

# Carry-Select Adder

# Faster Adders

The propagation delay of a ripple-carry adder grows linearly with the size of the inputs

$$N T_{FA}$$

It seems impossible to do better – after all, the carry *must* propagate all the way through the adder

Recall the “magic” of hardware: anything without dependencies happens in parallel

# Carry-Select Adder

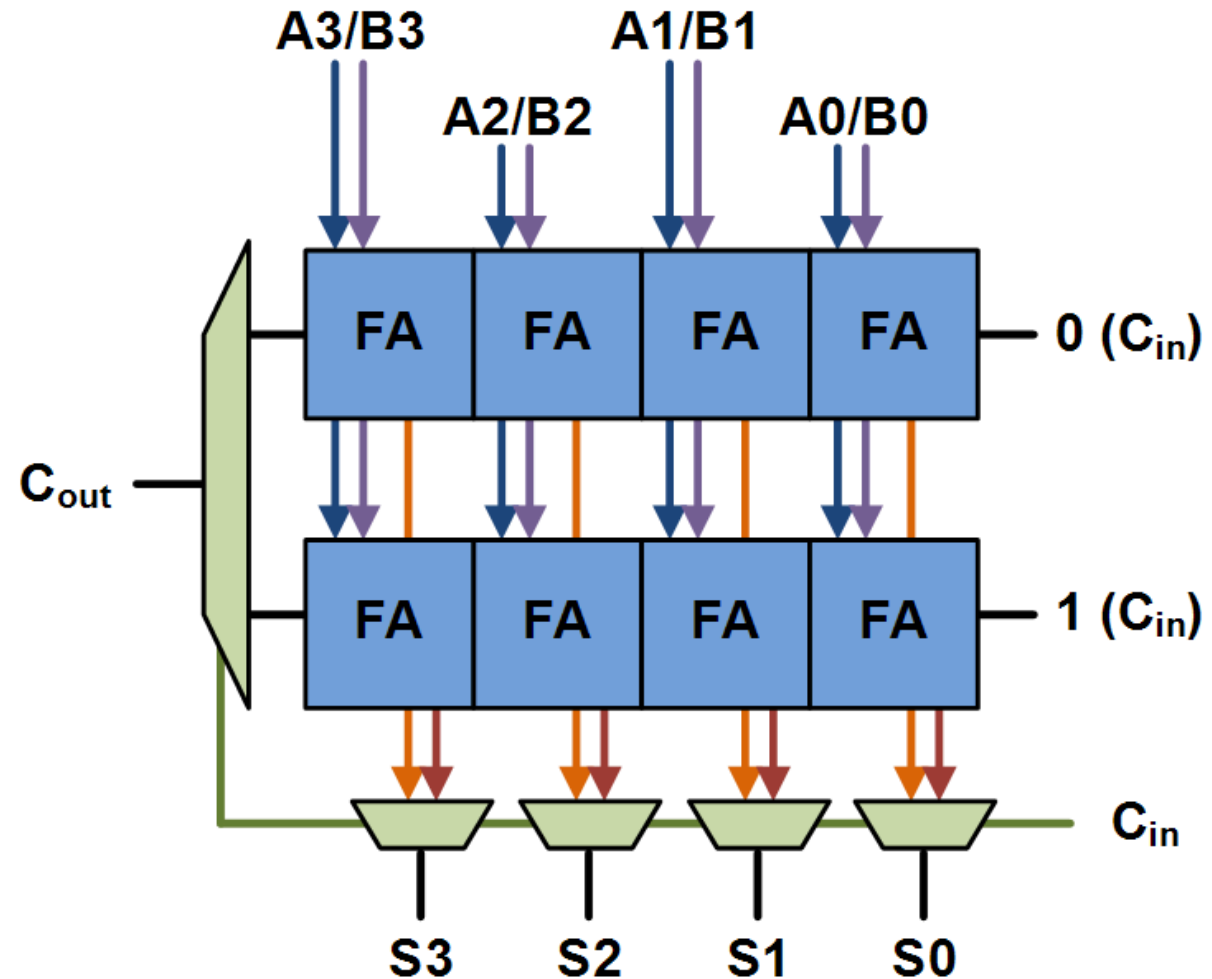
Must know whether carry-in is 0 or 1 before computing sum and carry-out of later adders

Gist: precompute answers for *both* possible carry-ins, then choose the answer matching the actual carry in

# Carry Select Adder

Use multiplexers to combine two Ripple Carry Adders.

Double the computation, but also potentially faster.

