BABEL

Going Parallel

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Goals

- Describe our vision to the CCA
- Solicit contributions (code) for:
  - RMI (SOAP | SOAP w/ Mime types)
  - Parallel Network Algs (general arrays)
- Encourage Collaboration

Outline

- Background on Components @llnl.gov
- General MxN Solution : bottom-up
  - Initial Assumptions
  - MUX Component
  - MxNRedistributable interface
- Parallel Handles to a Parallel Distributed Component
- Tentative Research Strategy

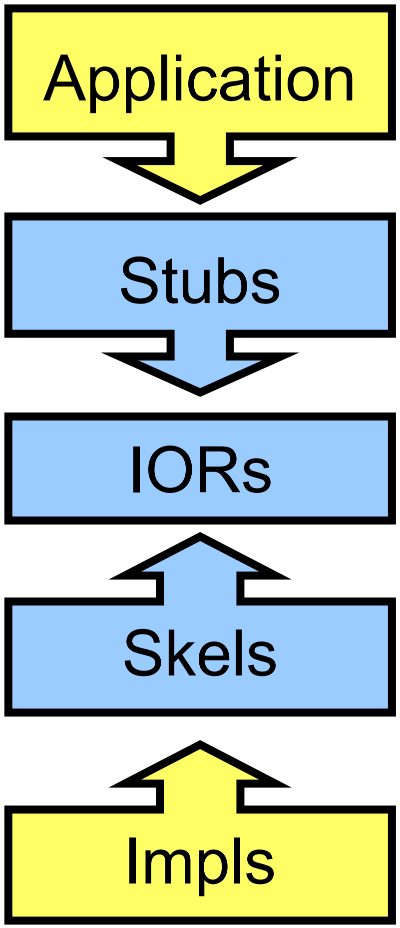
Components @llnl.gov

- Quorum - web voting
- Alexandria - component repository
- Babel - language interoperability
  - maturing to platform interoperability
    - … implies some RMI mechanism
    - SOAP | SOAP w/ MIME types
    - open to suggestions,
      & contributed sourcecode

Babel & MxN problem

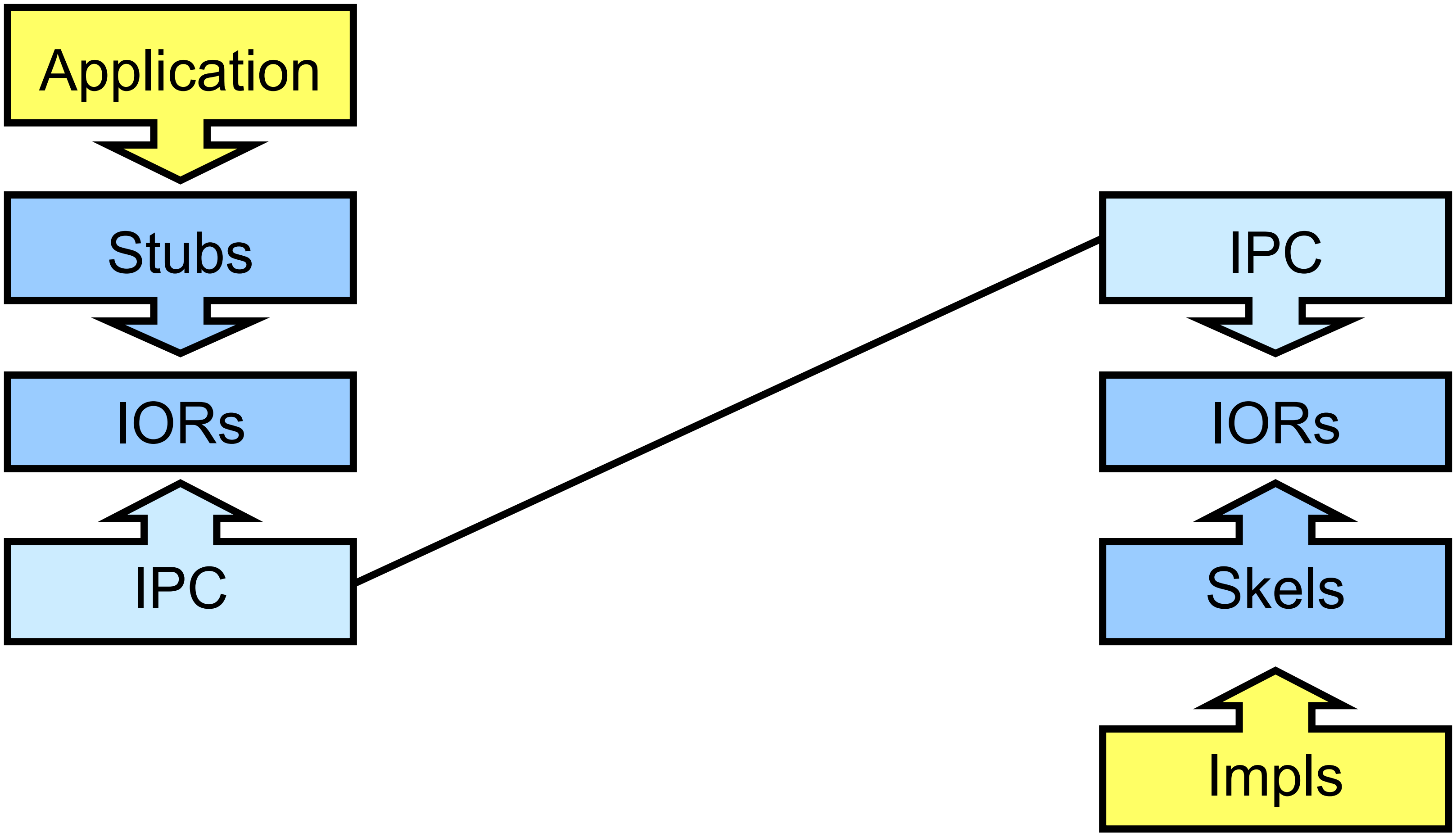
- Unique Opportunities
  - SIDL communication directives
  - Babel generates code anyway
  - Users already link against Babel Runtime Library
  - Can hook directly into Intermediate Object Representation (IOR)

Impls and Stubs and Skels

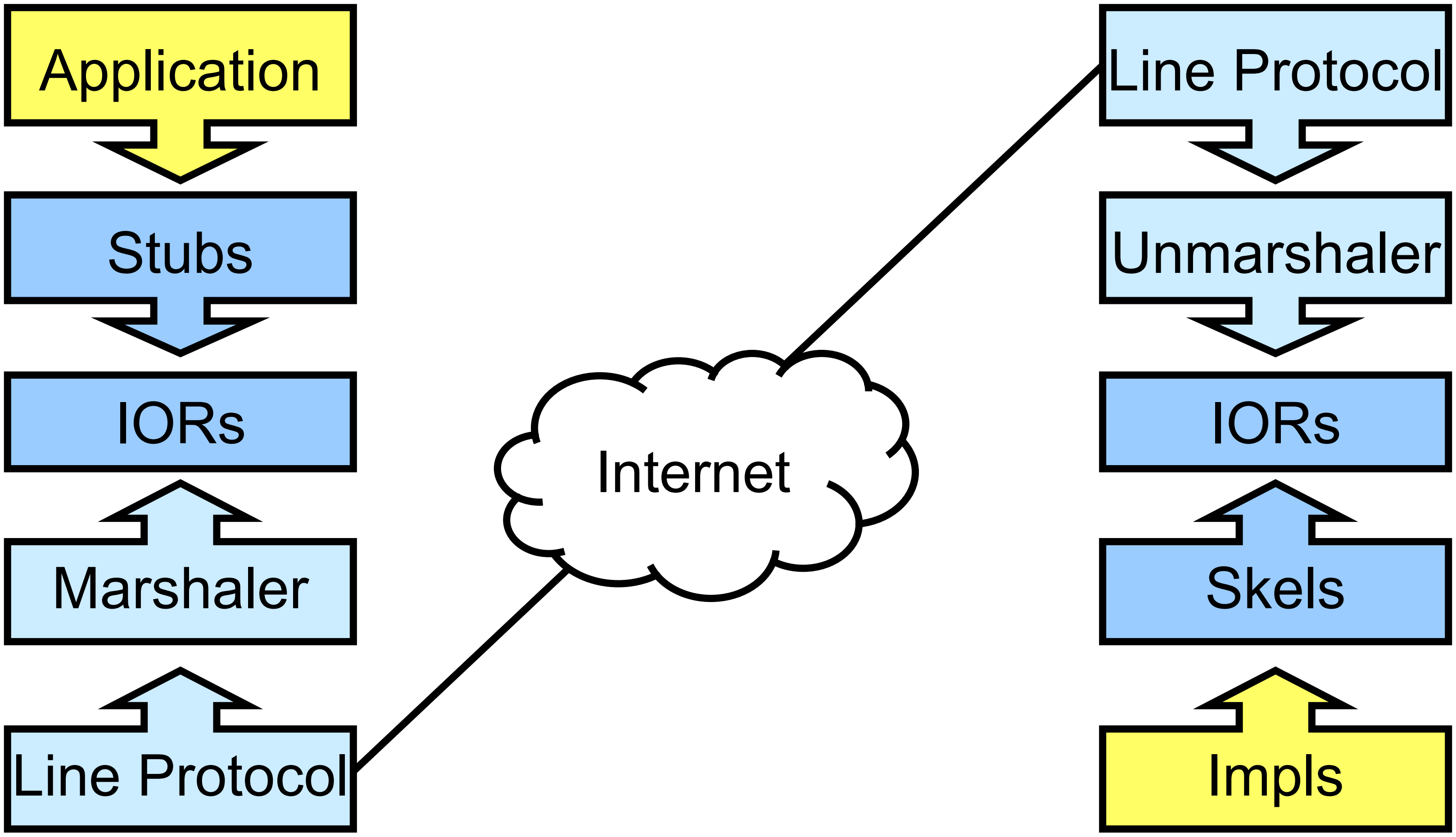


- **Application: uses components in user's language of choice**
- **Client Side Stubs: translate from application language to C**
- **Internal Object Representation: Always in C**
- **Server Side Skeletons: translates IOR (in C) to component implementation language**
- **Implementation: component developers choice of language. (Can be wrappers to legacy code)**

