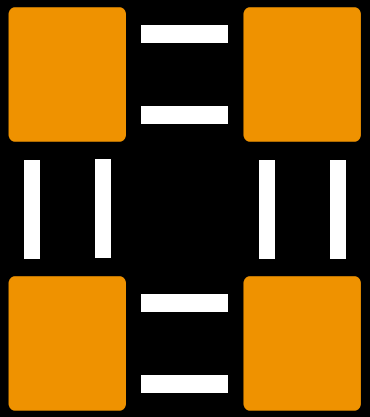

# OpenTRANSPUTER

*Reinventing a parallel machine from the past*

Andrés
Amaya García

aa1399@bristol.ac.uk

# About me…

- Andrés Amaya García
- Graduated from the University of Bristol in 2015
- MEng Computer Science

University of BRISTOL

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“

Once upon a time, nine (rainy) months ago…

# The Transputer


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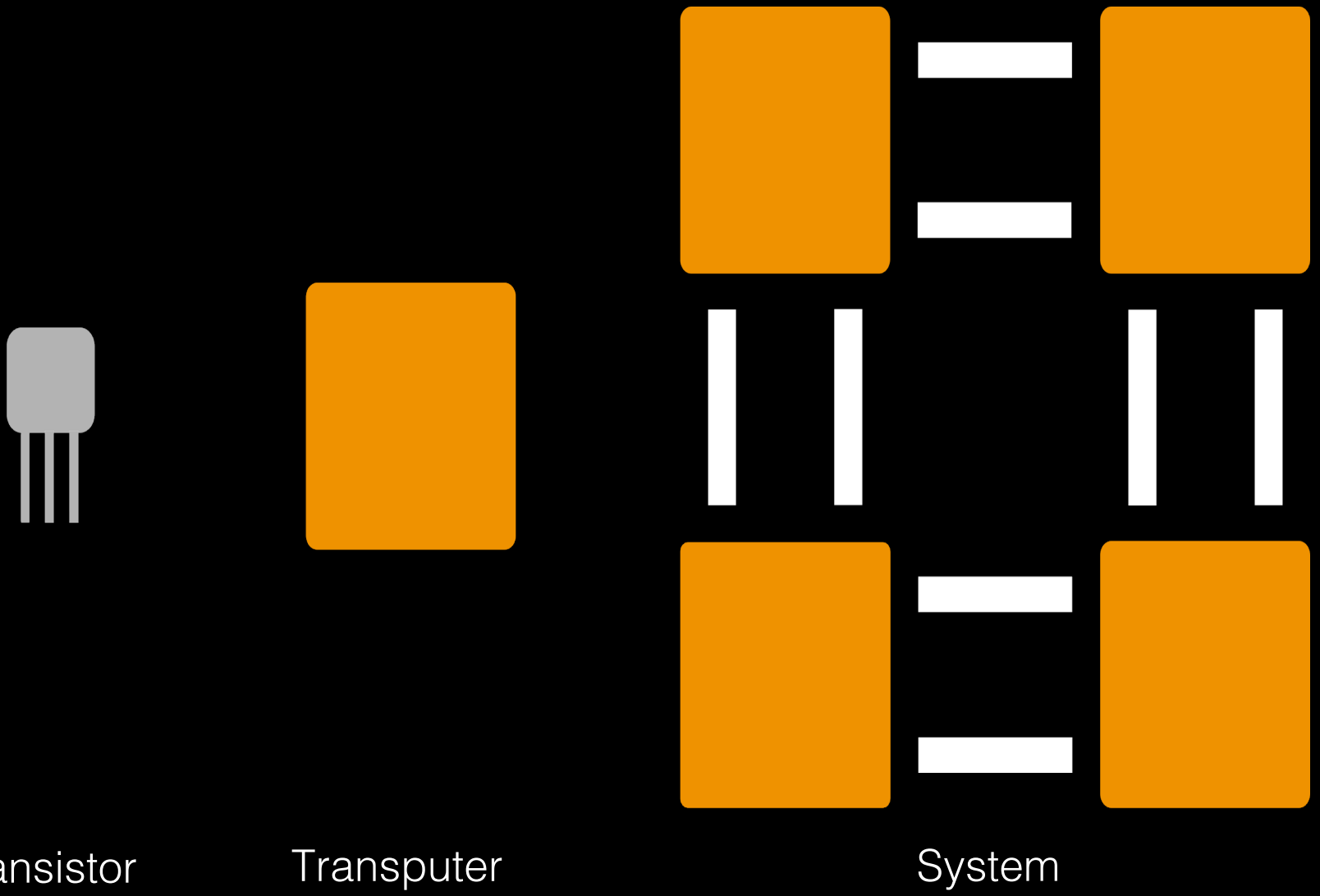


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# Transputer applications

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*Amstrad TV set-top box contains ST20*

# Transputer applications

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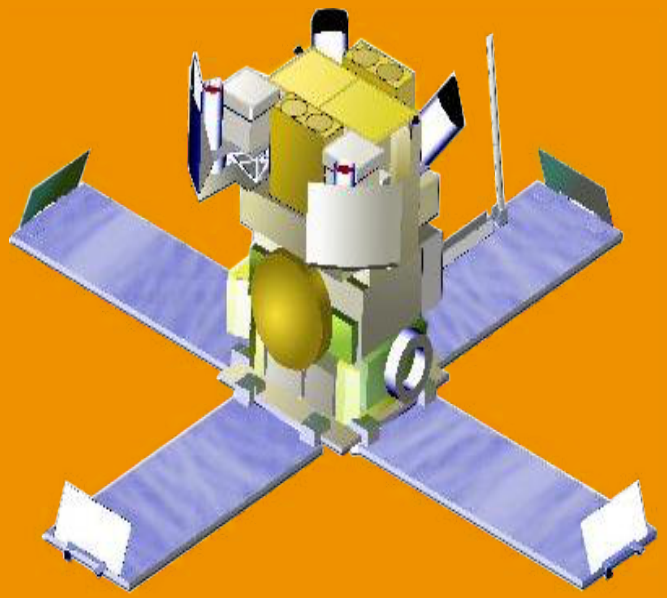
# Transputer applications


*Amstrad TV set-top box contains ST20*



*HETE-2 contains T805 Transputers*

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# Project objectives

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- Open-source.

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- Open-source.
- Supports Transputer instruction set.

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- Open-source.
- Supports Transputer instruction set.
- Different micro-architecture.

The Internet of Things (IoT) is all about connectivity!

# Project objectives

- Open-source.
- Supports Transputer instruction set.
- Different micro-architecture.

# Project objectives

- Open-source.
- Supports Transputer instruction set.
- Different micro-architecture.
- New external communication mechanism and I/O interface.

# How does the Transputer work?

# Occam

- Occam is a high-level programming language developed at Inmos hand-in-hand with the Transputer.
- Explicit concurrency and interprocess communication.

# Occam

- Occam is a high-level programming language developed at Inmos hand-in-hand with the Transputer.
- Explicit concurrency and interprocess communication.

“

# The Devil is in the detail

Microcomputer Division Confidential Author: Roger Shepherd

```
WHILE active
  VAL INT interruptable IS GotoSNPBit \/ (IOBit \/ (MoveBit \/
                          (TimeInsBit \/ TimeDelBit))) :
  SEQ
    -- completed indicates if current instruction has terminated
    completed := (StatusReg /\ interruptable) = 0
    validProcess := Wptr <> NotProcess.p

    PRI ALT
      (StatusReg /\ GotoSNPBit) <> 0 & SKIP
        StartNextProcess ()

      (Priority = 0) AND (NOT (TNextReg[0] AFTER ClockReg[0])) AND
                                                    completed & SKIP
          HandleTimerRequest (0)

      ALT hc = 0 FOR LinkChans
        (Priority = 0) AND completed & FromChan[hc][0] ? token
          HandleChannelRequest (token, hc)

      (Priority = 1) AND
                    (NOT (TNextReg[0] AFTER ClockReg[0])) & SKIP
        HandleTimerRequest (0)

      ALT hc = 0 FOR LinkChans
        (Priority = 1) & FromChan[hc][0] ? token
          HandleChannelRequest (token, hc)

      (Priority = 1) AND (NOT (TNextReg[1] AFTER ClockReg[1]))AND
                                              completed & SKIP
```

“

# The Devil is in the detail

Microcomputer Division Confidential — Author: Roger Shepherd

```
WHILE active
  VAL INT interruptable IS GotoSNPBit \/ (IOBit \/ (MoveBit \/
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      (Priority = 1) AND (NOT (TNextReg
```

