

- 4.15 We can add three 8-bit numbers by chaining one 8-bit carry-ripple adder to the output of another 8-bit carry-ripple adder. Assuming every gate has a delay of 1 time-unit, compute the longest delay of this three 8-bit number adder. Hint: you may have to look carefully inside the carry-ripple adders, even inside the full-adders, to correctly compute the longest delay (*Component use problem*).

An 8-bit carry-ripple adder features 8 full-adders. Internally, a full adder's co output is valid after 2 gate delays, and a full adder's s output is valid after 1 gate delay. Thus, each 8-bit carry-ripple adder requires  $8 \text{ FAs} * 2 \text{ gate delays/FA} = 16 \text{ gate delays}$ . With 3 8-bit carry-ripple adders chained together, the longest delay of adding three 8-bit numbers is  $16 * 3 = 48 \text{ time units}$ .