$P \propto V^2 f$ { dynamic / static

$P \approx f^3$

A $\Rightarrow$ P_{seq}

$\Rightarrow$ 2 cores 1,5 speedup

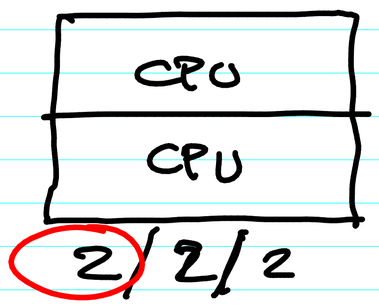
2 cores with $\frac{1}{1.5}$

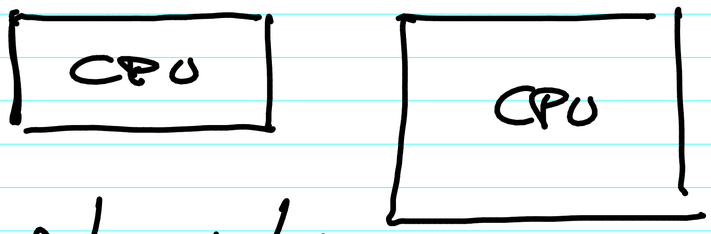
2 $\left(\frac{1}{1.5}\right)^3 P_{seq} = 0.6\, P_{seq}$

$\frac{1}{\frac{3}{2}} = \left(\frac{2}{3}\right)^3 = \frac{8 \cdot 2}{27} = \frac{16}{27} \approx 0.6$