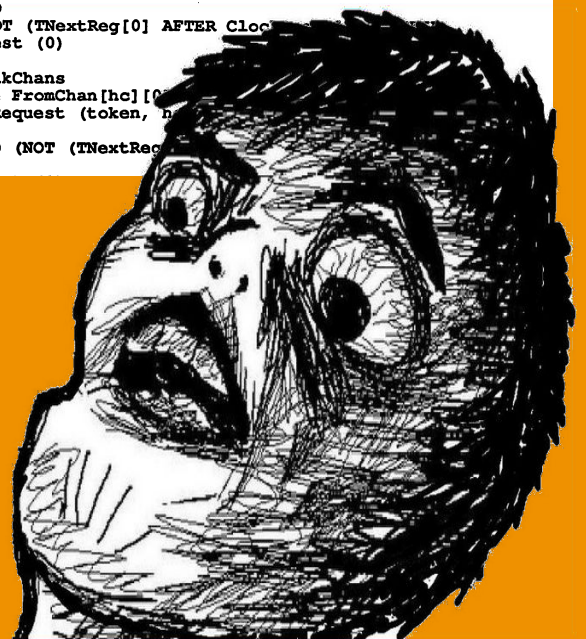

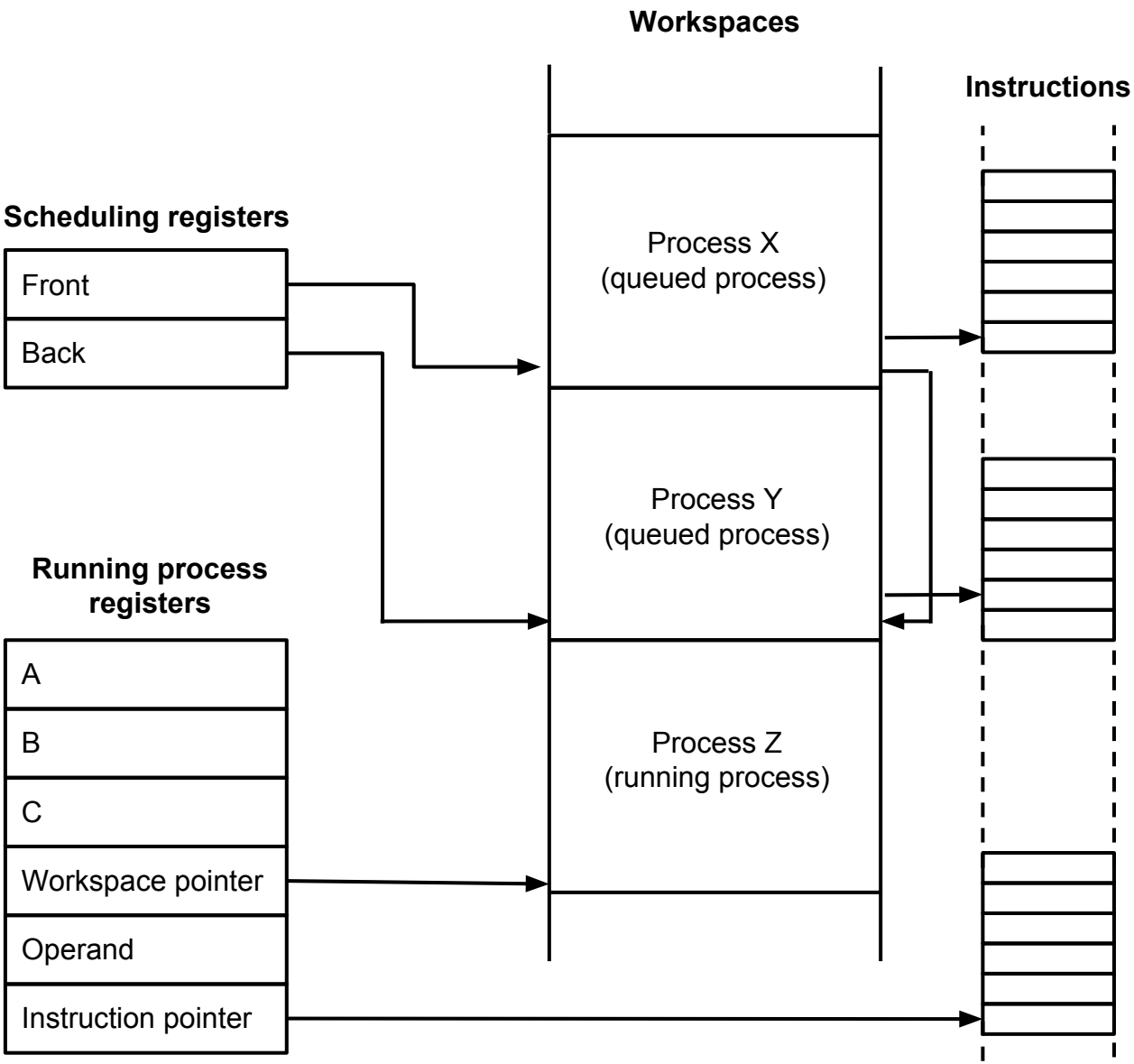


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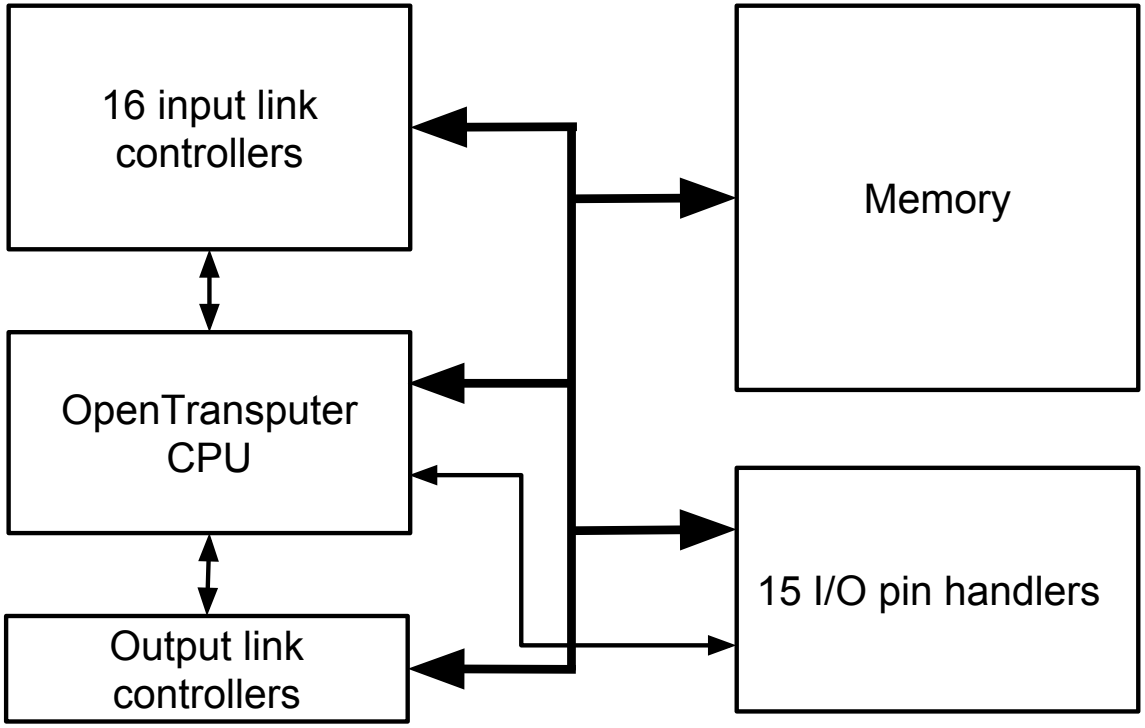
# Interprocess communication

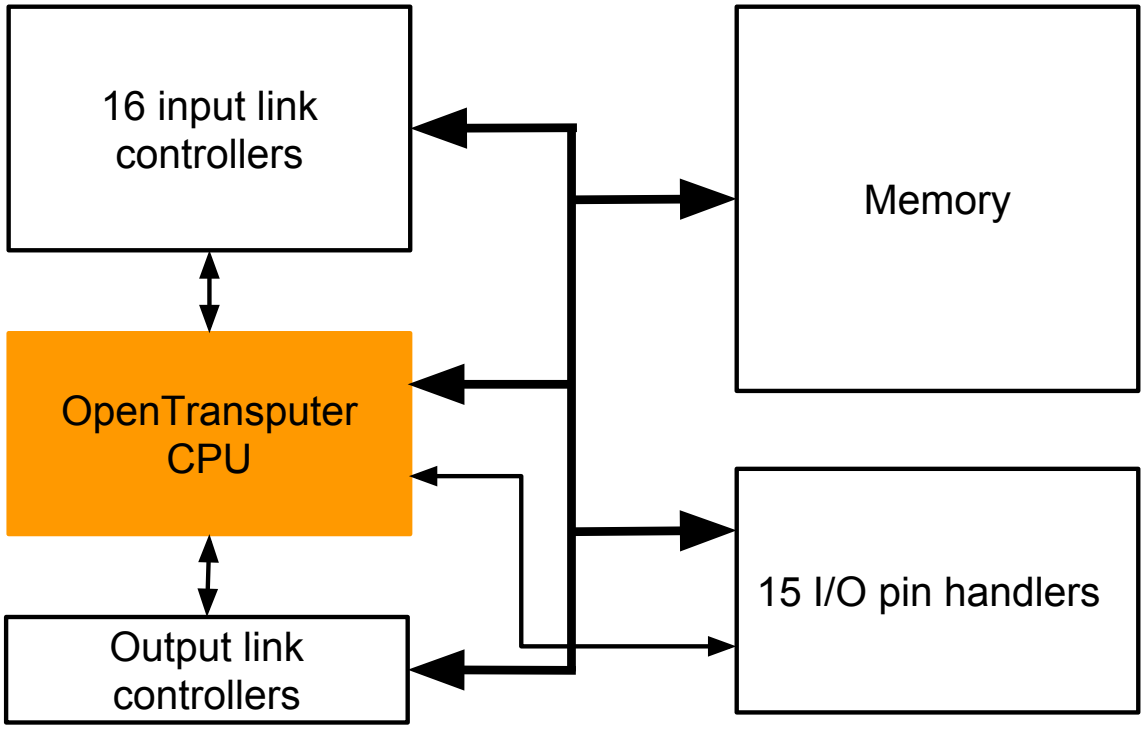
- Special Transputer instructions implement Occam primitives efficiently.
- Communication performed either through channel in memory or physical links.

But I want to hear about the OpenTransputer!

# Processor components



# Processor components



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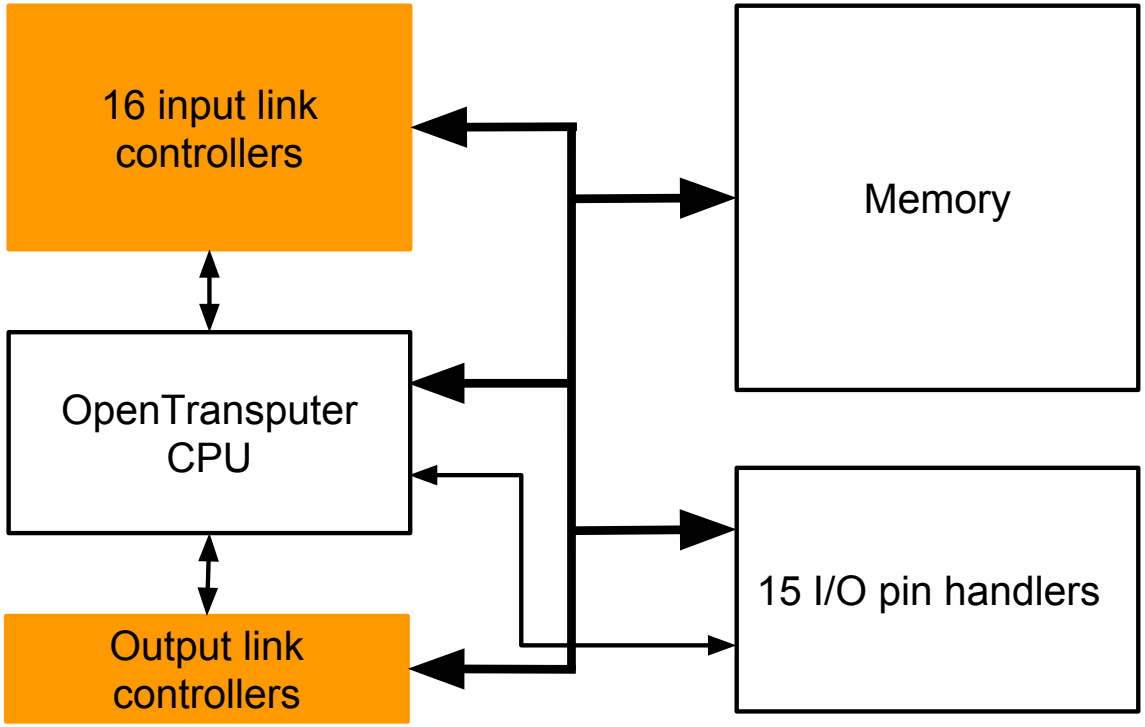