Out of Process Components



Remote Components



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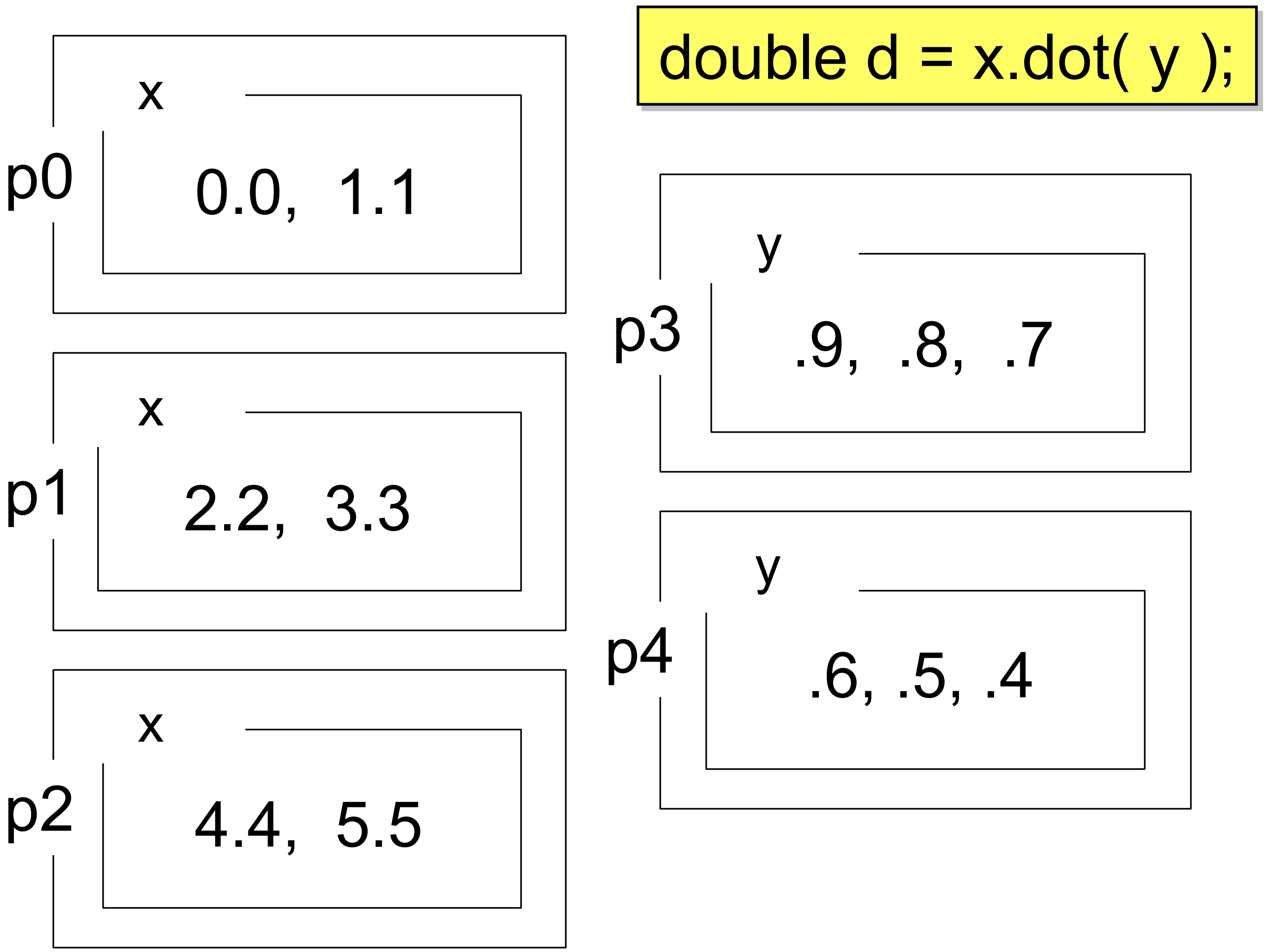
Initial Assumptions

- **Working Point-to-Point RMI**
- **Object Persistence**

Example #1: 1-D Vectors



Example #1: 1-D Vectors

```
double d = x.dot( y );
```

p0 — x

```
int       globalSize = 6;
int       localSize = 2;
int[ ]    local2global = { 0, 1 };
double[ ] localData = { 0.0, 1.1 };
```

p1 — x

```
int       globalSize = 6;
int       localSize = 2;
int[ ]    local2global = { 2, 3 };
double[ ] localData = { 2.2, 3.3 };
```

p2 — x

```
int       globalSize = 6;
int       localSize = 2;
int[ ]    local2global = { 4, 5 };
double[ ] localData = { 4.4, 5.5 };
```

p3 — y

```
int       globalSize = 6;
int       localSize = 3;
int[ ]    local2global = { 0, 1, 2 };
double[ ] localData = { .9, .8, .7 };
```

p4 — y

```
int       globalSize = 6;
int       localSize = 3;
int[ ]    local2global = { 3, 4, 5 };
double[ ] localData = { .6, .5, .4 };
```

Rule #1: Owner Computes

```
double vector::dot( vector& y ) {
   // initialize
   double * yData = new double[localSize];
   y.requestData( localSize, local2global, yData);
   // sum all x[i] * y[i]
   double localSum = 0.0;
   for( int i=0; i<localSize; ++i ) {
      localSum += localData[i] * yData[i];
   }
   // cleanup
   delete[] yData;
   return localMPIComm.globalSum( localSum );
}
```

Design Concerns

- vector y is not guaranteed to have data mapped appropriately for dot product.
- vector y is expected to handle MxN data redistribution internally

```
y.requestData( localSize, local2global, yData);
```

  - Should each component implement MxN redistribution?

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Vector Dot Product: Take #2

```
double vector::dot( vector& y ) {
    // initialize
    MUX mux( *this, y );
    double * yData =
        mux.requestData( localSize, local2global );

    // sum all x[i] * y[i]
    double localSum = 0.0;
    for( int i=0; i<localSize; ++i ) {
        localSum += localData[i] * yData[i];
    }

    // cleanup
    mux.releaseData( yData );
    return localMPIComm.globalSum( localSum );
}
```

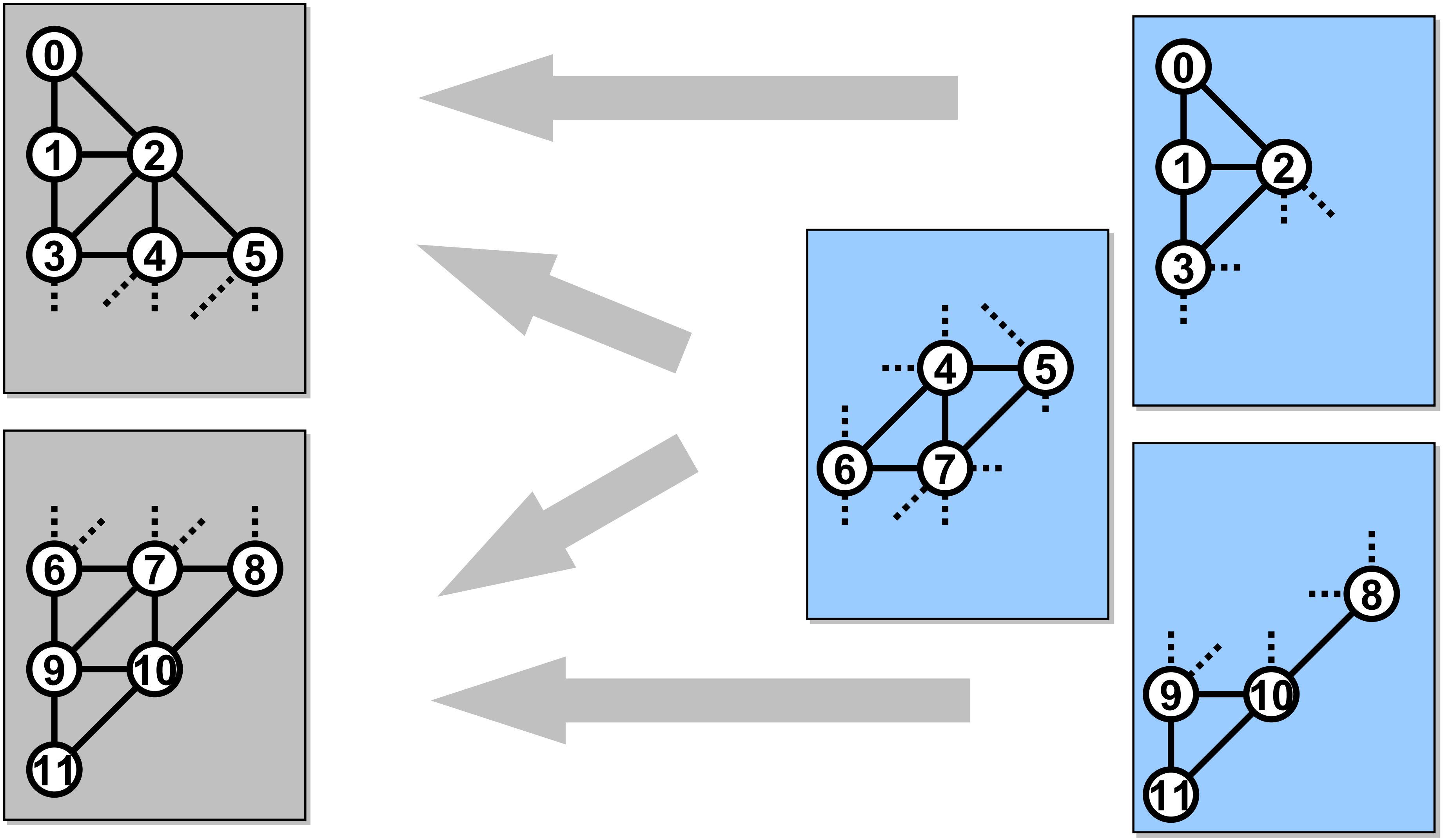
Generalized Vector Ops

```
vector<T>::parallelOp( vector<T>& y ) {
   // initialize
   MUX mux( *this, y );
   vector<T> newY =
      mux.requestData( localSize, local2global );
   // problem reduced to a local operation
   result = x.localOp( newY );
   // cleanup
   mux.releaseData( newY );
   return localMPIComm.reduce( localResult );
}
```

Rule #2: MUX distributes data

- Users invoke parallel operations without concern to data distribution
- Developers implement local operation assuming data is already distributed
- Babel generates code that reduces a parallel operation to a local operation
- MUX handles all communication
- How general is a MUX?

