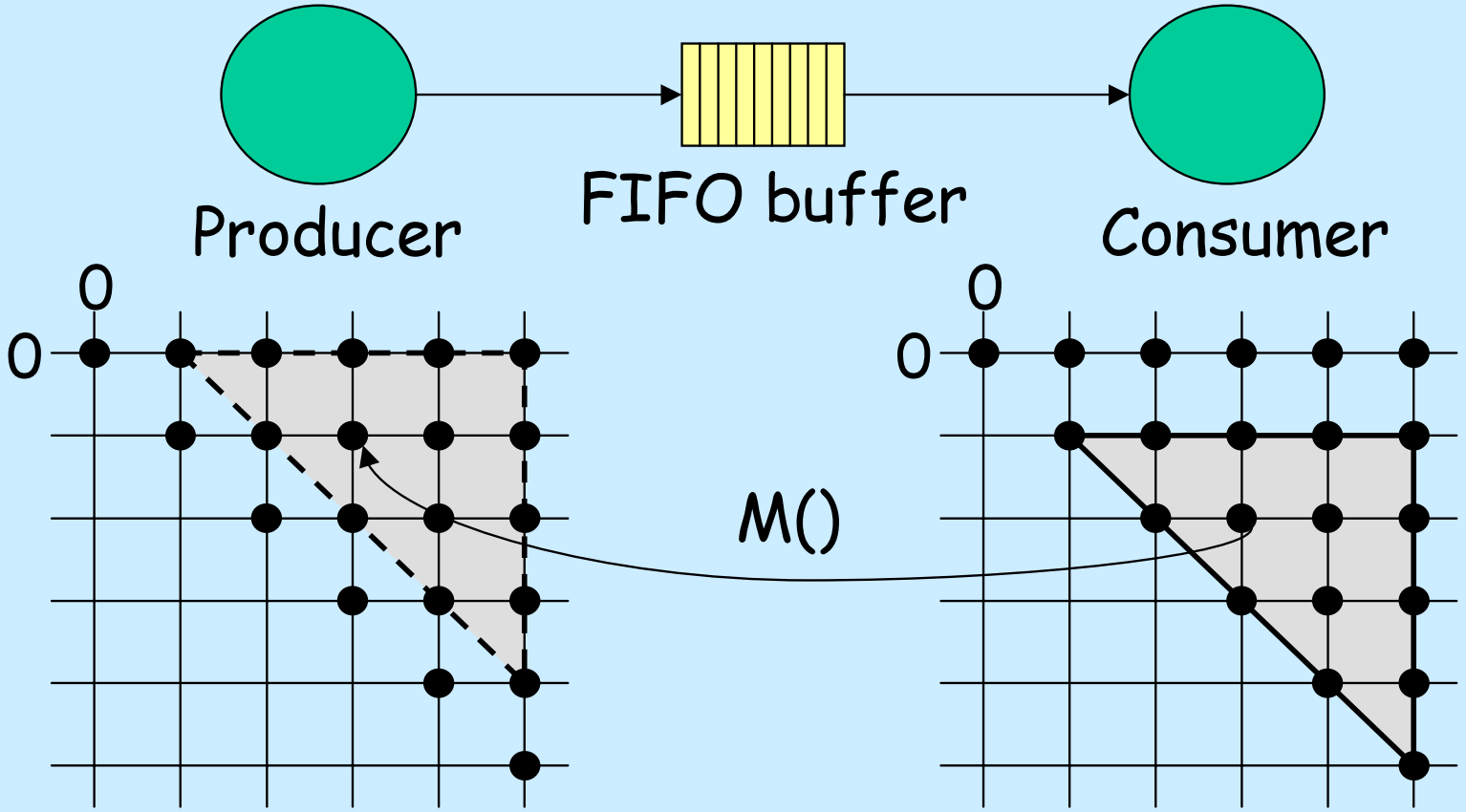
# Elements of an SBF Object

- Function Repertoire $F = \{ f_1, f_2, \ldots, f_{|F|} \}$
- Binding Function $\mu : C \rightarrow F$
- Transition Function $\omega : C \rightarrow C$



