Lecture 17

Realising dataflow programs. Hardware, reconfigurable logic arrays, software systems, general purpose hardware. Implementing recursion and procedures.

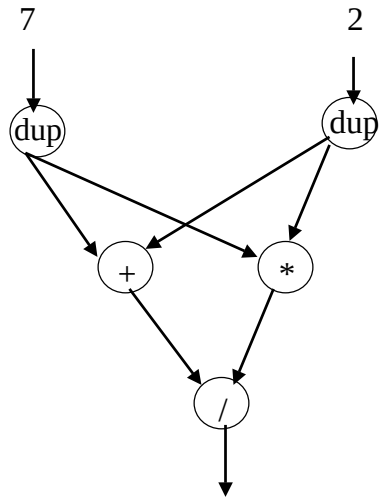
Defining Data-flow

- As previously stated dataflow discards many of the tenets of classical programming.
  - control by program counter
  - memory addresses
  - notion of sequences of operations
- This has profound implications for architecture design, as well as for the development of data-flow programming languages

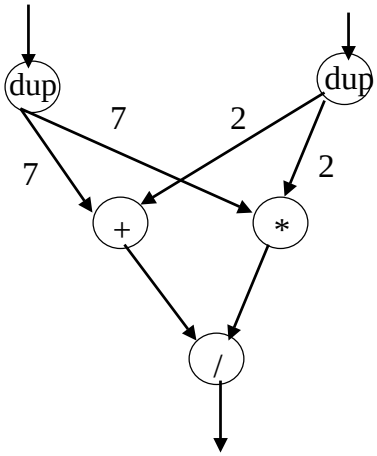
What is a data-flow program?

- In its purest sense a data-flow program is a graph.
  - The nodes of the graph are operations.
  - The arcs describe their relationship to one another.
- Such programs automatically reveal the maximum possible level of operation concurrency, since operations can execute as soon as the data they need is available.

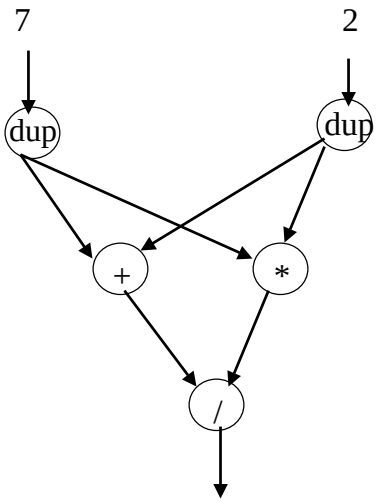
A data-flow program



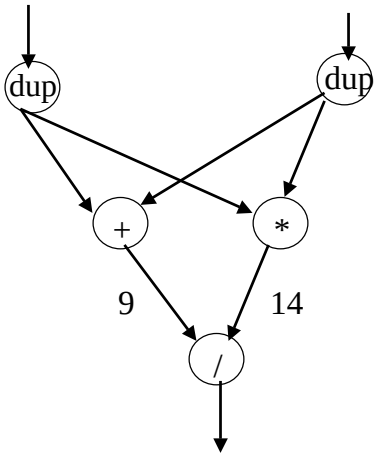
A data-flow program



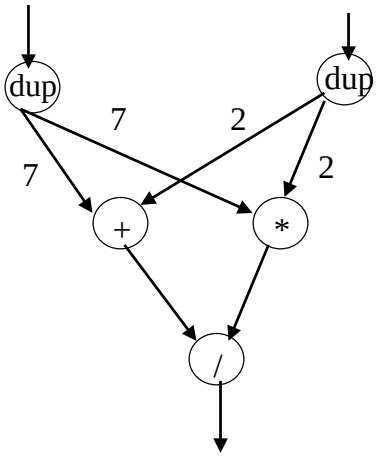
A data-flow program



A data-flow program



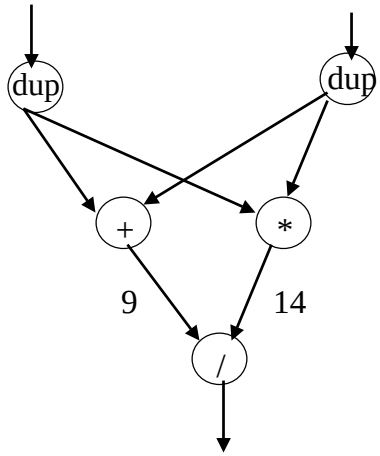
A data-flow program



Data-flow nodes

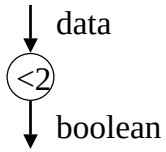
- Operators
  - arithmetic
  - trigonometric functions
  - etc.
- Flow control nodes
  - switch
  - duplicate
  - test
  - join