Example #2: Undirected Graph



Key Observations

- Every Parallel Component is a container and is divisible to subsets.
- There is a minimal (atomic) addressable unit in each Parallel Component.
- This minimal unit is addressable in global indices.

Atomicity

- Vector (Example #1):
  - atom - scalar
  - addressable - integer offset
- Undirected Graph (Example #2):
  - atom - vertex with ghostnodes
  - addressable - integer vertex id
- Undirected Graph (alternate):
  - atom - edge
  - addressable - ordered pair of integers

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MxNRedistributable Interface

```
interface Serializable {

   store( in Stream s );
   load( in Stream s );
};

interface MxNRedistributable extends Serializable {

   int getGlobalSize();
   local int getLocalSize();
   local array<int,1> getLocal2Global();

   split ( in array<int,1> maskVector,
           out array<MxNRedistributable,1> pieces);

   merge( in array<MxNRedistributable,1> pieces);
};
```

Rule #3: All Parallel Components implement "MxNRedistributable"

- Provides standard interface for MUX to manipulate component
- Minimal coding requirements to developer
- Key to abstraction
  - split()
  - merge()
- Manipulates "atoms" by global address

Now for the hard part...

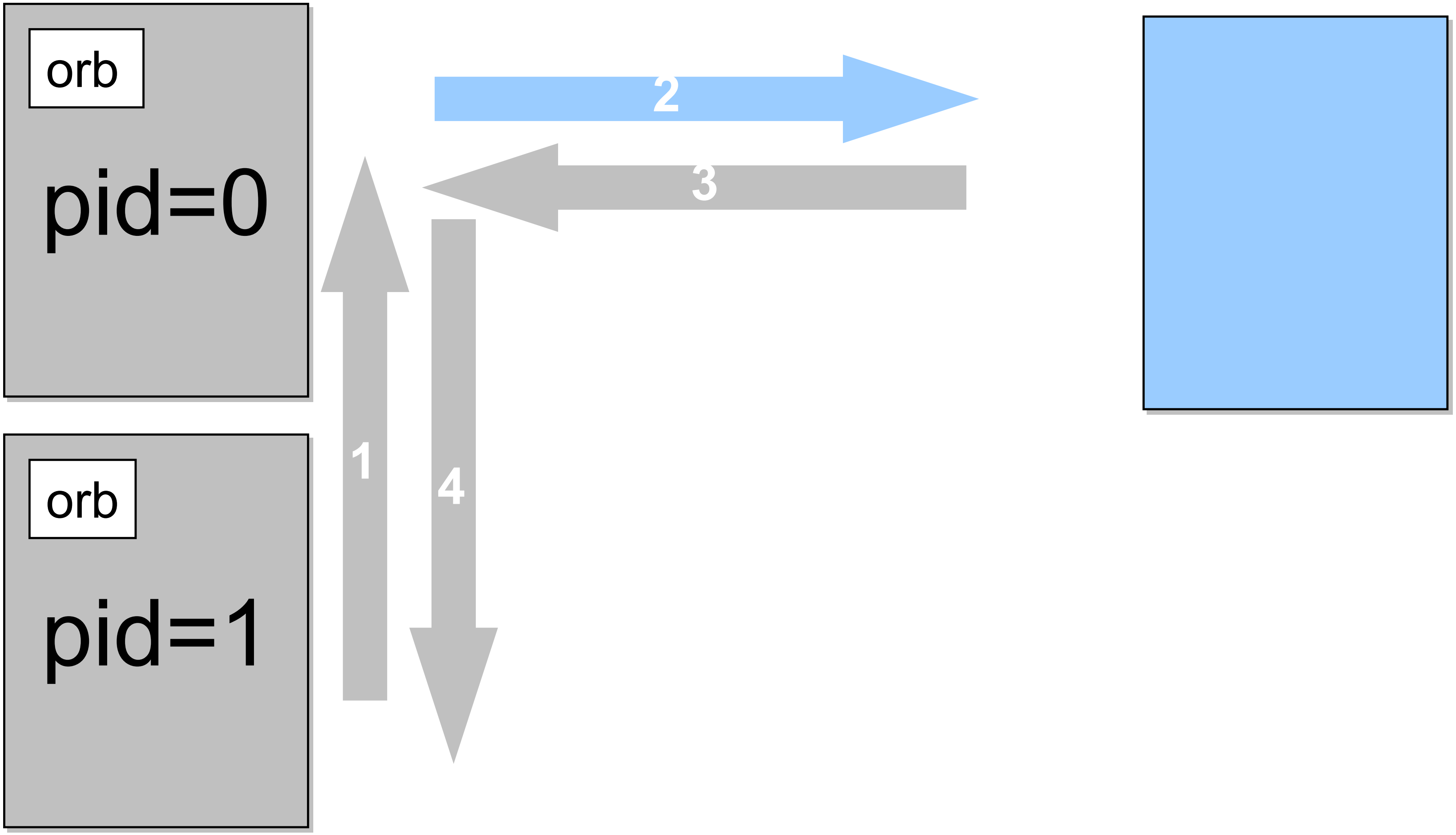
... 13 slides illustrating how it all fits together for an Undirected Graph

