A Very Simple Computer Datapath (Review)

- temp = a + b (a to left input...)

  ![Diagram of a simple computer datapath with temp = a + b]

- z = temp + c (temp to left input...)

  ![Diagram of a simple computer datapath with z = temp + c]

Connecting Inputs to Outputs

- What we'd like to do is something like the following: (warning — this doesn't work!)

  ![Diagram showing a connection issue where one output connects to multiple inputs]

- Unfortunately, although one output can connect to multiple inputs, multiple outputs cannot connect to one input!

Bus-Based Datapath

- A bus is a signal with multiple inputs (sources) and multiple outputs (sinks)

  ![Diagram of a bus-based datapath]

- We can use a new circuit element, called a tri-state device, to ensure that only one register drives each bus at a time

  ![Diagram of a tri-state device with control inputs and outputs]

Multiplexer-Based Datapath

- A 2-input multiplexer is a circuit element that can select between 2 inputs

  ![Diagram of a 2-input multiplexer with select inputs and outputs]

- Multiplexers can be used at each adder input to select the appropriate value

  ![Diagram of a multiplexer-based datapath with control and select inputs]

<table>
<thead>
<tr>
<th>select</th>
<th>out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>in0</td>
</tr>
<tr>
<td>1</td>
<td>in1</td>
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</tbody>
</table>
Building a Multiplexer

- A 2-input multiplexer is a circuit element that can select between 2 inputs

<table>
<thead>
<tr>
<th>select</th>
<th>in1</th>
<th>in0</th>
<th>out</th>
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<tbody>
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<td>1</td>
<td>1</td>
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<td>1</td>
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</tbody>
</table>

- Multiplexers can be built from simple gates...

- The inverse of a multiplexer — the demultiplexer — can also be useful at times

Building a Bigger Multiplexer

- A 4-input multiplexer can select one of four inputs as shown below.

<table>
<thead>
<tr>
<th>s1</th>
<th>s0</th>
<th>out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>in0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>in1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>in2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>in3</td>
</tr>
</tbody>
</table>

- The 4-input multiplexer can be built from simple gates, or from 2-input multiplexers

Controller

- A complicated digital circuit (such as a processor) typically consists of two main parts:
  - A datapath to perform the necessary functionality, consisting of registers, ALUs, multiplexers, buses, etc.
  - A controller to sequence the design and control the various registers and ALUs in the datapath

- The control logic has to decode the bits in the state register to decide what signals to activate to control the datapath

Decoding the State Register

- The state register might have bits to specify that:
  - Register temp should be loaded
    - Register a should be loaded
    - Same for other registers...
  - The multiplexer at the adder’s left input should select the value from register temp
    - The multiplexer at the adder’s left input should select the value from register a
    - Same for other multiplexer...
  - If the adder were a more general ALU, that it should perform an addition operation when executing our two example instructions
A decoder is a device to convert a set of inputs to a set of outputs according to a specific set of rules.

This decoder could be implemented with a 2-level and-or (or nand) circuit for each output.

Homework #2 — Due 9/28/98 (Part 2)

3. The register given on slide 10 of Lecture 08 is simpler than the register given on page 58 of the text. Explain how the two differ.

4. Show how an 8-input multiplexer (with inputs labeled i7 (msb) to i0 (lsb) can be constructed from 4-input multiplexers. Assume the lsb of the select line is labeled s0.