CS 130 : Computer Systems - V

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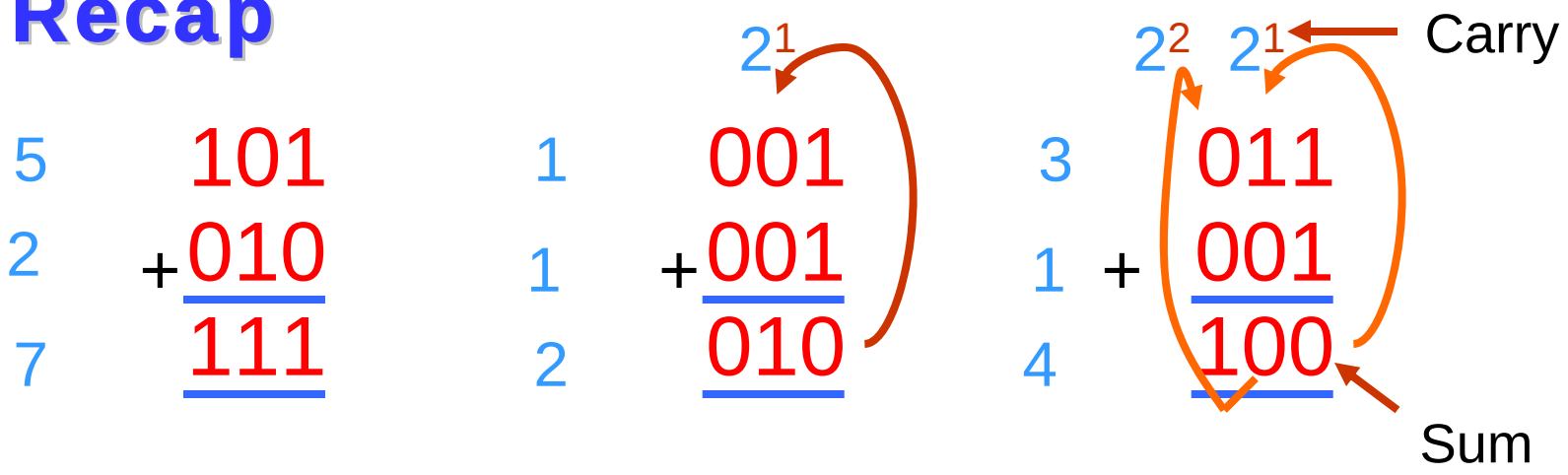
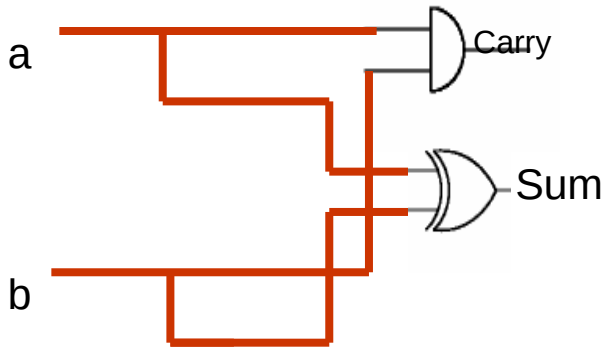
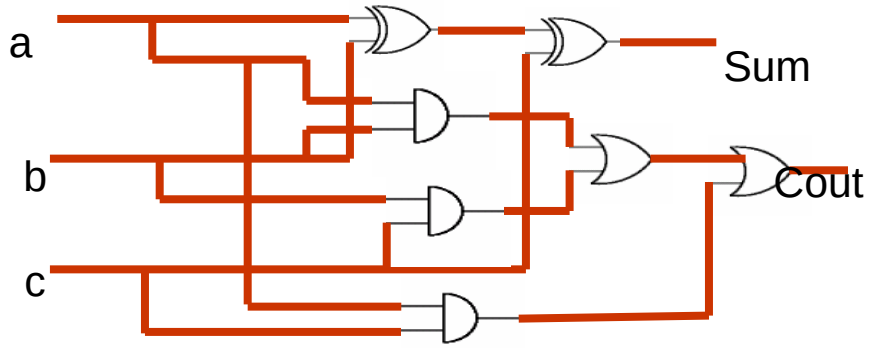
Recap



