UK Asynchronous Forum, Edinburgh

Multi-View Design of Asynchronous Micropipeline Systems using Rainbow

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Contents

- Background
- Rainbow Design Framework
- Example: Simple Processor
- Formal Semantics
- Simulation
- Summary

Background

Asynchronous hardware design:

- offers: increased speed, reduced power, easier design (compositional)
- example: AMULET microprocessor (Manchester)

Need:

- fast prototyping
- simulation
- early design analysis

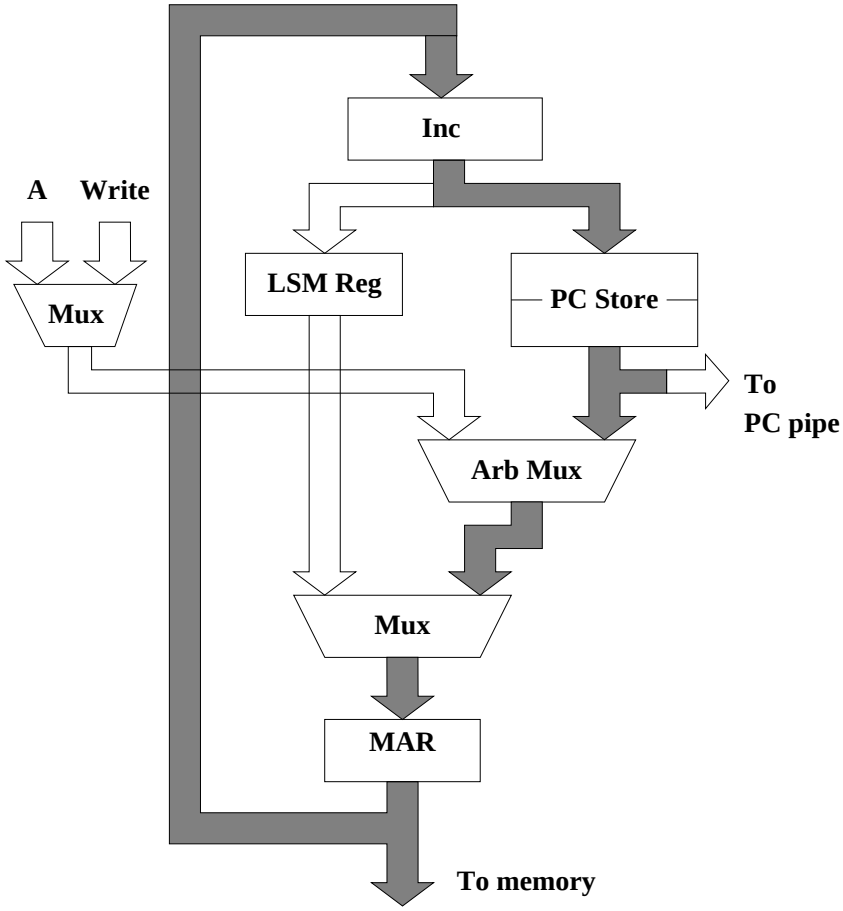
But...problems facing asynchronous design:

- lack of specialised design tools
- design analysis

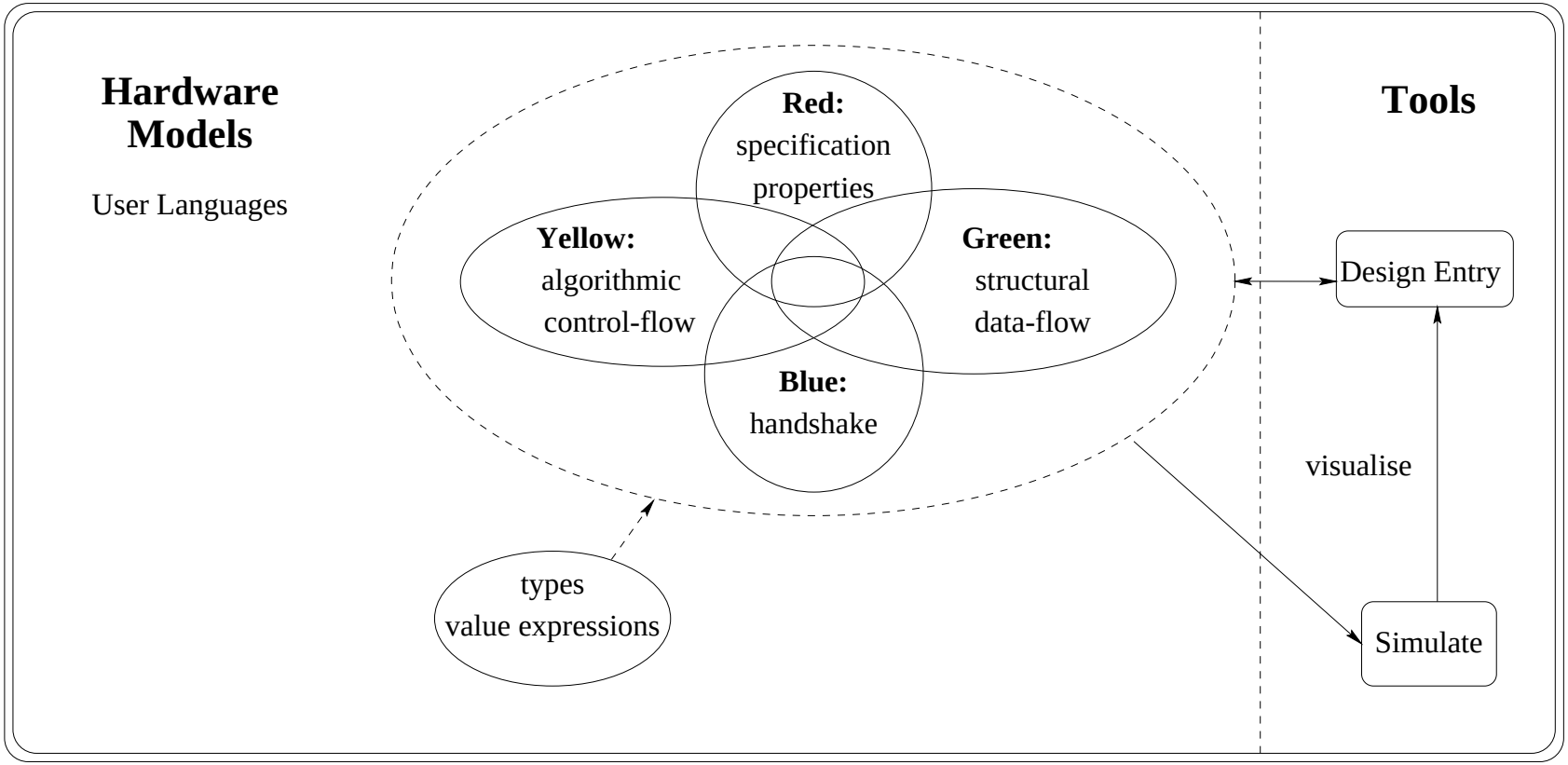
Require:

- design methodology: Micropipelines
- analysis tools
  - deadlock detection
  - high level power, speed estimation
  - functional verification