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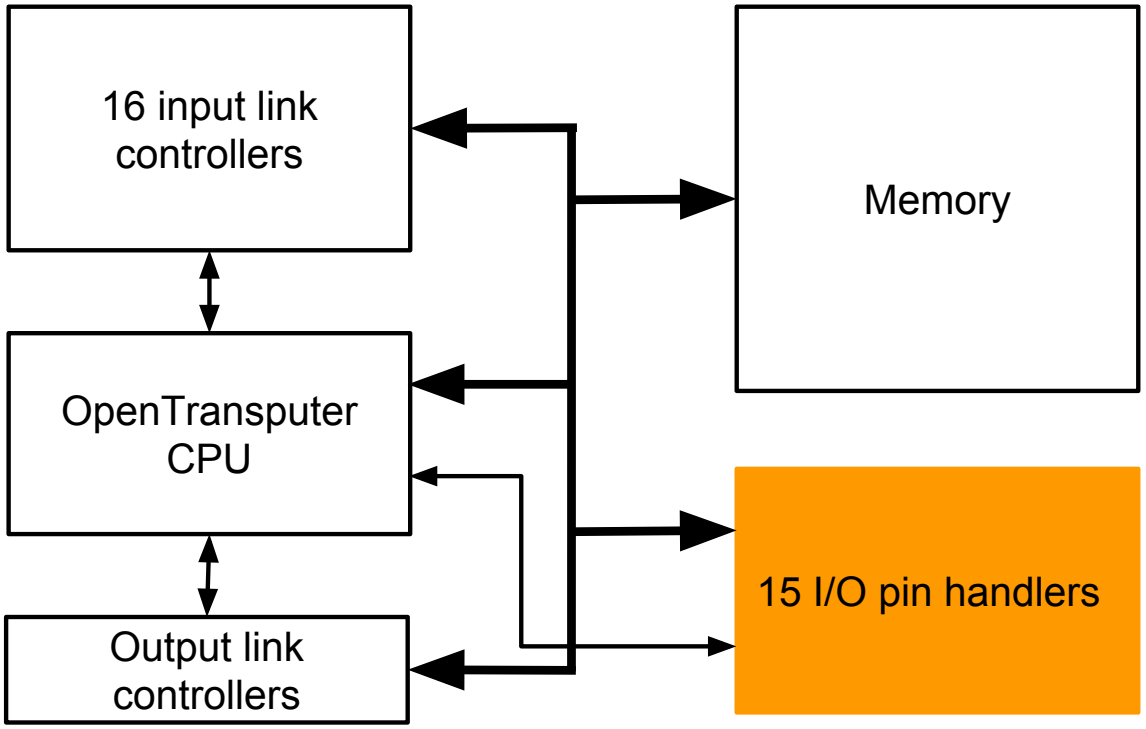

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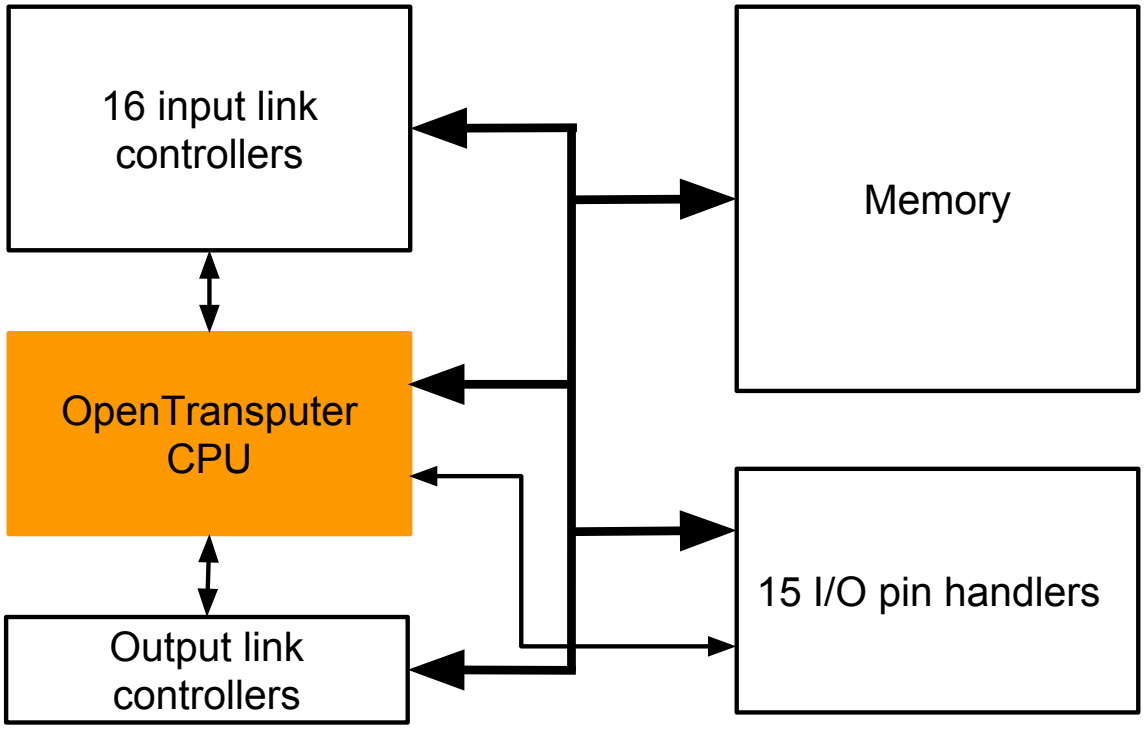
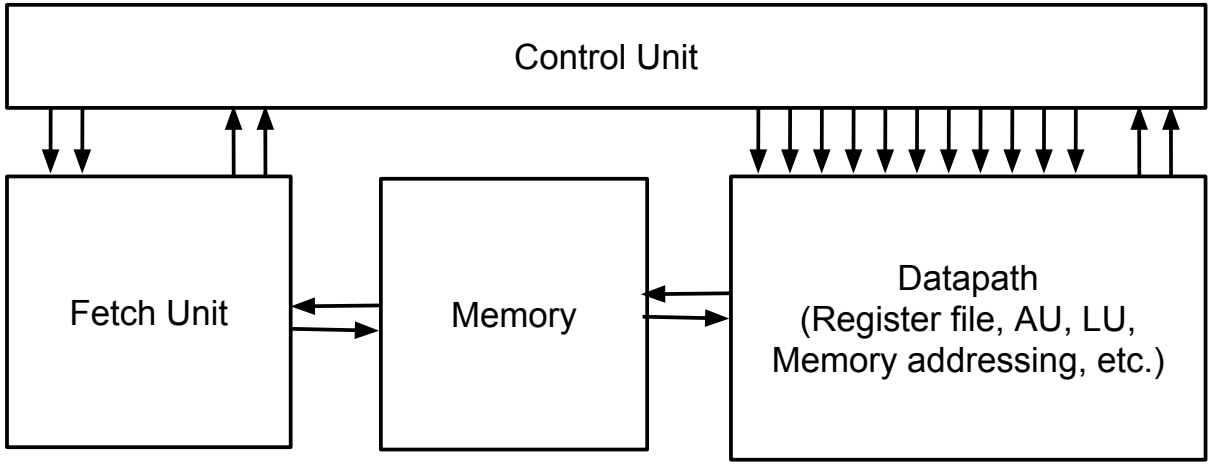
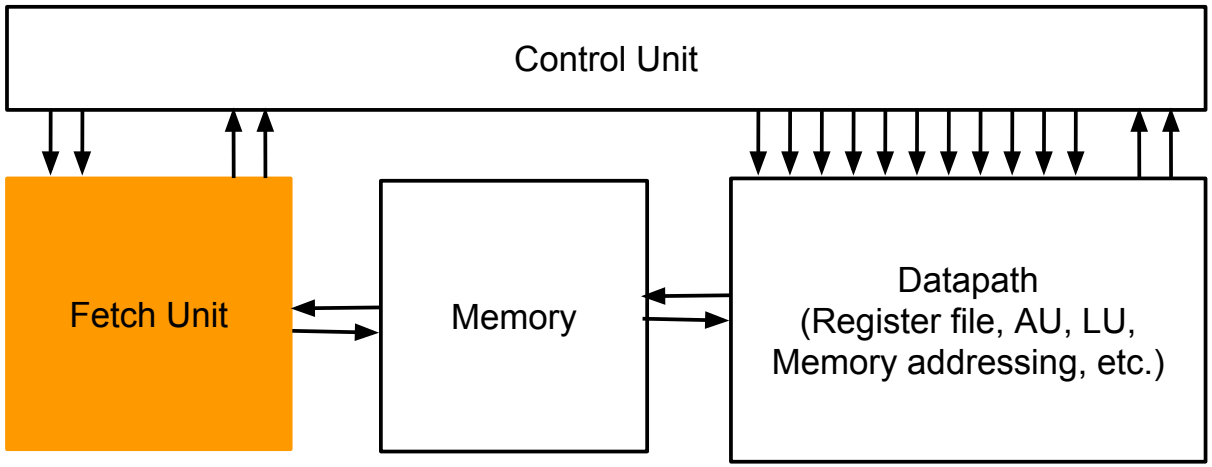


# CPU


Control Unit
Fetch Unit
Memory
Datapath
(Register file, AU, LU,
Memory addressing, etc.)