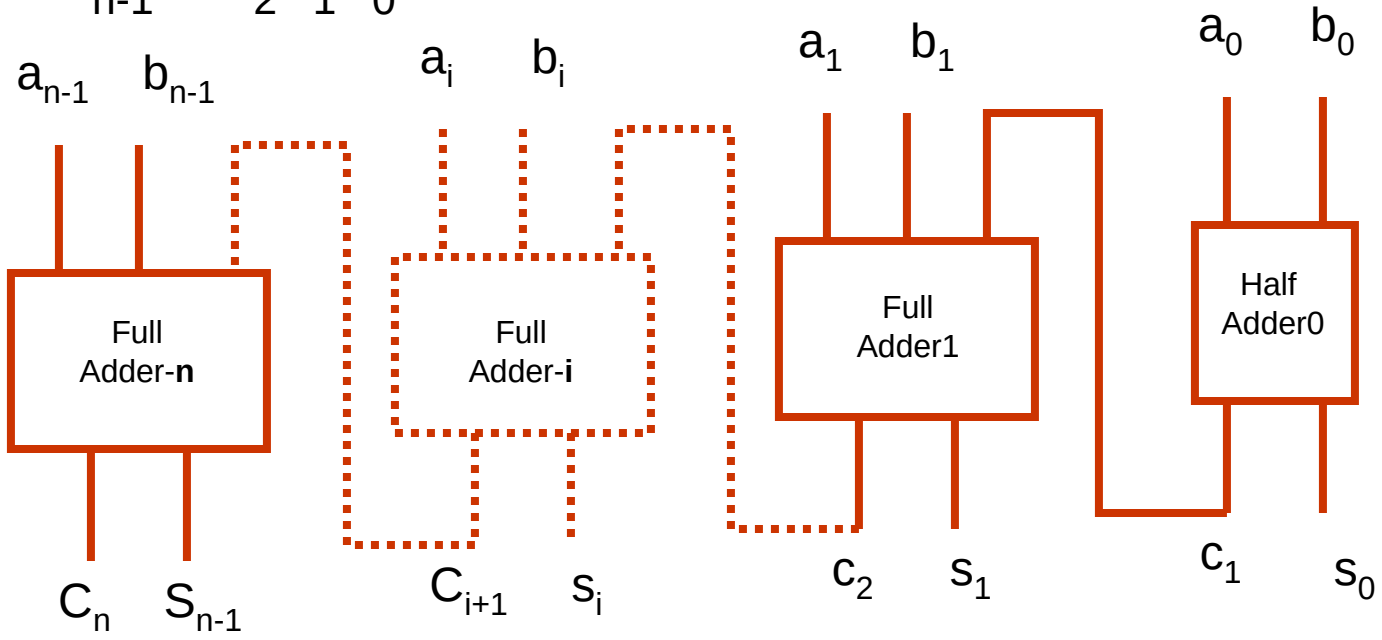
- Carry := A AND B
- Sum := A XOR B





Multi-Bit Adder - Recap

- Let A = $a_{n-1}\ldots a_2 a_1 a_0$
- Let B = $b_{n-1}\ldots b_2 b_1 b_0$

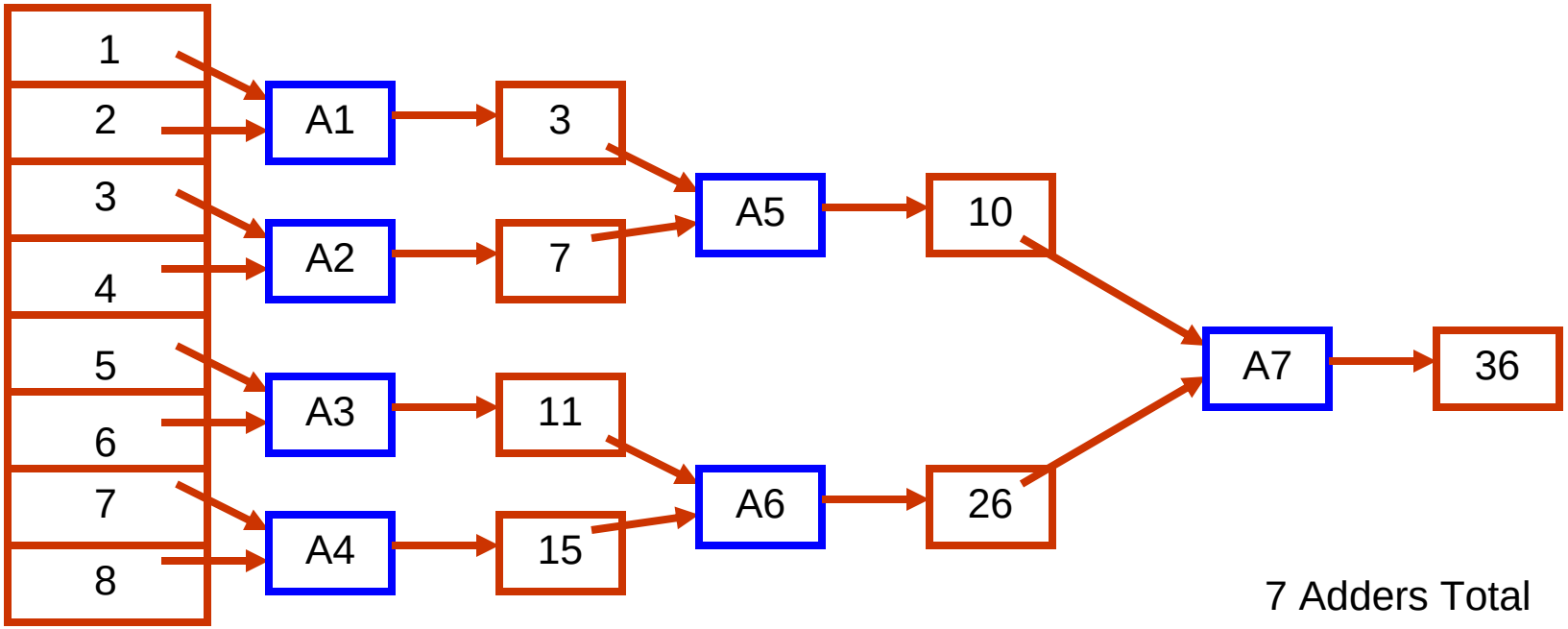


About N-Bit Adder

- Multiple adder units cascade
- Each unit increments data size by 1 bit
- Scalable
  - Can be done for any *n*.
- Simple easy procedure to repeat. Very regular in structure
  - Can be automated easily
  - Can be verified easily