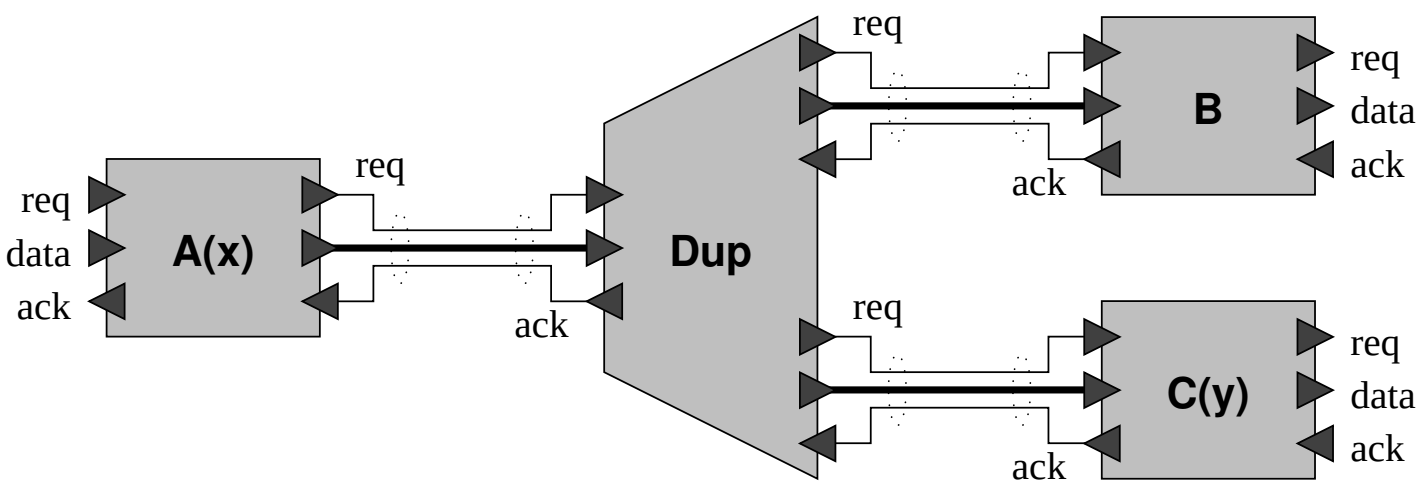
...and a suitable design representation

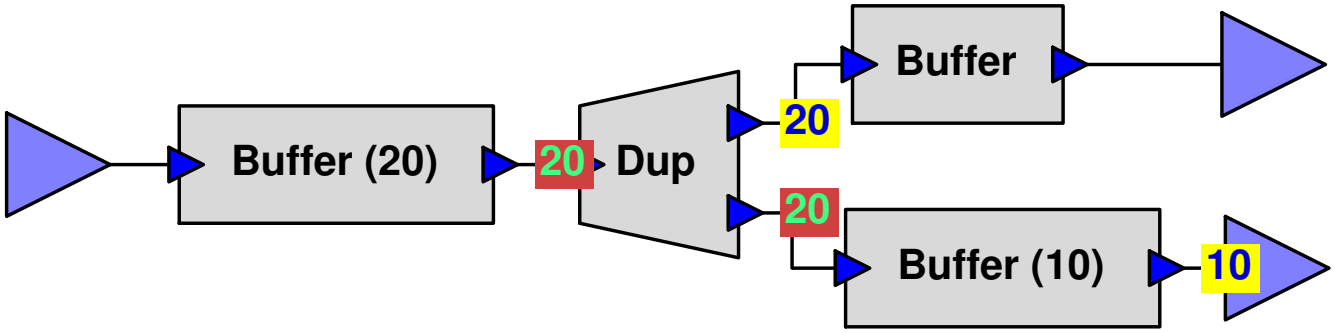

Inc
A
Write
LSM Reg
PC Store
Mux
To
PC pipe
Arb Mux
Mux
MAR
To memory

Rainbow Design Framework