A data-flow program

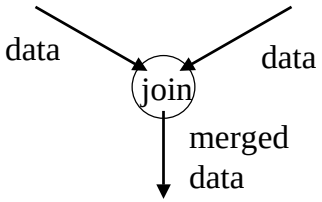


Flow control nodes

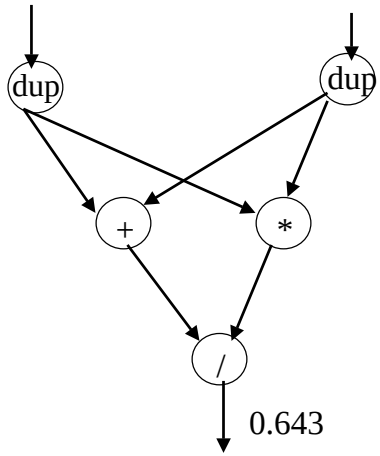
- test



- join



A data-flow program

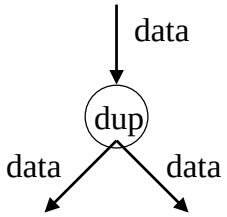


Loops

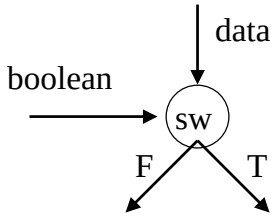
- To implement loops we need to use all the flow control nodes defined in the previous slides.
- Loops are formed by allowing data to feed back through sub-graphs.
- Consequently they are an augmentation of the choice graph.

Flow control nodes

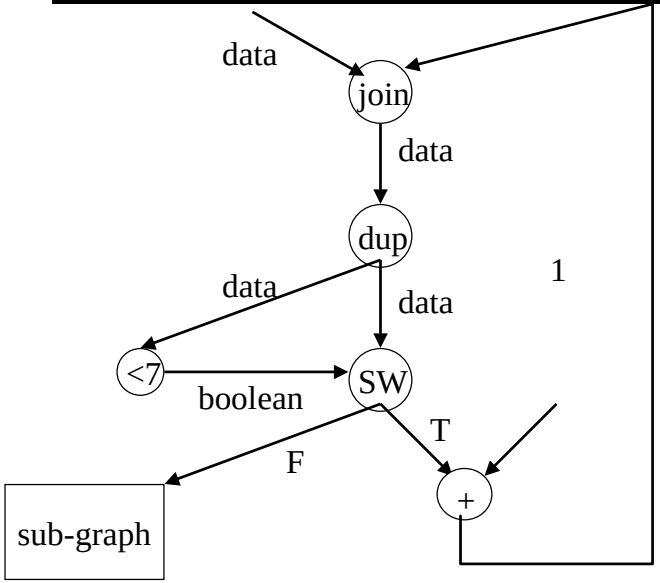
- duplicate



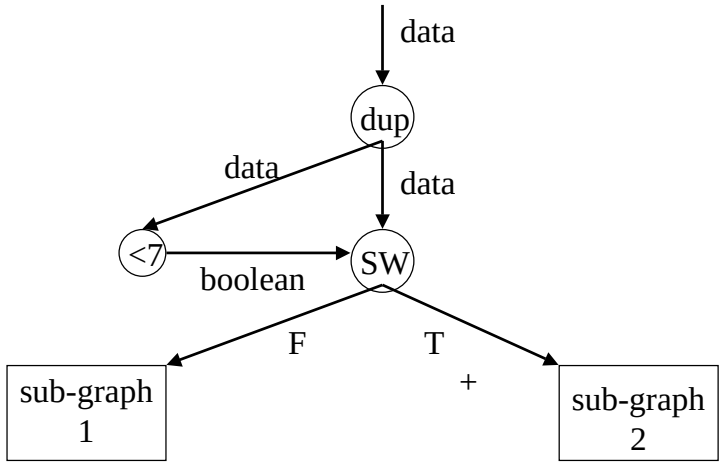
- switch



A loop



Alternation/Choice



Reconfigurable Hardware

- Normally implemented using a variant of programmable gate arrays.
- Advantages:
  - Multiple programs can be implemented.
  - Different sized problems can be solved.
- Disadvantages:
  - Not all operators can be used
  - Connection density
  - No support for recursion and procedures.

Implementing data-flow

- Several choices
  - direct hardware implementation.
  - programmable hardware implementation.
  - runtime reconfigurable hardware.
  - general purpose hardware.

General Purpose Hardware

- Execute any program/graph
- Capable of executing any sized graph
- Able to run multiple programs concurrently
- Supports arbitary depth procedure calls and recursion.

Hardware

- Advantages:
  - Fast,
  - Easily fabricated
- Disadvantages:
  - Solves a fixed size problem
  - Cannot be reprogrammed
  - Cannot support procdures or recursion.

Procedures and Recursion in Data-flow

- Procedures are common sub-graphs.
  - Multiple concurrent invocations?
  - Instantiation on demand?
- What is recursion in a data-flow program?
  - Dynamic replication of a sub-graph.
  - Replication is triggered by data flowing along specified arcs.