COMPUTING POWER $\approx \sqrt{\text{area}}$

POWER CONSUMPTION $\approx$ area





Perf / Watts / size

1 / 1 / 1

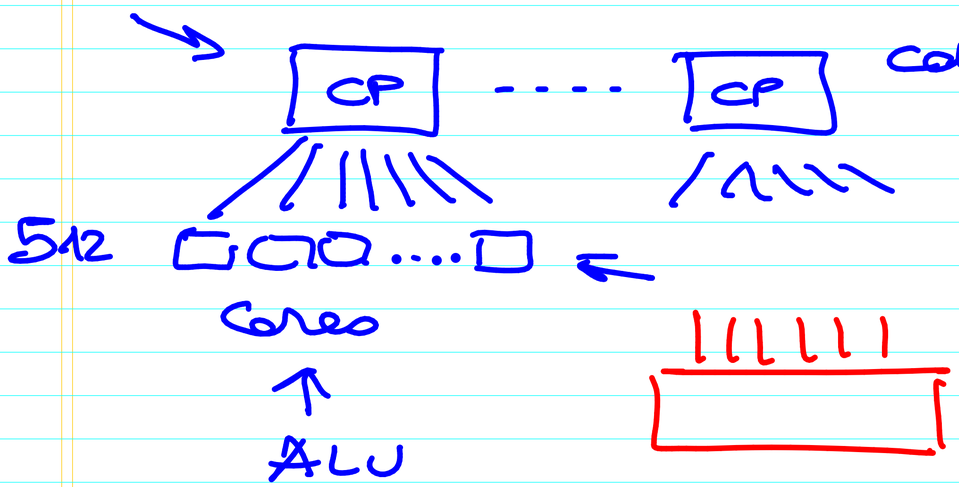
1.4 / 2 / 2

GPU* graphical processing unit

↳ GP-GPO

general purpose

```
C[i] = A[i] + B[i]
```

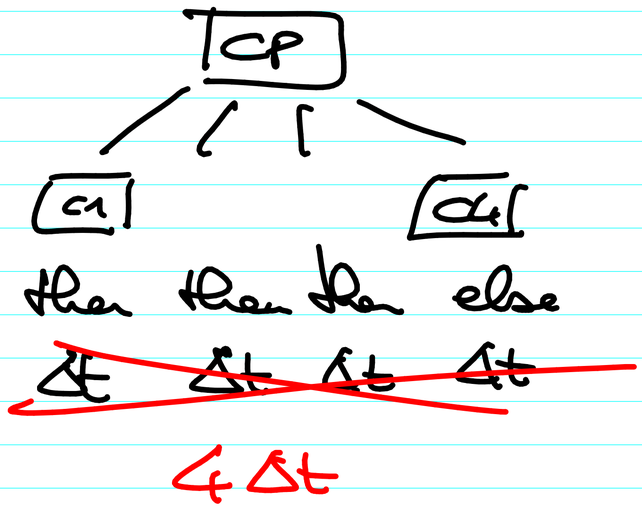


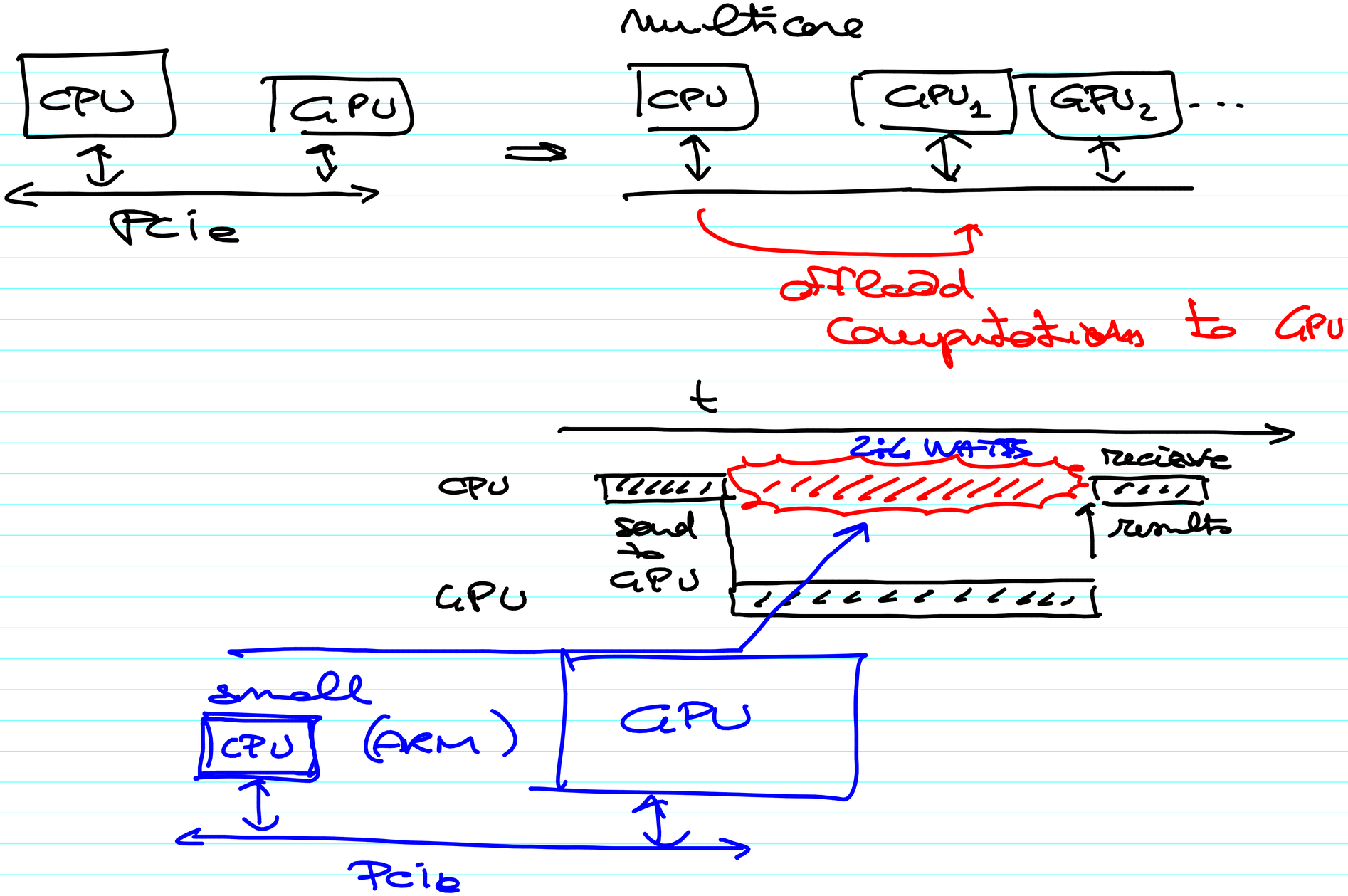

```
if(A[i] % N == 0)
    C[i] = B[i];
else C[i] = A[i];
```