%> mpirun -np 2 graphtest

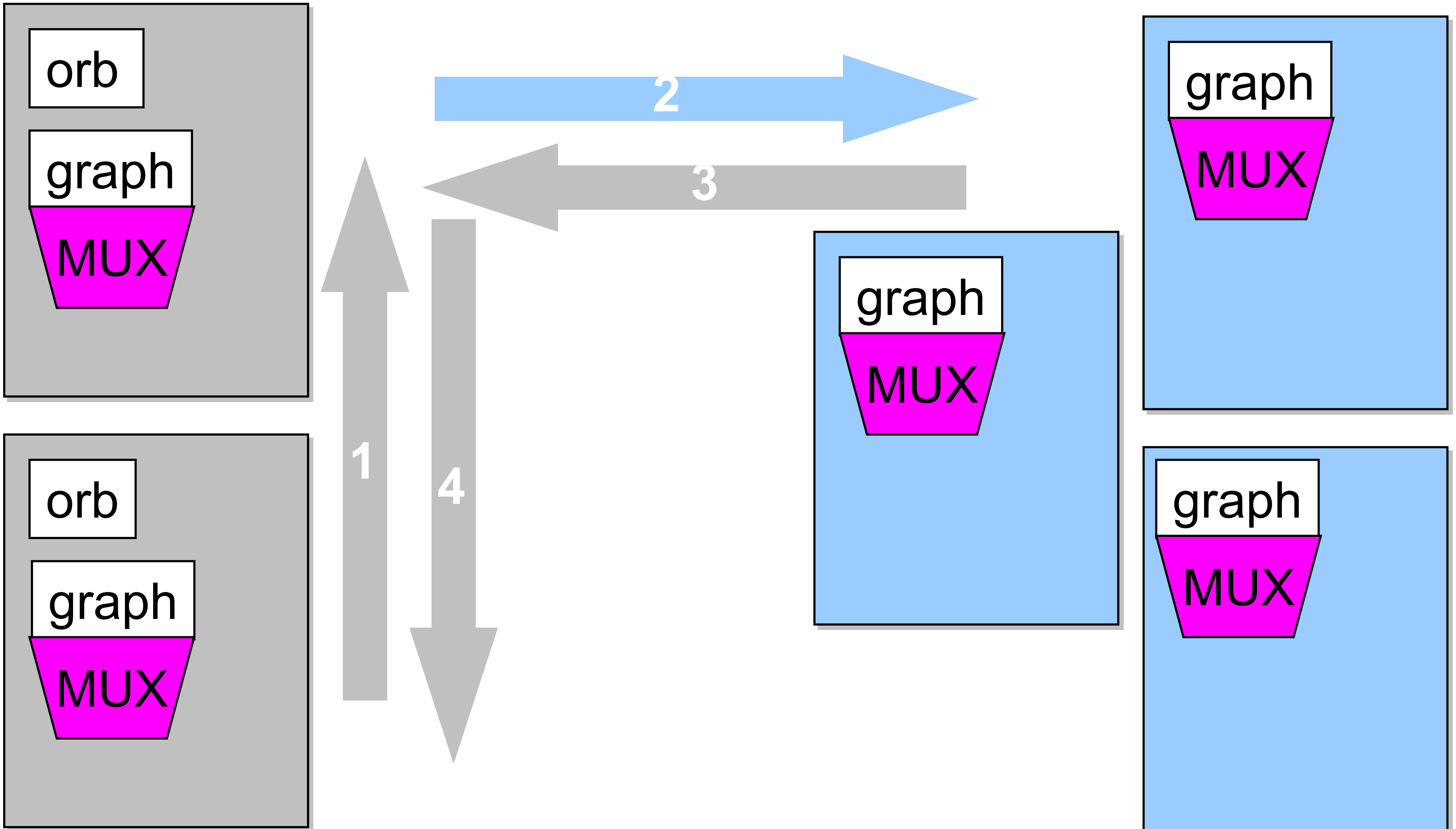
pid=0

pid=1

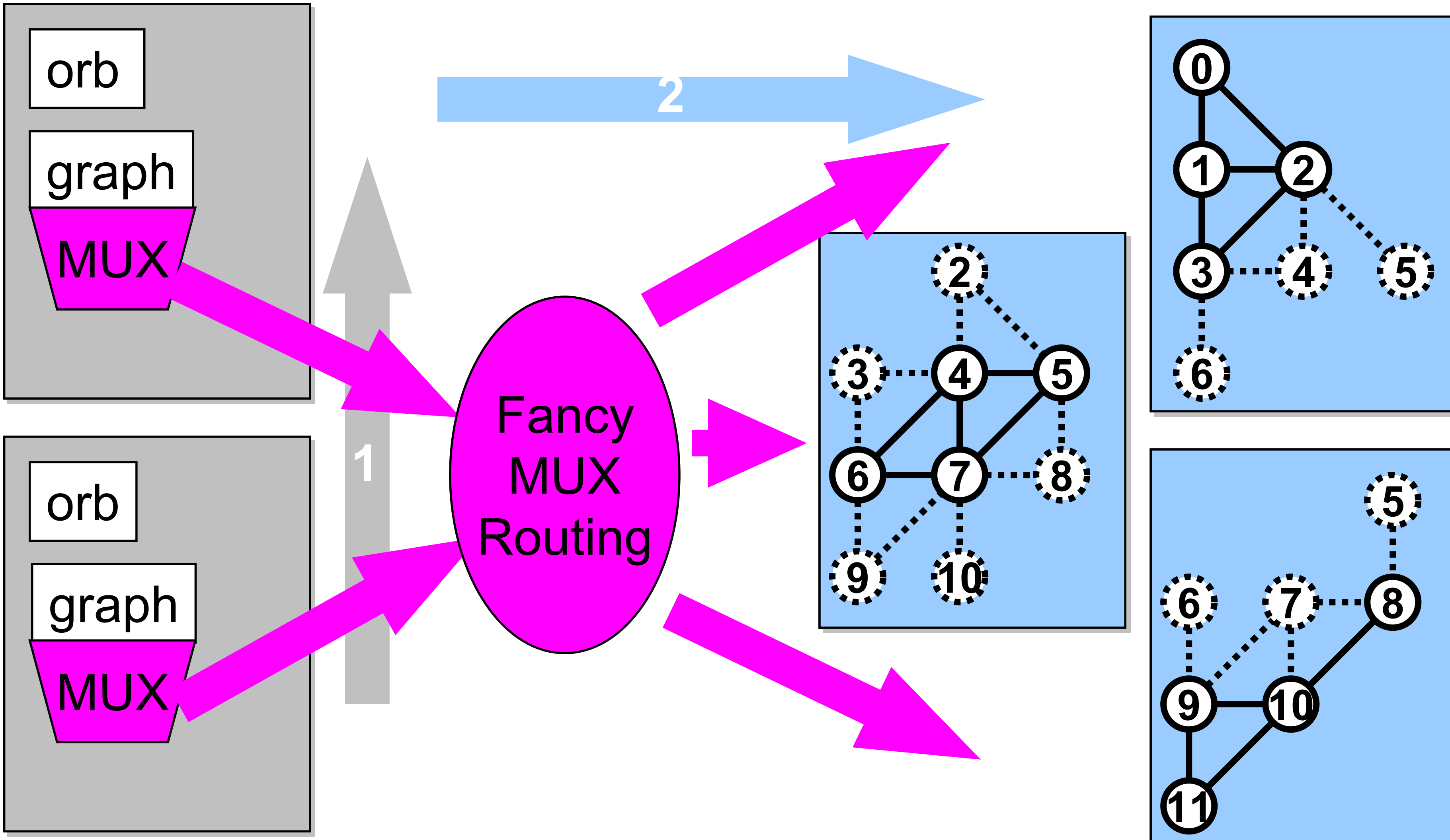
BabelOrb * orb = BabelOrb.connect(“http://...”);



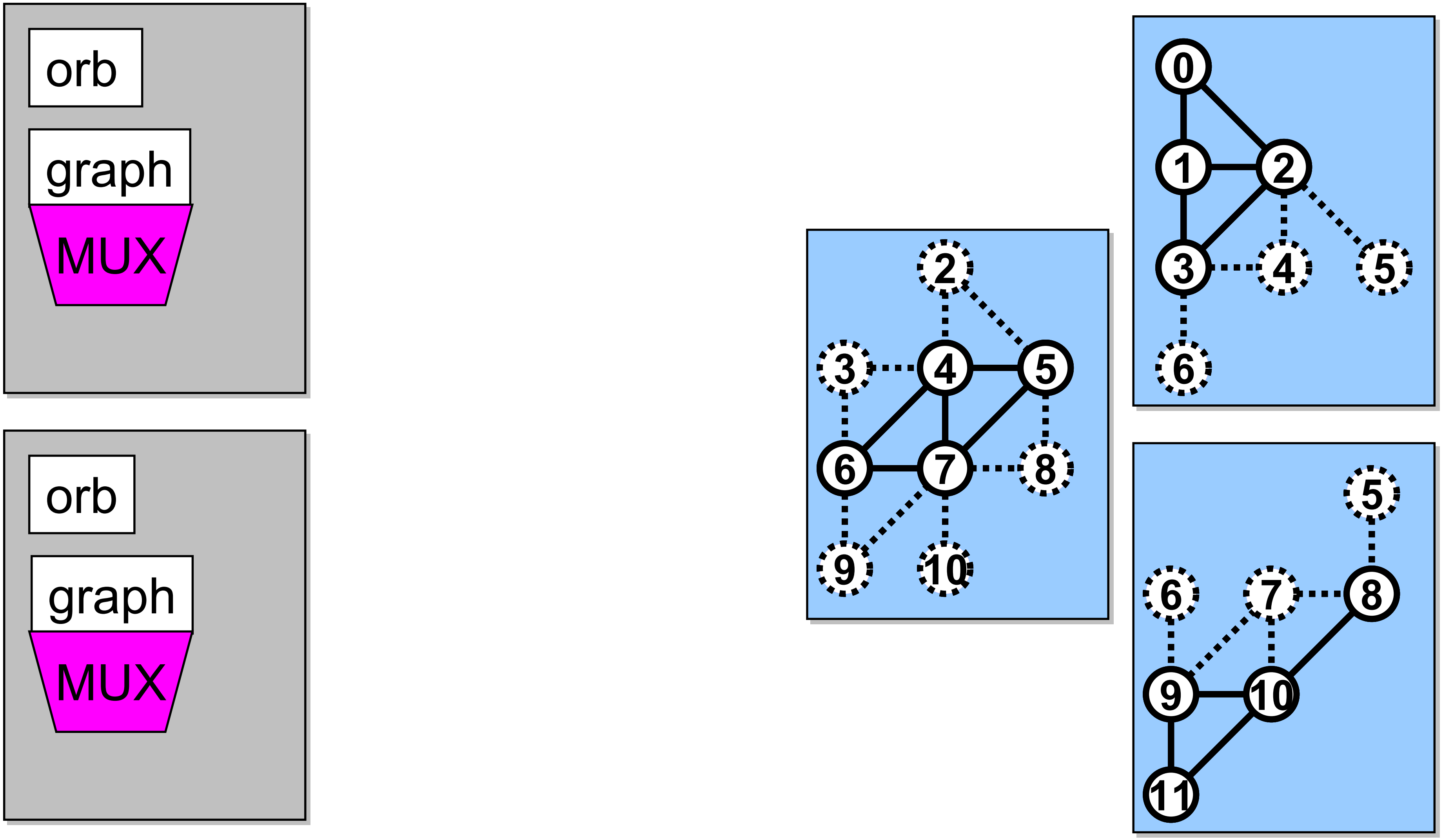
Graph * graph = orb->create("graph",3);