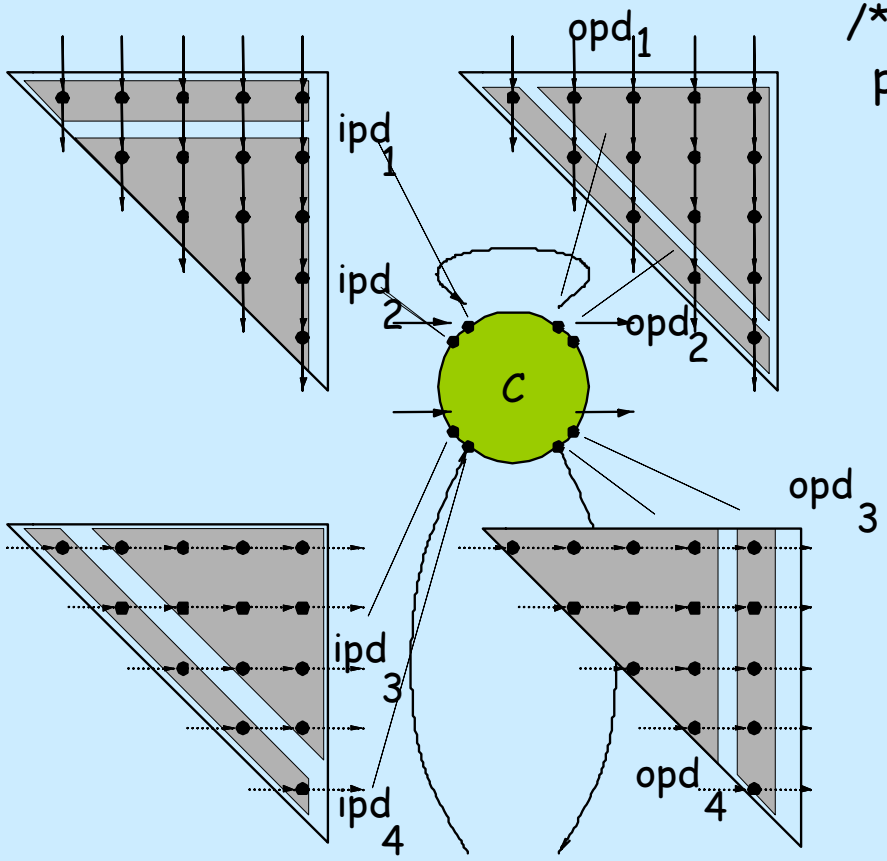

$$f_{init} \xrightarrow{\mu(\omega(c))} f_a \xrightarrow{\mu(\omega(c))} f_b \xrightarrow{\mu(\omega(c))} \ldots f_x \xrightarrow{\mu(\omega(c))} \ldots$$