# CPU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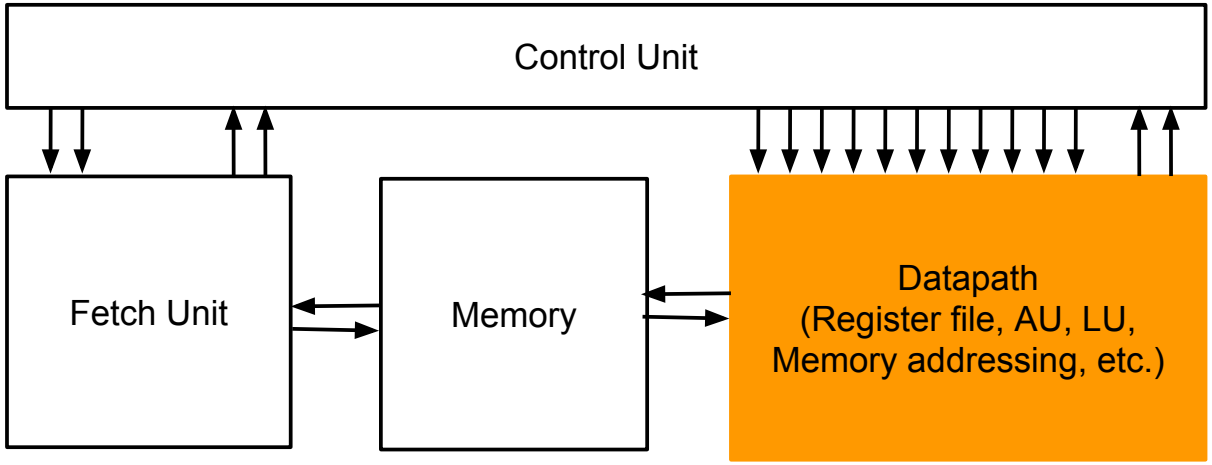
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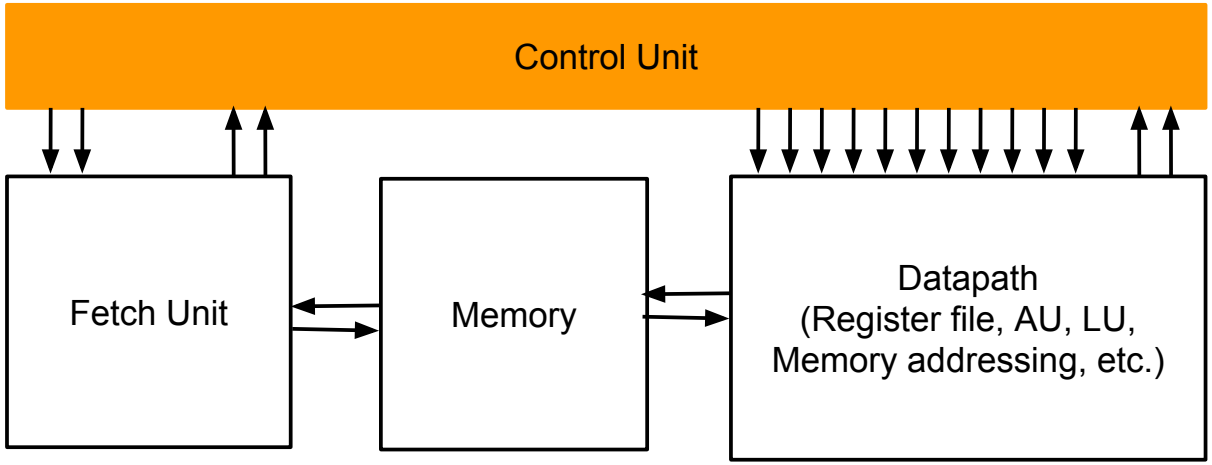

Control Unit
Fetch Unit
Memory
Datapath
(Register file, AU, LU,
Memory addressing, etc.)

# Control unit

## Inmos Transputer

- Microcoded control unit.
- Control signals stored in Read-Only Memory (ROM).
- Area savings and potentially less complex.

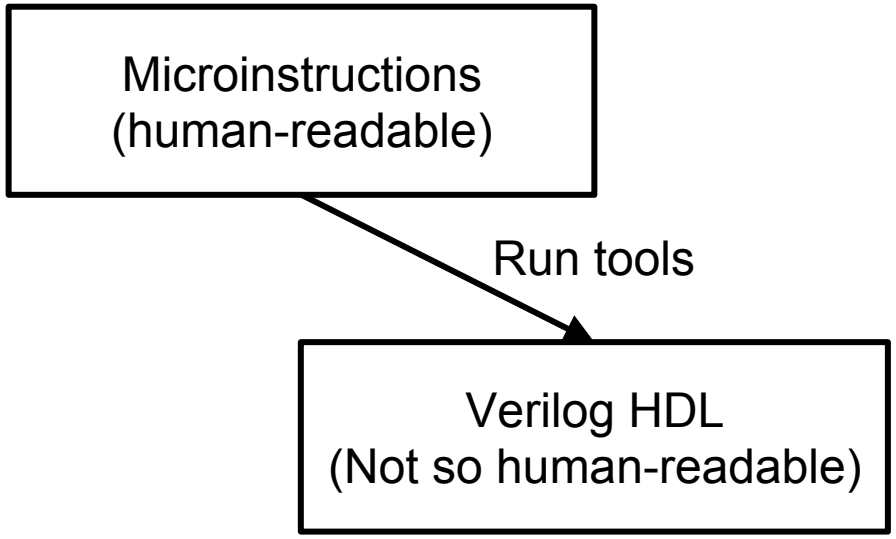
## OpenTransputer

- Designed with a microcode strategy.
- Control signals generated by hardwired logic.
- Potentially faster than ROM.

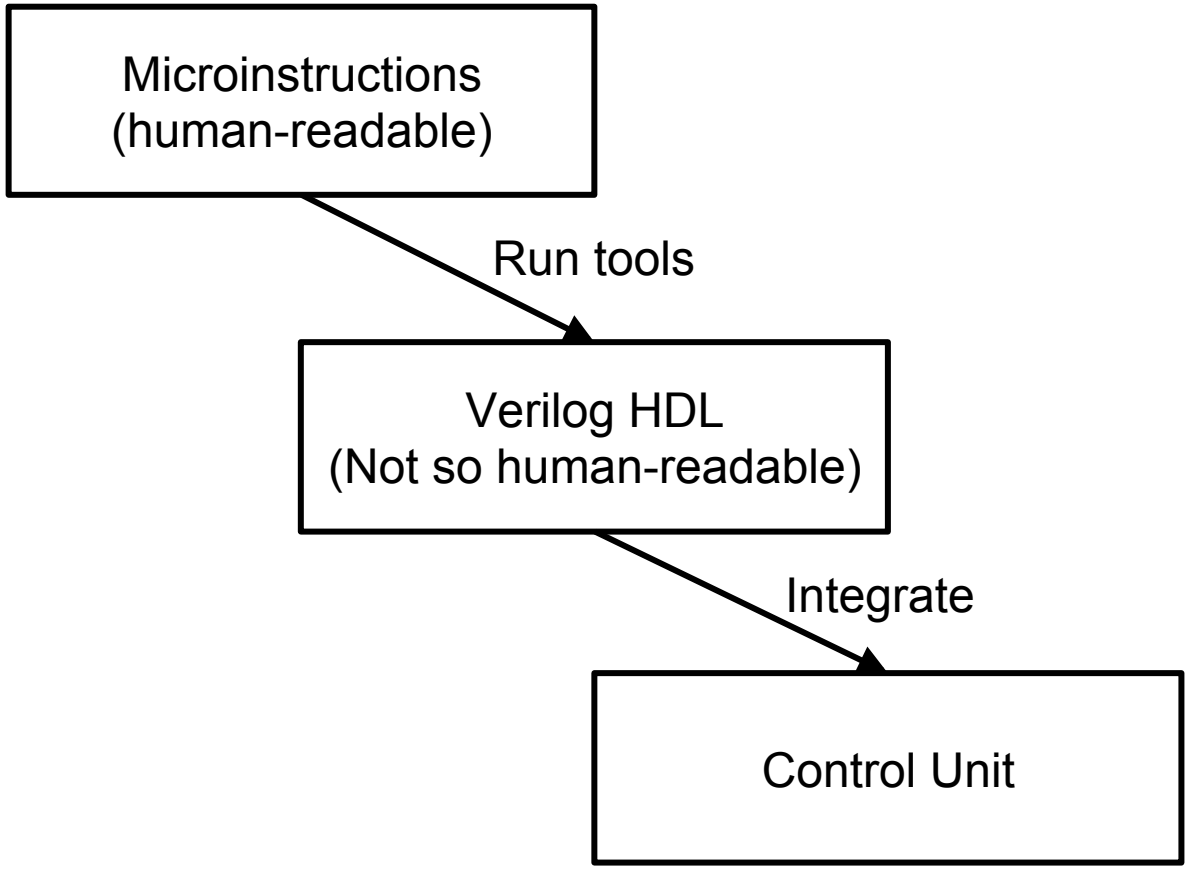
# Control unit

Microinstructions
(human-readable)

# Control unit



# Control unit

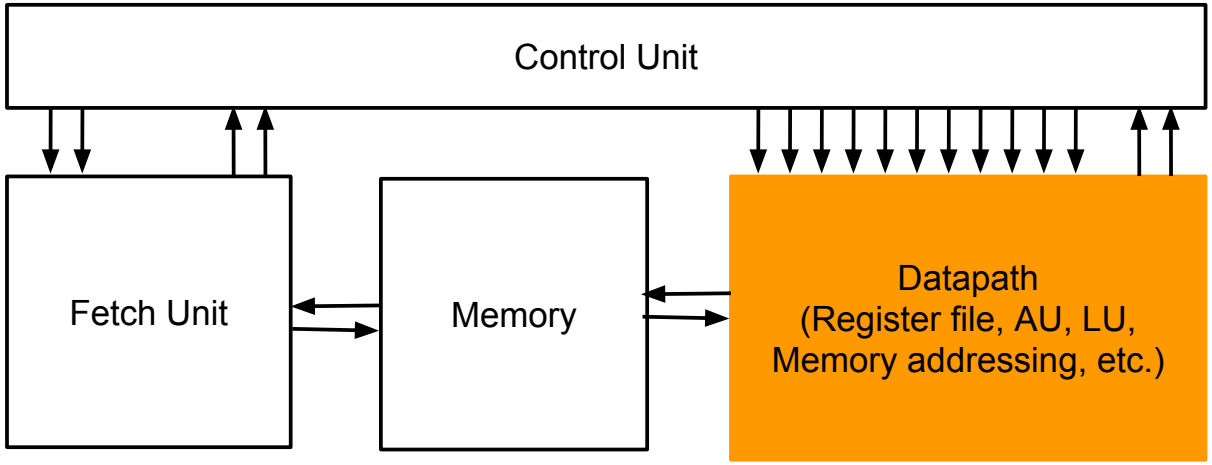


# OpenTransputer microinstructions

```
CJ0 ROMp0(0)
    CmpconstfromA
    Condall(CJ1,CJ2);
```

```
CJ1 AfromB
    BfromC
    OfromClear
    Gotoplus1;
```