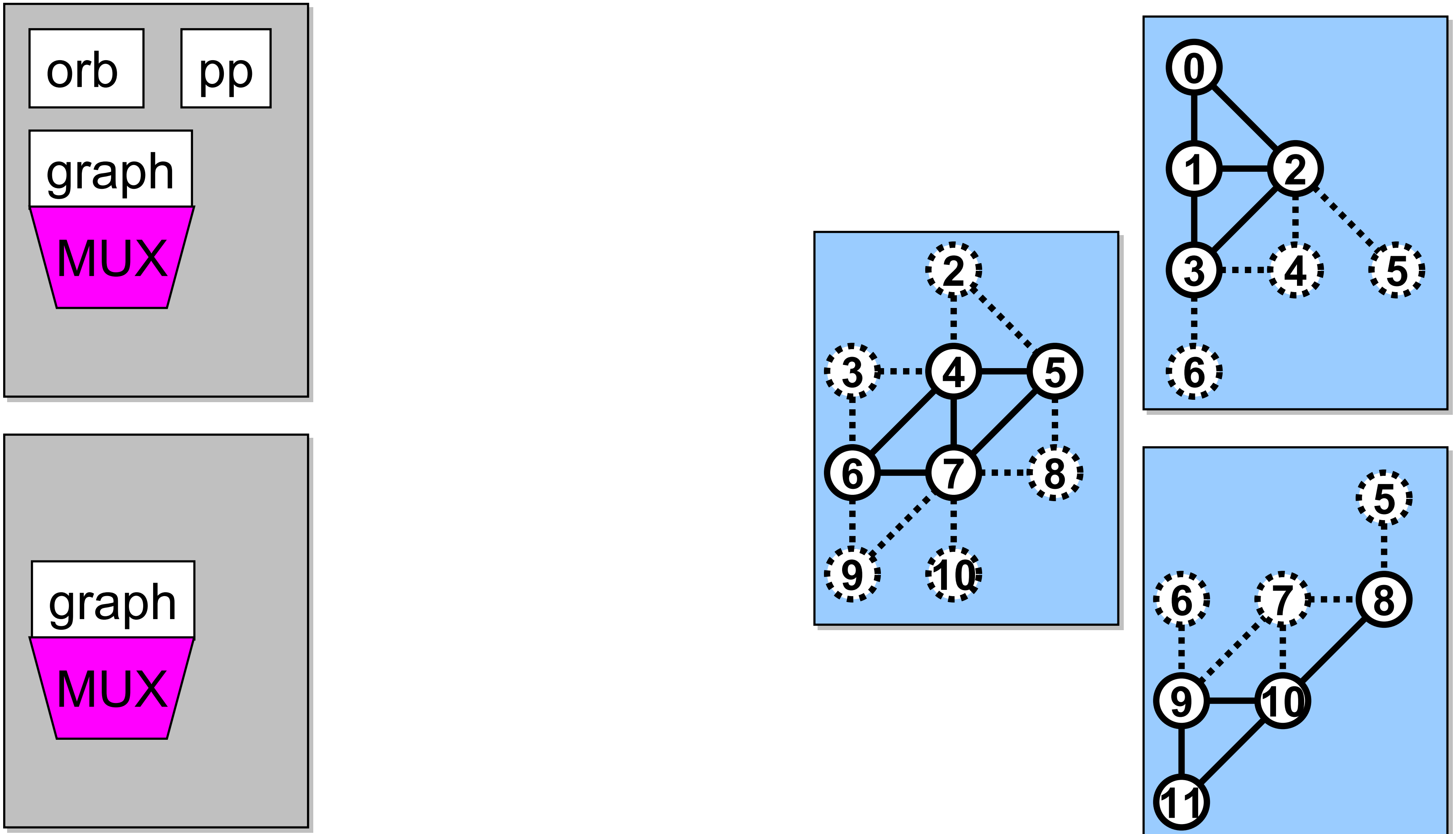
graph->load("file://...");



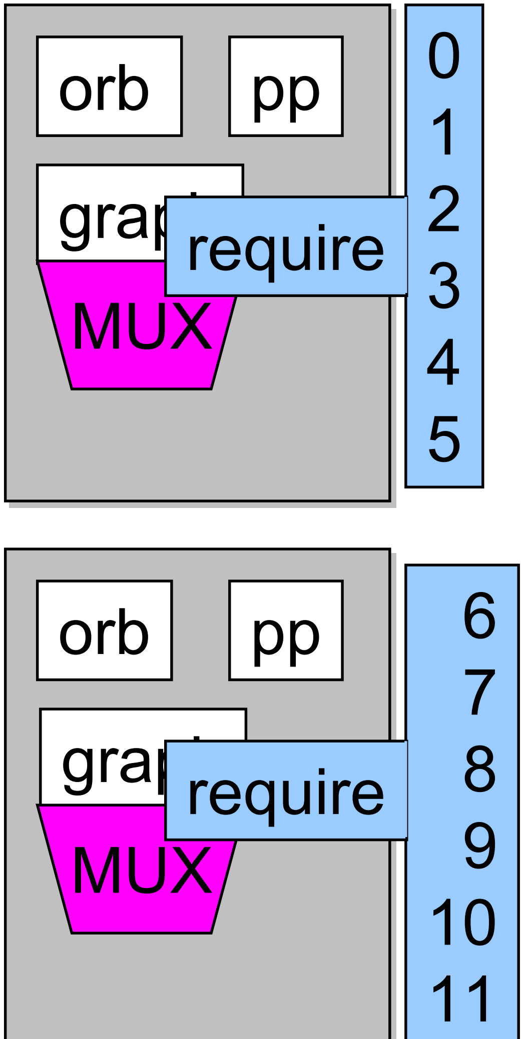
graph->doExpensiveWork();



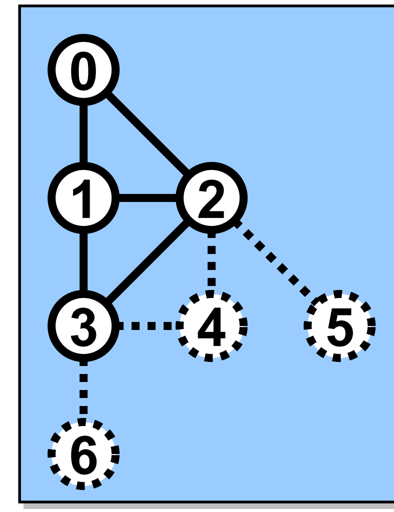
PostProcessor * pp = new PostProcessor;

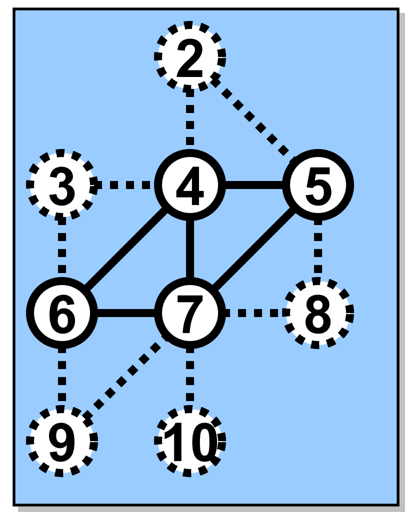


pp->render(graph);

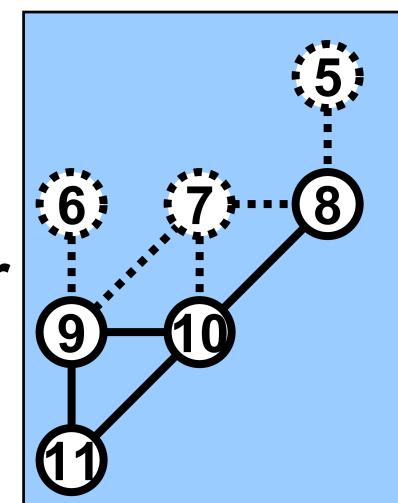


- **MUX queries graph for global size (12)**
- **Graph determines particular data layout (blocked)**

