Register Direct

- Similar to direct addressing. The only difference is that the address field refers to a register that contains the operand.
- To clarify, if the content of R is 5, then register R5 is the intended address, and the operand value is contained in R5.
- Typically, R is 3 to 5 bits, so that a total of form 8 to 32 general-purpose registers can be referenced.
- **Advantages** compared with Direct:
  - *small address field in the instruction*
  - *no memory reference* (memory reference are time-consuming)
- **Disadvantages** compared with Direct: *limited storage space* (limited number of registers compared with main memory locations)

Register Indirect

- Analogous to indirect addressing. The only difference is that the address field refers to a register. The value stored in the register is the actual address of the operand in main memory.
- **Advantage** compared with Indirect:
  - *one less memory reference, and smaller address field*
- **Disadvantage** compared with Indirect:
  - limited storage space
Example:

Given the following memory values and register values, assume the LOAD instruction loads the value at a specific address to the accumulator based on the addressing mode. What values do the following instructions load into the accumulator?

<table>
<thead>
<tr>
<th>Address</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>101</td>
</tr>
<tr>
<td>C</td>
<td>110</td>
</tr>
<tr>
<td>D</td>
<td>111</td>
</tr>
</tbody>
</table>

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<tr>
<td>110</td>
<td>103</td>
</tr>
<tr>
<td>111</td>
<td>104</td>
</tr>
</tbody>
</table>

LOAD Direct 100 [101]
LOAD Indirect 100 [102]
LOAD RegisterDirect C [110]
LOAD RegisterIndirect C [103]
Displacement

- **Combines** the capabilities of direct addressing and register indirect addressing.
- Instructions have **two address fields**, at least one of which (A) is explicit. The other address field (R) can be an implicit reference based on opcode, or can explicitly refer to a register whose contents are added to A to produce the actual address.
- **Advantage: flexibility**
- **Disadvantage: complexity**

**Relative addressing**
- The R field refers to the PC, which is implicitly in the instruction.
- Typically the explicit address field is treated as 2’s complement
- The actual address the operation needs is a displacement relative to the PC’s value that is considered current execution point in a program.
- The actual address is PC’s value + explicit address field value.
- Generally used by control flow instructions

**Indexed addressing**
- The A field refers a main memory address, and the register referred by the R field, usually is the index register, contains a positive displacement from that address
- The actual address is the address in A field + the value in the index register
- Used to access an array whose elements are in successive memory locations. By incrementing or decrementing index register value, different element of the array can be accessed.
- Index register is a general register. It is initialized to 0. After each operation, the index register is incremented by 1.