Let's Add *m* Numbers

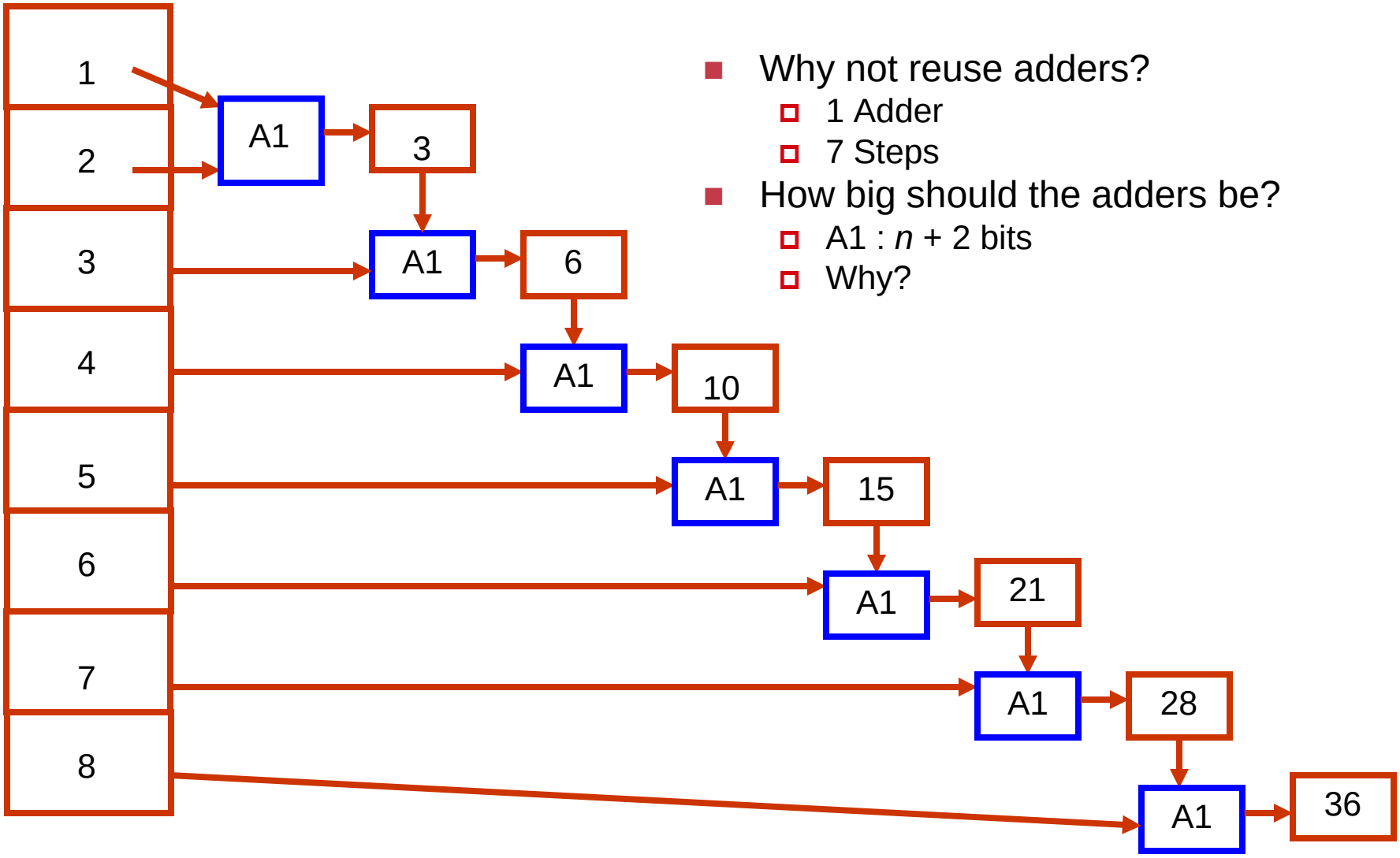
- Numbers are n-bits each



Analysis

- How big should the adders be?
  - A1 : n bits
  - A2 : n bits
  - A3 and A4 : n bits
  - A5 and A6 : $n + 1$ bits;
    - In general, we don't know whether operands are big or not
  - A7 : $n + 2$ bits
  - How many full adders and half-adders?
- How many steps are needed to finish the operation?
  - A1, A2, A3 and A4 need not wait for any one
  - A5 and A6 should wait for (A1,A2) and (A3,A4) respectively
  - A7 must wait for A5 and A6
  - Three steps
- Summary : Three Steps, Seven Adders

Can we cut down on adders?