# CPU


Control Unit
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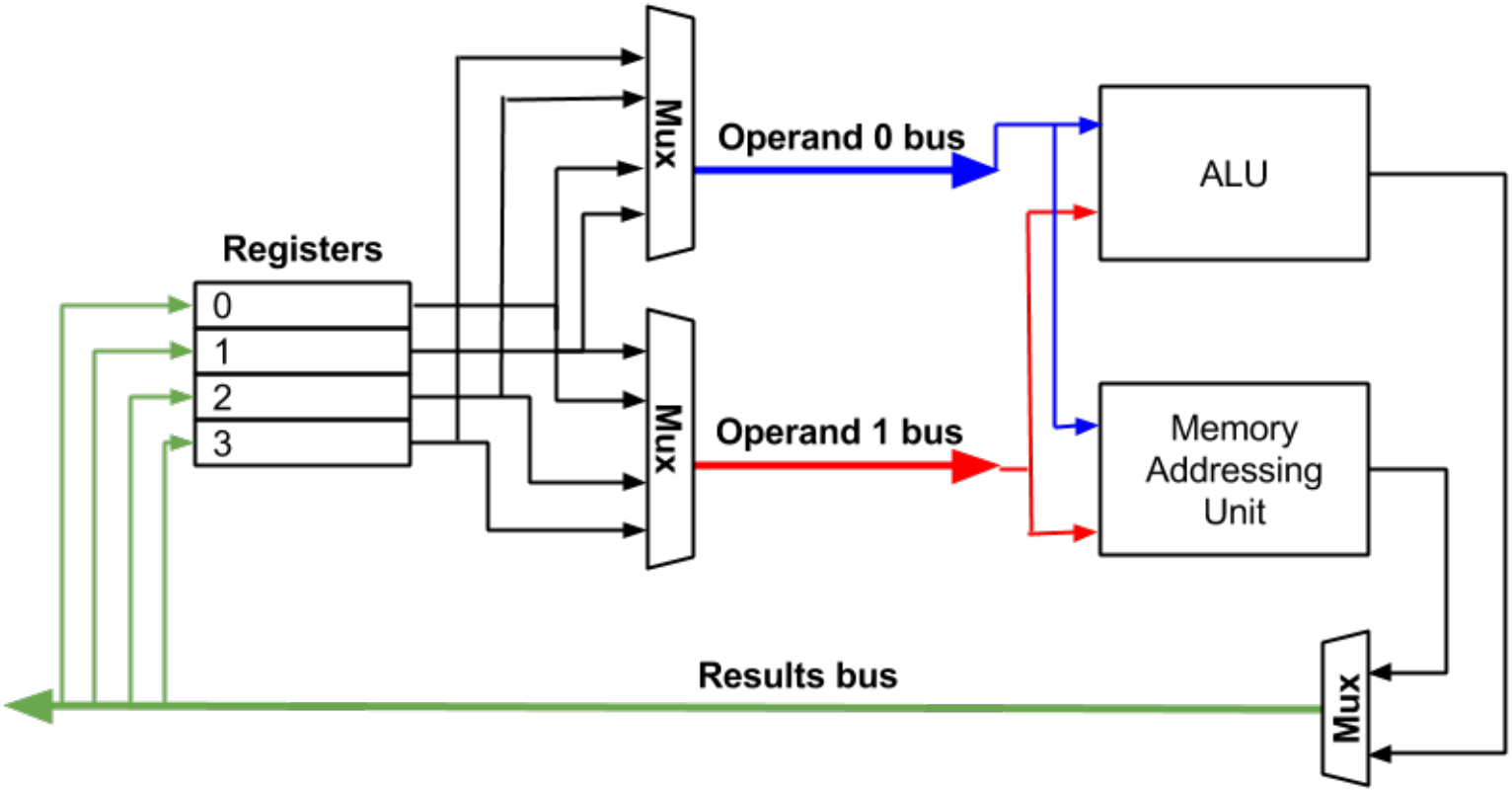
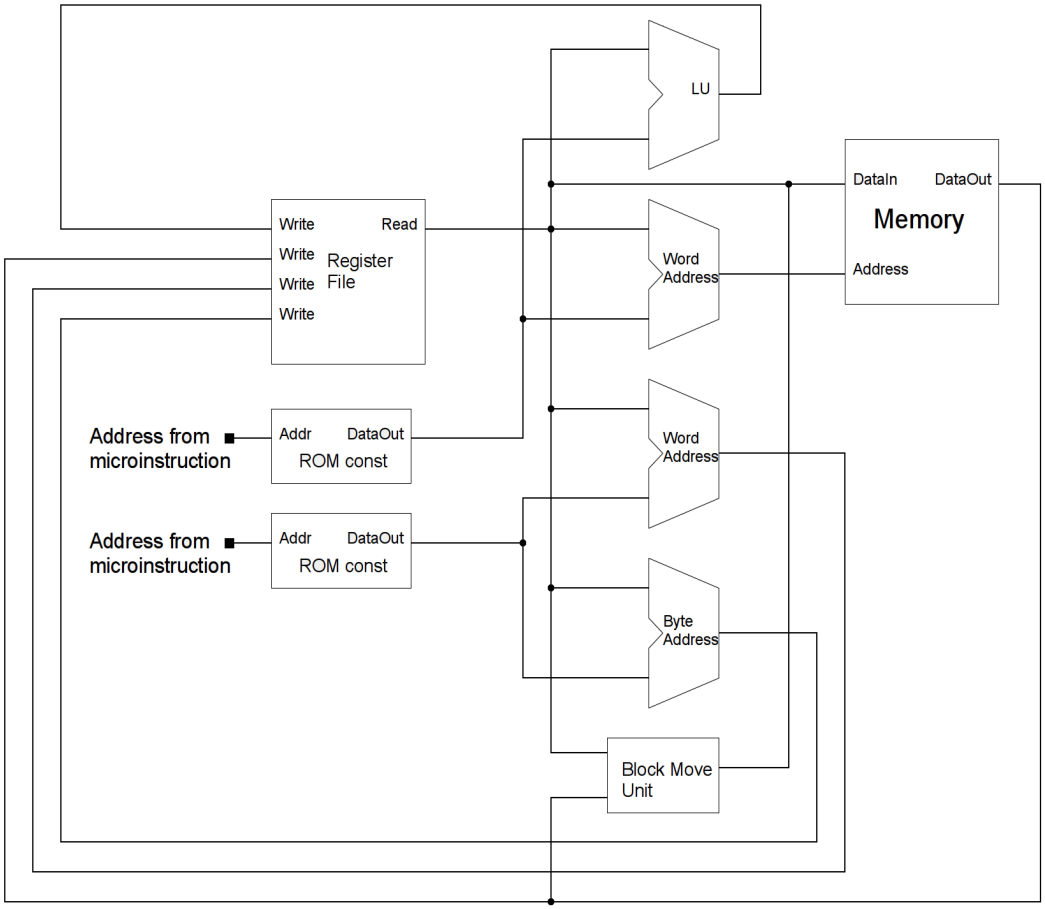
# Inmos Transputer datapath



# OpenTransputer datapath



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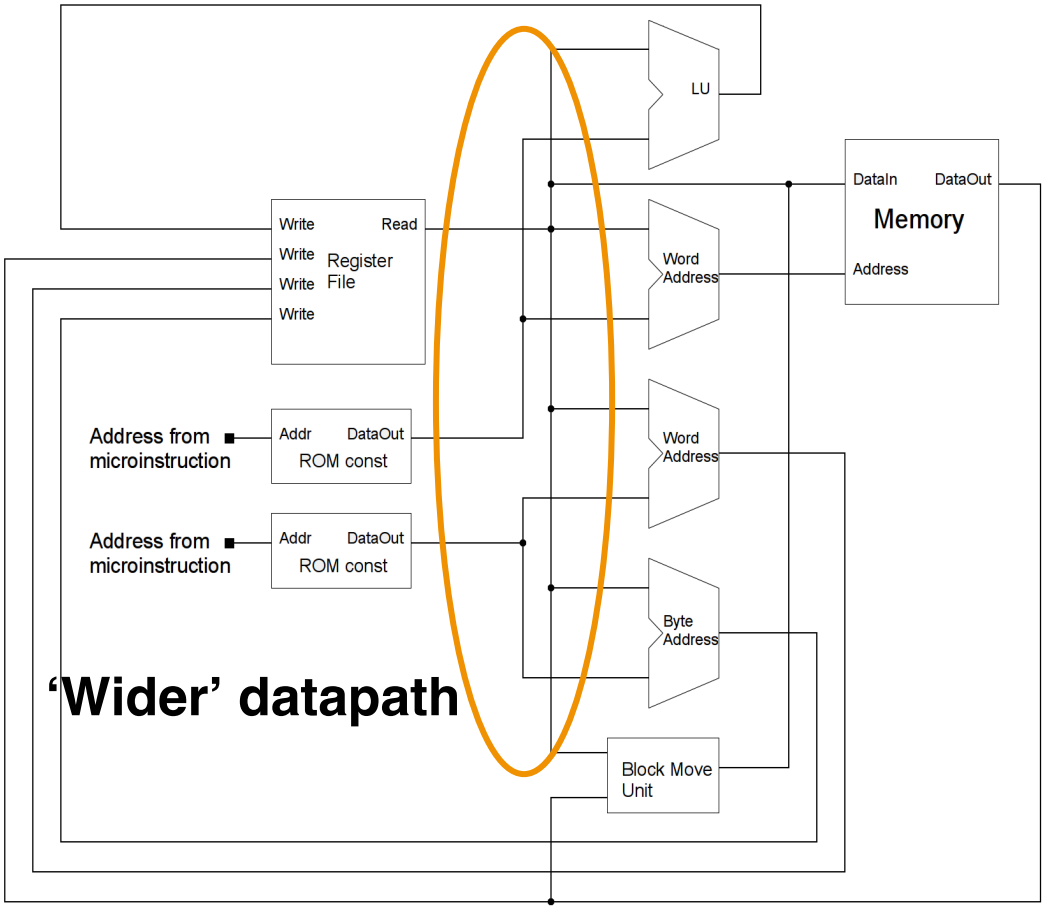

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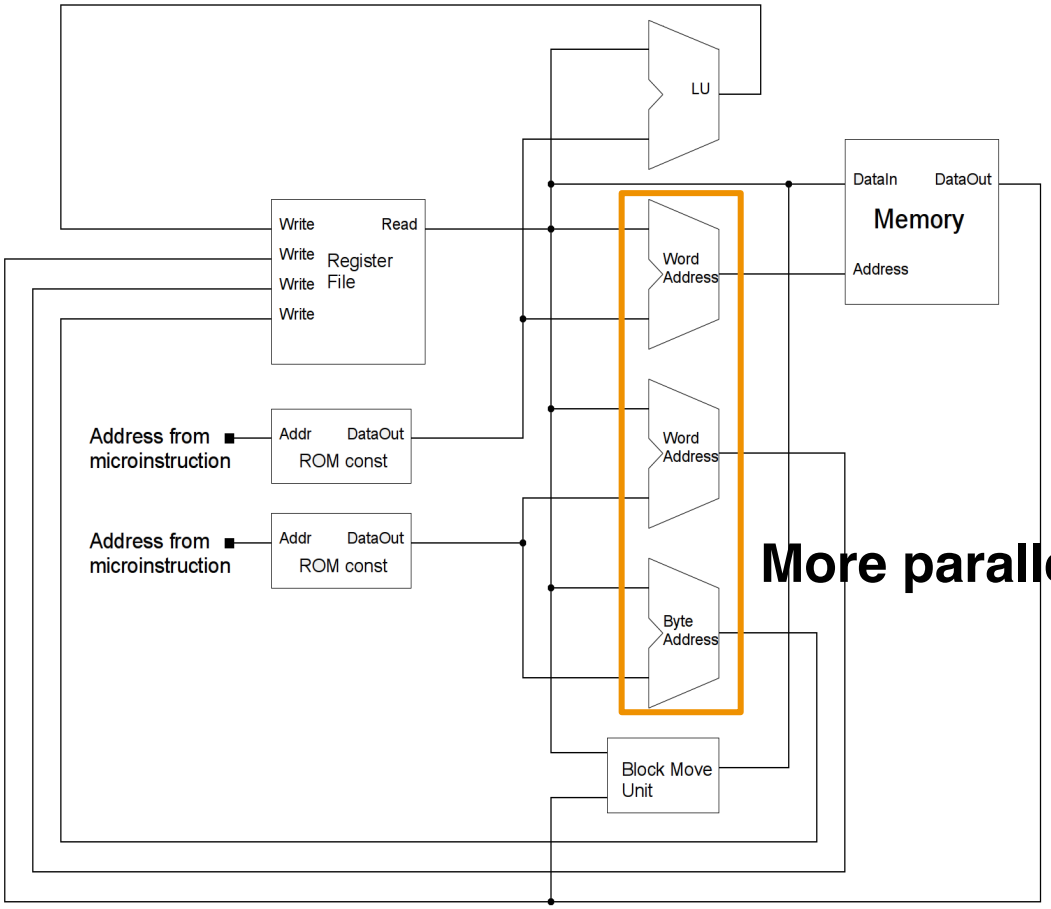