# Step 3: PANDA




- Domain Reconstruction
- Domain Scanning
- Linearization

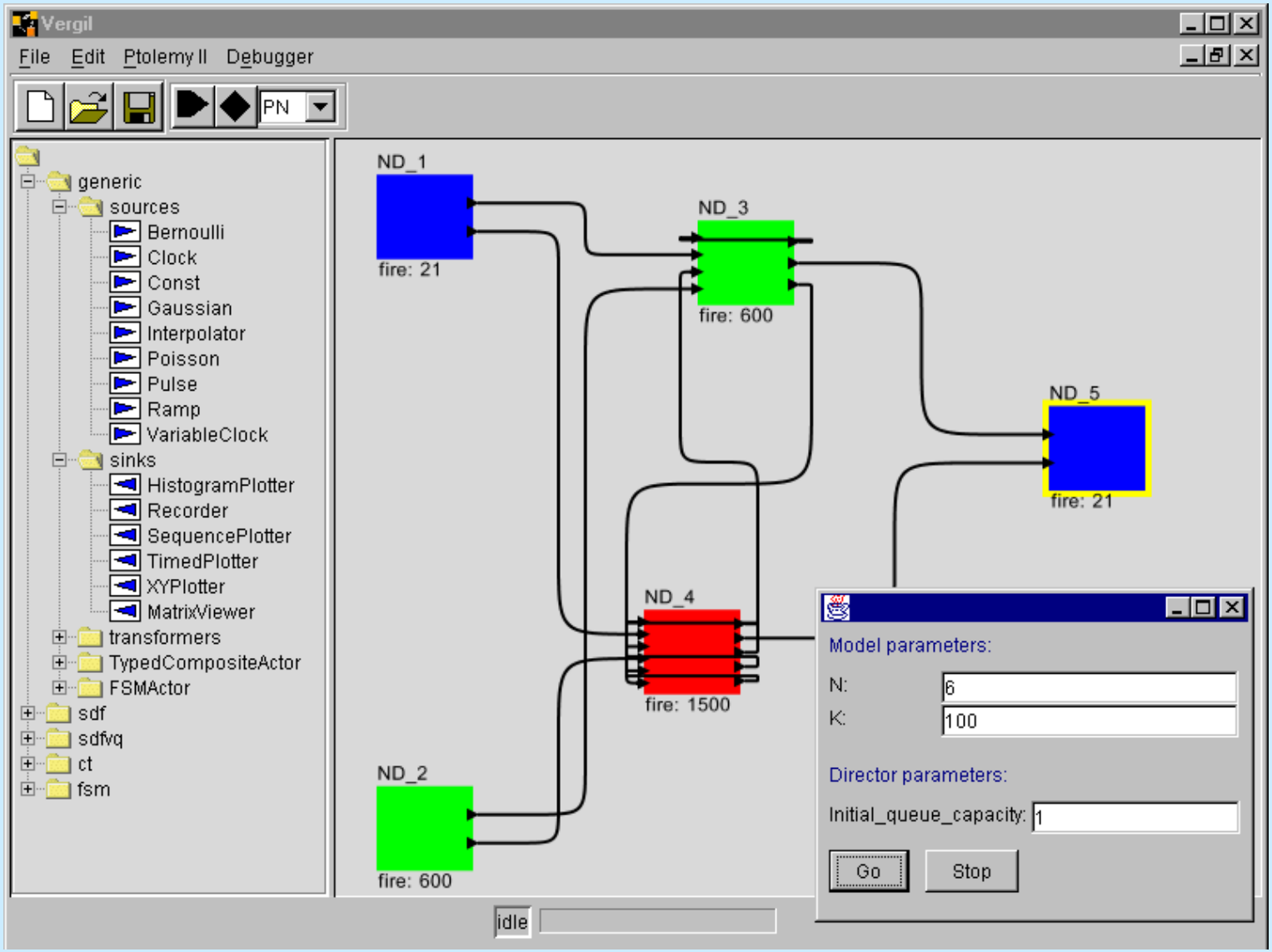
# PN Model in Ptolemy II



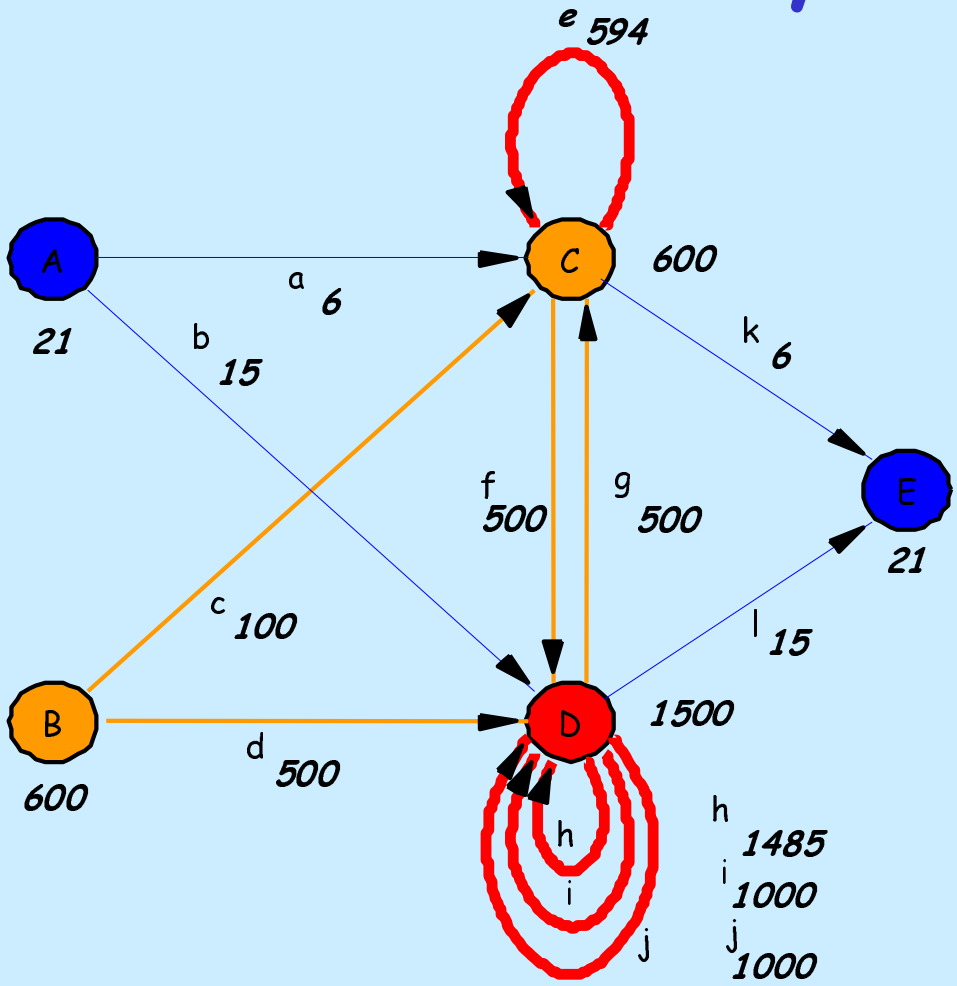

Port Domains

```
/** fire the actor. */
  public void fire() throws IllegalActionException {

    for ( int k = 1 ; k <= 1*K ; k += 1 ) {
      for ( int j = 1 ; j <= 1*N ; j += 1 ) {

        if ( k - 2 >= 0 ) { in_0 = RP_1.get(0);  }
        if ( k - 1 == 0 ) { in_0 =RP_2.get(0);   }
        if ( j - 2 >= 0 ) { in_1 = RP_3.get(0);   }
        if ( j - 1 == 0 ) { in_1 = RP_4.get(0);   }

        // Execute the function
        [out_0, out_1, out_2] = F.Vectorize(in_0, in_1);

        if ( K - k - 1 >= 0 ) { WP_1.send( out_0 );  }
        if ( -K + k == 0 ) { WP_11.send( out_0 );   }
        if ( N - j - 1 >= 0 ) { WP_10.send( out_2 );  }

      }
    }
  }
```

