A Java-based Programming Environment for the Grid: Jojo

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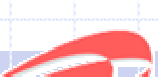
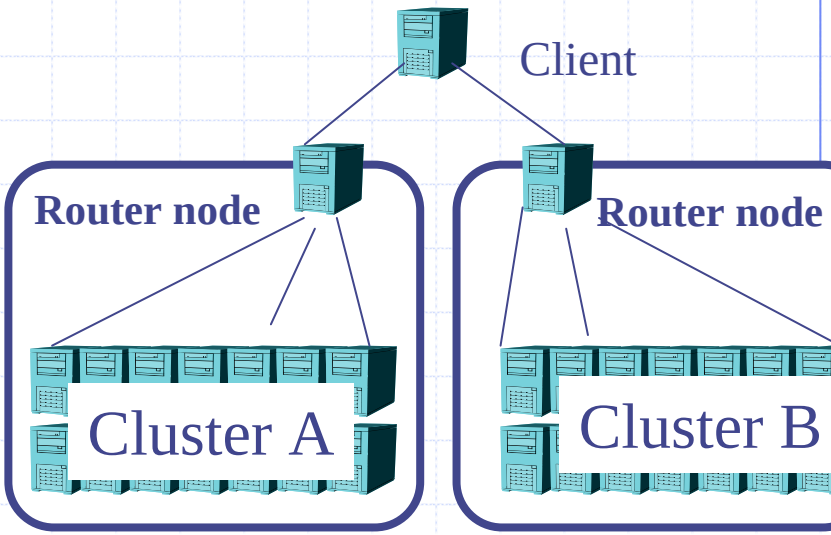


Background



- Grid and cluster are popularized
  - Clusters as Grid nodes
- Problem1: All the cluster nodes cannot have global IP
  - Existing middleware does not handle private IP nodes
    - Ex. MPICH-G2 、C.f. NXProxy [Tanaka]
- Problem2: Client scalability
  - Client node cannot handle hundreds of Servers

⇒Hierarchical Grid

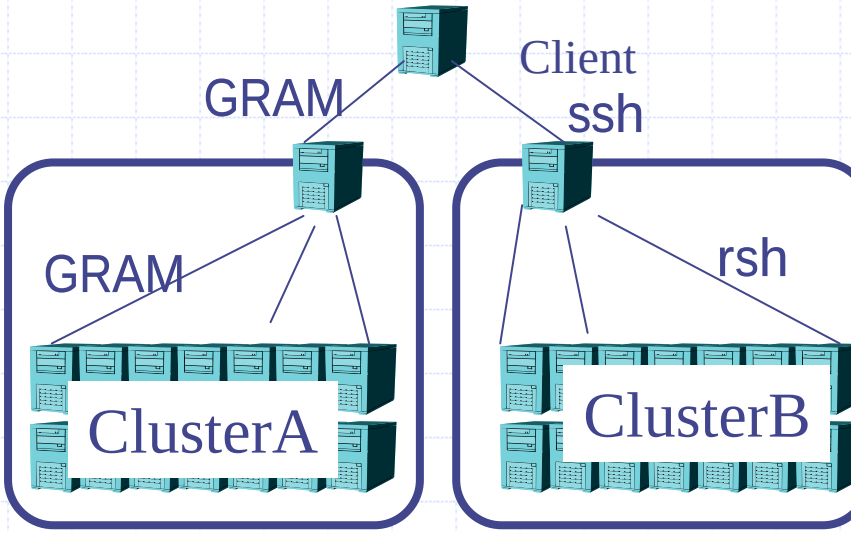
Goal

- Provide a programming environment that fits to hierarchical Grid
  - Works with private addressed clusters
  - Scales to hundreds of nodes

Java based Grid middleware **Jojo**

Jojo (1)

- Communication with tree structure
  - Private addressed cluster ready
  - Protocol :Globus GRAM、ssh、rsh



Jojo (2)

- Adopt Java language
  - Code portability
    - Good for heterogeneous environment
  - Integrated Thread support
    - Good for latency hiding
  - Lot of libraries are available
    - XML, Web related, network communication

Jojo (3)

- Executes each codes on each nodes
  - Each nodes can communicate with its parent, siblings, children.
- Automatically downloads user programs, and Jojo system program.
  - Avoids system version miss-match
  - Requires Java VM only on the cluster nodes

Programming Model

- Requirements
  - Simple, intuitive
  - Flexible message passing
    - Latency hiding with threaded programming

⇒ Complex asynchronous communication can be programmed easily

Programming model of Jojo

- Each node executes its own code
  - Subclass of Code class
  - SPMD
- Object based messaging
  - Incoming messages are handled by handler method
  - RPC style call is supported
    - Several message transfer modes are supported

API (1) Code

```
abstract class Code{
  Node [] siblings;    /** Brothers  */
  Node [] descendants; /** children */
  Node    parent;      /** parent */
  int     rank;  /** order in the brothers */
  /** initialize */
  public void init(Map arg);
  /** actual task */
  public void start();
  /** handler to handle incoming messages */
  public Object handle(Message mes);
}
```