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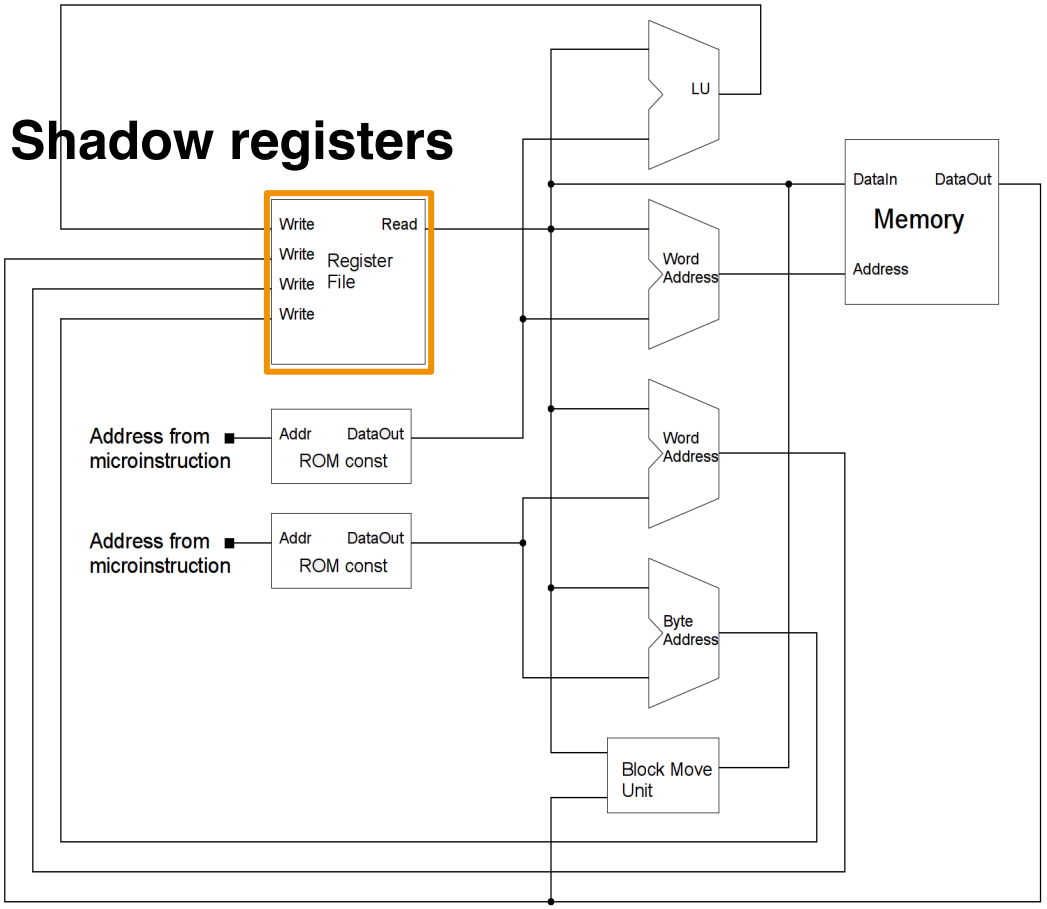
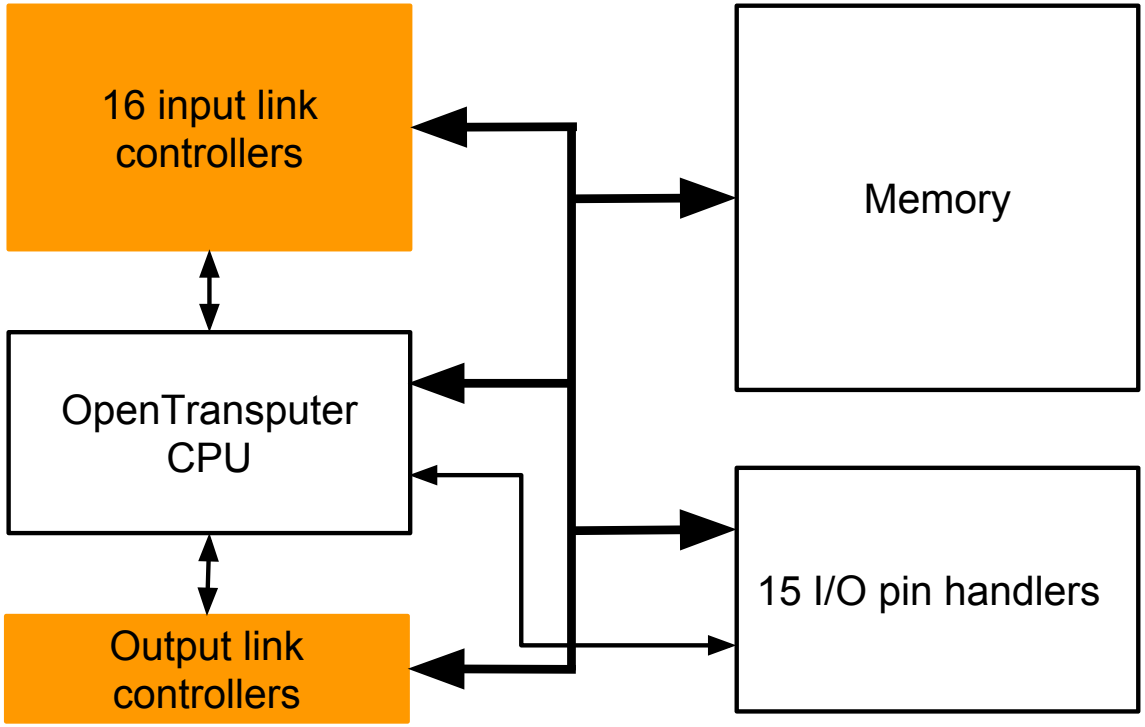
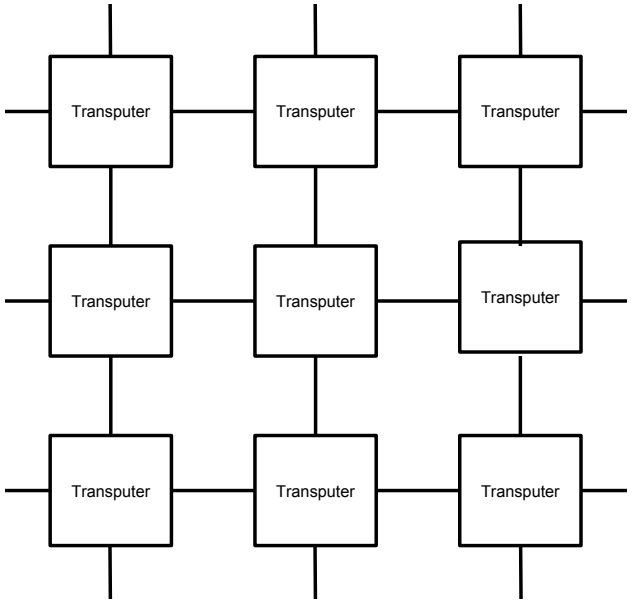


