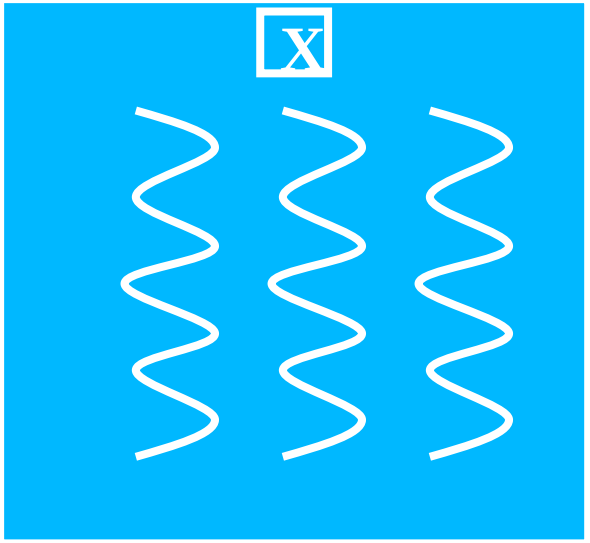
Parallel programming in Java

Parallel programming in Java

- Java has 2 forms of support for parallel programming:
  - Multithreading
    - Multiple threads of control (sub processes), useful for
      * Pseudo-parallelism within a single machine
      * Real parallelism on shared-memory machine
  - Remote Method Invocation (RMI)
    - Allows invocation on an object located at another machine
    - Useful for distributed-memory machines
- Many additional parallel programming libraries exist:
  - MPJ Express (based on MPI)
  - Lab course uses IPL (Ibis Portability Layer)

Multithreading



A thread has

- Its own program counter
- Its own local variables

All threads on same Java Virtual Machine share global variables

Threads can communicate through shared variables

Threads can run concurrently (on multiprocessor or multicore) or are time-sliced

Creating threads in Java

```
public class mythread extends Thread {
    public void hi() {
      System.out.println("hi");
    }
    public void run() {
      System.out.println("hello");
    }
}
mythread t1 = new mythread();  // allocates a thread
mythread t2 = new mythread();  // allocates another thread
t1.start();                    // starts first thread and invokes t1.run()
t2.start();                    // starts second thread and invokes t2.run()
t1.hi();
```

Thread synchronization

Problem-1:

Thread-1 does: X = X + 1;

Thread-2 does: X = X + 2;

Result should be +3, not +1 or +2.

Need to prevent concurrent access to same data:
mutual exclusion synchronization

Mutual exclusion in Java

```
public class example {
    int value;

    public synchronized increment (int amount) {
        value = value + amount;
    }
}
```

The synchronized keyword guarantees that only one call to increment is executed at a time

More thread synchronization

Problem-2:

- Sometimes threads have to wait for each other
- Condition synchronization
- Supported in Java with wait/notify/notifyAll

wait	blocks (suspends) a thread
Notify	wakes up (resumes) one blocked thread
notifyAll	wakes up all blocked threads

Remote Method Invocation

RMI is 2-way synchronous communication, like RPC

RMI invokes a method on a (possibly) remote object

Integrates cleanly into Java's object-oriented model

Example

```
public interface Hello extends Remote {
    String sayHello();
}

public class HelloImpl extends UnicastRemoteObject implements
    Hello {

    public String sayHello() {
        return "Hello World!";
    }
}
```

Asynchronous communication with Java RMI

Can you do asynchronous messages passing in Java?