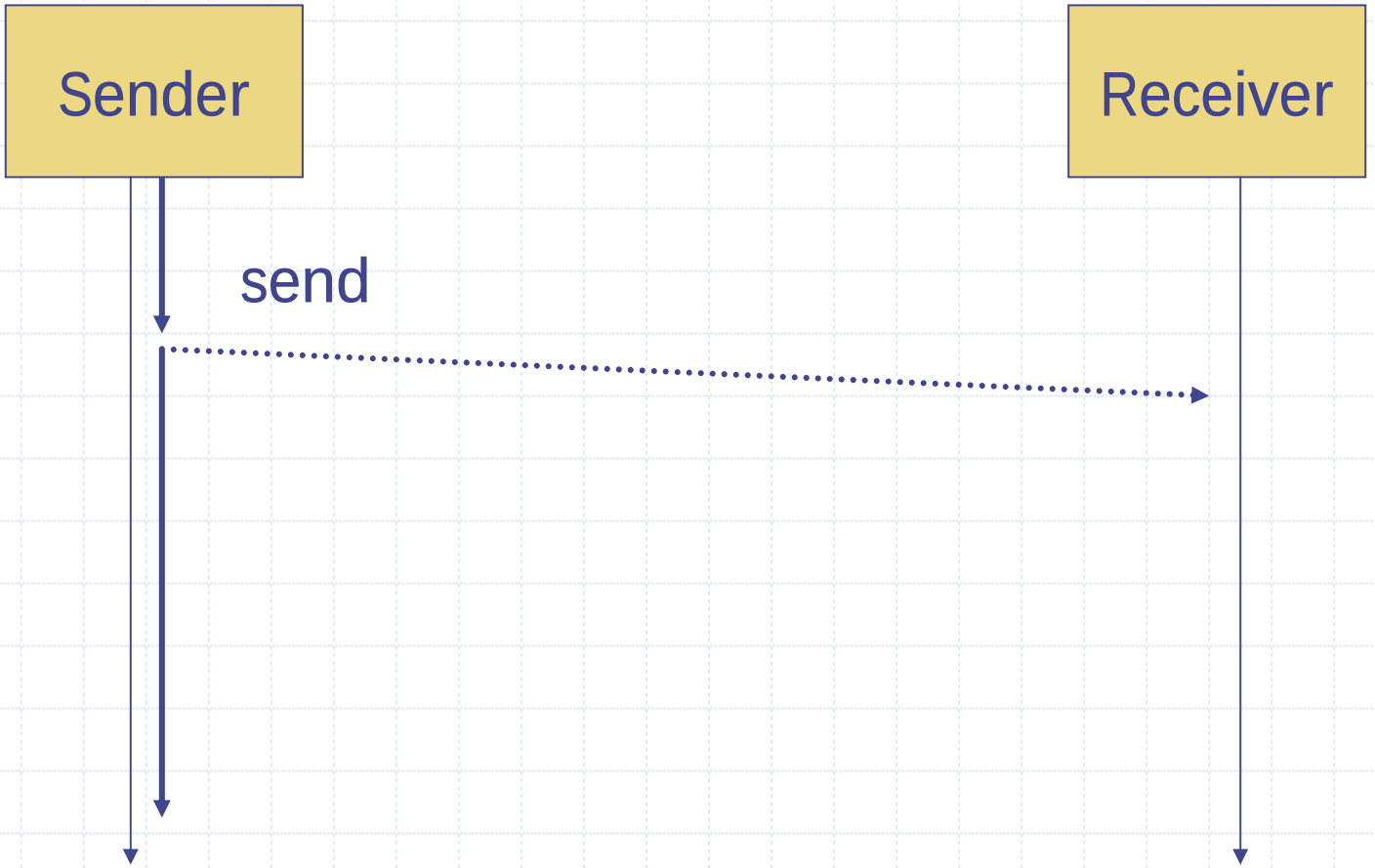
API (2) Node

```
public interface Node {
  /** non-blocking send; do not wait for reply */
  void send(Message msg) ;

  /** blocking call; wait for reply */
  Object call(Message msg) ;

  /** non-blocking call; do not wait for reply.
   *  returns Future to synchronize the reply. */
  Future callFuture(Message msg) ;

  /** non-blocking call; execute unnable */
  void callWithContext(Message msg, Context context) ;
}
```

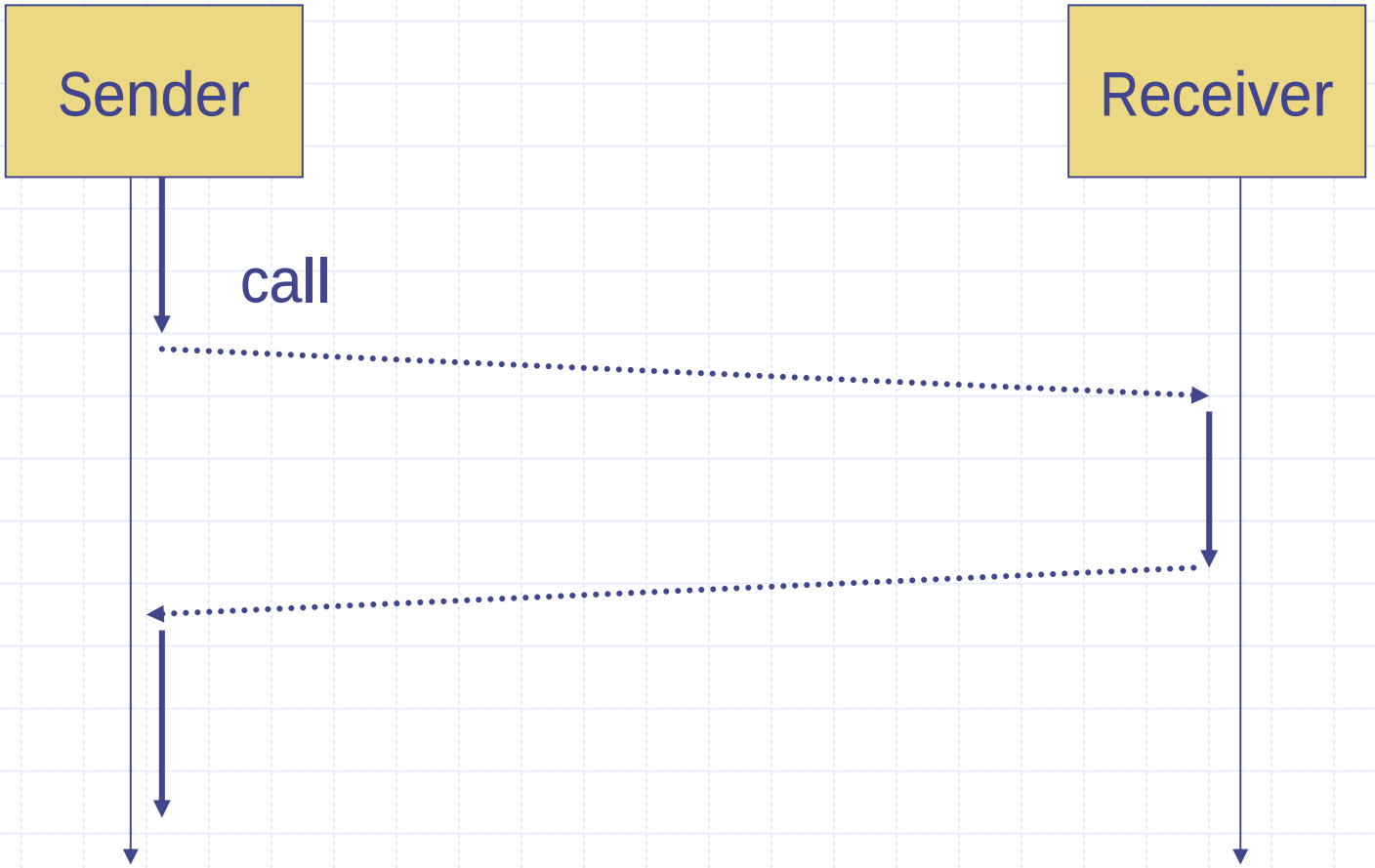
API (3) Message

```
public class Message implements Serializable{
  /** message id */
  public int tag;

  /** message contents */
  public Serializable contents;
}
```

