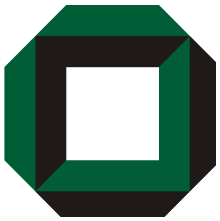

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High-Level Multicore Programming with XJava

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New Ideas and Emerging Results (NIER)

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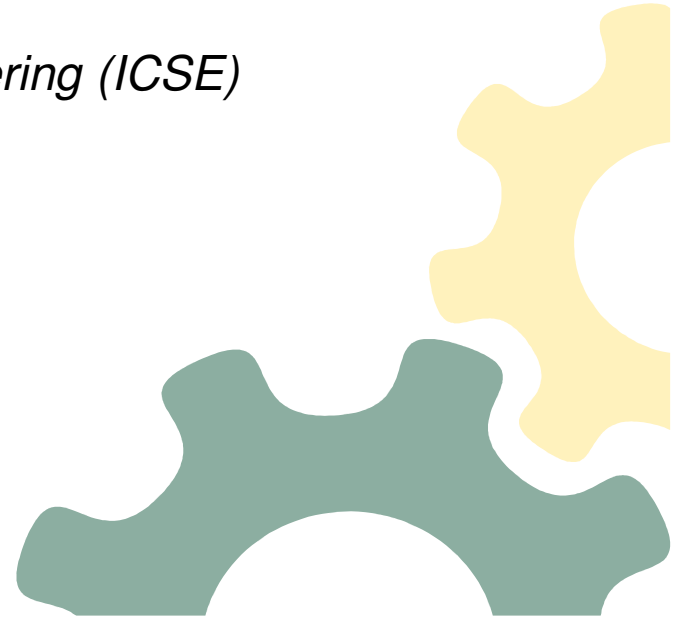
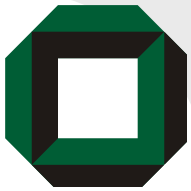
Fakultät für **Informatik**

