C340 Concurrency: Concurrent Architectures - Supervisor/Worker

Wolfgang Emmerich

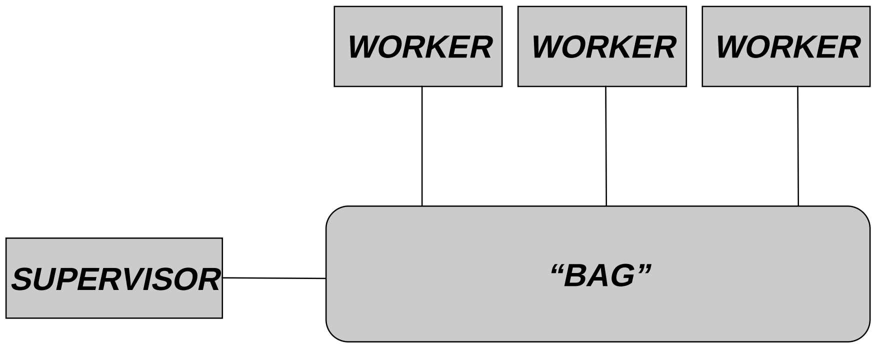
Outline

- Motivation
- Linda Tuple Spaces
- Modelling Tuple Spaces in FSP
- Implementing Tuple Spaces in Java
- Supervisor-Worker Model
- Supervisor-Worker Java Implementation

Motivation

- ***Exploiting parallel execution on multiple processors***
- ***Communication between different processors by a connector called "bag"***
- ***Supervisor creates tasks and puts them into bag***
- ***Workers pick tasks from bag and perform them***
- ***Workers may themselves be supervisors***

Supervisor-Worker Architecture



Linda Tuple Spaces

- ***Primitive for implementing "bag" connectors***
- ***Tuple is a tagged data record***
- ***Tuples are exchanged in tuple spaces using associative memory***
- ***Available basic operations:***
  - **`out("tag",expr1,…,exprn)`**
  - **`in("tag",field1,…,fieldn)`**
  - **`rd("tag",field1,…,fieldn)`**
  - **`inp("tag",field1,…,fieldn)`**
  - **`rdp("tag",field1,…,fieldn)`**

Tuple Space Model

```
const N=2
set Tuples={any}
const False = 0
const True = 1
range Bool = False..True
TUPLE(T='any) = TUPLE[0],
TUPLE[i:0..N]=(out[T] -> TUPLE[i+1]
          |when (i>0) in[T] -> TUPLE[i-1]
          |when (i>0) inp[True][T] -> TUPLE[i-1]
          |when (i==0)inp[False][T] -> TUPLE[i]
          |when (i>0) rd[T] -> TUPLE[i]
          |rdp[i>0][T] -> TUPLE[i]).
||TUPLESPACE = forall [t:Tuples] TUPLE(t).
```

LTSA

Tuple Space Java Implementation

```
public interface  TupleSpace {
  //deposits data in tuple space
  public void out(String tag, Object data);
  //extracts object with tag from tuple space
  public Object in(in tag) throws
                           InterruptedException;
  //reads object with tag from tuple space
  public Object rd(String tag) throws
                           InterruptedException;
  //extracts object if avail else return null
  public Object inp(String tag);
  //read object if avail else return null
  public Object rdp(String tag);
}
```

Supervisor-Worker Algorithm

- ***Supervisor::***

```
forall tasks do out("task",...) end
forall results: in("result",...) end
out("stop")
```

- ***Worker::***

```
while not rdp("stop") do
    in("task",...)
    compute result
    out("result",...)
end
```