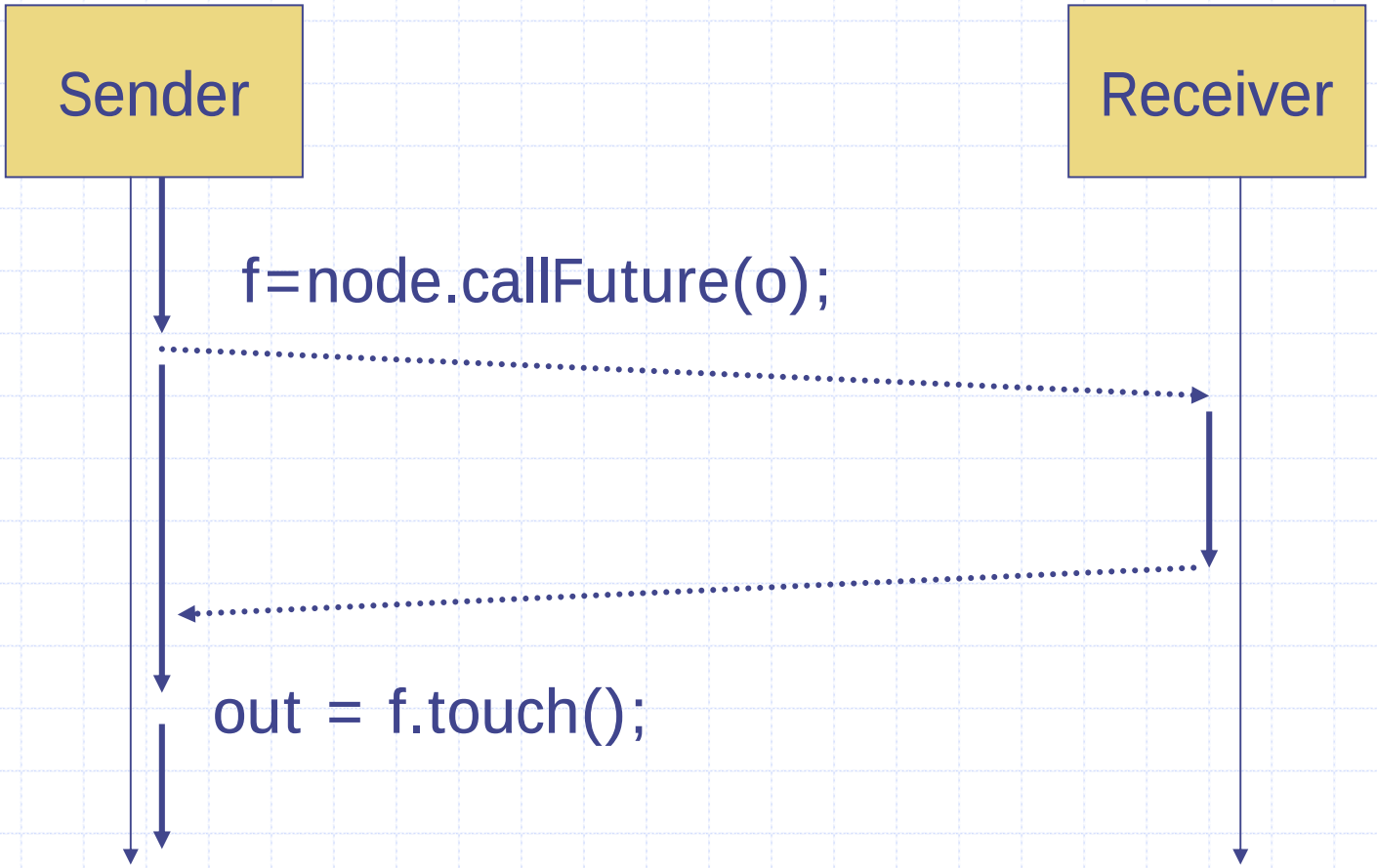
Transmission mode (1) send



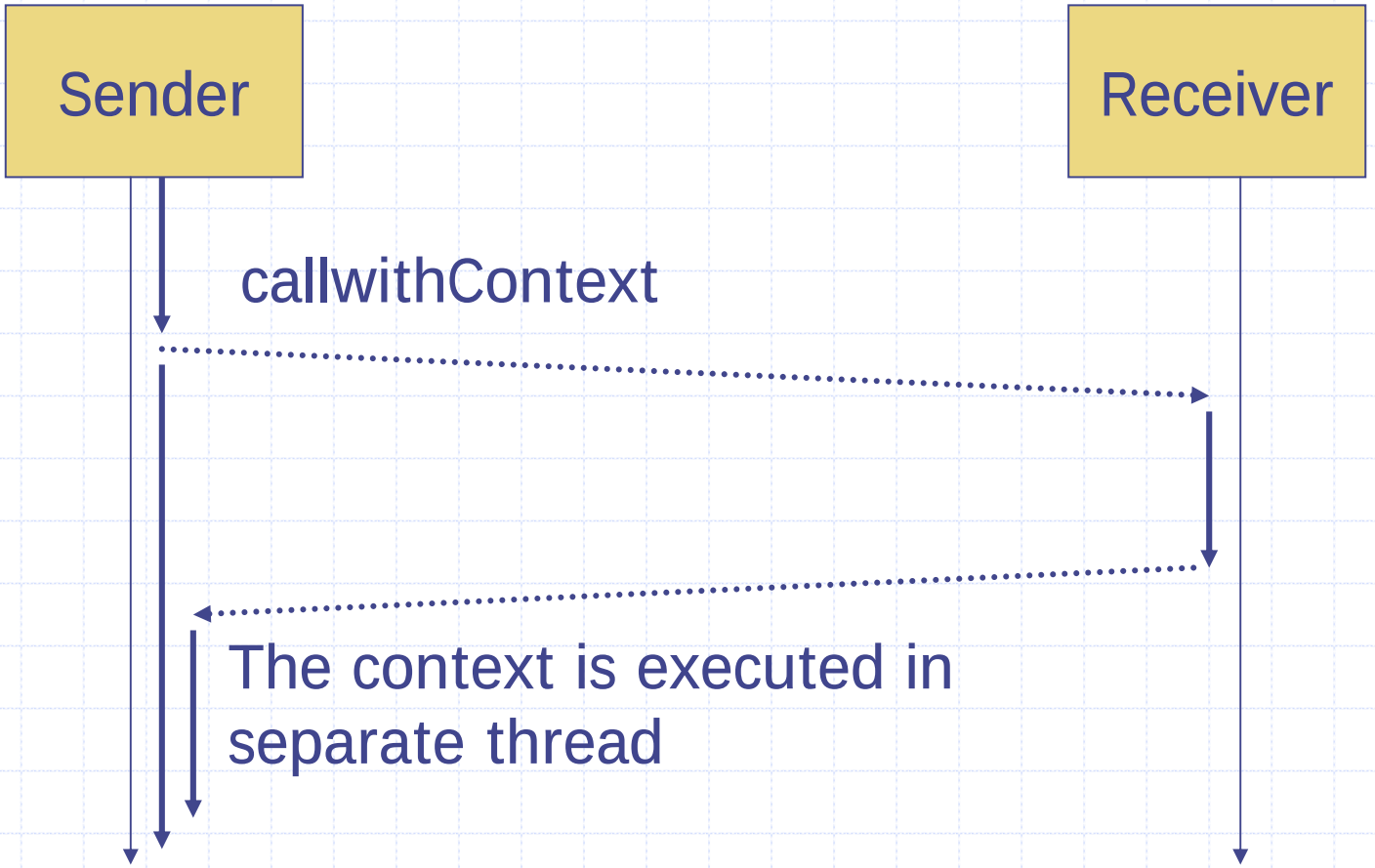
Transmission mode (2) blocking call



Transmission mode(3) Future



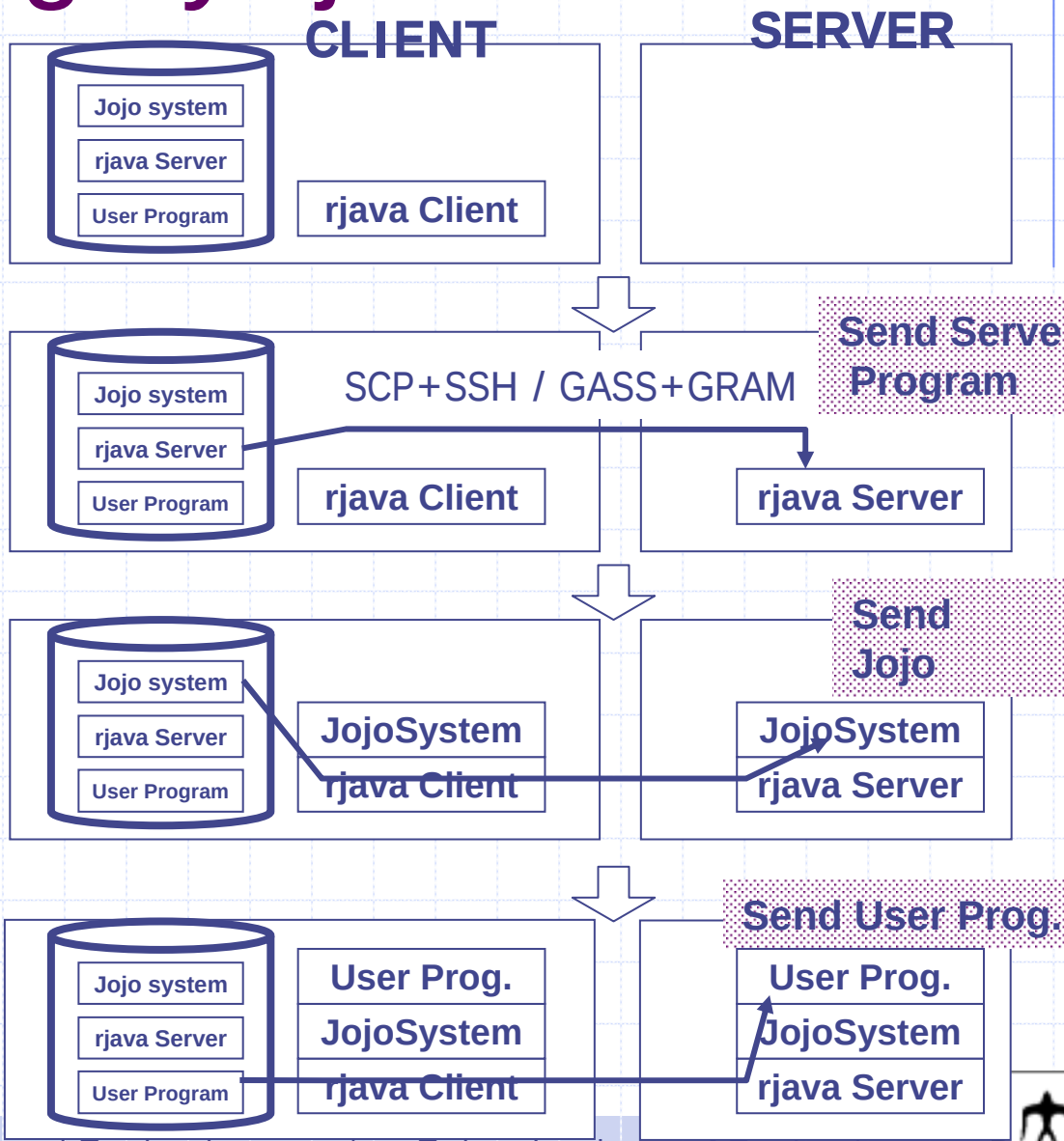
Transmission mode(4) with Context



Starting up Jojo Program

- Configuration file includes node and code configuration.
- Properties file is to specify the
- All the programs including Jojo itself automatically staged from the client
  - Boot strap server rjava