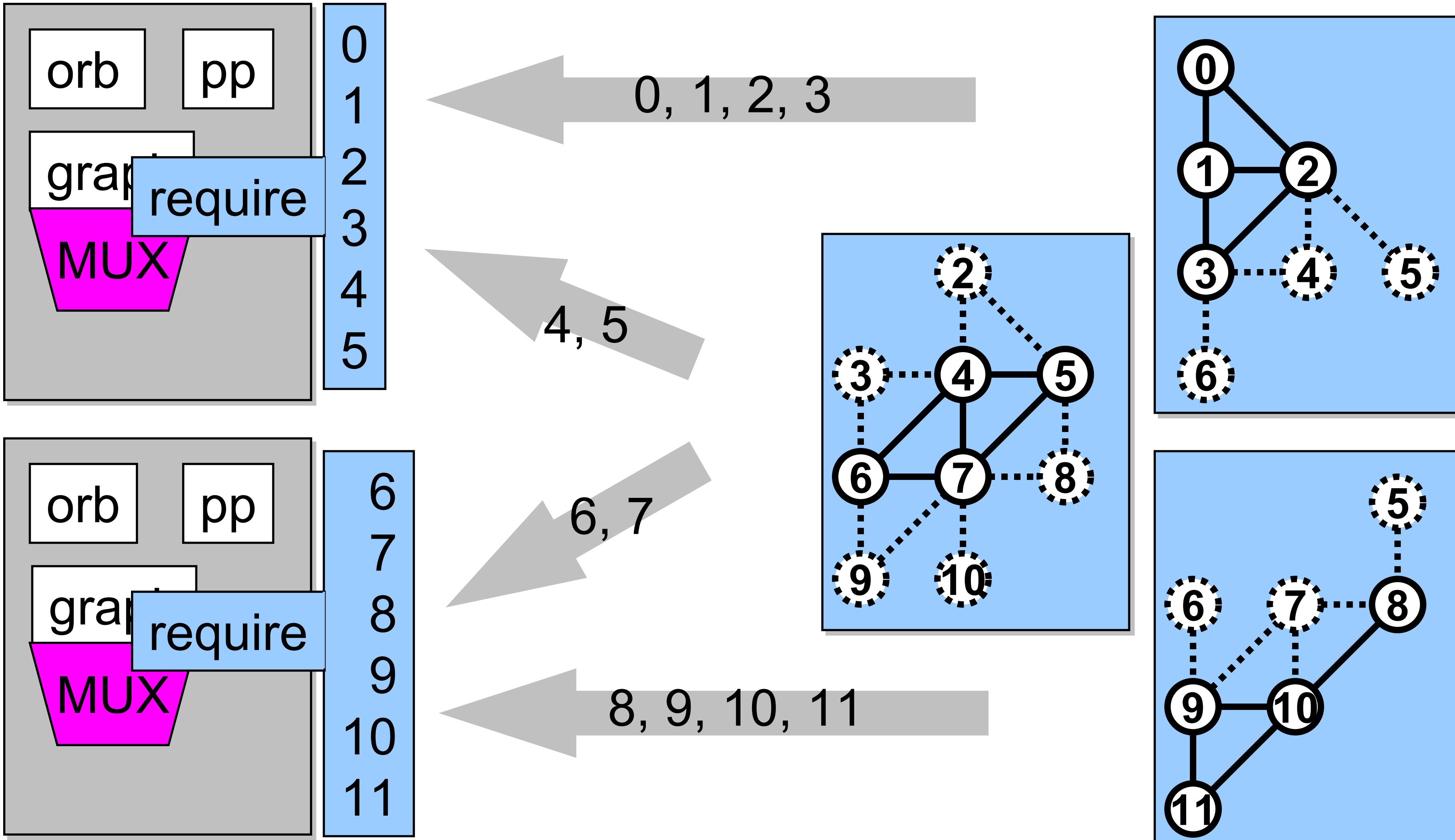




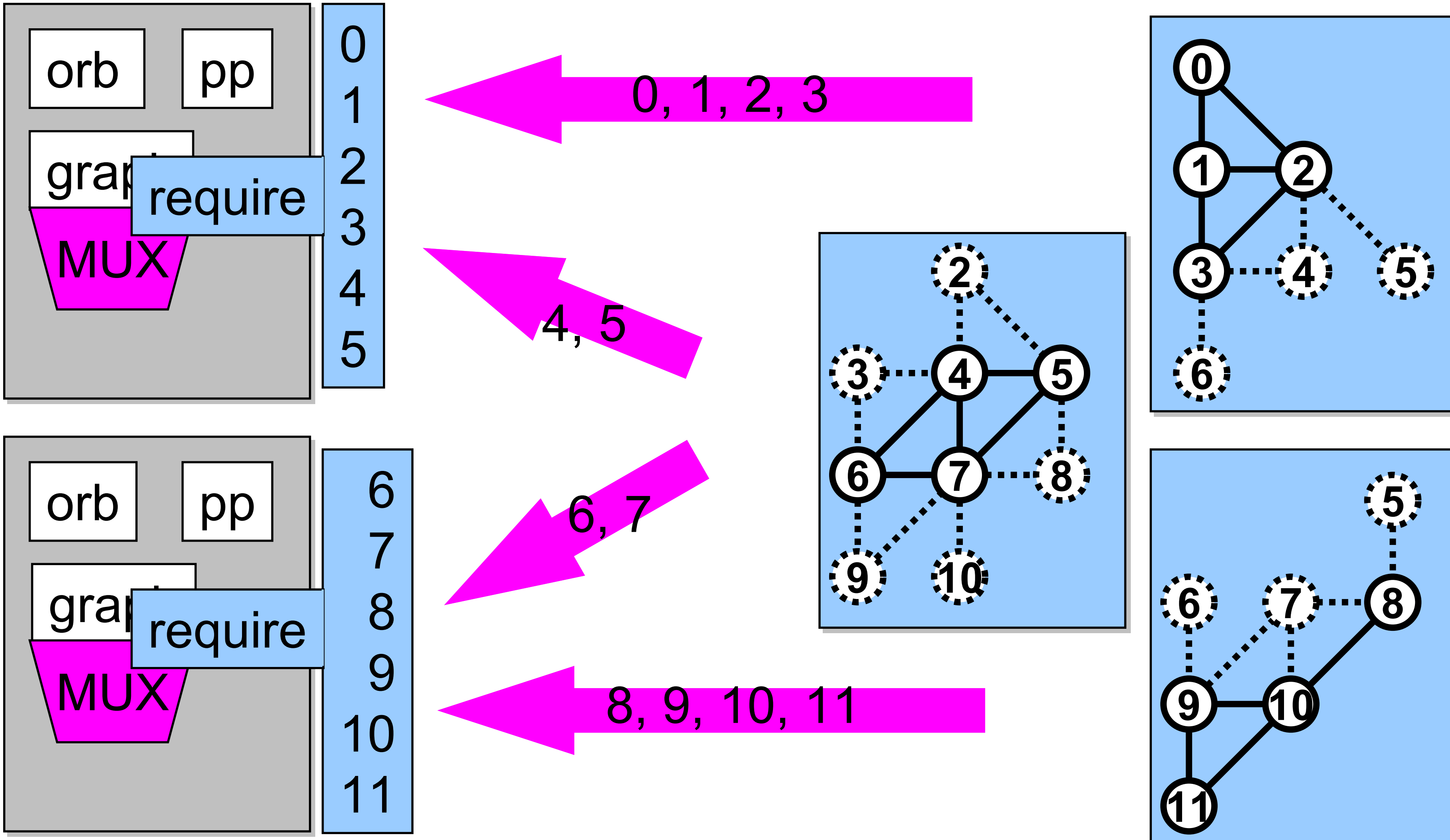
- **MUX is invoked to guarantee that layout before render implementation is called**



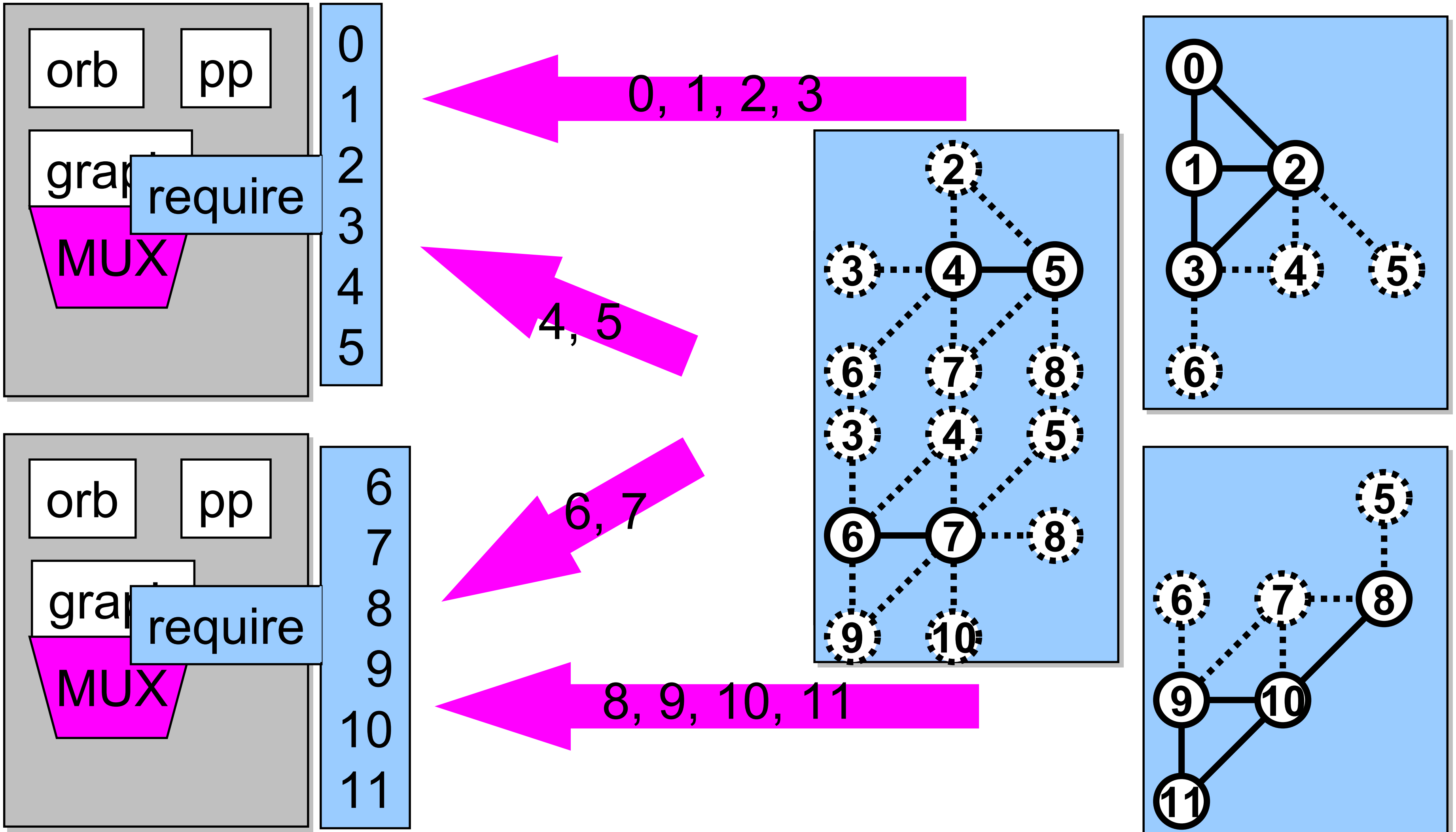
MUX solves general parallel network flow problem (client & server)