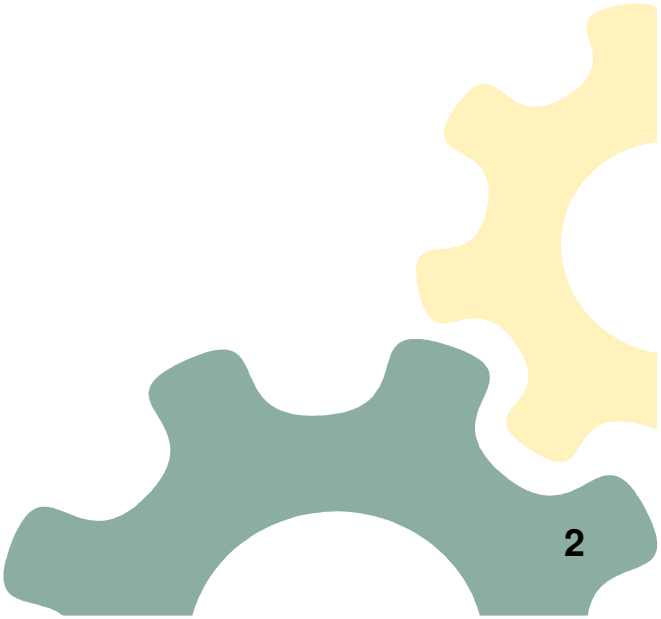
Lehrstuhl für Programmiersysteme



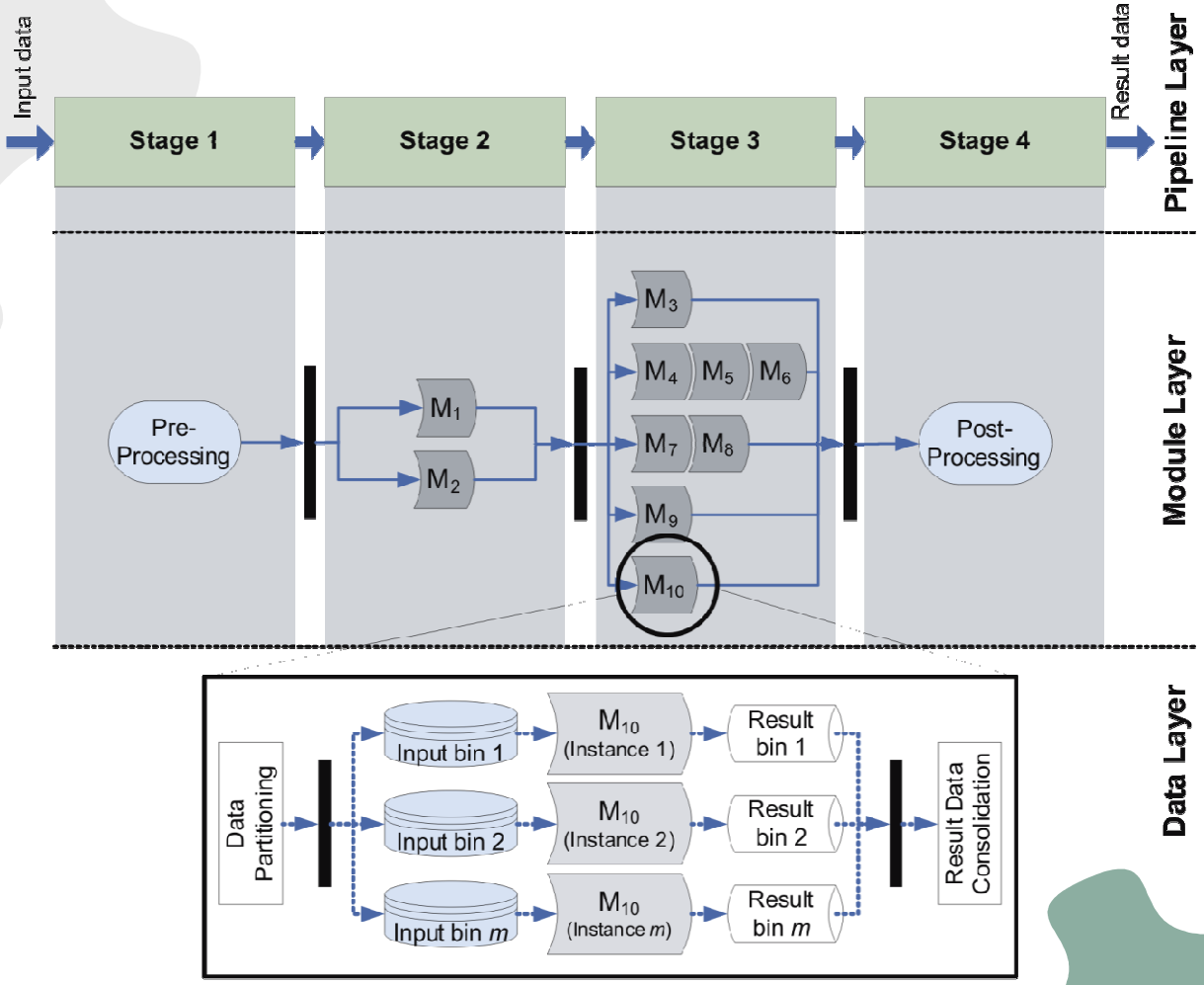


The Problem

- Clock rates are stagnating
  - „The free lunch is over“
- Multicore processors enter the mainstream
  - Renewed interest in parallel programming



