Addressing Modes (cont.)

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 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 or decremented by 1.

**Register base-indexed addressing**
- Two address fields, A and R, both refer to the registers, which usually are the index register and the base register.
- The actual address is the value in the base register + the value in the index register

**Register base-scaled indexed addressing**
- Three address fields, two refer to the registers, one is the scale
- The actual address is the value in the base register + (the value in the index register x scale)

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>GPRs</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>110</td>
</tr>
<tr>
<td>D</td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Main Memory</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>101</td>
</tr>
<tr>
<td>101</td>
<td>102</td>
</tr>
<tr>
<td>110</td>
<td>103</td>
</tr>
<tr>
<td>111</td>
<td>104</td>
</tr>
</tbody>
</table>
LOAD RegisterDirect C  [110]
LOAD RegisterIndirect C  [103]
LOAD Register Base-Indexed A, D [104]  # A is base reg. and D is index reg.
LOAD Register Base-Scaled Indexed A, B, 2 [103]  # A is base reg. and B is index reg.