

EEE3096S: Embedded Systems II

LECTURE 29:
CPU ARCHITECTURE AND
DATAPATH (PART I)

Presented by:

STANLEY MBEWE



Electrical Engineering
University of Cape Town

OUTLINE OF LECTURE

- Terminology moment: Datapath
- Computer Design Fundamentals

Linked reading, for going deeper into these topics that are more introduced in these lectures:

Chapter 2 of Textbook: D. Patterson and J. Hennessy - Computer Organization and Design - ARM Edition.pdf

Terminology Moment

TEMPORAL AND SPATIAL COMPUTATION

Temporal Computation

The traditional paradigm

Typical of Programmers

Things done over time steps

```
A = input("A= ? ");  
B = input("B=? ");  
C = input("B multiplier ?");  
X = A + B * C  
Y = A - B * C
```

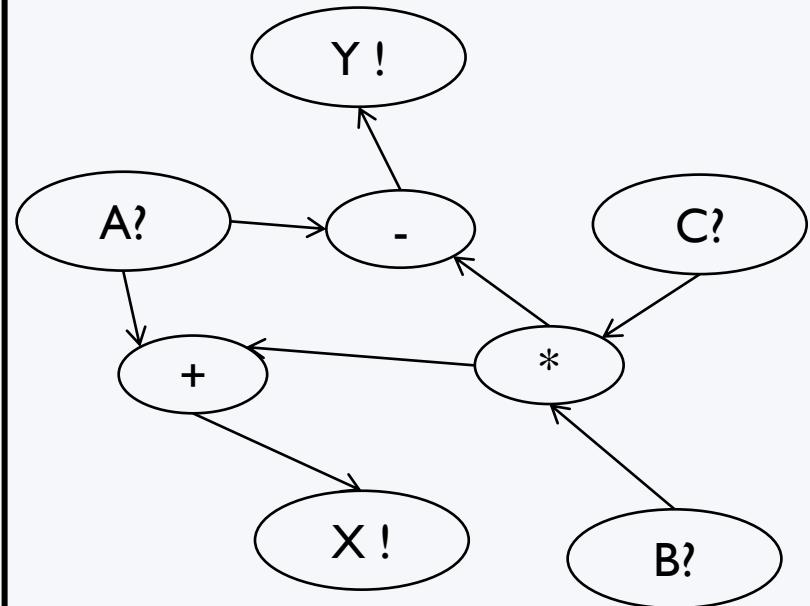
*Which do you think is
easier to make sense of?*

Spatial Computation

Suited to hardware

Possibly more intuitive?

Things related in a space



Can provide a clearer indication of relative dependencies.

Datapath:
An essential concept
For processor (and
Computer) design

DATAPATH: BASIC CONCEPT ... METAPHORICALLY

Can think of a datapath as something like a railway (or underground) transport system).

This is where one has schedules, ways to move people (i.e. 'data'), ways that people are admitted to the network, board the 'path', time it takes to get from one place to the other (transport happening at similar speed).



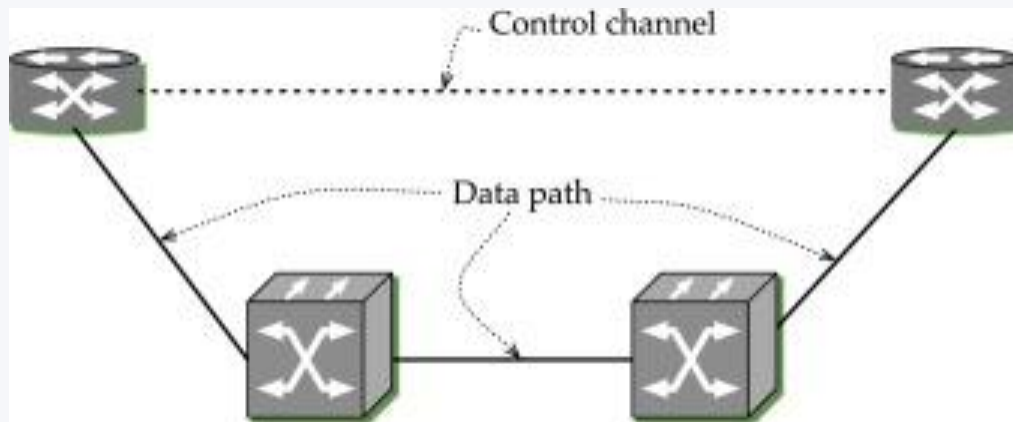
DATAPATH

- Definition: data path or **datapath**
 - This is the **set of functional units** that carry out data processing operations for a computer system.
 - The datapaths, together with a control unit and ALU, makes up the CPU of a computer
 - Larger datapath (or **composite datapaths**) can be created by joining more than one together using (e.g.) multiplexers
- Reconfigurable datapaths *:
 - These are datapaths that can be re-purposed at run-time using a programmable fabric e.g. may allow for more efficient processing and substantial power savings for particular types of application

