EECS 151 Disc 10

Rahul Kumar (session 1)
Yukio Miyasaka (session 2)

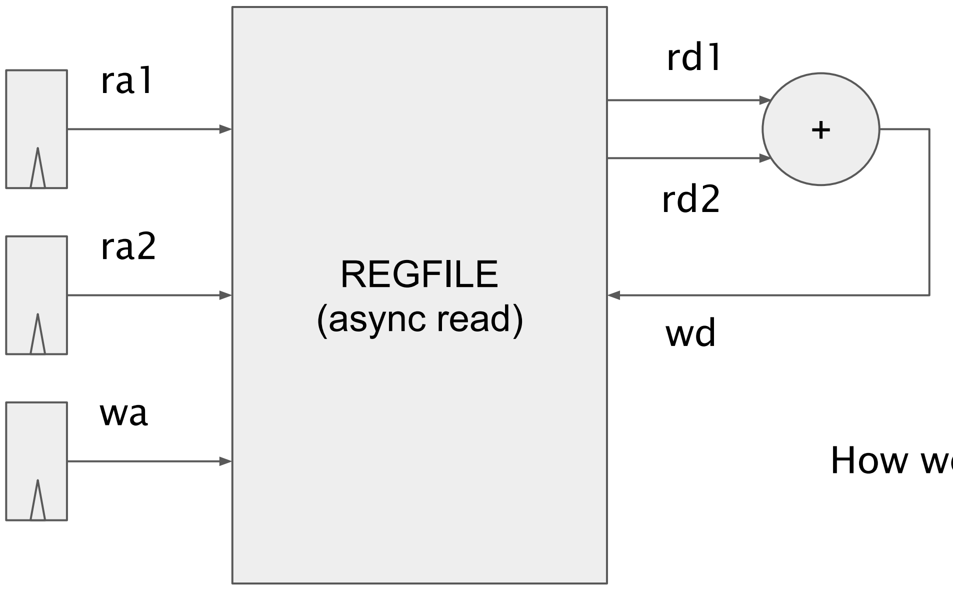
Berkeley
UNIVERSITY OF CALIFORNIA

Contents

- Pipelining