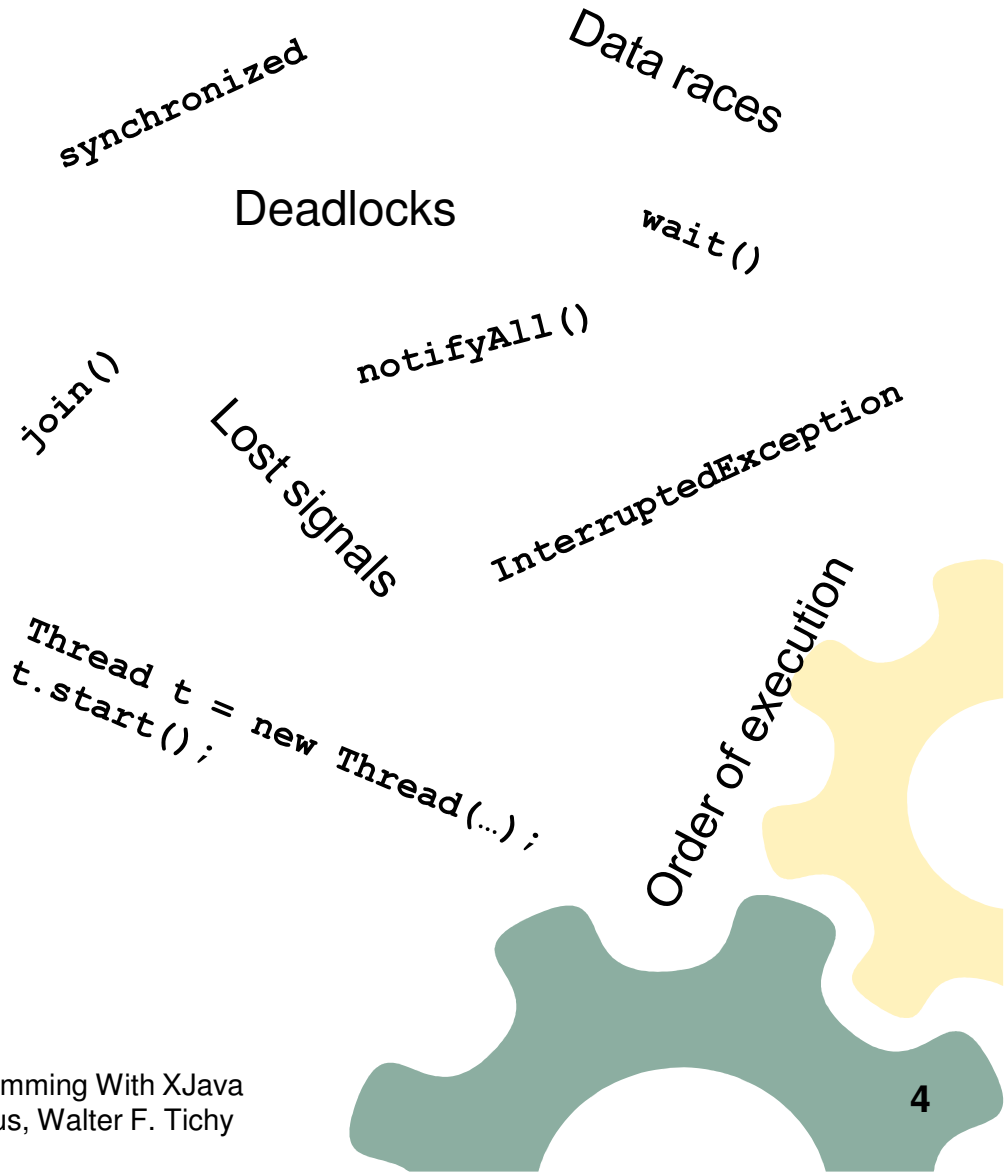
Motivation: A Parallelized Object-Oriented Real-World Application

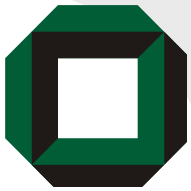


Multithreading and OO

- Create and manage threads manually
- Synchronization is difficult an error-prone

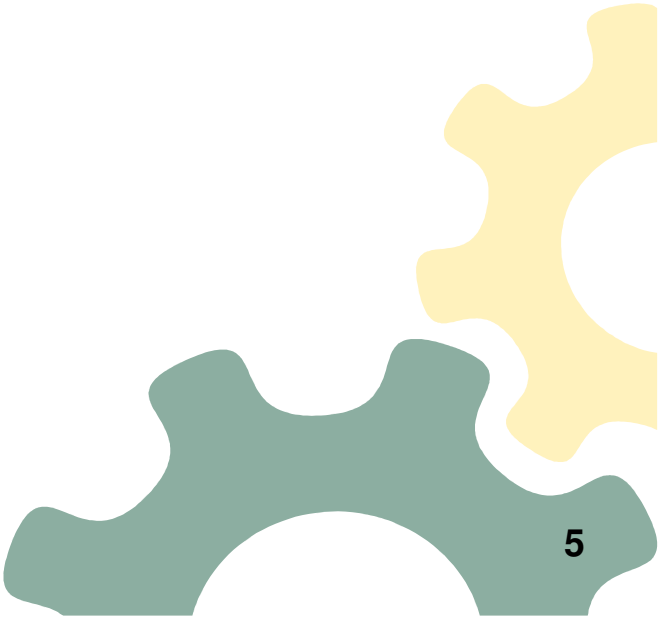
➔ **We need abstractions for parallelism!**