Computer Design Fundamentals

DATAPATH & CONTROL

- A processor design can be considered as comprising
 - *Datapath*: moving data/signals around; and
 - *Control*: making decisions (e.g. whether or not to do an operation) and doing operations (e.g. adding two registers)



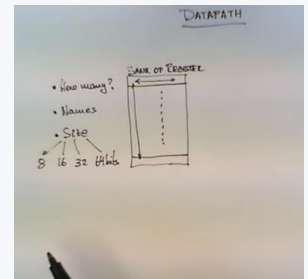
APPROACH TO COMPUTER DESIGN

- The specification of a computer is provided by defining its appearance to the programmer at its lowest level, its Instruction Set Architecture (ISA) level
- From the ISA the computer architecture is developed...
- Computer architecture development essentially involves deciding its datapath and control.
- Is effective approach for also designing a processor/CPU or designing a special-purpose application accelerator or co-processor

BUT WHAT EXACTLY IS THE DATAPATH?

- Datapaths
 - Most generally this refers to the registers, processing units, and interconnections (busses) that are used to process and transfer data in a computer system
- Datapath comprises
 - A set of registers (that store data)
 - Microoperations to perform operations on data stored in the registers
 - Control interfaces (for sequencing and arbitrating operations)

Recommended video: “How a datapath works inside a computer system”. Available at: <https://youtu.be/ibYYqvp9FmU>