Supervisor-Worker Model

LTSA

```
const N = 2
set Tuples = {task,result,stop}
set TupleAlpha =
        {{in,out,rd,rdp[Bool],inp[Bool]}.Tuples}
SUPERVISOR = TASK[1],
TASK[i:1..N] = (out.task ->
   if i<N then TASK[i+1] else RESULT[1]),
RESULT[i:1..N]= (in.result ->
   if i<N then RESULT[i+1] else FINISH),
FINISH = (out.stop->end->STOP)+TupleAlpha.
WORKER = (rdp[b:Bool].stop->
   if (!b) then (in.task->out.result->WORKER)
           else (end -> STOP) )+TupleAlpha.
END = (end ->ENDED), ENDED = (ended->ENDED).
||SUPERVISOR_WORKER=(supervisor:SUPERVISOR
  ||{redWork,blueWork}:WORKER
  ||{supervisor,redWork,blueWork}::TUPLESPACE
  ||END)/{end/{supervisor,redWork,blueWork}.end}.
```

Analysis of Supervisor-Worker Model

- *Trace to DEADLOCK:*

```
supervisor.out.task
supervisor.out.task
redWork.rdp.0.stop
redWork.in.task
redWork.out.result
supervisor.in.result
redWork.rdp.0.stop
redWork.in.task
redWork.out.result
supervisor.in.result
redWork.rdp.0.stop
supervisor.out.stop
```

Deadlock Free Algorithm

■ *Supervisor::*

```
forall tasks:- out("task",...)
forall results: in("result",...)
out("stop")
```

■ *Worker::*

```
while true do
    in("task",...)
    If value is stop then out("task",stop); exit
    compute result
    out("result",...)
```

Deadlock Free Model

```
set Tuples = {task,task.stop,result}
SUPERVISOR = TASK[1],
TASK[i:1..N] = (out.task ->
   if i<N then TASK[i+1] else RESULT[1]),
RESULT[i:1..N] = (in.result ->
if i<N then RESULT[i+1] else FINISH),
FINISH=(out.task.stop->end->STOP)+TupleAlpha.
WORKER=(in.task -> out.result -> WORKER
       |in.task.stop->out.task.stop->end->STOP
       )+ TupleAlpha.

progress={ended}
```

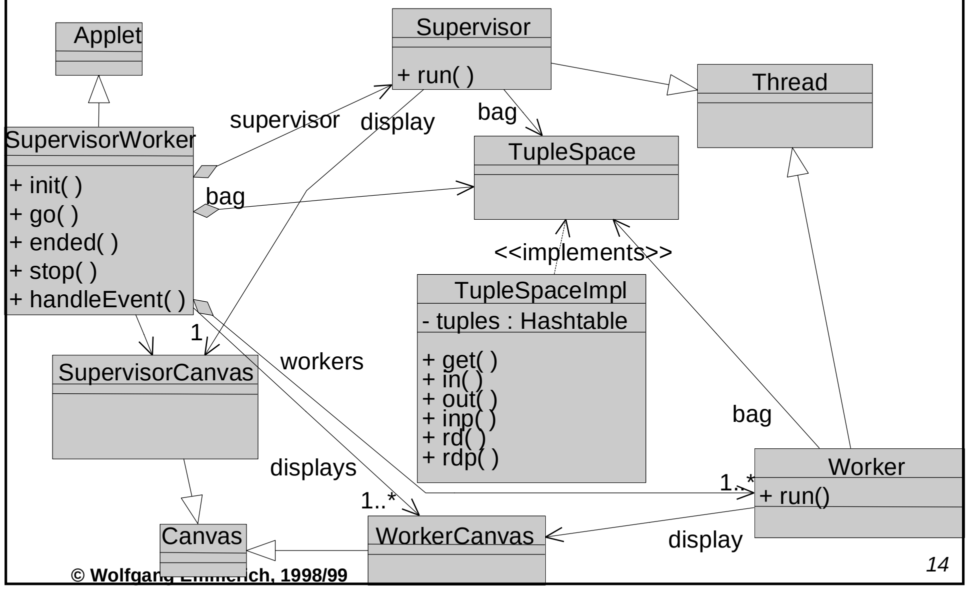
LTSA

Supervisor-Worker Example

- Compute the area under a curve
- Approximate using rectangles
- Parallelize task by delegating computation of different rectangles to one of 4 workers
- Supervisor adds results computed by 4 workers

Demo

Supervisor-Worker Example Design



Summary

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