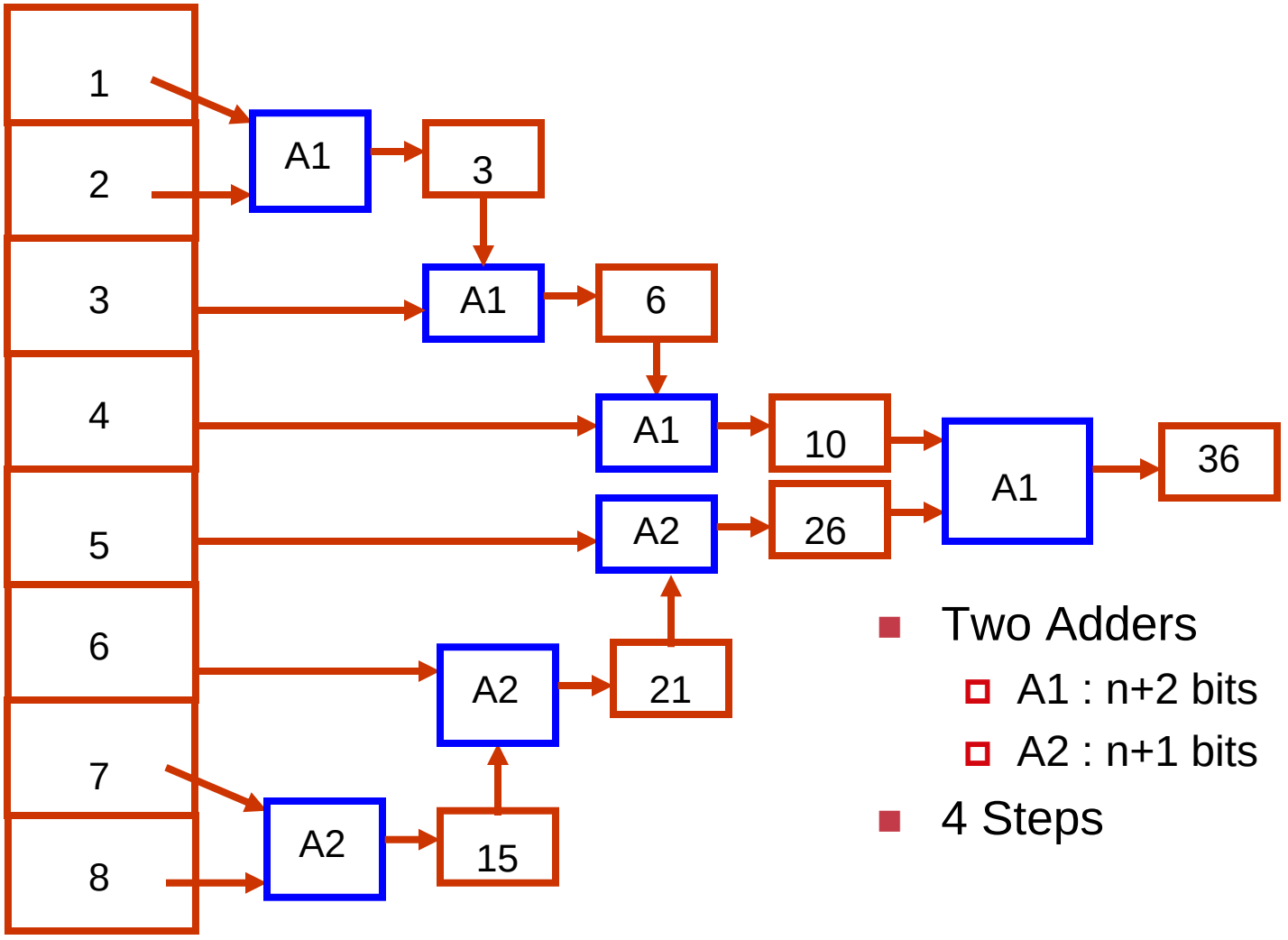


- Why not reuse adders?
  - 1 Adder
  - 7 Steps
- How big should the adders be?
  - A1 : *n* + 2 bits
  - Why?