- Power

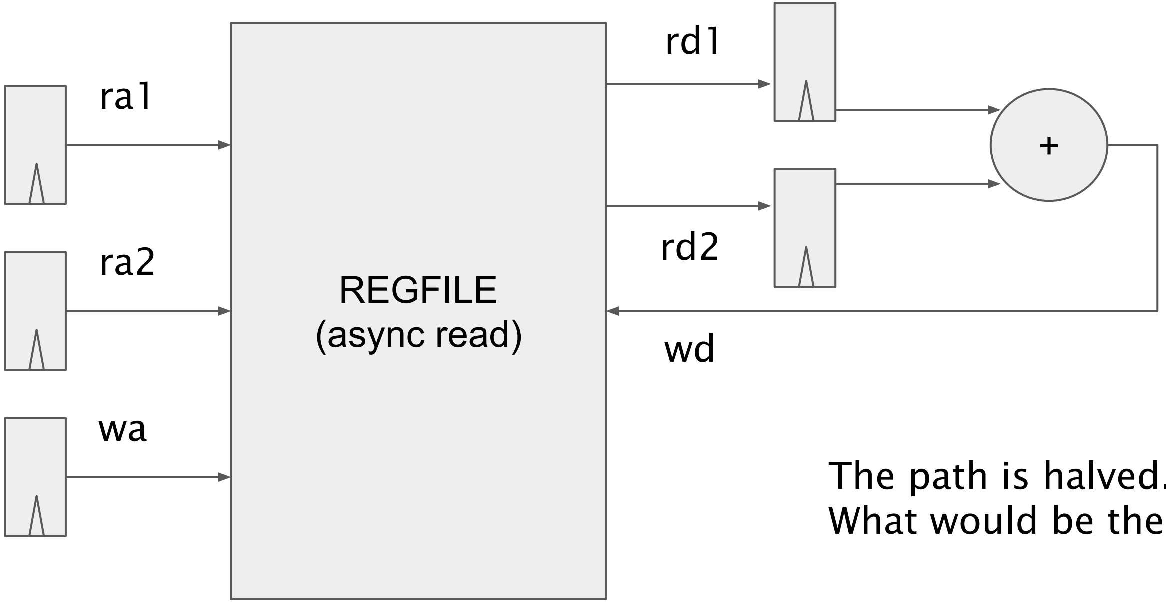
Berkeley
UNIVERSITY OF CALIFORNIA

Pipelining



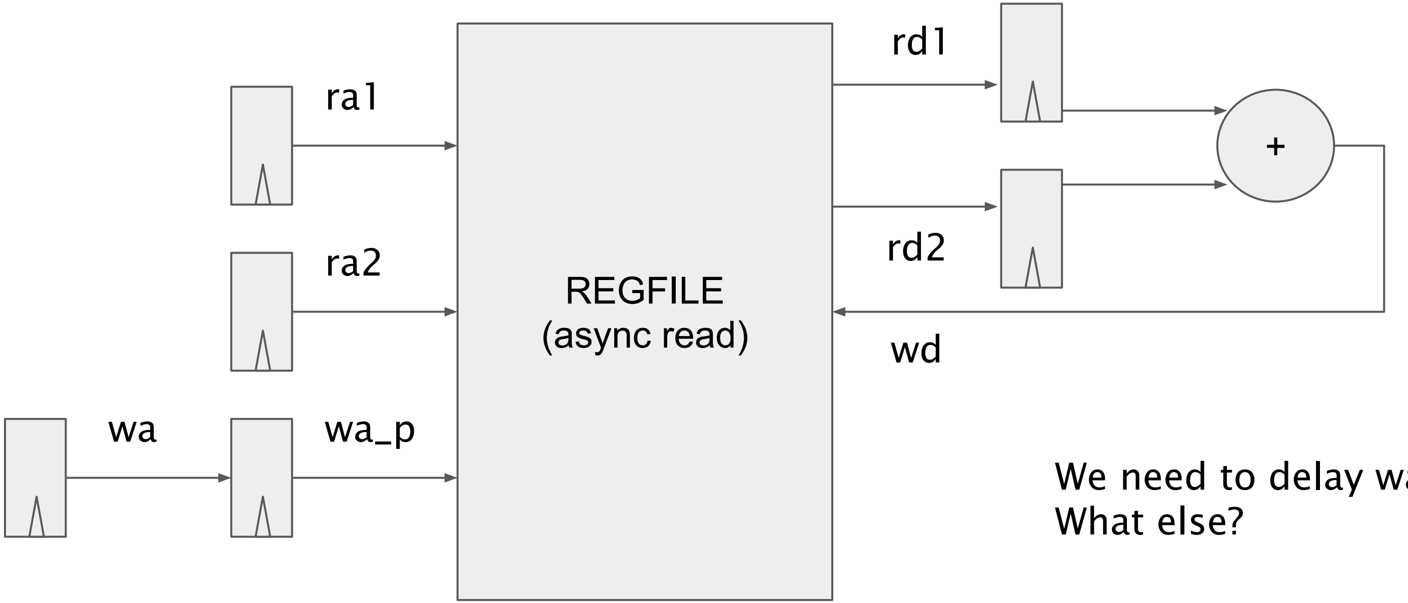
How would you pipeline?