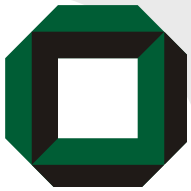




XJava's Goal

- „What you see is what you get“ parallelism
  - More predictable
- High-level programming
  - No explicit threads or manual synchronization

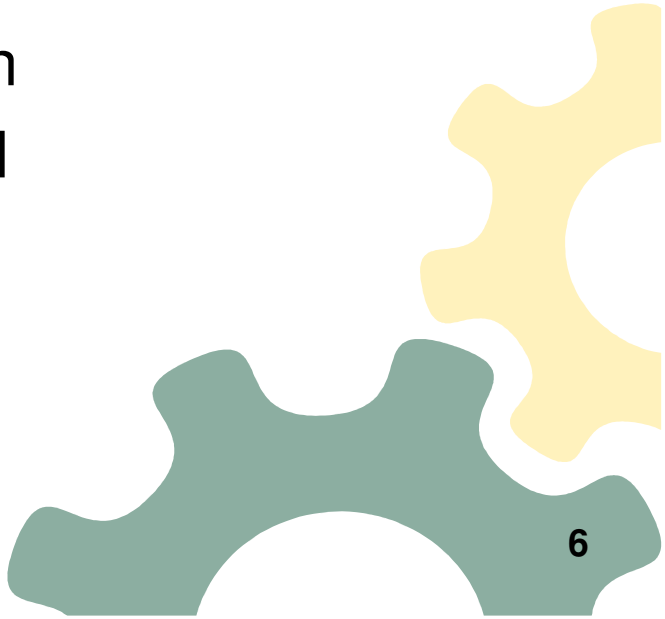


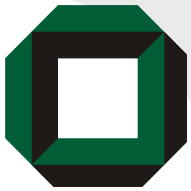


Idea

- Combine the concepts from **object-orientation**, **parallel design patterns**, and **stream languages**

- Stream programs
  - Interconnected filters
  - Input: data stream of arbitrary length
  - Domain-specific, not object-oriented



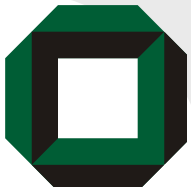


XJava Tasks

- Specialized methods that are concurrently executable

- Typed input and output ports for receiving and generating streams of data

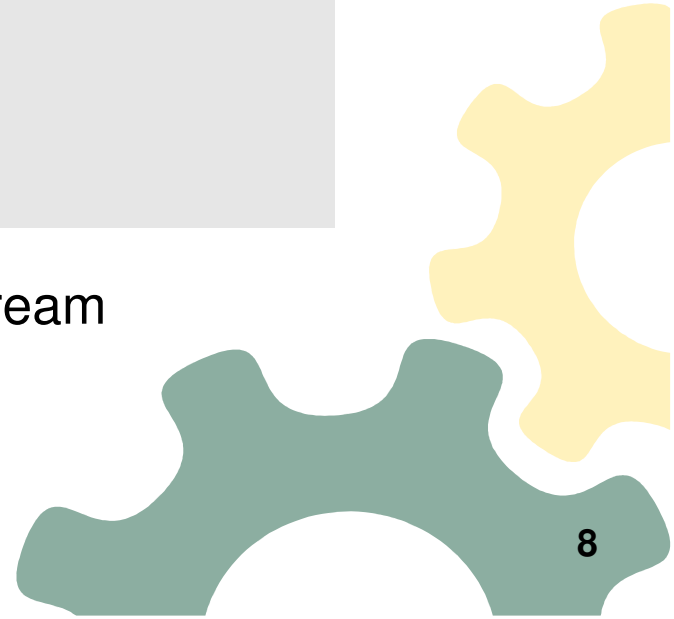
```
public Object => String foo() {
  /* task body */
}
```

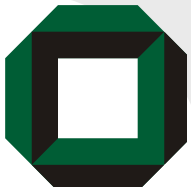


Task Declarations

```
public void => Block read(File f) {
  Iterator i = f.blockIterator();
  while(i.hasNext()) { push (Block) i.next(); }
}
```