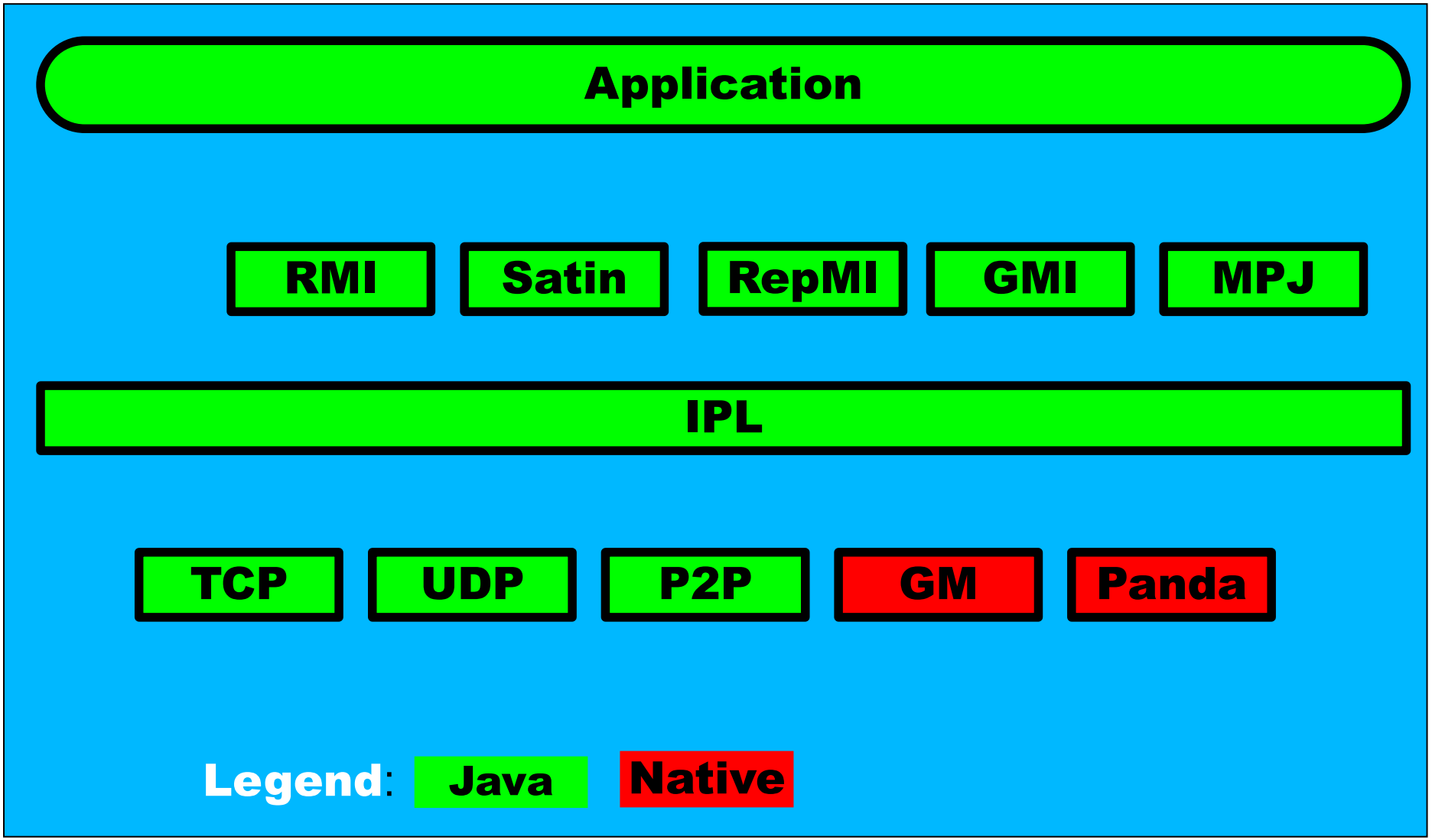
Yes: create a new thread to do the RMI for you and wait for the result

Awkward to program, performance overhead

IPL (Ibis Portability Layer)

- Ibis: Java-centric communication system designed for grid computing
  - Supports heterogeneous and dynamic (malleable) systems
  - Discussed in Cluster & Grid class
- IPL: flexible message passing library for Java

Structure of the Ibis system



Functionality of IPL

- Based on setting up *connections*
  - Programmer can create *send*-ports and *receive*-ports
  - These can be connected in a flexible way: one-to-one, one-to-many (multicast), many-to-one
- Programmer can define properties of connections and ports:
  - FIFO ordering, reliability, delivery mechanisms, streaming
- IPL supports explicit message receipt, implicit message receipt (upcalls), polling

More information

Tutorials/documentation about multithreading and IPL are available through the web site of the lab course:

http://www.cs.vu.nl/ppp