# Ptolemy II, simulation



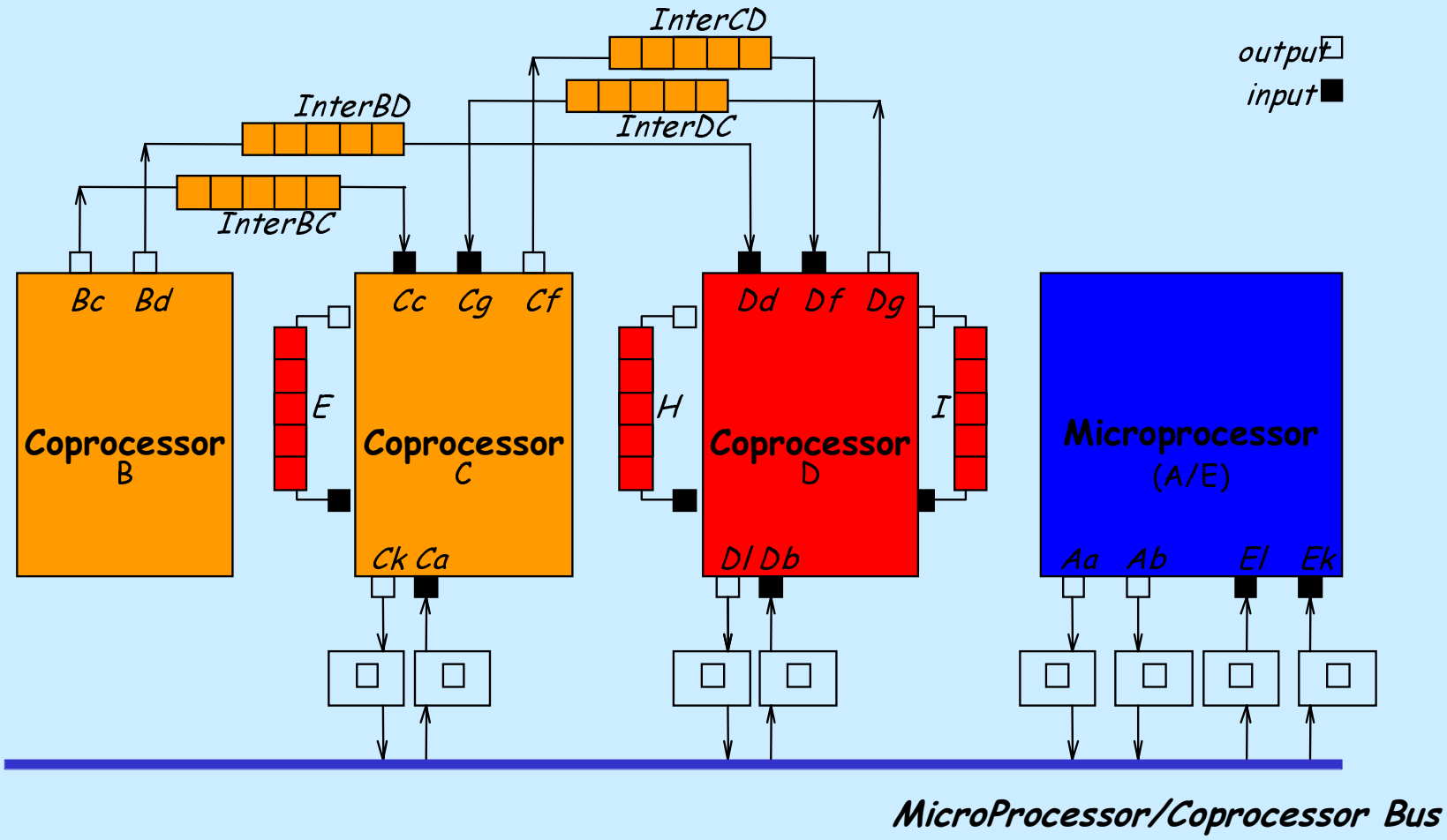
# Workload Analysis




6 Antenna's
100 Updates

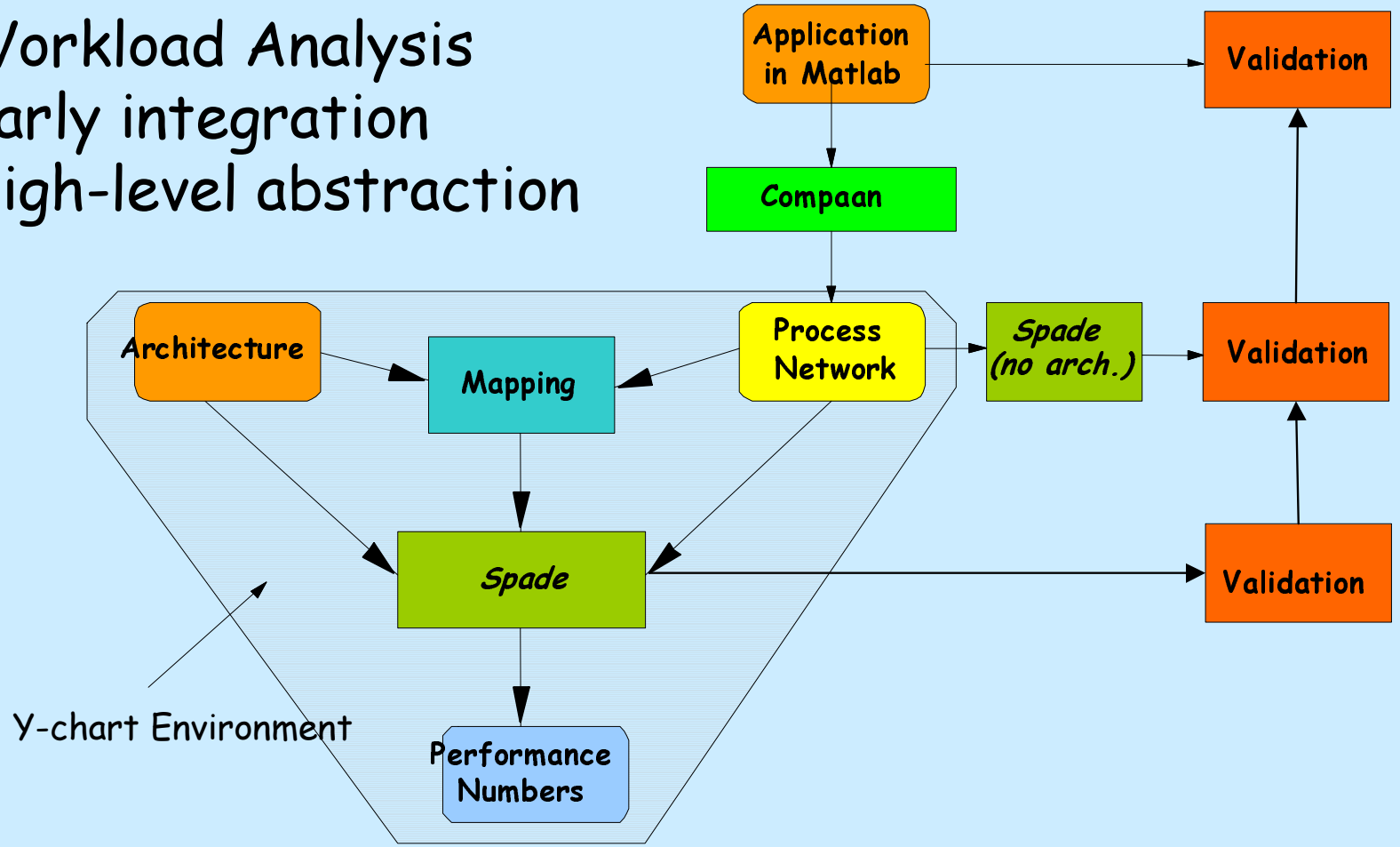
- Separation Communication/Computation
- Higher levels of granularity

# Possible Architecture



# Y-chart

- Workload Analysis
- Early integration
- High-level abstraction



# Conclusions

- Described the Compaan Tool:
  - Polyhedral Reduced Dependence Graph
    - Good Mathematical model
  - SBF Model of Computation
    - Possible candidates for coprocessors
- Implemented a 3-step approach
  - MatParser/DgParser/Panda
- Why did we do it?
  - Process Networks are better match
    - Expresses parallelism (fine grained/coarse grained)
    - Easier mapping

Http://gigascale.org/compaan