`push` puts an element to the output stream





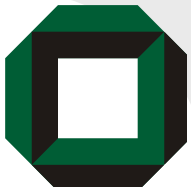
Task Declarations

```
public void => Block read(File f) {
  Iterator i = f.blockIterator();
  while(i.hasNext()) { push (Block) i.next(); }
}

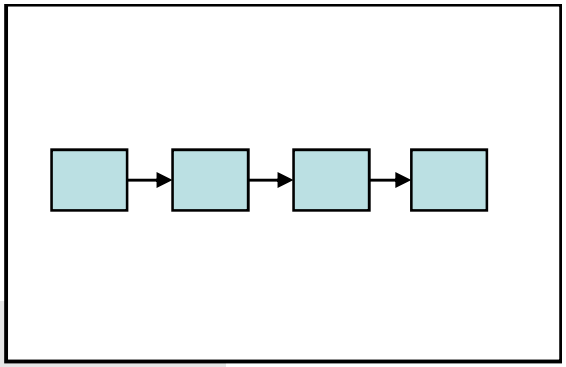
public Block => Block compress() {
  work(Block b) { push b.compressBlock(); }
}

public Block => void write(File f) {
  work(Block b) { f.add(b); /* no push */ }
}
```

A **work**-Block is repeatedly executed for each incoming element of the input data stream



Pipe Statements



```
public void => Block read(File f) {
  Iterator i = f.blockIterator();
  while(i.hasNext()) { push (Block) i.next(); }
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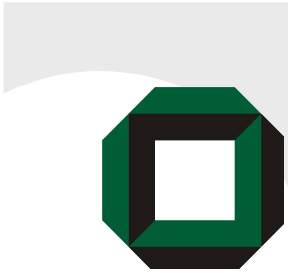
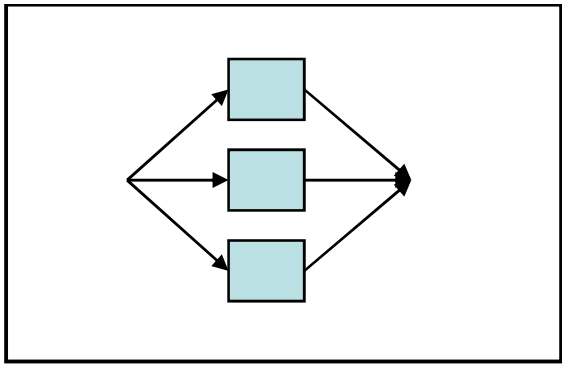
  work(Block b) { push b.compressBlock(); }
}

public Block => void write(File f) {
  work(Block b) { f.add(b); /* no push */ }
}
```

```
read(inFile) => compress() => write(outFile);
```



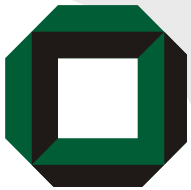
Concurrent Statements



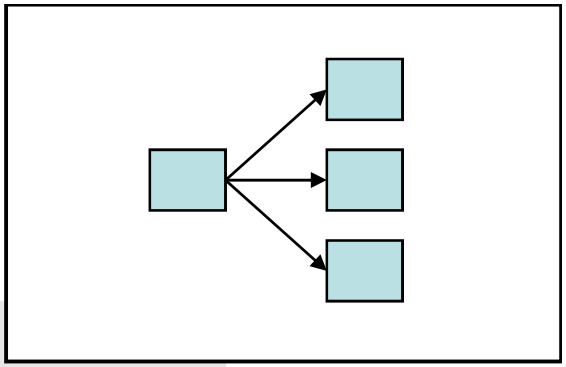
```
public void => void compress(File in, File out) {
  read(in) => compress() => write(out);
}
```

Compress two files in parallel:

```
compress(f1, f1out) ||| compress (f2, f2out);
```