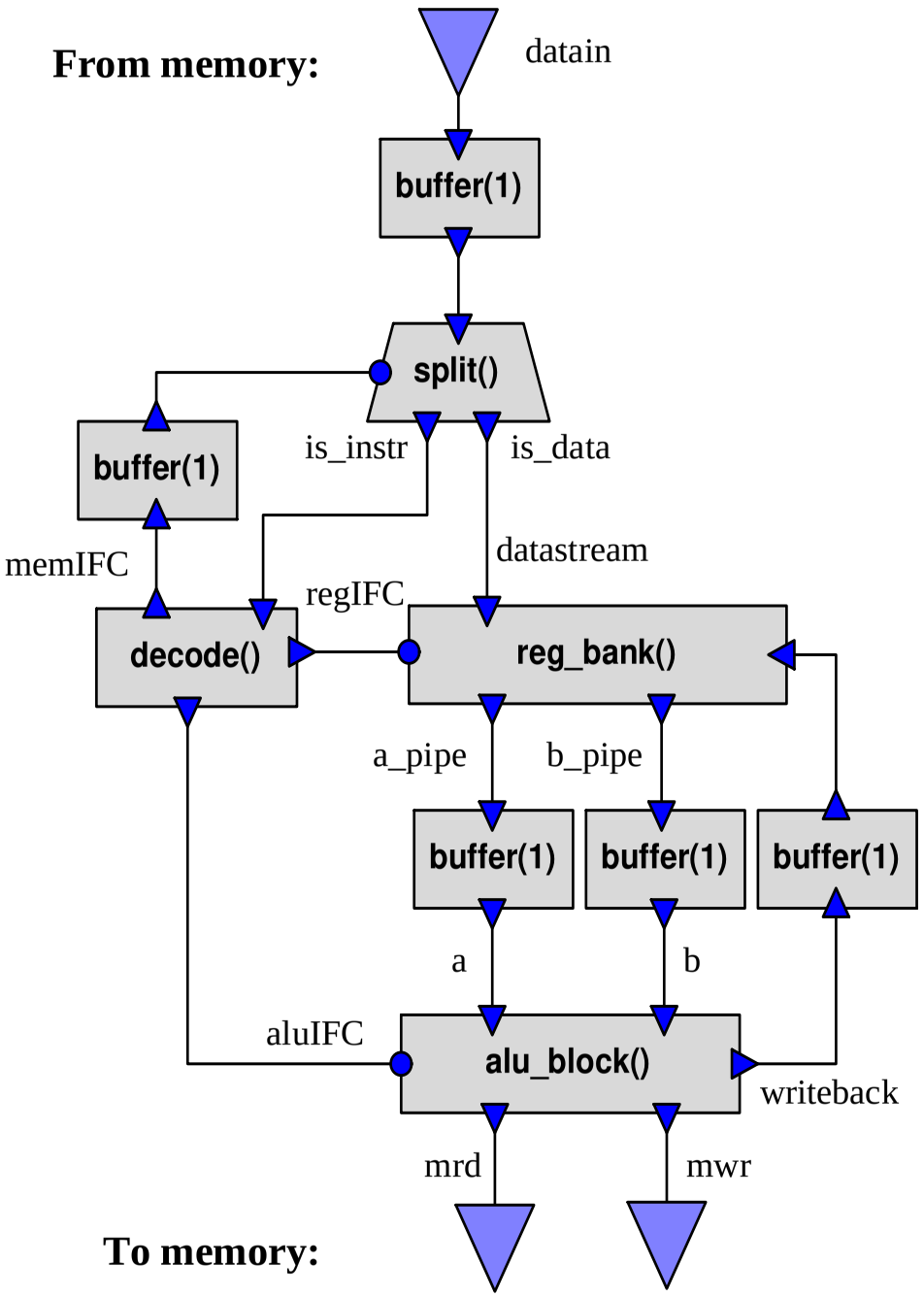


- Application-specific
- User-oriented language design (AMULET)
- Abstract representation of bundled data
- Mixed-view modelling
- Hierarchical design