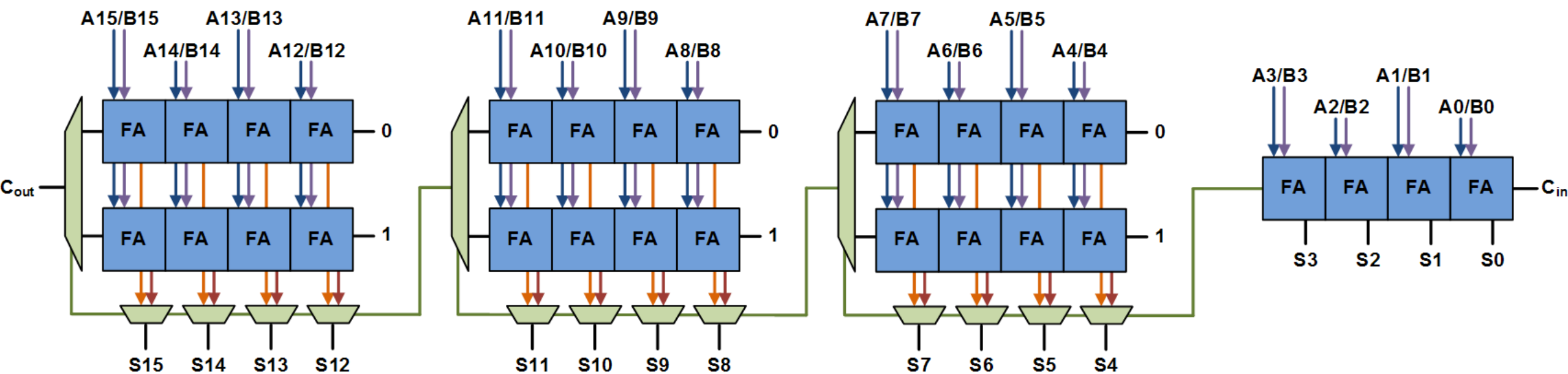


# Splitting into blocks

Great! So, what have we gained so far?

Nothing. In fact, that 4-bit adder would be slower than a 4-bit ripple-carry adder

Must split larger adder (we will use 16-bits as an example) into smaller blocks to take advantage



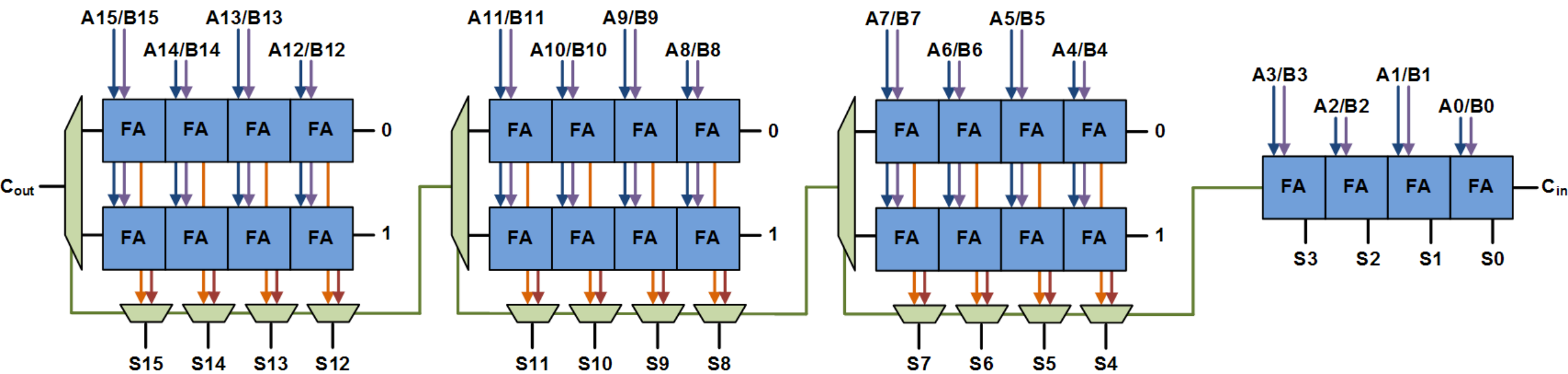
# Some simplifications

To make analyzing the time easier, we're going to make a few simplifications

First, we are going to count time in multiples of full adders ( $T_{FA}$ ) rather than gates

We know from previous lectures that time for two full adders is less than  $2T_{FA}$ , but we are more interested in asymptotic differences in time

Second, we will assume time for a multiplexor ( $T_{mux}$ ) is about the same as time for a full adder





# Timing of Carry-Select Adder

For 16-bit adder with 4-bit blocks:

$$T_{CSA} = 4T_{FA} + 3T_{MUX}$$

which is approximately  $7T_{FA}$

Compared to  $16T_{FA}$  for a ripple-carry adder, this is a big improvement

# Downside of Carry-Select Adder

Speeding up the computation requires doing work in parallel

That, in turn, means additional hardware is necessary compared to ripple-carry adder

Adding hardware leads to increased cost, increased space taken up, and increased heat, all of which are downsides

Adders are fundamental to performance of computers, so tradeoff is worth it in this case

# Credit

Images taken from “Carry-select adder” article on Wikipedia.  
Retrieved Feb. 3, 2021. Images in public domain.