Bootstrapping by rjava



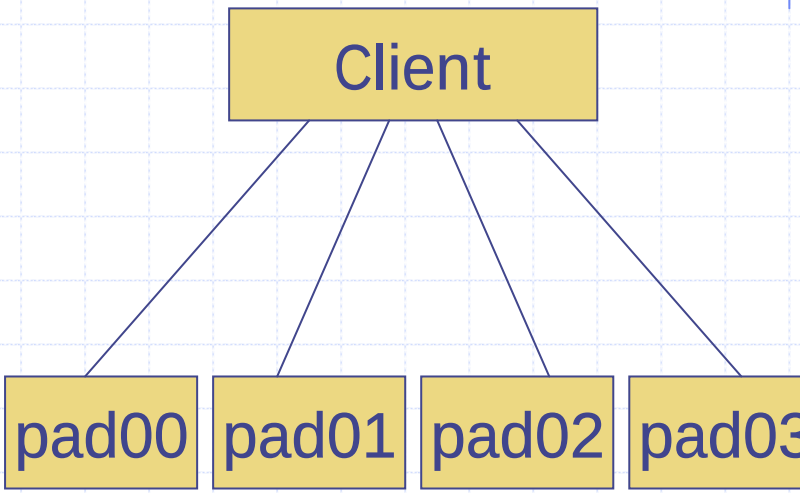
Configuration File

- Described in XML
- Represent hierarchical structure

```
<!ELEMENT node (code?,invocation?,node*)>
<!ATTLIST node host CDATA #REQUIRED>
<!ELEMENT code (#PCDATA)>
<!ELEMENT invocation EMPTY>
<!ATTLIST invocation
        javaPath CDATA #IMPLIED
        rjavaProtocol CDATA #IMPLIED
        rjavaRsh CDATA #IMPLIED
        rjavaRcp CDATA #IMPLIED
        xtermDisplay CDATA #IMPLIED
        xtermPath CDATA #IMPLIED
>
```

Sample configuration file

```
<node host="root">
 <code> PiMaster </code>
 <node host="default">
  <code> PiWorker </code>
  <invocation
   javaPath="java"
   rjavaJarPath="/tmp/rjava.jar"
   rjavaProtocol="ssh"
   rjavaRsh="ssh"
   rjavaRcp="scp" />
 </node>
 <node host="pad00" />
 <node host="pad01" />
 <node host="pad02" />
 <node host="pad03" />
</node>
```



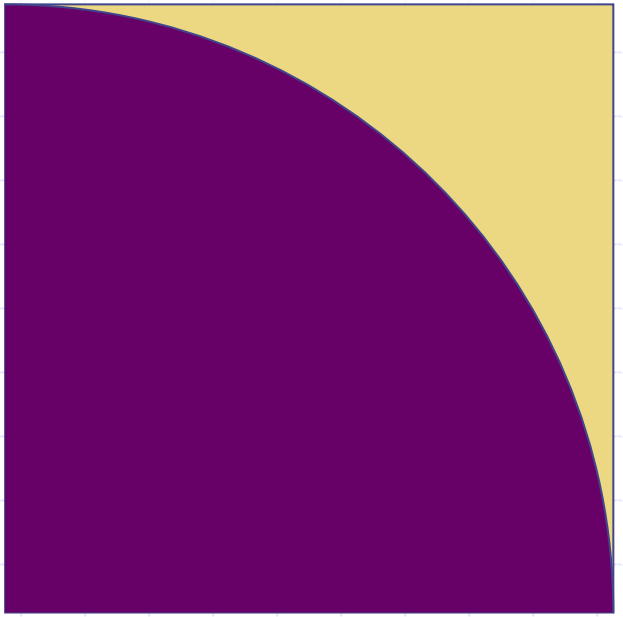
Program input

- Specifies properties file
  - Properties are passed to all the Codes

```
> java silf.jojo.Jojo CONF_FILE  PROP_FILE
```

Sample Program

- Calculate Pi
  - Randomly generates large number of points in a square
  - Count the number in the arc
  - Calculate Pi from the probability
  - Master – Worker model
    - Dynamic load balancing



times=100000

divide=10

Sample Program (Master)

```
public class PiMaster2 extends Code{
  .......
  synchronized public Object handle(Message msg) throws JojoException{
    if (msg.tag == PiWorker.MSG_TRIAL_REQUEST){
      long [] pair = (long[])(msg.contents);
      doneTrial  += pair[0];
      doneResult += pair[1];
      if (doneTrial >= times){
        synchronized (this) {done = true; notifyAll();}
        return new Long(0);
      } else
        return new Long(perNode);
    } else
      throw new JojoException("cannot handle the message: " + msg);
  }
}
```

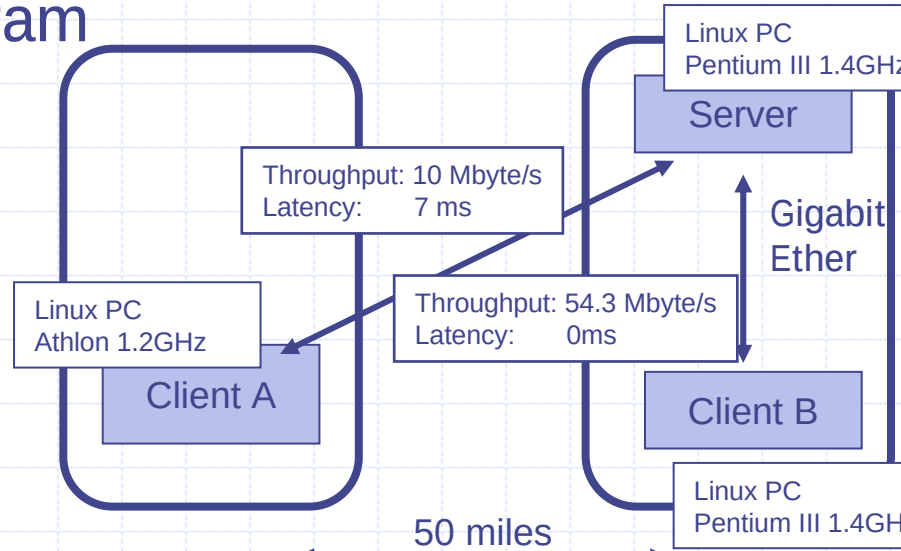
Sample Program (Worker)

```
public class PiWorker2 extends Code{

  public void start() throws JojoException{
    long trialTimes = 0, doneTimes  = 0;
    while (true){
      Message msg =
        new Message(MSG_TRIAL_REQUEST,
                    new long[]{trialTimes, doneTimes});
      trialTimes =
            ((Long)(parent.call(msg))).longValue();
      if (trialTimes == 0) break;
      doneTimes = trial(trialTimes);
    }
  }
```