req
data
ack
A(x)
req
ack
Dup
req
ack
B
req
data
ack
req
ack
C(y)
req
data
ack


Buffer (20)
20
Dup
20
Buffer
20
Buffer (10)
10

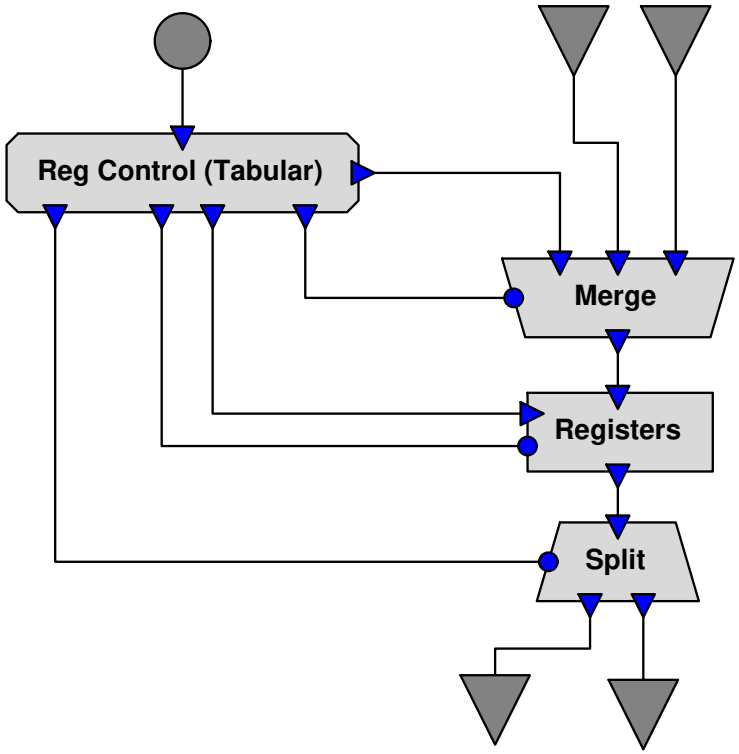
Example: Simple Processor



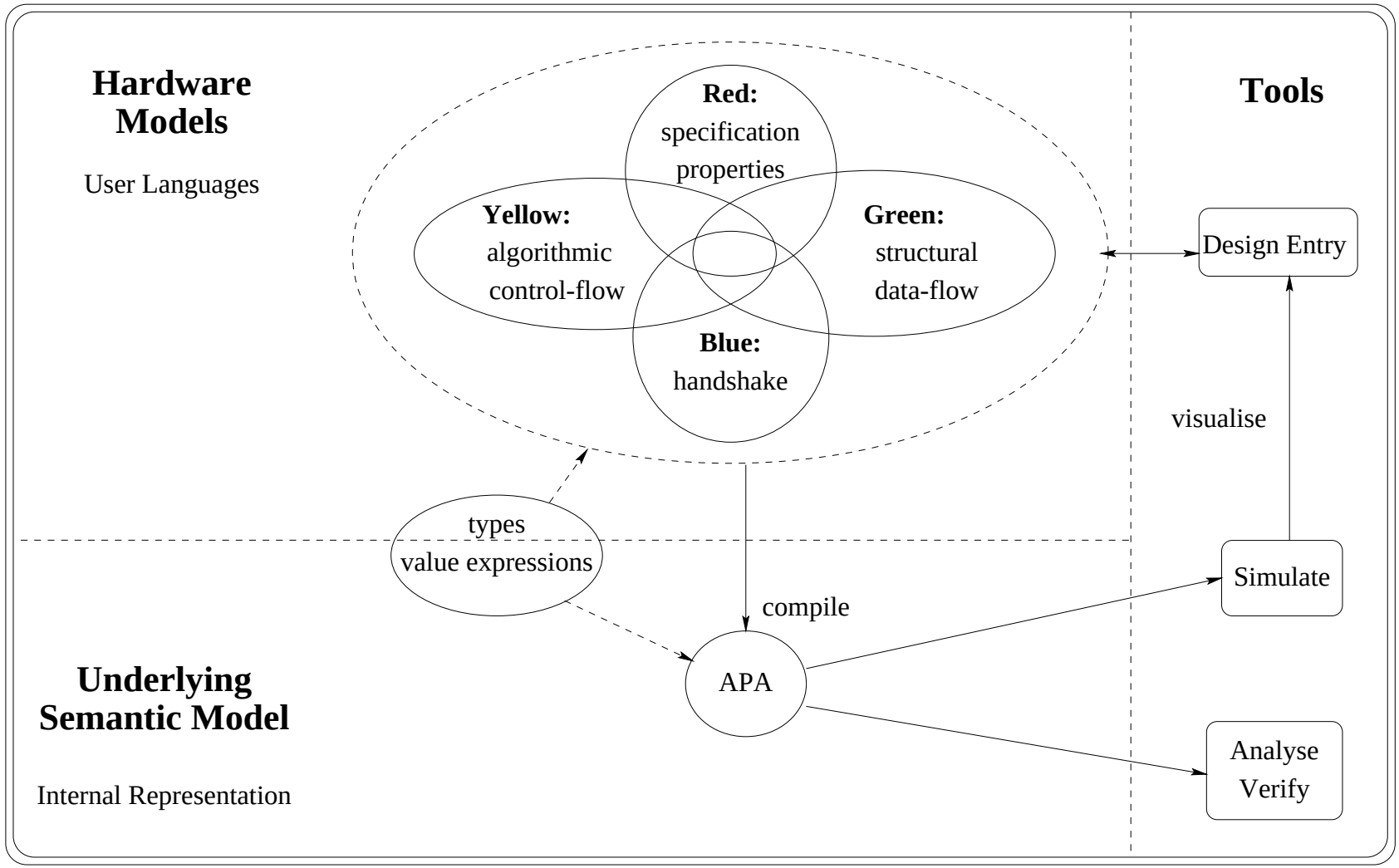
Green Table — ALU:

```
table alu_block (input  aluIFC: aluctrl;
                 input  a,b: val;
                 output mrd: memread;
                 output mwr: memwrite;
                 output writeback: val) = {
    FETCHINC, a,   -  =>  a,    -,      a+1
 or FROMMEM,  a,   b  =>  a+b,  -,      -
 or TOMEM,    a,   b  =>  -,    (a,b),  -

 or ADD,      a,   b  =>  -,    -,      a+b
 or SUB,      a,   b  =>  -,    -,      a-b
 or AND,      a,   b  =>  -,    -,      a/\b
 or CMP,      a,   b  =>  -,    -,      a>b

 or MOV,      a,   -  =>  -,    -,      a
 or NOT,      a,   -  =>  -,    -,      not a
}.
```