# Processor components

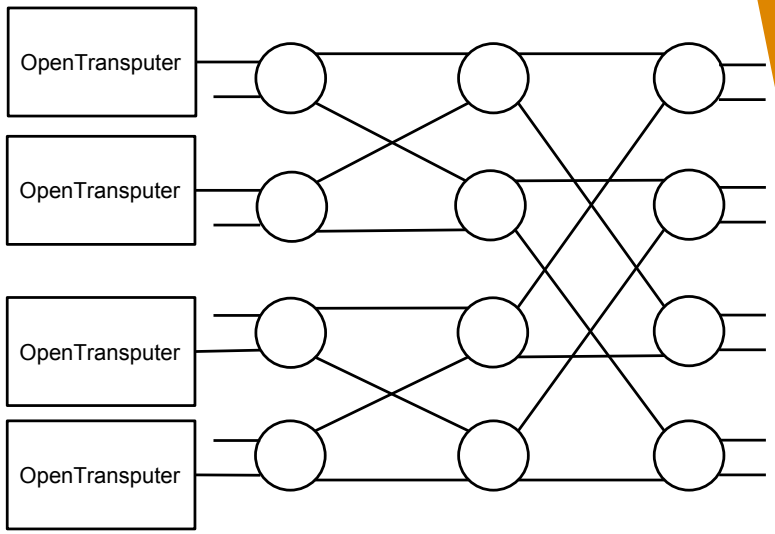


# External communication

## Inmos Transputer



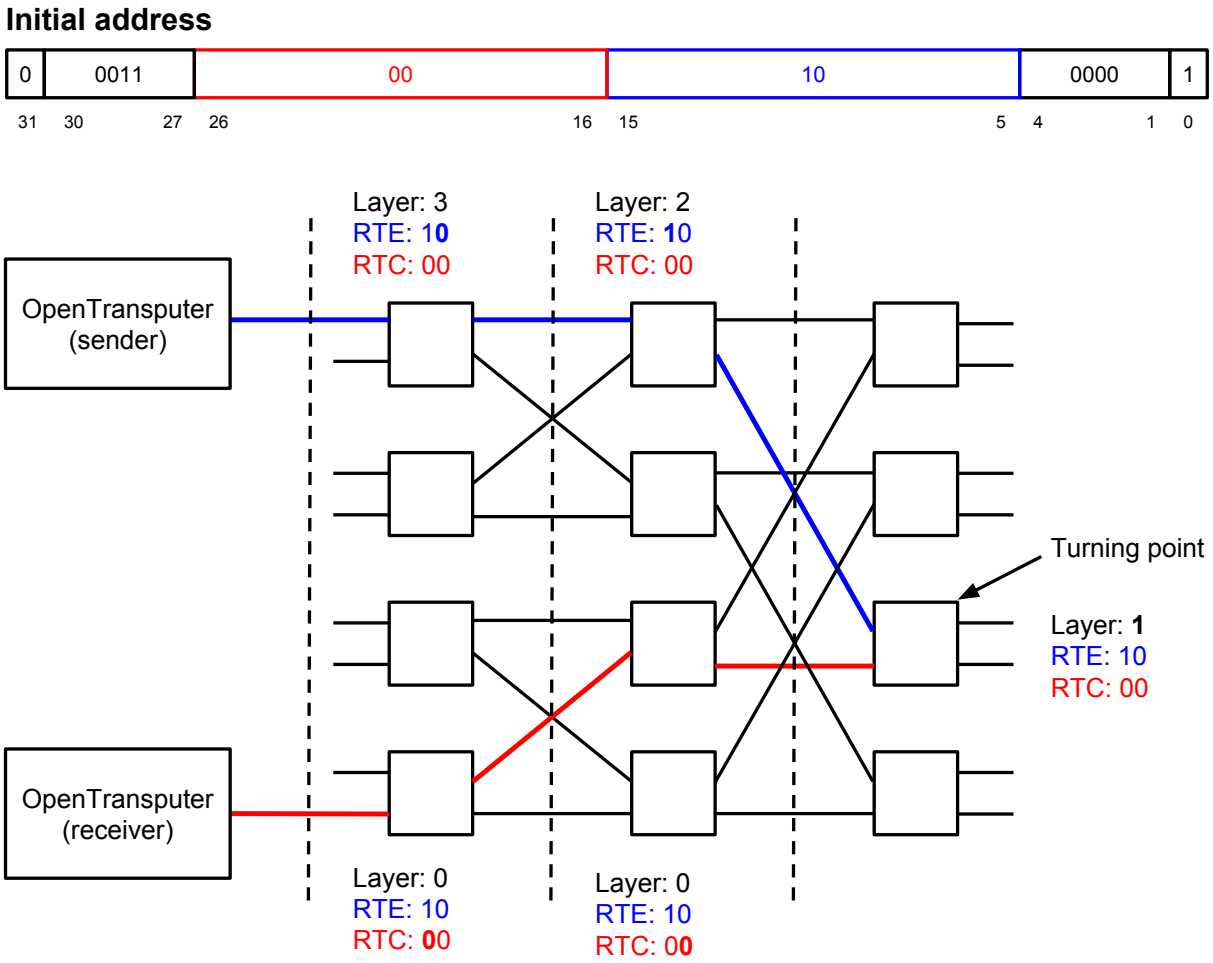

## OpenTransputer



# Autonomous link controllers

- There are 16 input ports and a single output port.
- Extended the original Transputer controllers to support *virtual channels* allowing an arbitrary number of processes to be queued to perform output operations.

# Message routing



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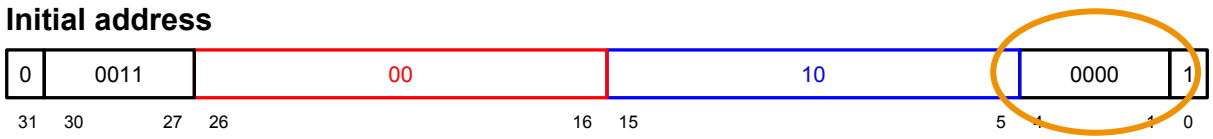


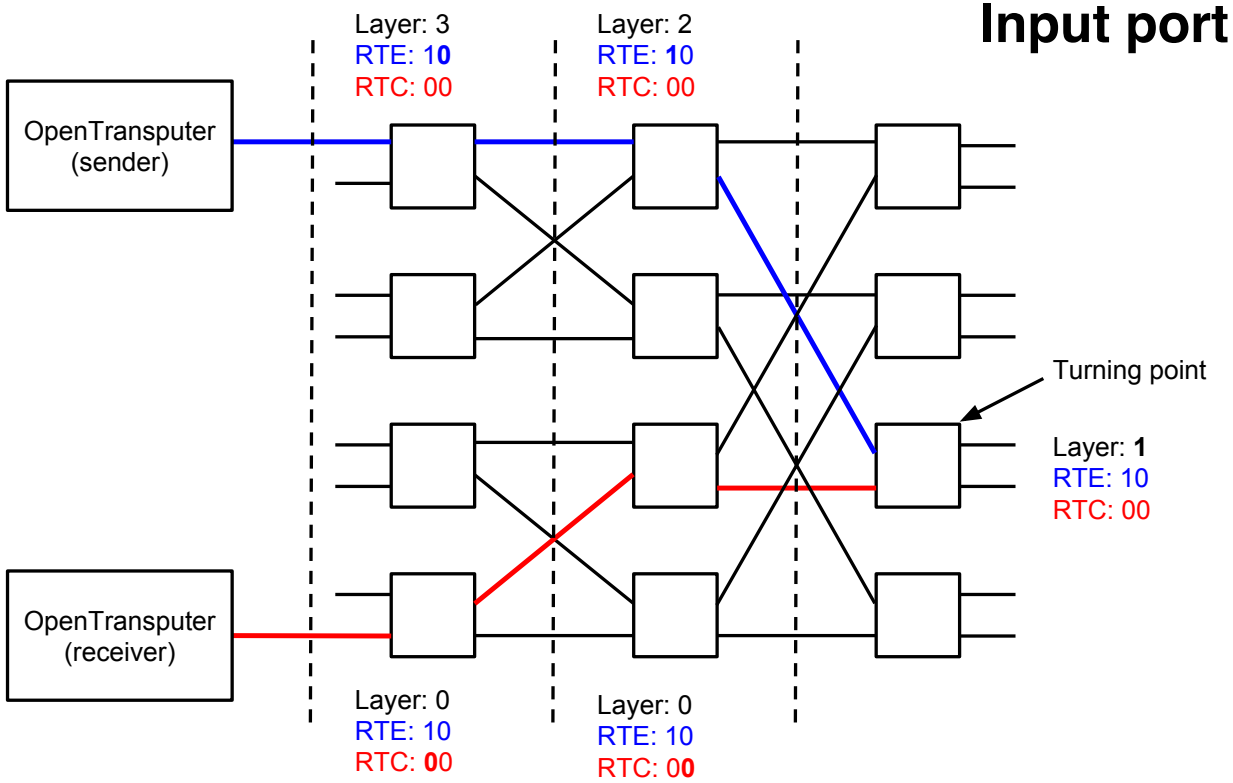


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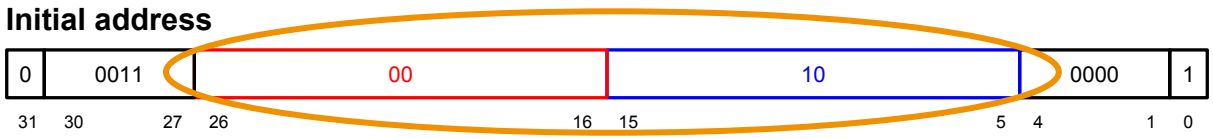