Pipelining



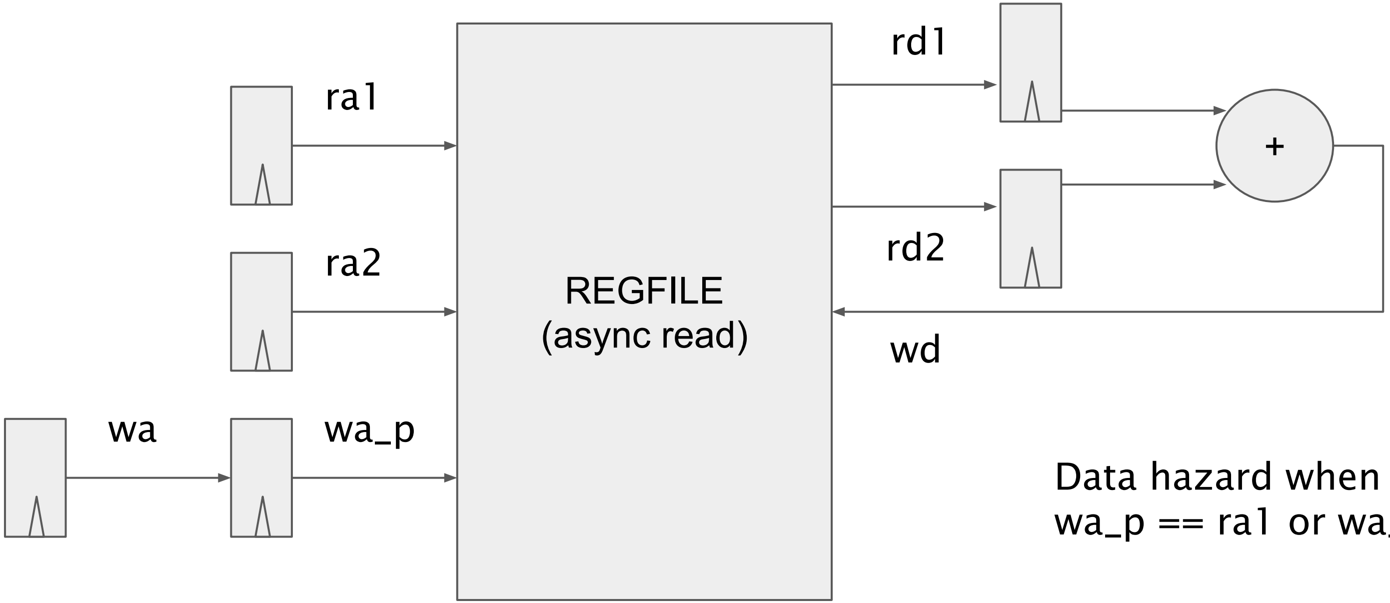
The path is halved.
What would be the issue?