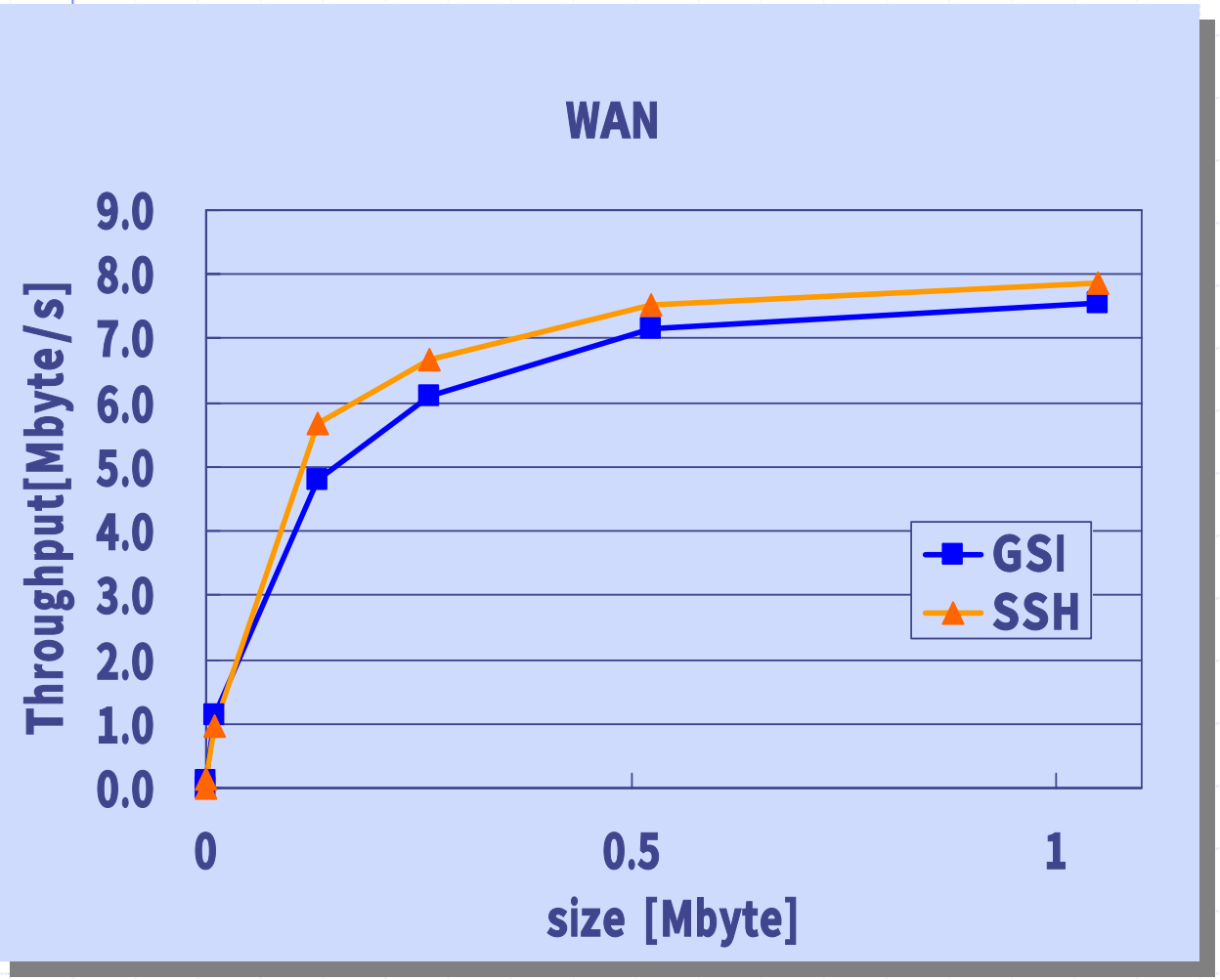
```
  private long trial(long trialTimes){
      long counter = 0;
      for (long i = 0; i < trialTimes;
       i++){
        double x =
       random.nextDouble();
        double y =
       random.nextDouble();
        if (x * x + y * y < 1.0)
       counter++;
      }
      return counter;
    }
  }
```

Preliminary Evaluation

- Throughput measurement in LAN and WAN
  - AIST and Titech
- GSI and SSH
  - GSI uses pure-Java SSL
  - SSH uses external program
    - Written in C