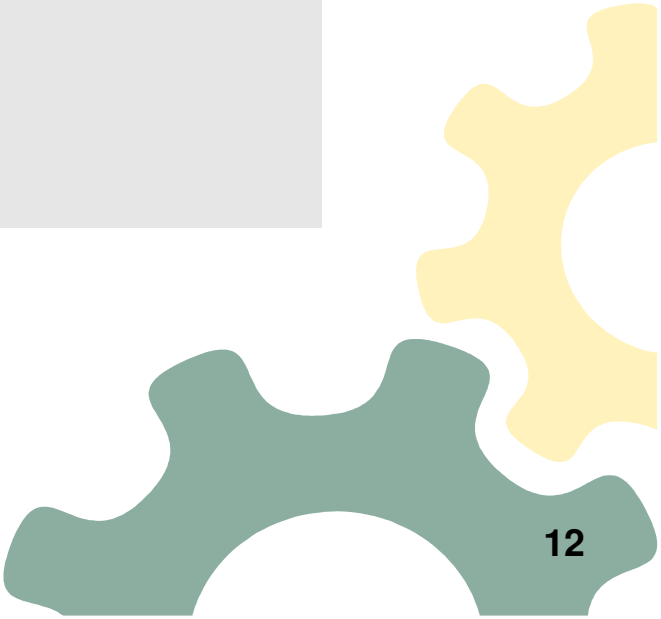
Master/Worker

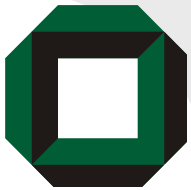


```
public void => Item master() {
  while (moreWork) { Item item = …
    push item; }
}

public Item => void worker() {
  work(Item item) { … }
}

public Item => void wPool(int i) {
  worker():i;    // create i workers
}
```





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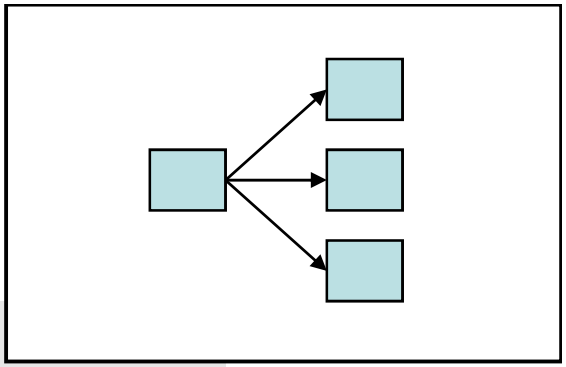

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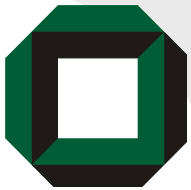
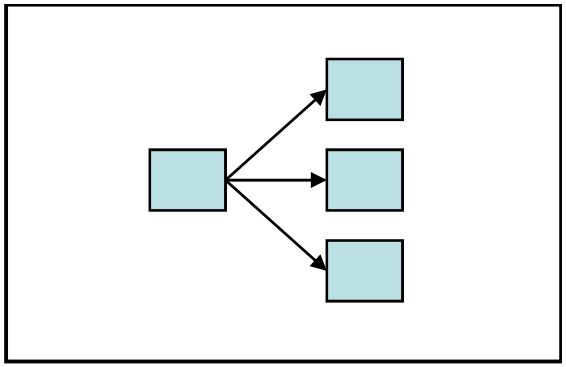
}

public Item => void wPool(int i) {
  worker():i;   // create i workers
}
```

```
master() => wPool(3);
```



Master/Worker



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    push item; }
}

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  work(Item i) { … }
}

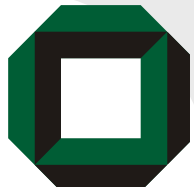
public Item => void wPool(int i) {
  worker():i;   // create i workers
}
```

How to distribute work items? What does „=>“ mean?

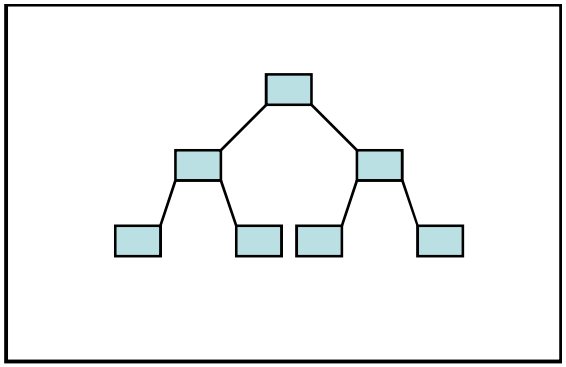
```
master() => wPool(3);     // round robin
```

```
master() =>? wPool(3);    // FCFS
```

```
master() =>* wPool(3);    // broadcast
```