Sequential and Parallel

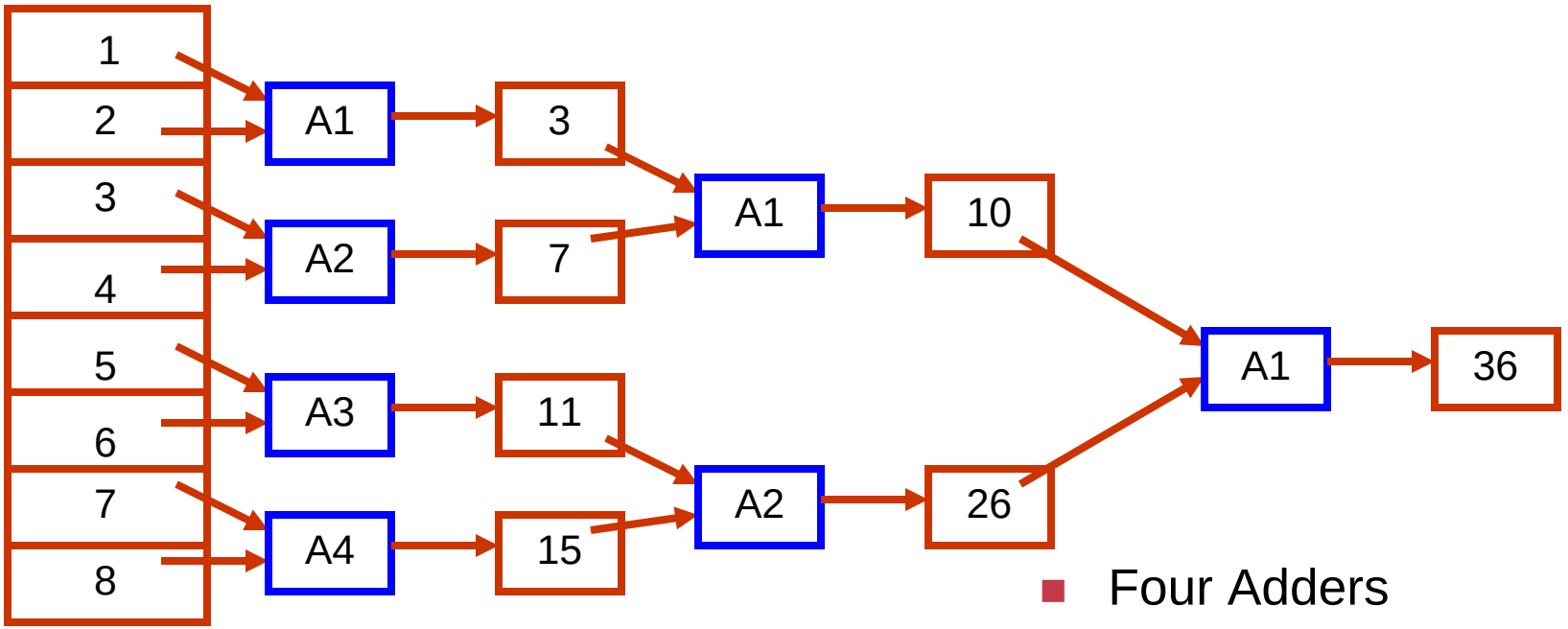
- Sequential
  - One operation at a time
  - Less resources
  - More steps
- Parallel
  - Many operations at the same time
  - More resources
  - Less steps
- Are there sweet spots in between?
  - Yes!
  - Partly sequential, partly parallel

Example (1)



- Two Adders
  - A1 : n+2 bits
  - A2 : n+1 bits
- 4 Steps

Example (2)



- Four Adders
  - A1 : n+2 bits
  - A2 : n+1 bits
  - A3 and A4 : n bits
- 3 Steps

Trade-offs

- Life is all about trade-offs ☺
- Adders occupy area
  - Assume unit area
  - Every adder used takes 1 unit of area
- Adders have delays
  - Assume unit delay
  - Every step takes 1 unit of delay
- What we did here is called the area-delay tradeoff analysis

Which Adder Scheme is Better?

- Define better ☺
- In terms of area
  - Sequential
    - But slow
- In terms of delay
  - Parallel
    - But a lot of resources
- What about area delay product?
  - Combines area and delay
  - Sequential : 7
  - Parallel : 21
  - Combination(1) : 8
  - Combination (2) : 12
  - Is Sequential better?
    - When does it stop to be better?

Comparison Metrics

Plane	DC to Paris	Speed	Passengers	Passengers/ Hr
Boeing 747	6.5 hours	610 mph	470	72.3
Concorde	3 hours	1350 mph	132	44

- Which is faster?
  - Concorde
- But is it better?
  - For speed : yes
  - Passengers carried per hour : No

Be Warned

- Comparison metrics should be chosen carefully
- Sometimes there is no agreement among engineers
- As an amateur engineer, how do you decide?
- Ask questions :
  - What is the design goal?
  - What are the design constraints?
  - What are the costs involved?
  - Are there established practices?