Pipelining



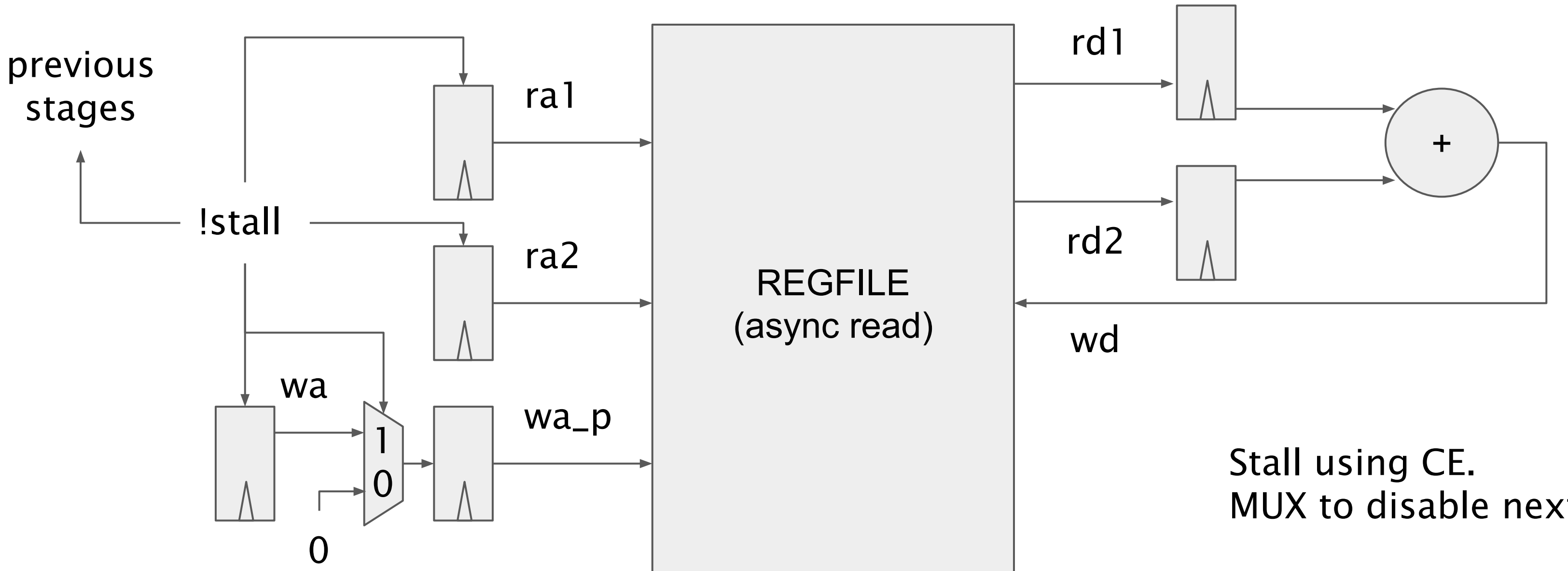
We need to delay wa.
What else?

Data Hazard



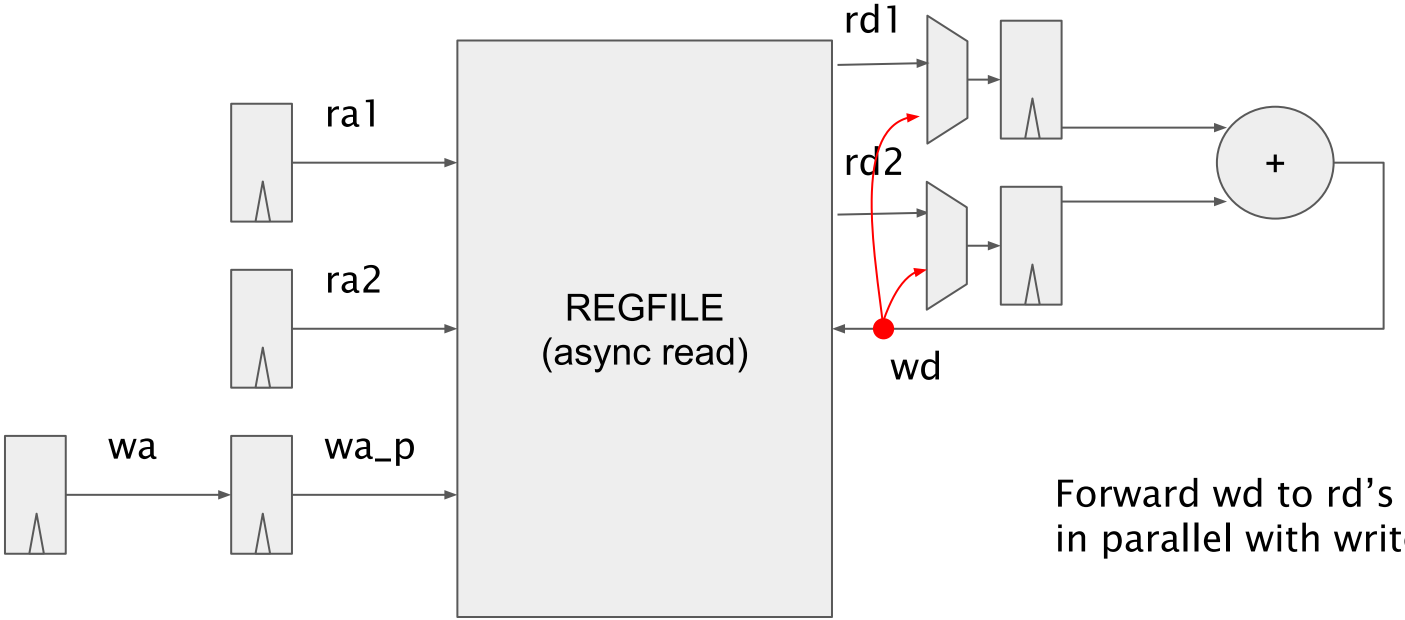
Data hazard when
wa_p == ra1 or wa_p == ra2.