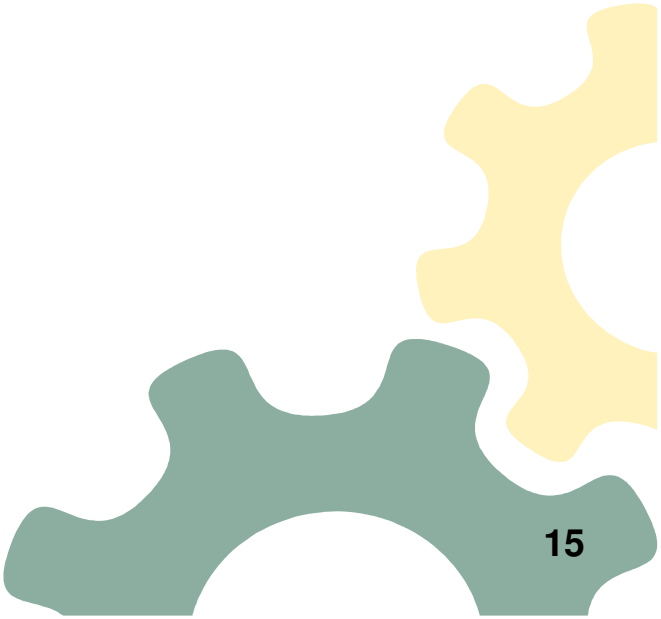
Divide & Conquer Parallelism

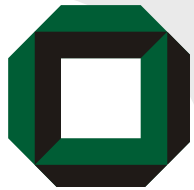


- Compare sequential and parallel MergeSort

```
void mergesort(int from, int to) {
  if (to - from > threshold) {
    int x = from + (to - from)/2;
    mergesort(from, x);
    mergesort(x + 1, to);
    merge(from, x + 1, to);
  }
  else sort(from, to);
}
```

sequential





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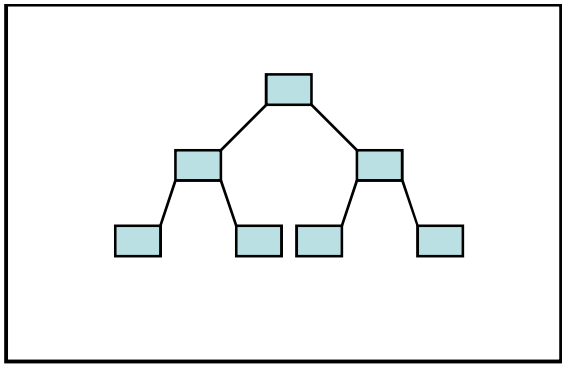

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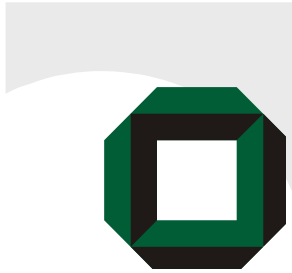
    merge(from, x + 1, to);
  }
  else sort(from, to);
}
```

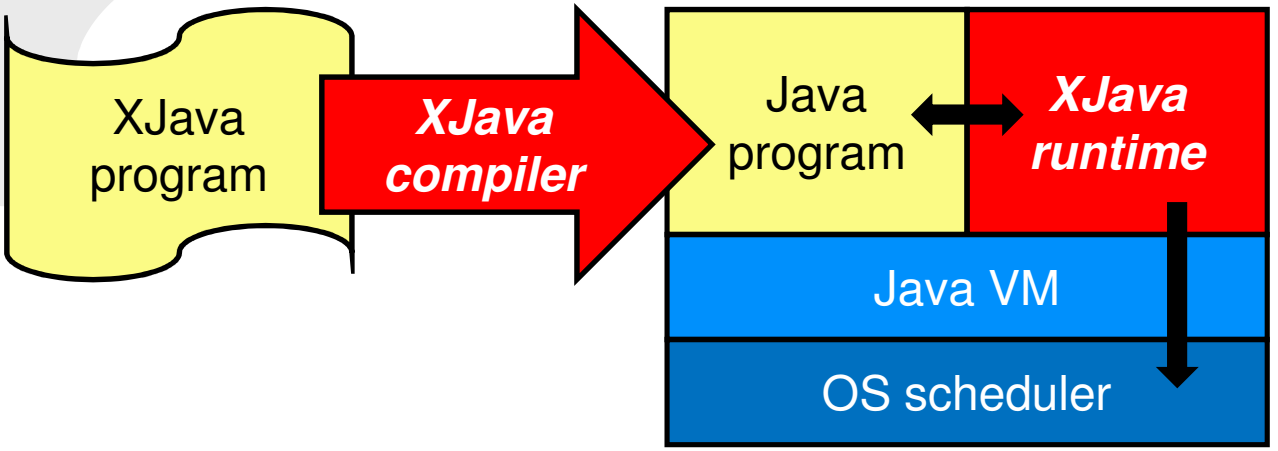
sequential