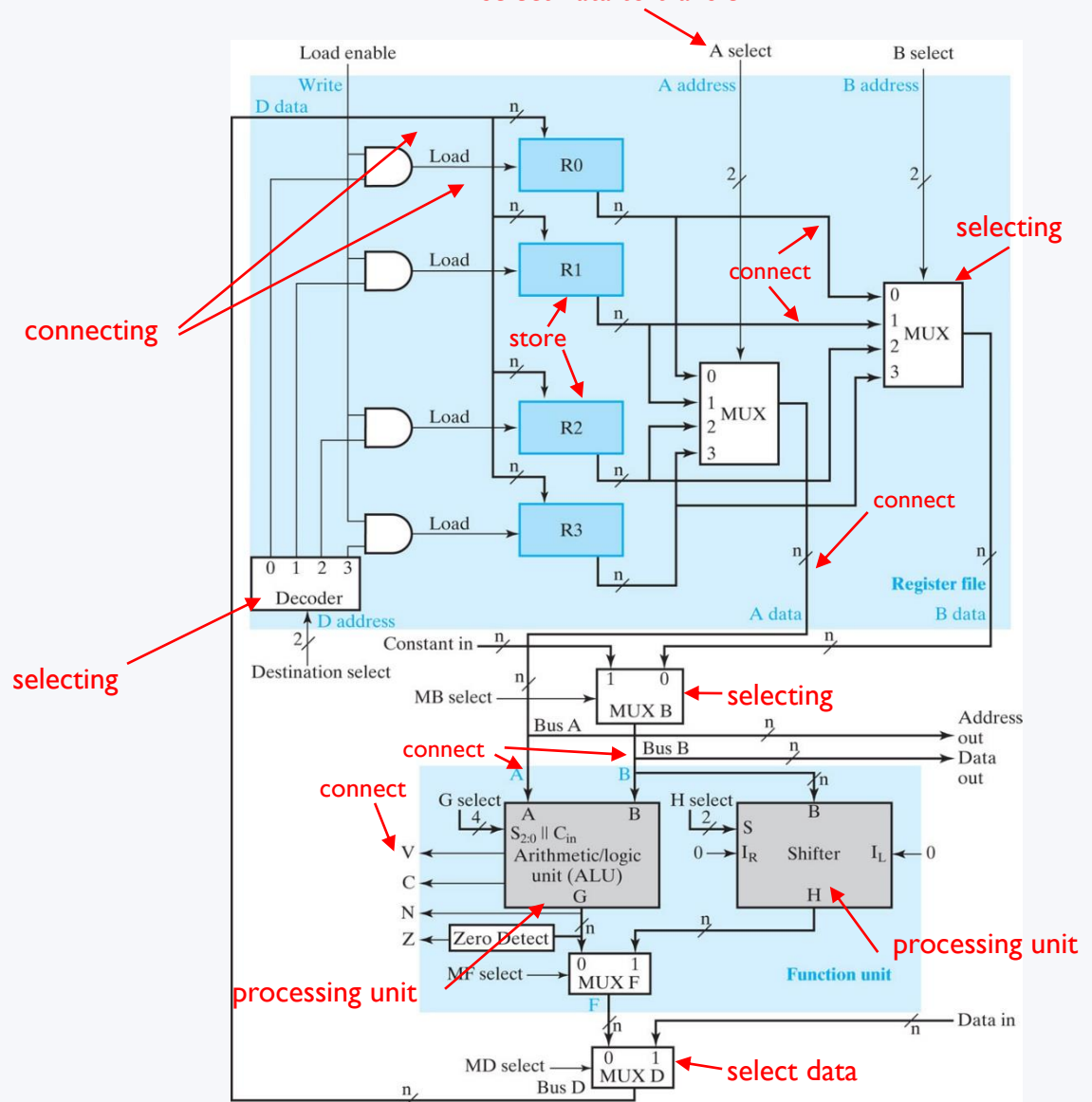


DATAPATH – 1ST PASS

Datapath design is largely about the circuitry to store data and to select and connect data to be transferred between processing units in a processor

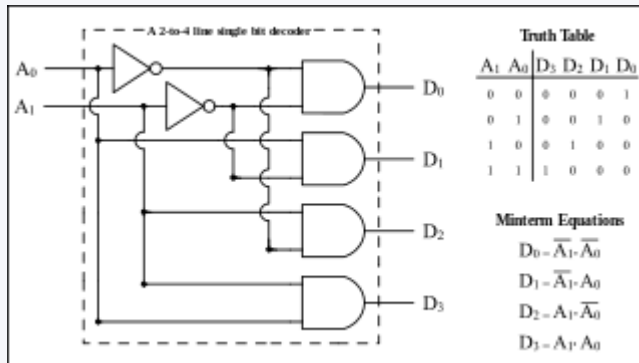
Will briefly explain the parts...

Onwards to....



Example of a Datapath

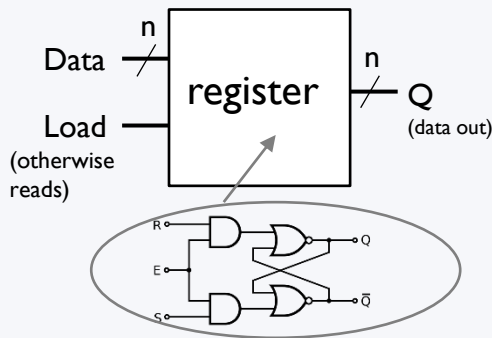
BRIEF REFRESHER – PROCESSOR PIECES



The Decoder

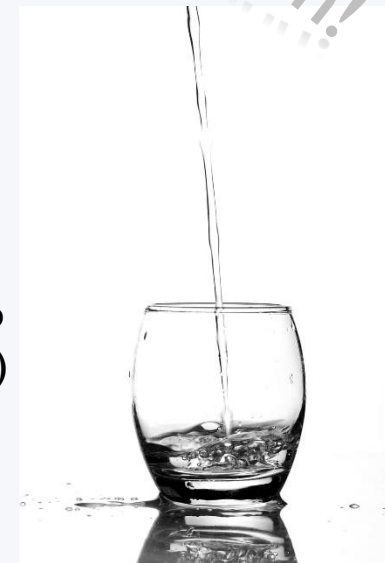
‘Fans out bits’

i.e. converts m-bit input to activating one of 2^m output signals. This is used for decoding an instruction, to chip select one of multiple operations

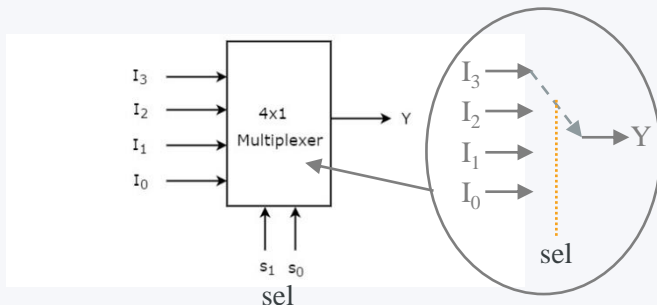


The Register

Stores values. Basically a D-type flip flop that can be enabled(load)/disabled(read)



Ahhhh!



The Multiplexer

m-input sel line to select 1 of 2^m input lines (I) to connect through to the output line (Y)