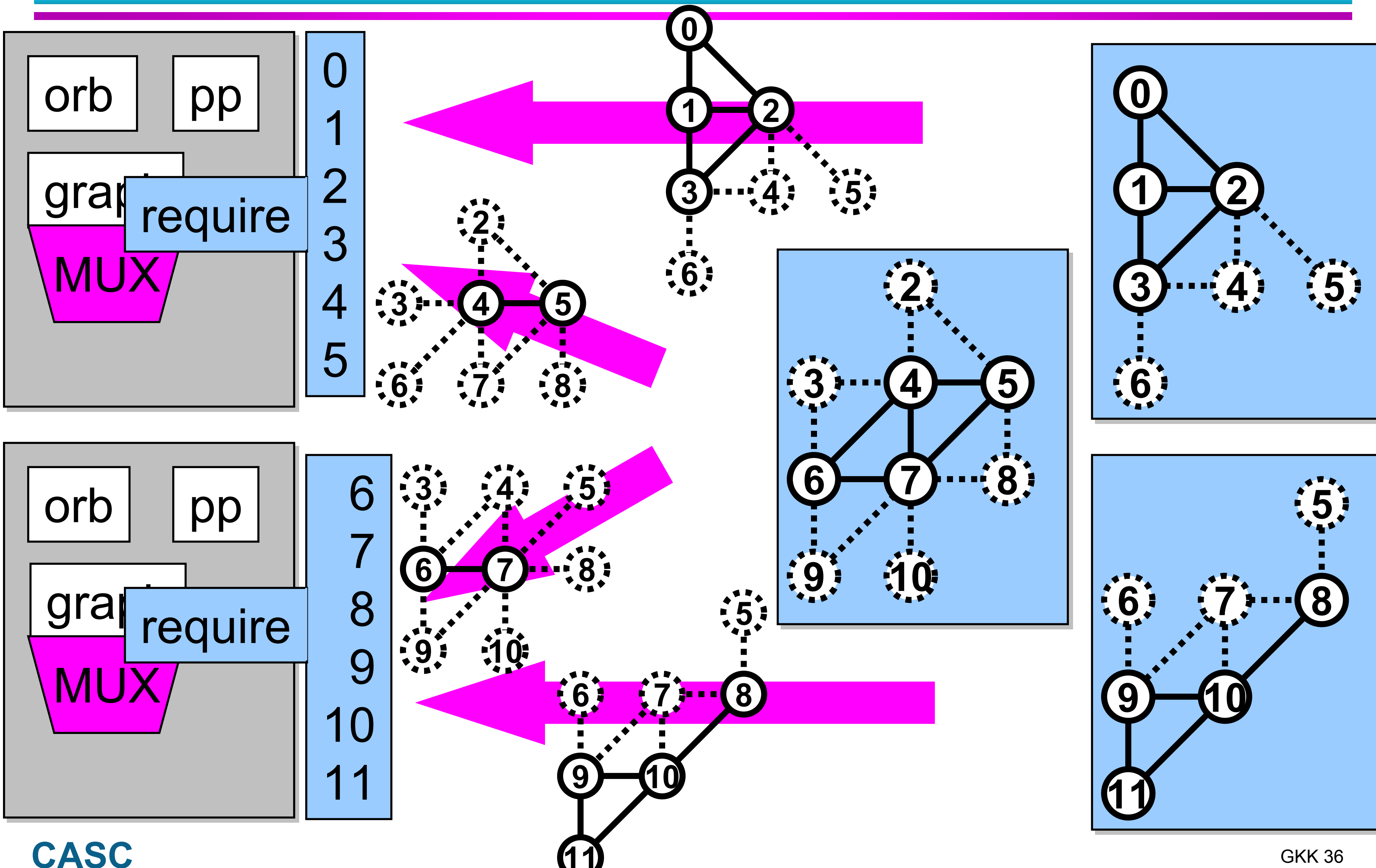
MUX opens communication pipes



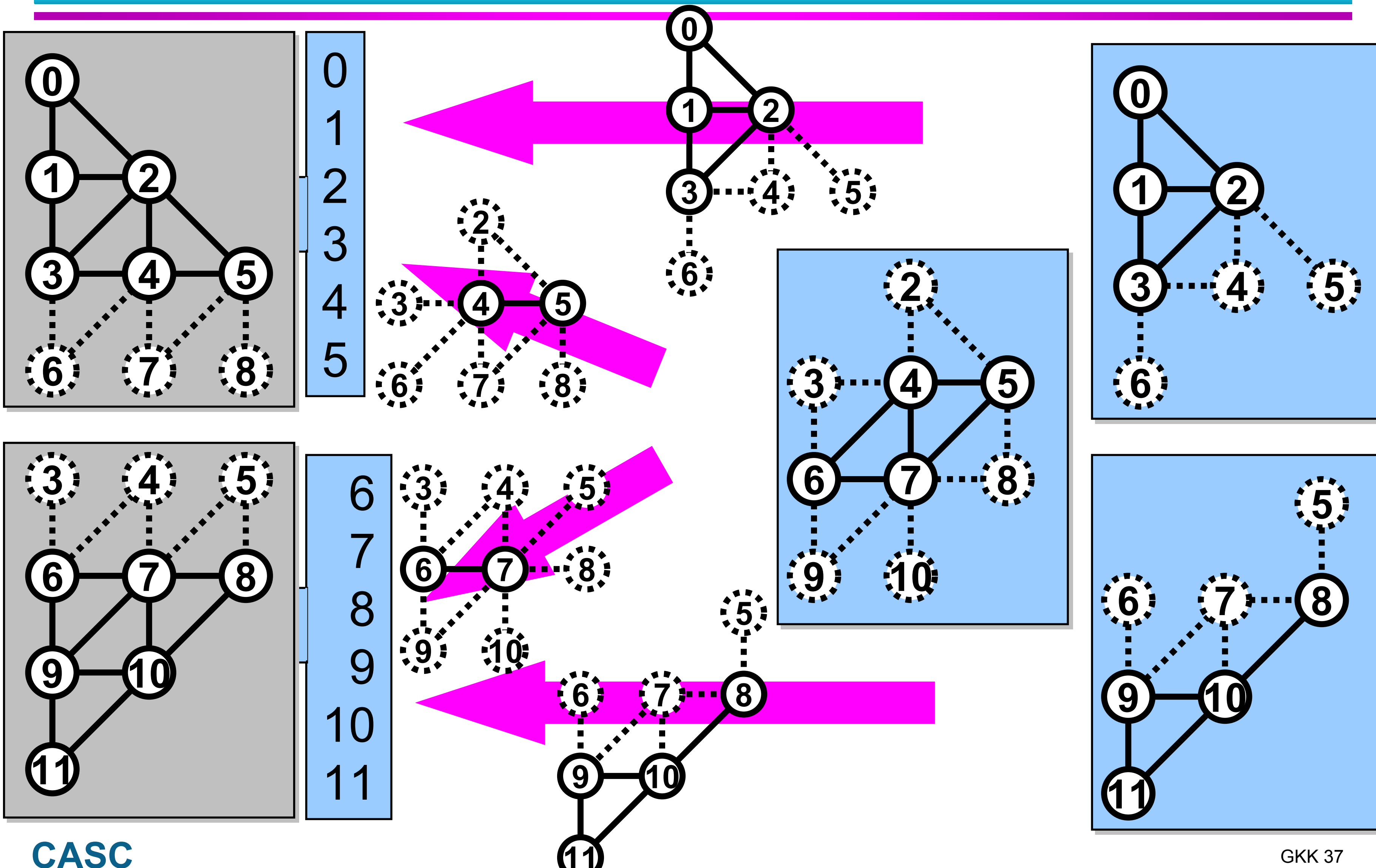
MUX splits graphs with multiple destinations (server-side)



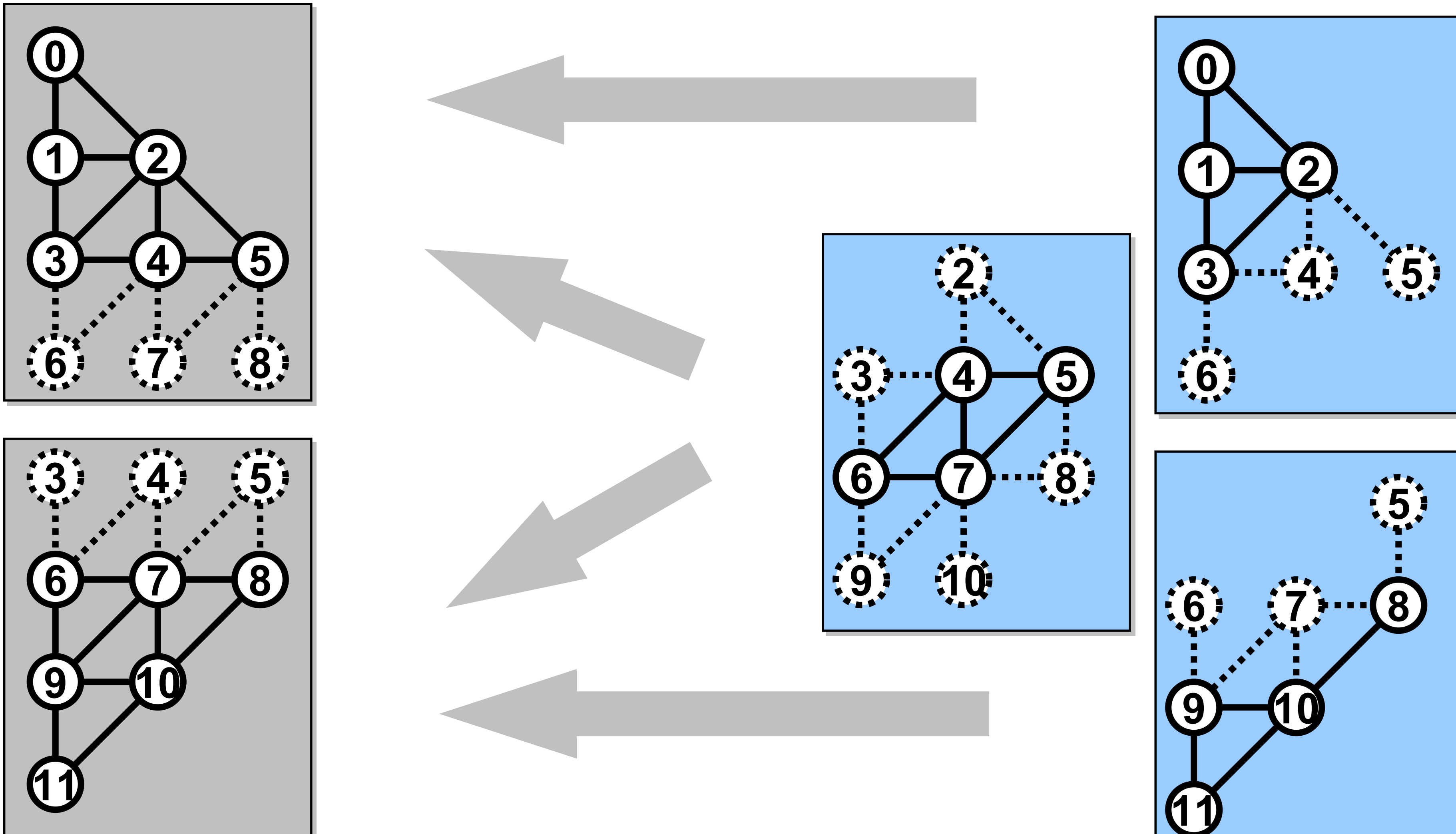
MUX sends pieces through communication pipes (persistance)