- Yellow Decoder: `fetch(); execute(); store()`
- Green sub-network: register bank (textual or schematic)



Formal Semantics



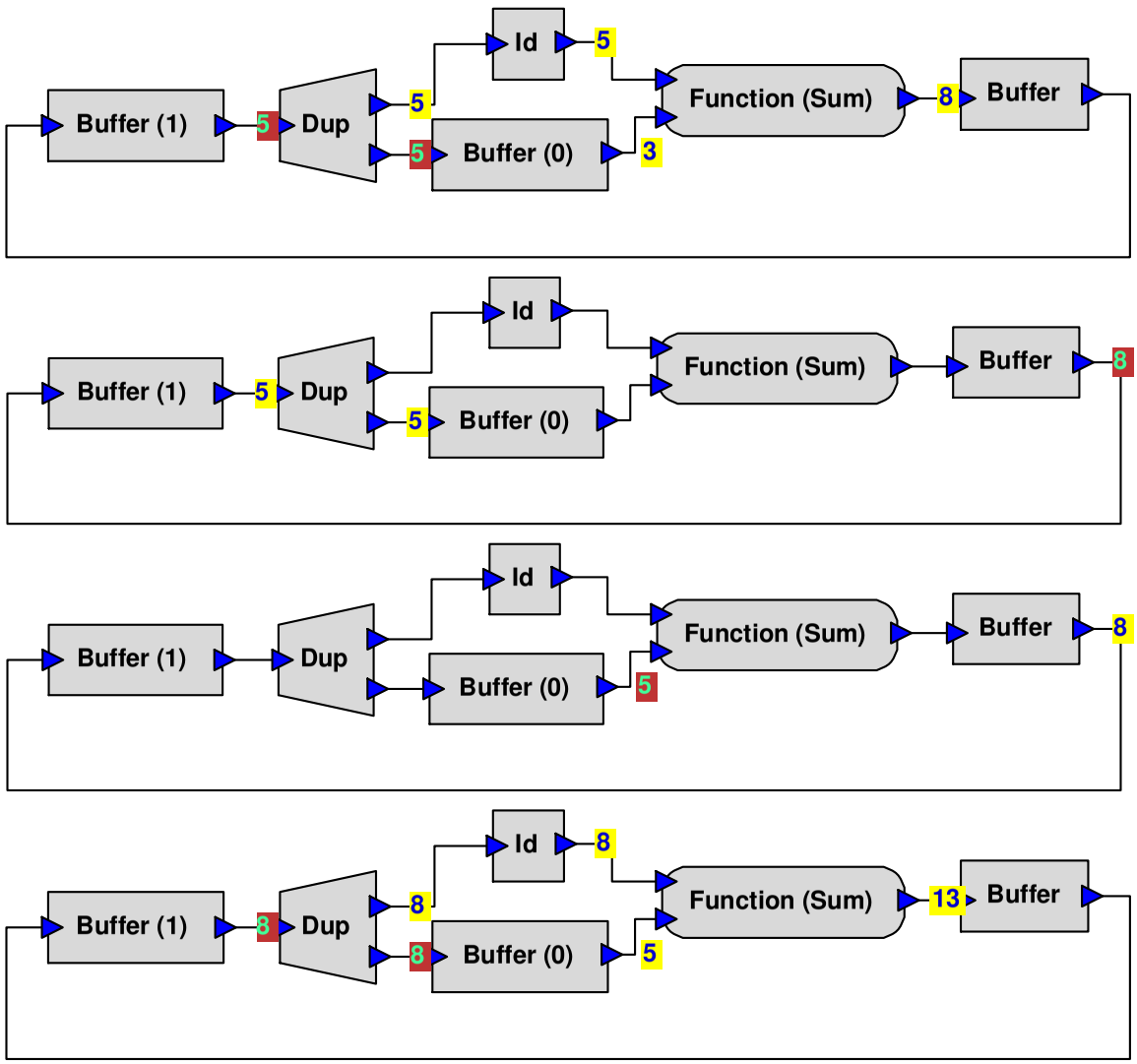
APA

- complex actions
- bundled dataflow blocks as basic constructs
- Ada-like rendezvous communication primitive
- transition rules define APA semantics

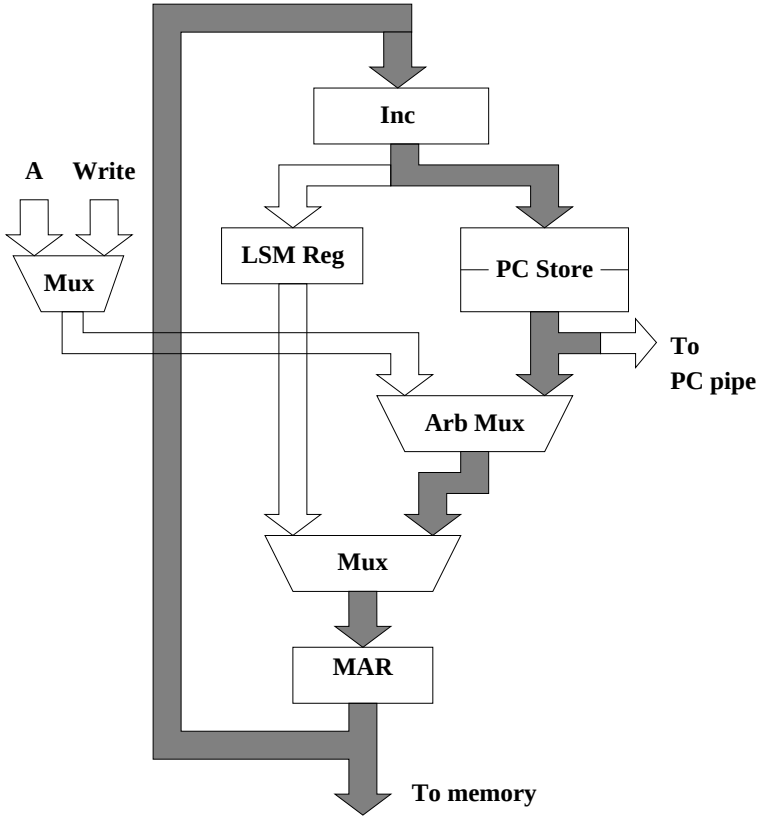
Rainbow sub-languages all map to APA:

- interworking
- semantic consistency

Simulation


Buffer (1)
5
Dup
5
5
Id
5
Buffer (0)
3
Function (Sum)
8
Buffer
Buffer (1)
5
Dup
5
Id
Buffer (0)
Function (Sum)
Buffer
8
Buffer (1)
Dup
Id
Buffer (0)
5
Function (Sum)
Buffer
8
Buffer (1)
8
Dup
8
8
Id
8
Buffer (0)
5
Function (Sum)
13
Buffer

Summary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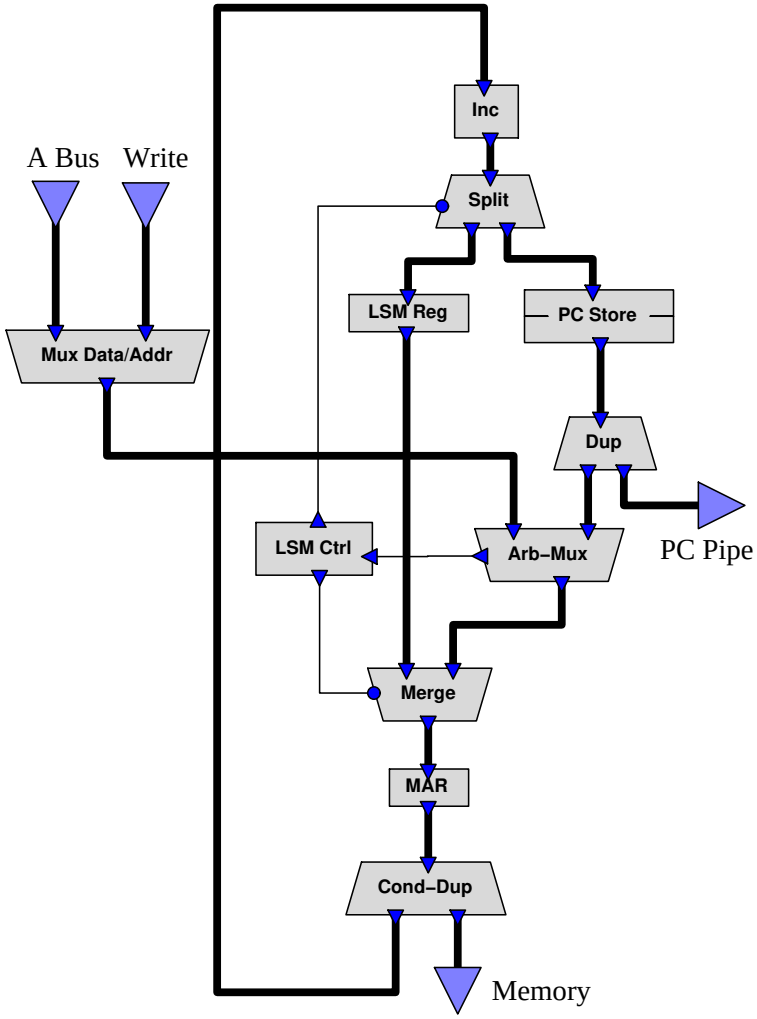
A Bus
Write
Mux Data/Addr
Inc
Split
LSM Reg
PC Store
Dup
LSM Ctrl
Arb–Mux
PC Pipe
Merge
MAR
Cond–Dup
Memory

- micropipeline design methodology
- rainbow Design framework with interworking
- abstract modelling
- application-specific methods
- prototype tool implementation
  - Visual Green editor/simulator
  - Rainbow expression compiler/evaluator
  - embedded into extensible design environment
- formal semantics
- analysis

URL:

`http://www.cs.man.ac.uk/fmethods/projects/AHV-PROJECT/ahv-project.html`