Occam and Transputers

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Occam: An Explicitly Parallel Language

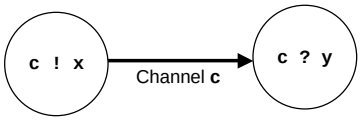
- **Occam based on Communicating Sequential Processes (CSP) formalism developed by Tony Hoare, Oxford, UK, and an experimental language by David May, Bristol, UK**
- **Designed to have a formal semantics suitable for automatic program transformations**
- **Many groups investigated direct translation of Occam into hardware**

Transputers

- The transputer architecture was designed as an Occam engine
  - Transputer C compiler didn't appear until much later, and initially produced inferior code compared with Occam compiler
- Original target for transputer was embedded control (robots) where interfacing to hardware directly was important
- Designed to allow large arrays of transputers to be connected easily
- Almost no glue logic required for minimal transputer node

Occam Basics

- Occam primitive is a *process,* five kinds:
  - Assignment `x := y + 2`
  - Input `keyboard ? char`
  - Output `screen ! Char`
  - Skip `SKIP -- NOP that terminates`
  - Stop `STOP –- NOP that never terminates`
- *Channels* provide communication between processes
  - Unbuffered, point-to-point synchronous communication
  - Channels have declared protocol types



Composing Sequential Processes

- SEQ executes sub-processes sequentially

```
SEQ
    keyboard ? char –- read char from keyboard
    screen ! char -- write char to screen
```

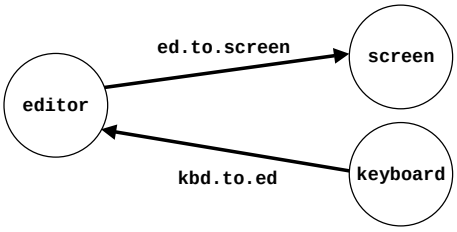
- Can do replicated SEQ

```
SEQ i = 0 FOR array.size
    stream ! data.array[i]
-- equivalent to
SEQ
    stream ! data.array[0]
    stream ! data.array[1]
    ...
```


Composing Parallel Processes

- PAR executes sub-processes in parallel

```
PAR
    keyboard(kbd.to.ed)
    editor(kbd.to.ed,ed.to.screen)
    screen(ed.to.screen)
```



PAR for parallel execution

```
WHILE next <> EOF
  SEQ
    x := next
    PAR
      in ? next
      out ! x * x
```

Restrictions on parallel data access

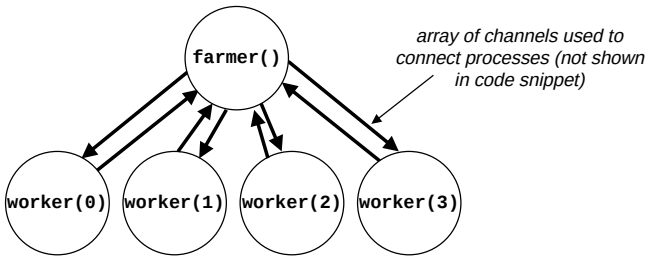
- **variables modified in one arm of PAR cannot be read or written in other parts of PAR, e.g.,**

```
PAR -- this PAR is invalid
  SEQ
    mice := 42 -- assigns to mice
    c ! 42
  c ? mice -- assigns to mice
```


Replicated PAR

- **Can use replicated PAR to build array of parallel processes**

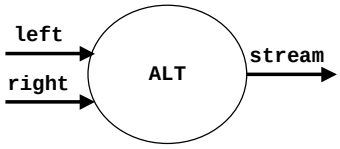
```
PAR
  farmer()
  PAR i = 0 FOR 4 -- count must be constant
    worker(i)
```



Alternation

- ALT combines a number of processes only one of which is executed
- Each process has a guard:
  - input on channel
  - wait on timer
  - can be predicated with boolean expression

```
ALT
  left ? packet -- guard input statement
     stream ! packet
  right ? packet –- guard input statement
     stream ! packet
```



- PRI ALT prioritizes sub-processes in textual order

Channel Protocols

- All channels have set of legal message types, the channel protocol. Compiler checks all uses of channels to ensure all communications are compatible with type of channel.
  - `CHAN OF [36]BYTE message : -- explicit array type`
  - `CHAN OF COMPLEX32 imp : -- named record (struct)`
  - `CHAN OF INT::[]BYTE link: -- length + vector`

  - `message ! “Hello, World!”`
  - `link ! len::[buffer FROM start]`
- Also supports tagged type channels, and sequential message channels
- Goal is type-safe communication

Configuration

- Occam application written as network of communicating processes
- Configuration step maps parallel process components onto available physical processors and maps channels to hardware links
- Configuration should not change correctness