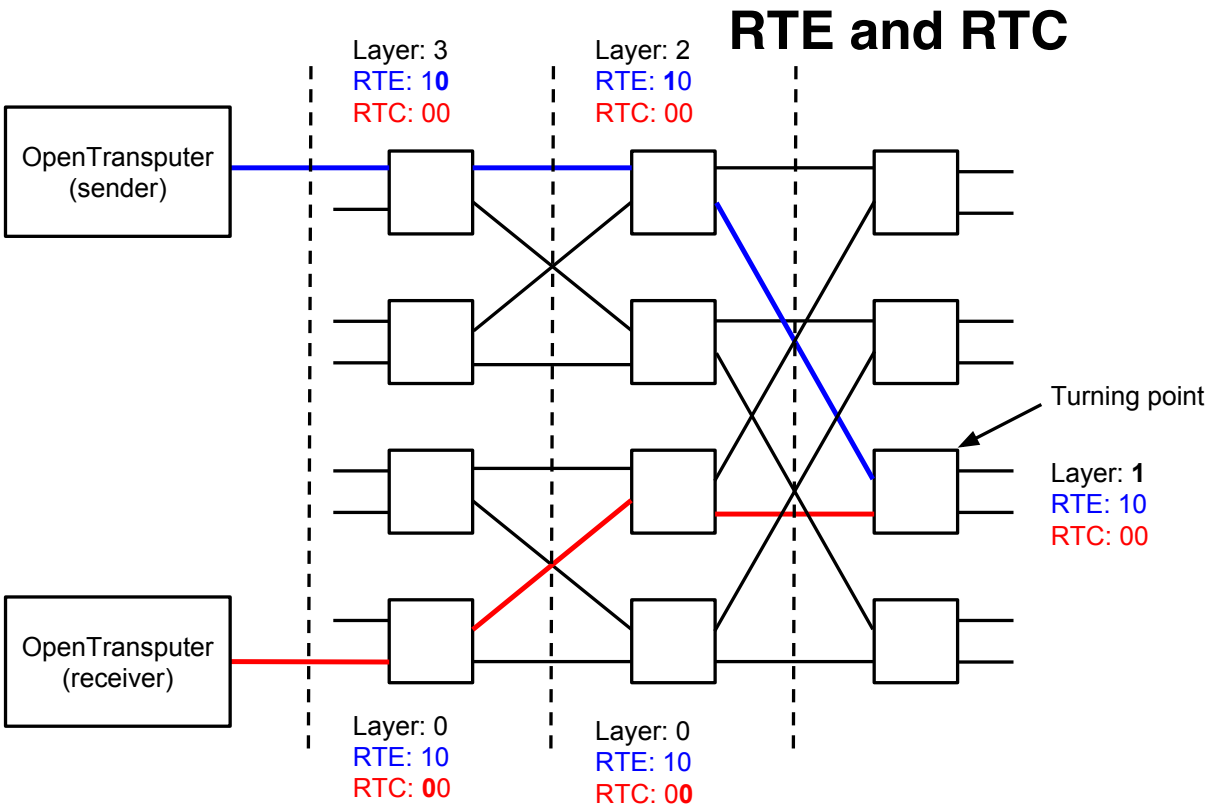

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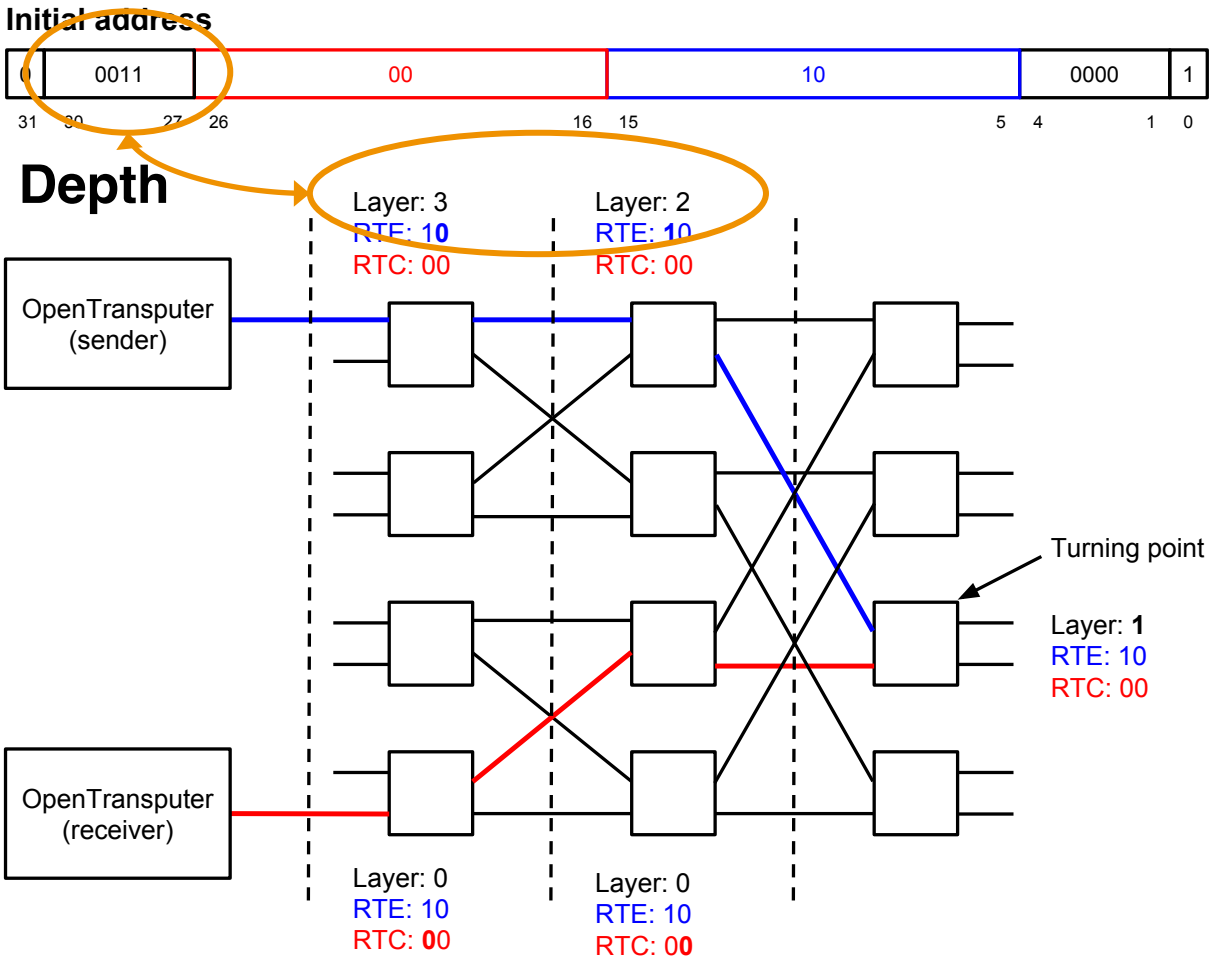

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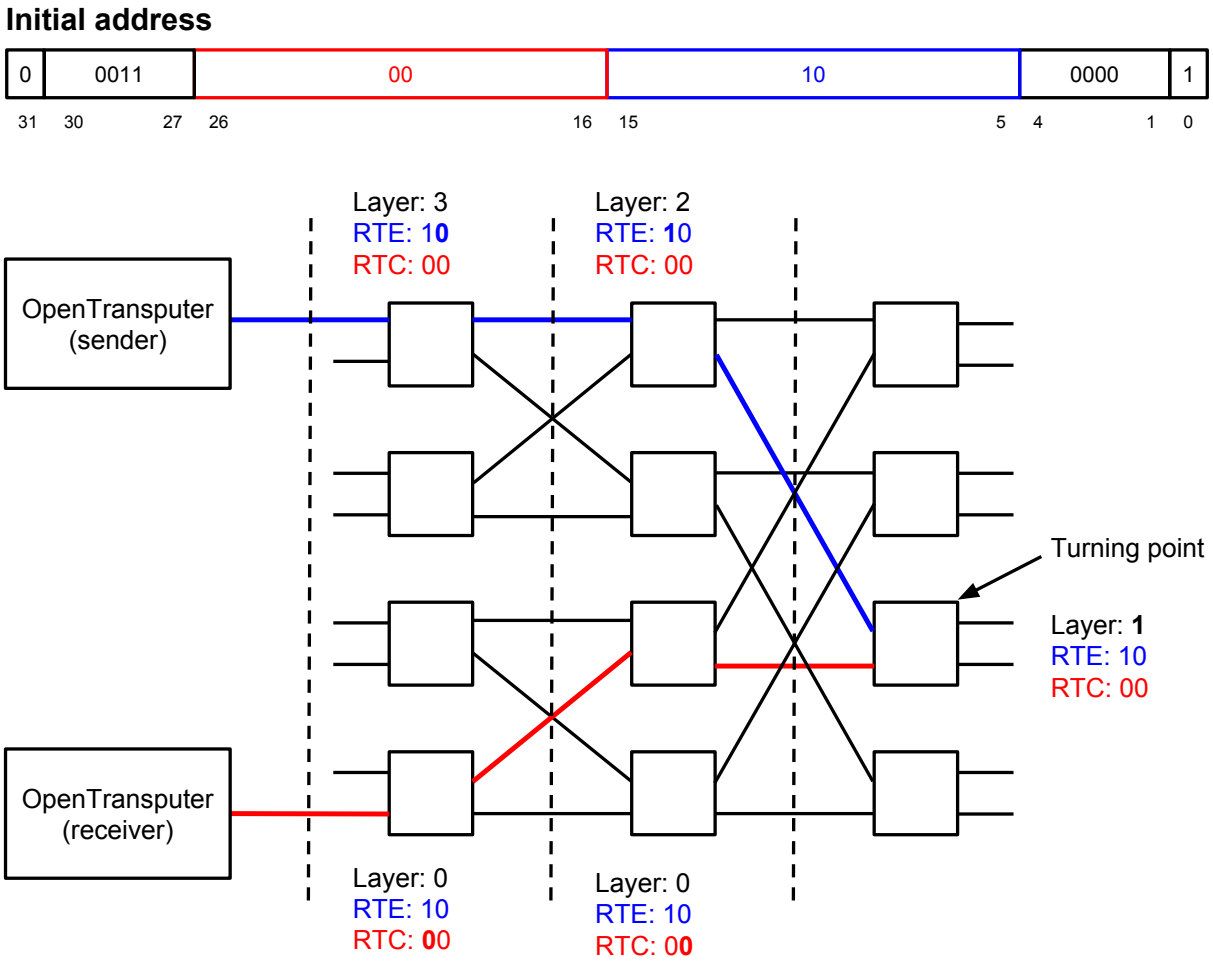
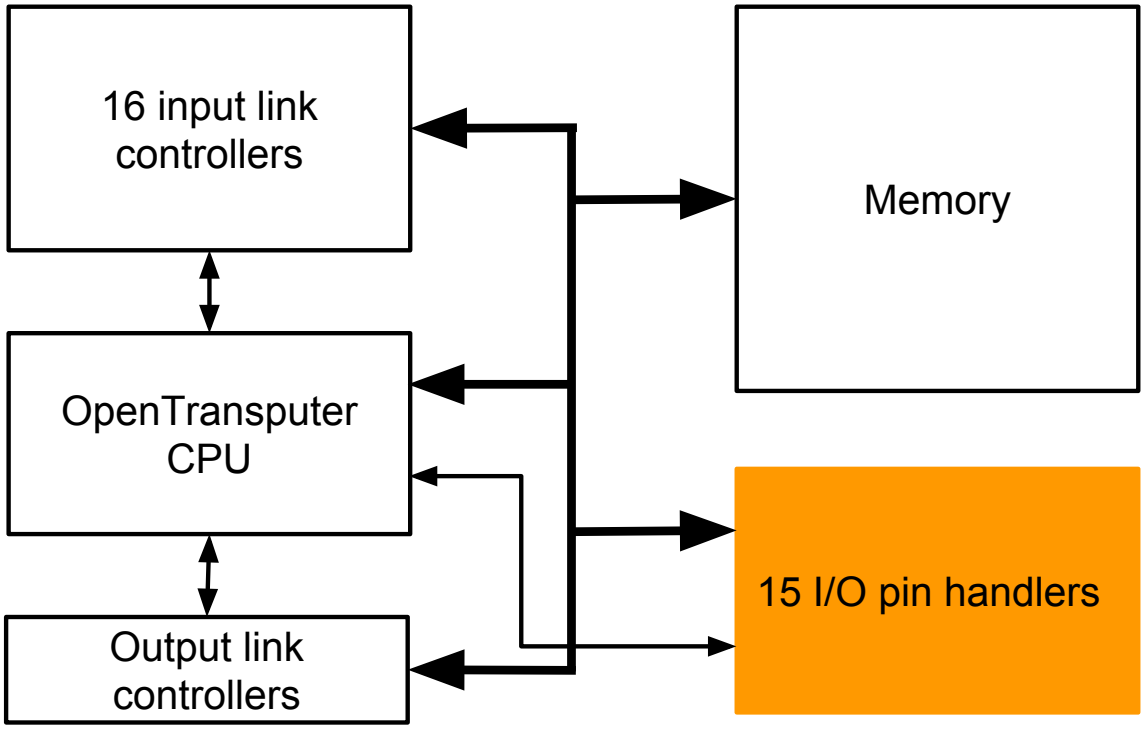


# Processor components



# OpenTransputer I/O interface

- I/O pins expose the same interface as communication links.
- Introduced an instruction (`confio`) that can be used to configure the I/O pins.

# So… what about performance?

# Synthesis

Synthesised design for both the ZedBoard XC7Z020-CLG484 FPGA and a 180nm manufacturing process.

# Comparing synthesis results

| | Inmos Transputer | OpenTransputer |
|---|---|---|
| **Area** | 64 $mm^2$ | 3.69 $mm^2$ |
| **Manufacturing technology** | 1000 nm | 180 nm |

# Comparing synthesis results

| | Inmos Transputer | OpenTransputer |
|---|---|---|
| **Area** | 64 $mm^2$ | 3.69 $mm^2$ |
| **Manufacturing technology** | 1000 nm → 5.6 | 180 nm |

# Comparing synthesis results

| | Inmos Transputer | | OpenTransputer |
|---|---|---|---|
| **Area** | 64 $mm^2$ | **$4.2^2$** | 3.69 $mm^2$ |
| **Manufacturing technology** | 1000 nm | **5.6** | 180 nm |

# Comparing cycle counts

| Instruction | Inmos Transputer | OpenTransputer |
|---|---|---|
| ldl | 2 | 1 |
| startp | 12 | 3-5 |
| endp | 13 | 3 |
| move | 8 + 2w* | 6 + 5w* |

** w is the number of words to copy.*

# Conclusion

- ✓ OpenTransputer based on the Transputer architecture.
- ✓ Different micro-architecture to take advantage of modern manufacturing technologies
- ✓ New external communication mechanism.
- ✓ New I/O interface.

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*aa1399@my.bristol.ac.uk*

# Conclusion

- ✓ OpenTransputer based on the Transputer architecture.
- ✓ Different micro-architecture to take advantage of modern manufacturing technologies
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# Thank you!

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