Data Hazard: Stalling



Stall using CE.
MUX to disable next write.

Data Hazard: Forwarding

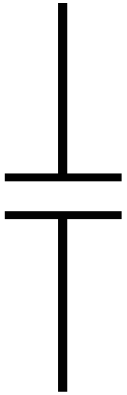


Forward wd to rd's
in parallel with write-back.

Power

- Dynamic power
  - Switching power
  - Short-circuit power
- Static power
  - Leakage power = Leakage current * Vdd

Discharging Capacitor

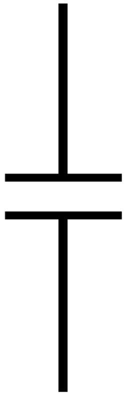


Energy dissipated:

$$\int IV\,dt = \int \frac{dQ}{dt} V\,dt = \int C\frac{dV}{dt} V\,dt = \int CV\,dV = \frac{1}{2} CV_{dd}^2$$

Charging Capacitor

GND -> Vdd



GND

Energy provided from source:

$$\int IV_{dd}dt = V_{dd}\int \frac{dQ}{dt}dt = V_{dd}\int dQ = CV_{dd}^2$$

One half is charged to capacitor; the other half is dissipated.

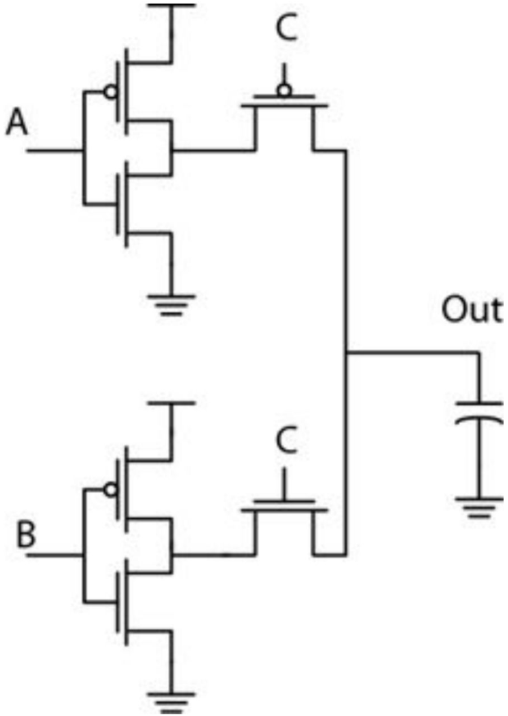
Switching Power

If the output flips every cycle, $\frac{1}{2}CV_{dd}^2 f$

If the output flips with the probability α for each cycle,