```
void => void mergesort(int from, int to){
  if (to - from > threshold) {
    int x = from + (to - from)/2;
    mergesort(from, x)
             ||| mergesort(x + 1, to);
    merge(from, x + 1, to);
  }
  else sort(from, to);
}
```

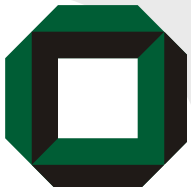
XJava



XJava Compiler and Runtime



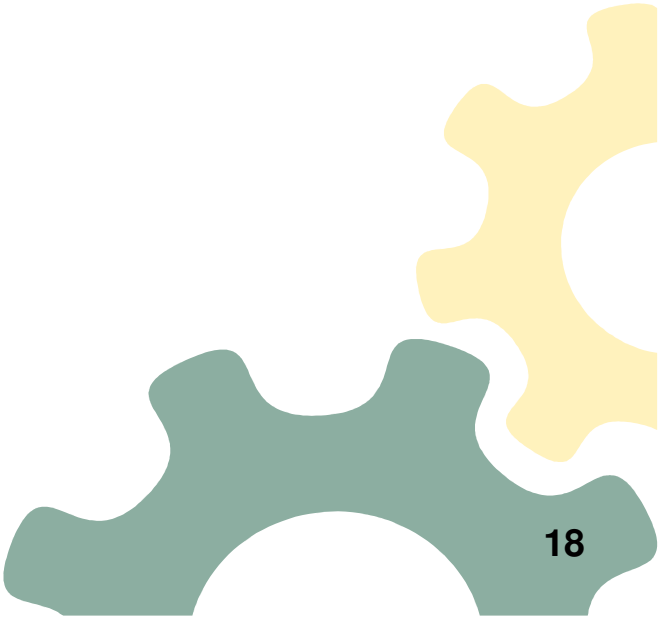
- XJava runtime is the place where parallelism actually happens

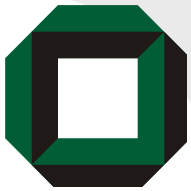


Preliminary Results

- **Up to 40% code savings** over threaded Java
  - Almost no manual synchronization needed

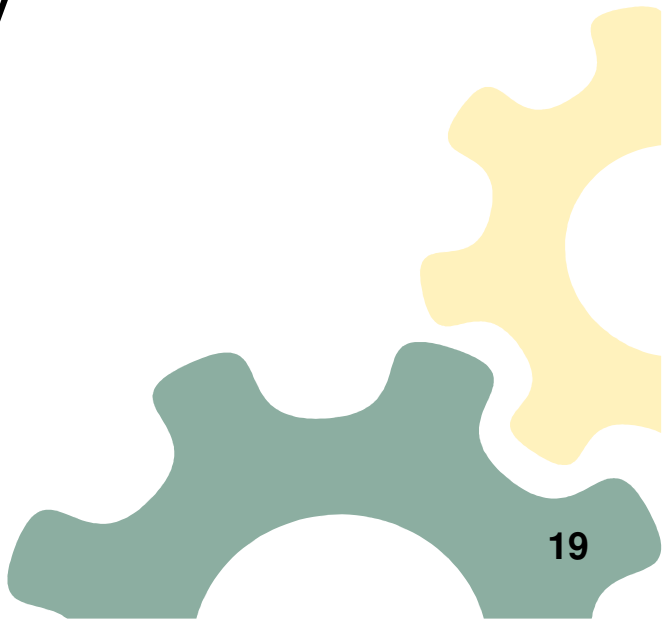
- Good **speedups** over sequential Java
  - **Up to 3.5** (Quadcore)
  - **Up to 31.5** (Sun Niagara 2)

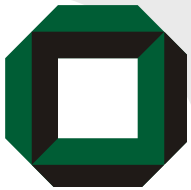




XJava: Conclusion

- High-level parallel OO programming
- Lower risk of synchonization bugs
- Code savings, higher productivity
- Performance





Thank you!

Questions?