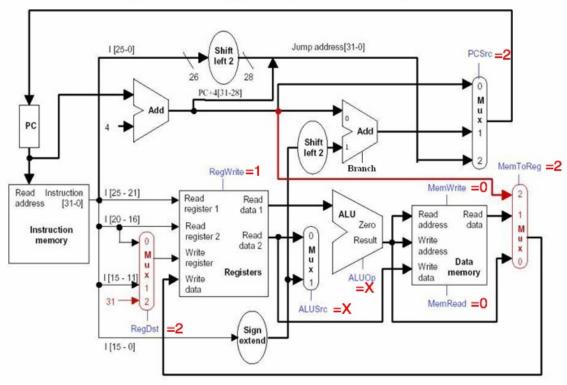
## 1 Single-cycle datapath modifications

Implementing the jal requires a number of datapath additions. First a 26-bit immediate needs to be extracted and shifted 2 bits to the left to create a 28-bit number. To create a 32-bit PC, the top 4 bits of the current PC are merged in. The PCSrc multiplexor needs to be extended with a third input.

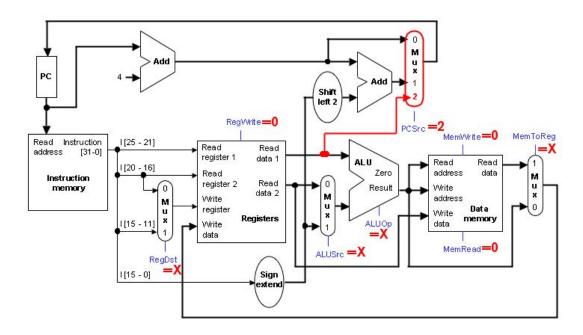
Second, the return address (PC+4) needs to be routed to the Write data port of the register file. This can be done by extending the MemToReg mux.

Finally, the return address needs to be written to register 31, but there is no guarantee that the rs, rt, or rd fields will hold the value 31, so we have to have a "hard-coded" 31 and extend the RegDst mux to permit its selection.

## jal - single-cycle datapath



1. **Implementing jr:** Expand the PcSrc mux to take a third input (thus, it becomes a two-bit control signal). The third input will be from the Read data 1 line – see the diagram:



2. **Implementing lui:** Insert a "Shift Left by 16" unit which takes the 16-bit immediate as its input (it doesn't matter whether this is before or after the "Sign Extend" unit). The resulting 32-bit signal is routed to the 3rd input of an extended MemToReg multiplexor.