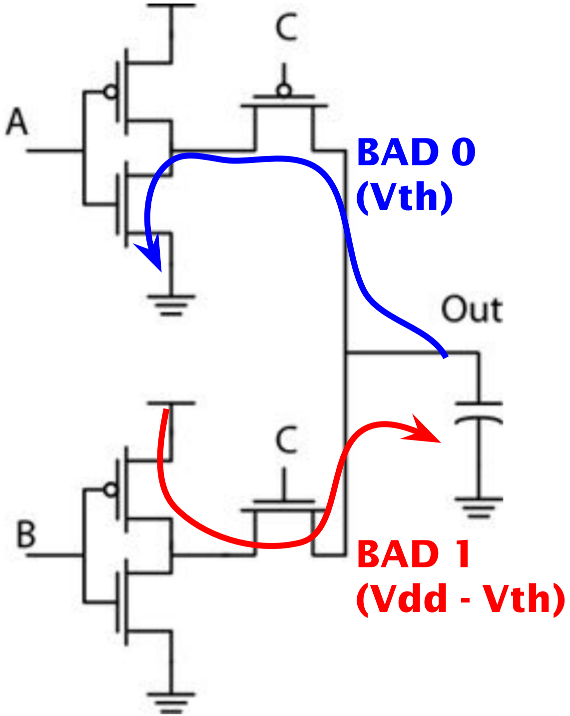
$$\frac{1}{2}\alpha CV_{dd}^2 f$$

Tricky Example



Why is this tricky?

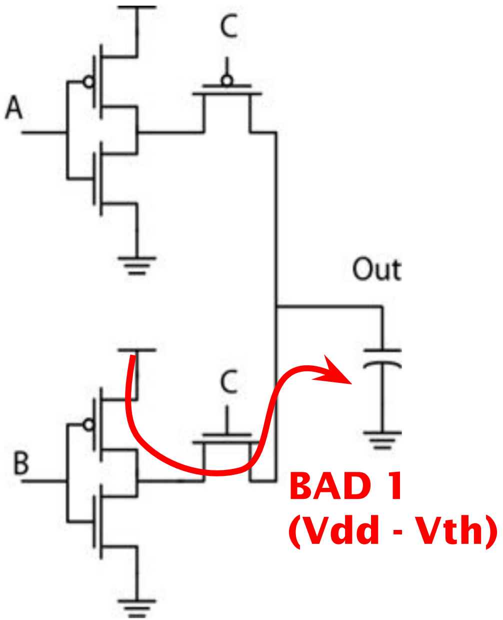
Tricky Example



How much energy dissipated?

- when 0 -> (Vdd - Vth)
- when Vdd -> Vth

Tricky Example



Energy provided from source:

$$\int IV_{dd}dt = V_{dd}\int \frac{dQ}{dt}dt = V_{dd}\int dQ = CV_{dd}(V_{dd} - V_{th})$$

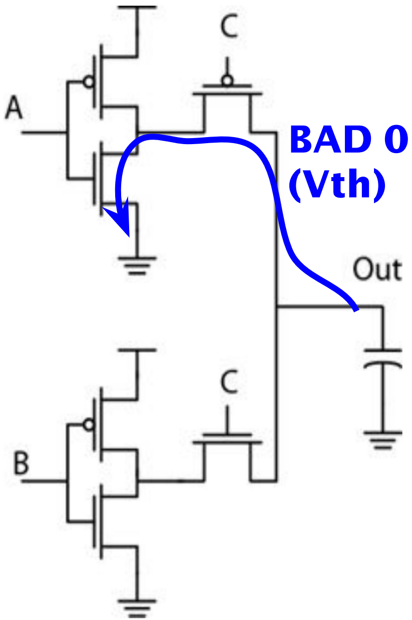
Energy charged in capacitor:

$$\frac{1}{2}C(V_{dd} - V_{th})^2$$

Energy dissipated:

$$CV_{dd}(V_{dd} - V_{th}) - \frac{1}{2}C(V_{dd} - V_{th})^2 = \frac{1}{2}CV_{dd}^2 - \frac{1}{2}CV_{th}^2$$

Tricky Example



Energy originally in capacitor:

$$\frac{1}{2}CV_{dd}^2$$

Energy remaining in capacitor:

$$\frac{1}{2}CV_{th}^2$$

Energy dissipated:

$$\frac{1}{2}CV_{dd}^2 - \frac{1}{2}CV_{th}^2$$

Short-Circuit Current