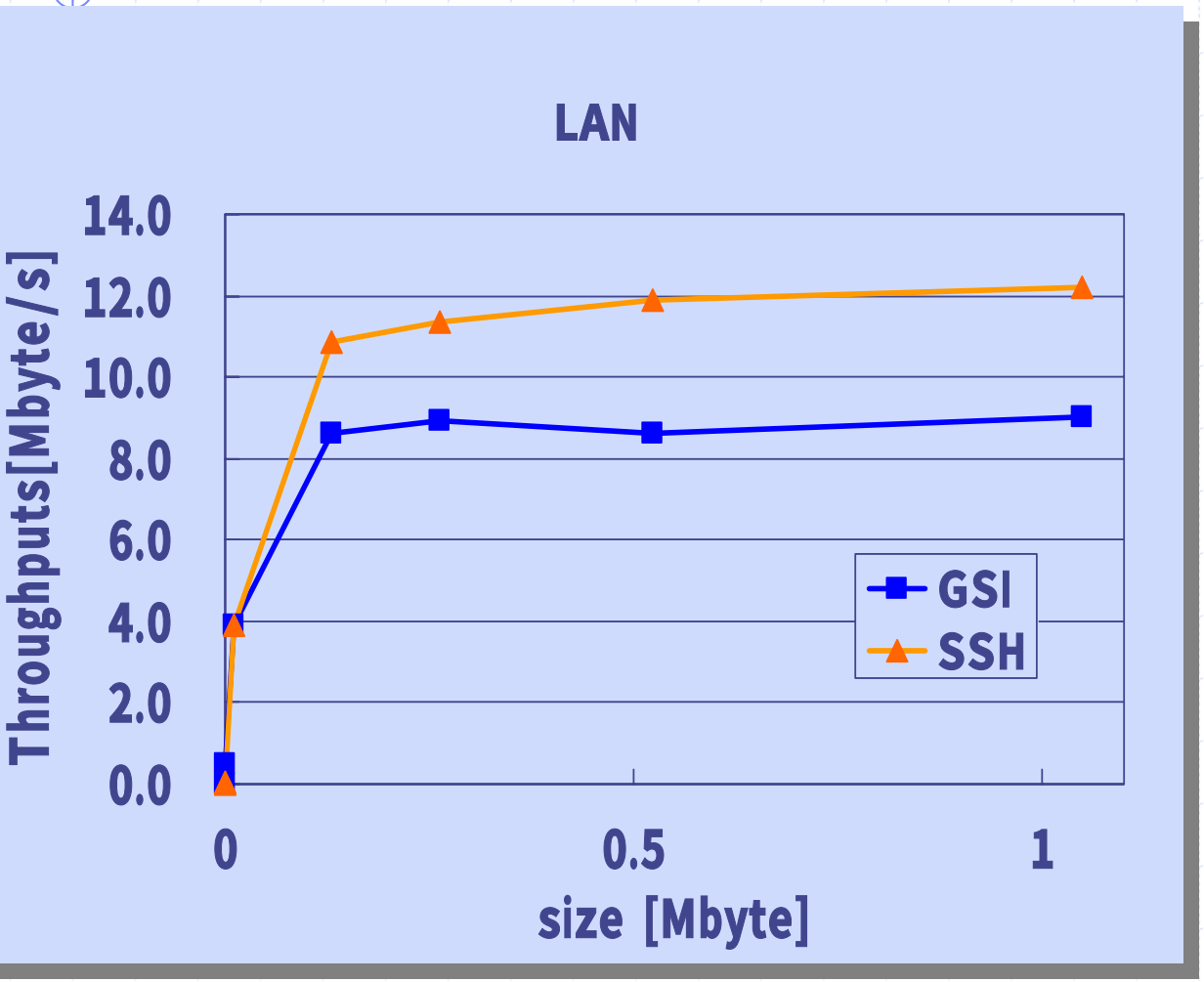


Result(WAN)



- Bandwidth of the link is 10Mbyte/s
- 70-80 % of the bandwidth
- SSH is faster slightly

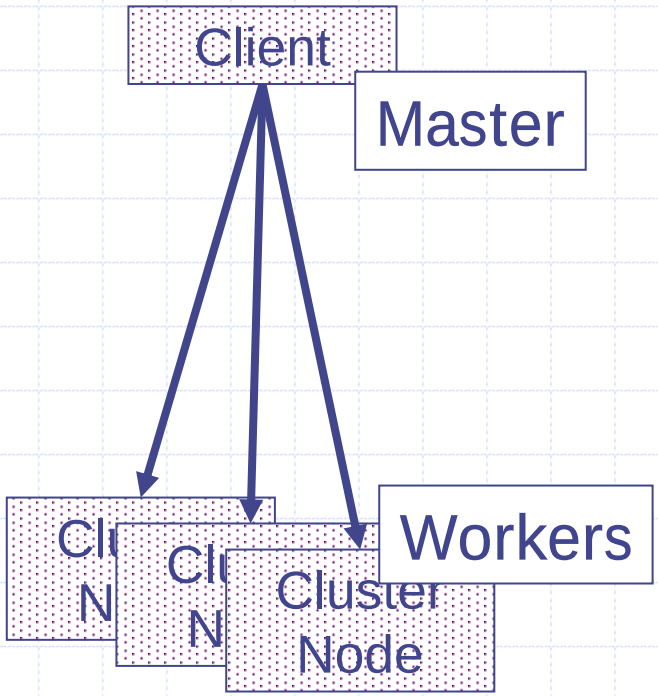
Result(LAN)



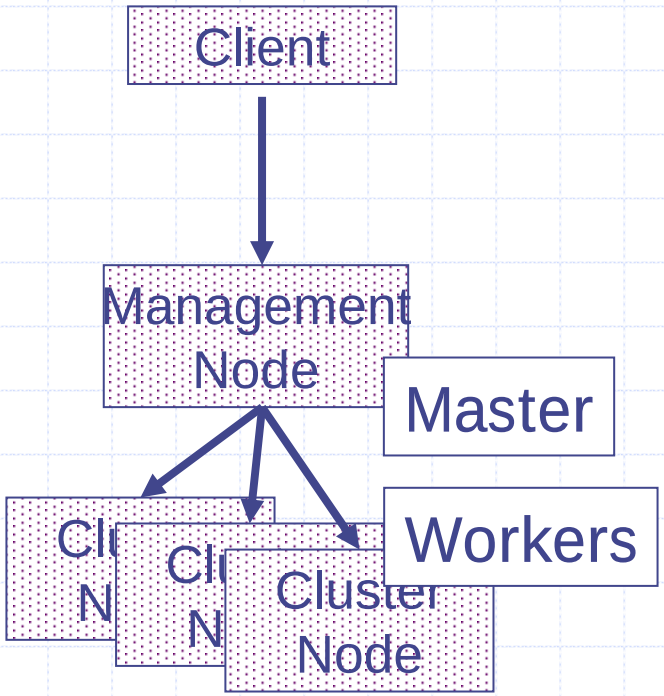
- Bandwidth of the link is 54Mbyte/s
- GSI is much slower than SSH (2/3 of SSH)