MUX receives graphs through pipes & assembles them (client side)



pp -> render_impl(graph);
(user's implementation runs)



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Summary

- All distributed components are containers and subdivisable
- The smallest globally addressable unit is an atom
- MxNRedistributable interface reduces general component MxN problem to a 1-D array of ints
- MxN problem is a special case of the general problem N handles to M instances
- Babel is uniquely positioned to contribute a solution to this problem

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Tentative Research Strategy

Fast Track

- Java only, no Babel
  - serialization & RMI built-in
- Build MUX
- Experiment
- Write Paper

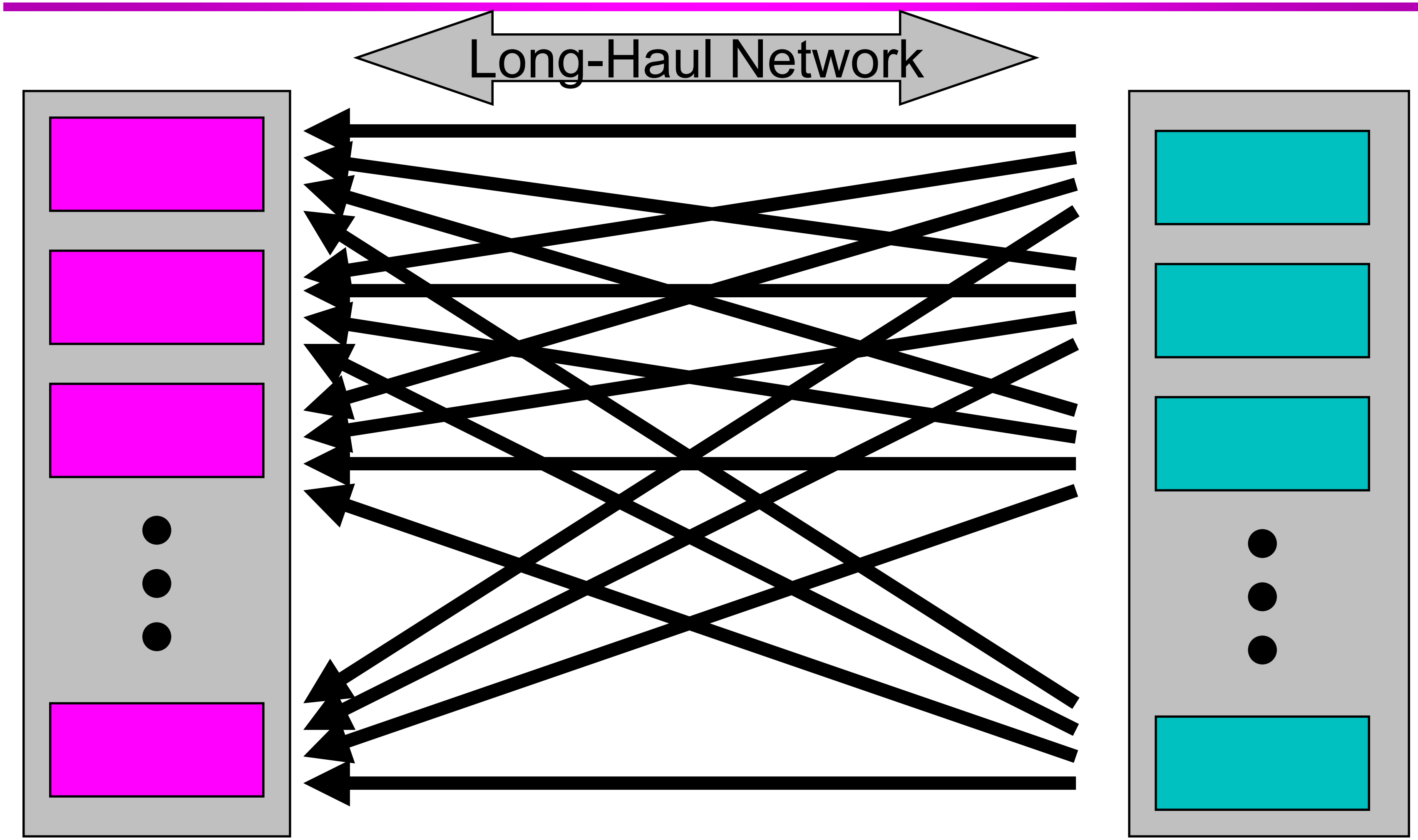
Sure Track

- Finish 0.5.x line
- add serialization
- add RMI
- Add in technology from Fast Track

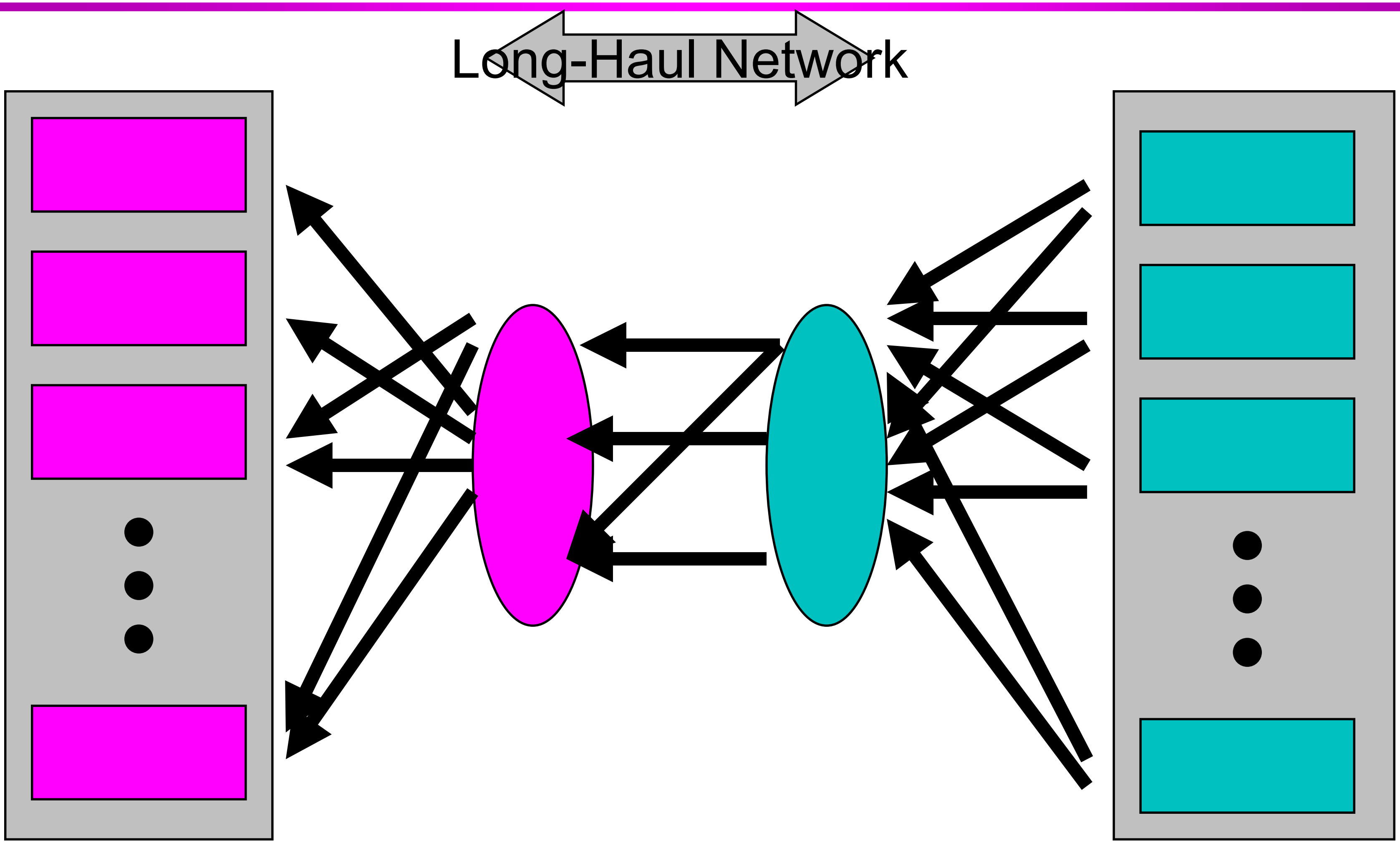
Open Questions

- Non-general, Optimized Solutions
- Client-side Caching issues
- Fault Tolerance
- Subcomponent Migration
- Inter vs. Intra component communication
- MxN , MxP, or MxPxQxN

MxPxQxN Problem



MxPxQxN Problem



The End

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