Master-Worker evaluation

- Compare 2-layered and 3-layered



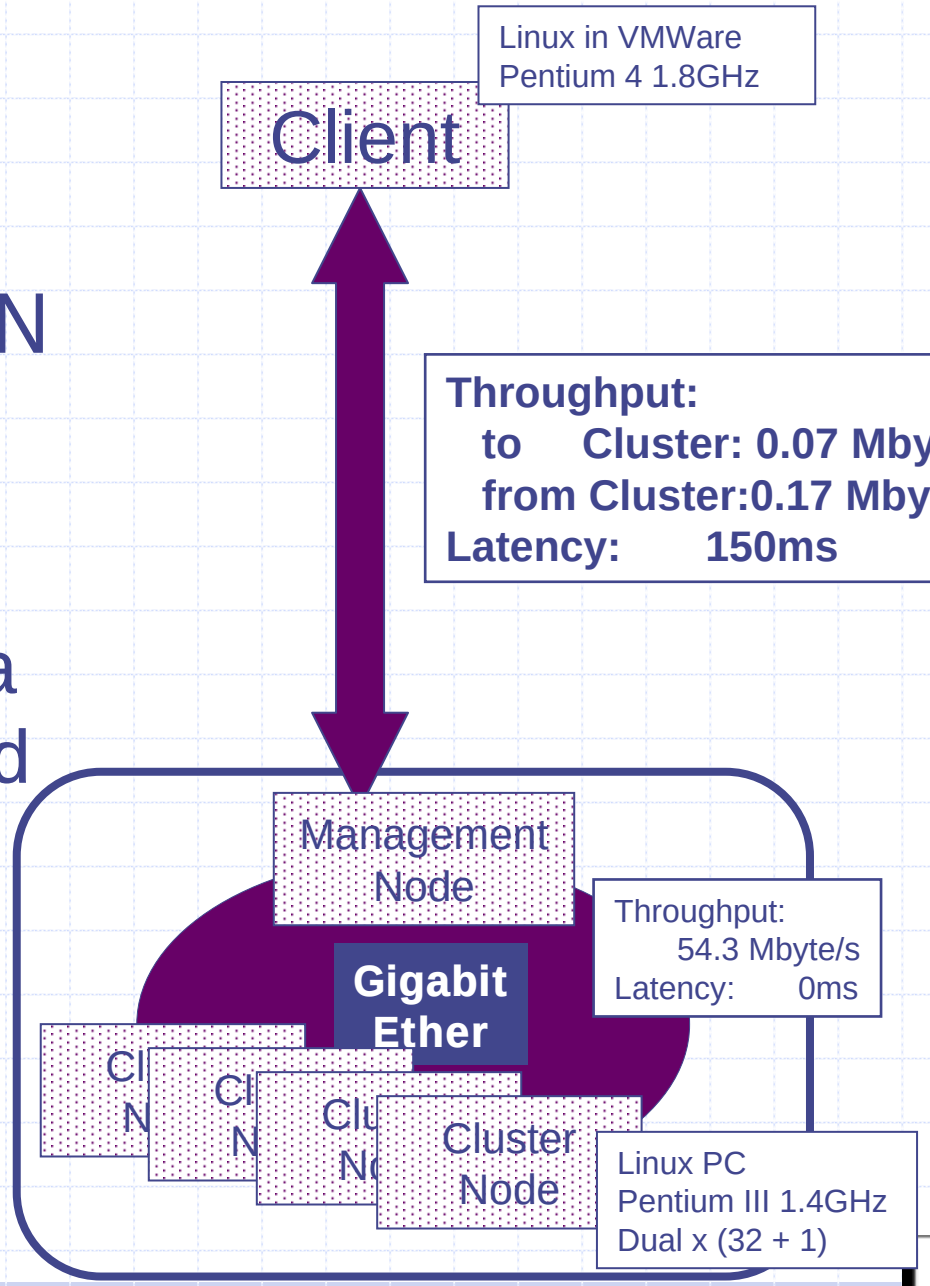
2layers model



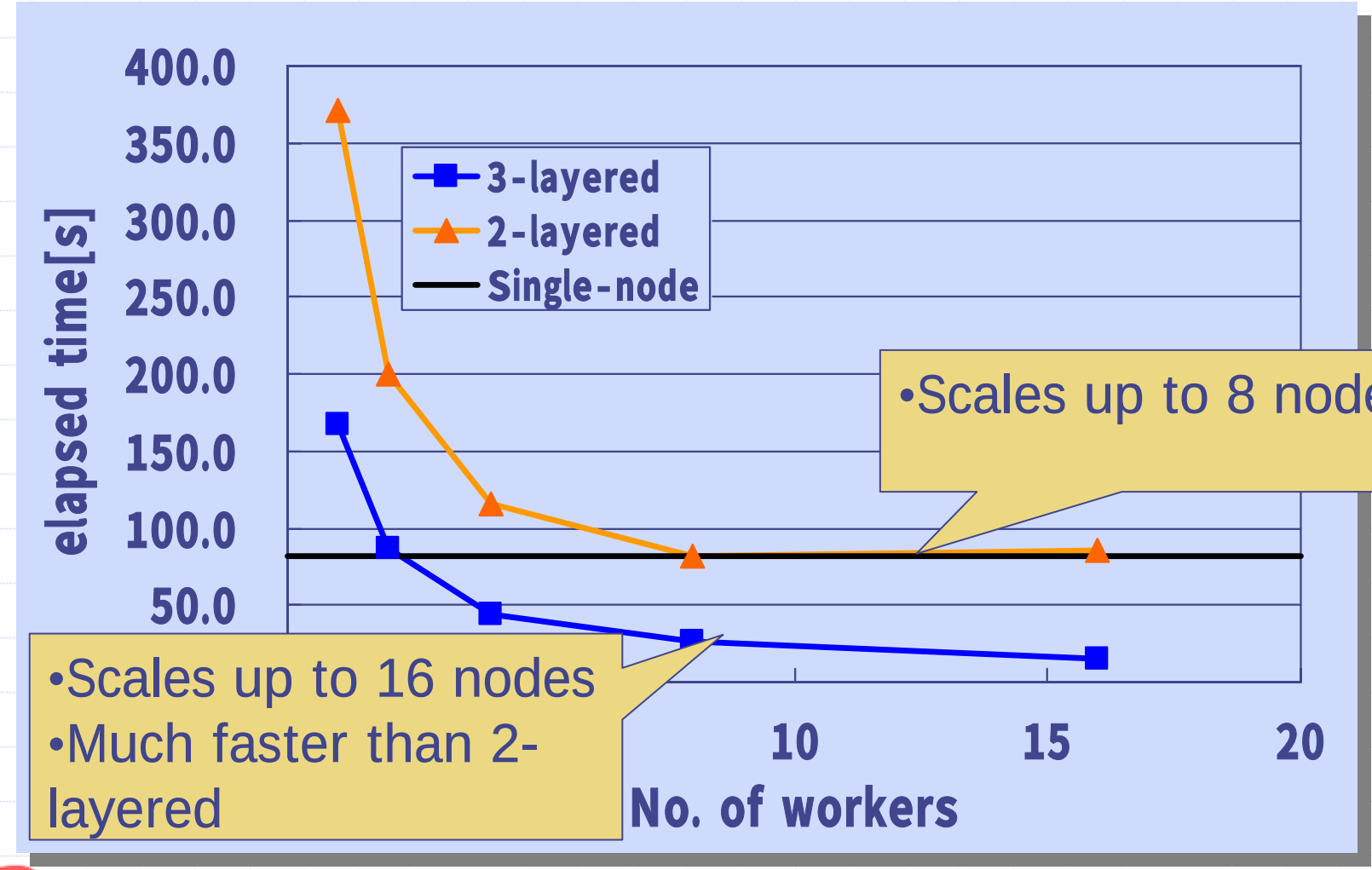
3layers model

Environment

- CATV＋Wireless LAN
- Master-worker PI
  - 10^4 tasks
  - Execution time for a single task is around 8ms



Master-Worker result



Discussion

- Data size for each task is just few bytes
  - Time for data transfer time is negligible
  - Latency
- Execution time for each task is just 8ms
  - Not suitable for master-worker execution
    - As shown in the 2-layered model score
  - Still can be effectively executed in 3-layered model

Summary

- Proposed a grid middleware Jojo
- Shows sample programs
- Shows preliminary evaluation results
  - Pingpong
  - Master-worker