150 – 250 W

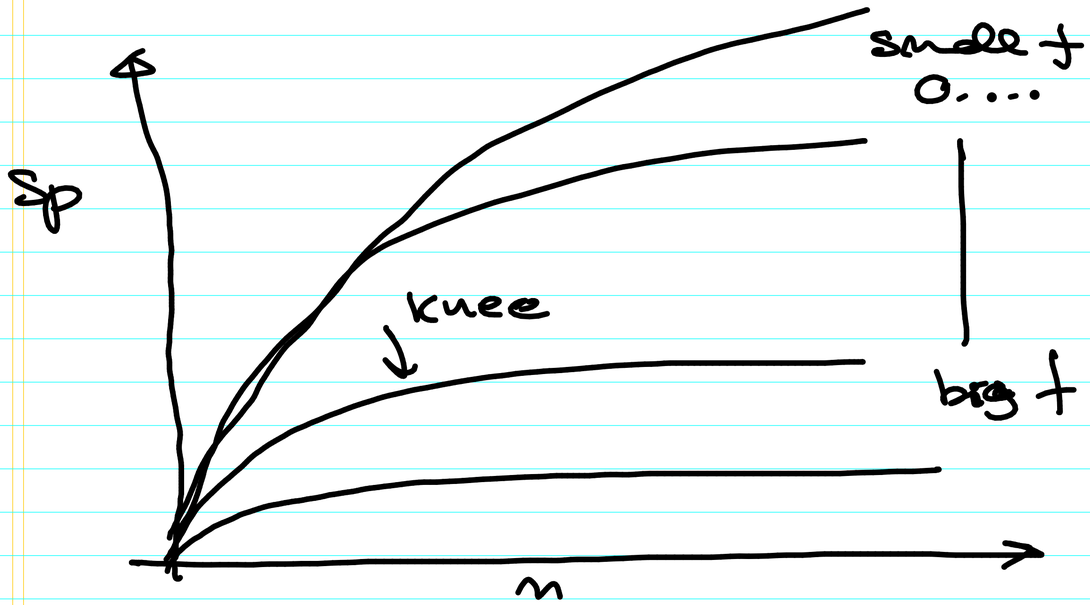
≈ ½ k cores of FLOP

4 – 8 ÷ 16 100 W




CPU
GPU
PCIe
multicore
CPU
GPU1
GPU2
...
offload computations to GPU
t
CPU
GPU
send to GPU
WAITS
recieve
results
small
CPU
(ARM)
GPU
PCIe

Amdahl law $Sp(n) = \frac{1}{f}$ ← serial fraction of the applicat



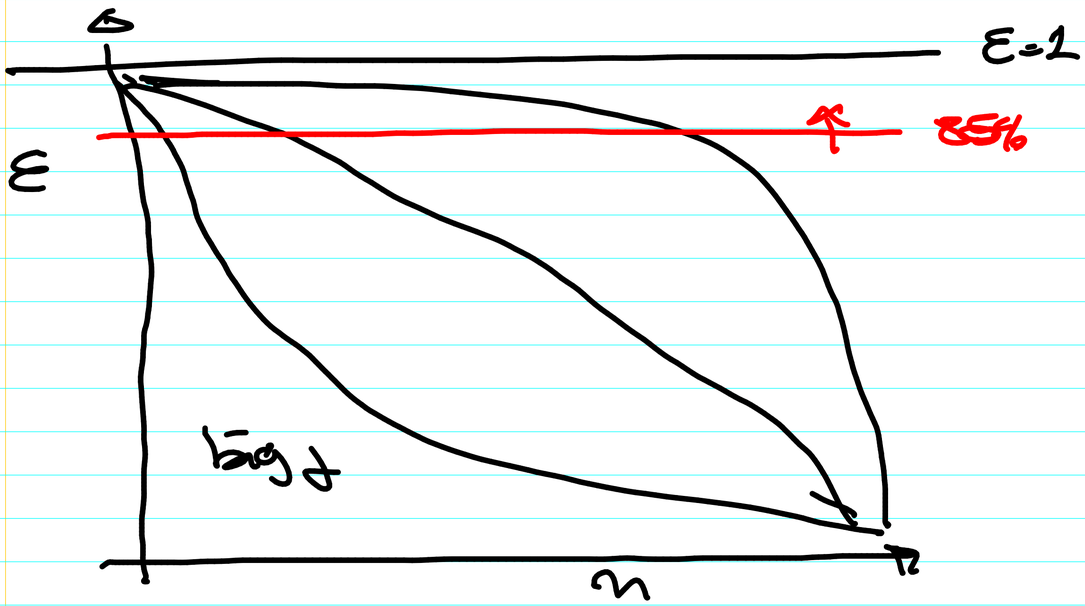
1% ⇒ Sp(∞) = 100

Top500

#cores ∈ [10k ÷ 100k]

Sp( ) up 100k

sp=1000

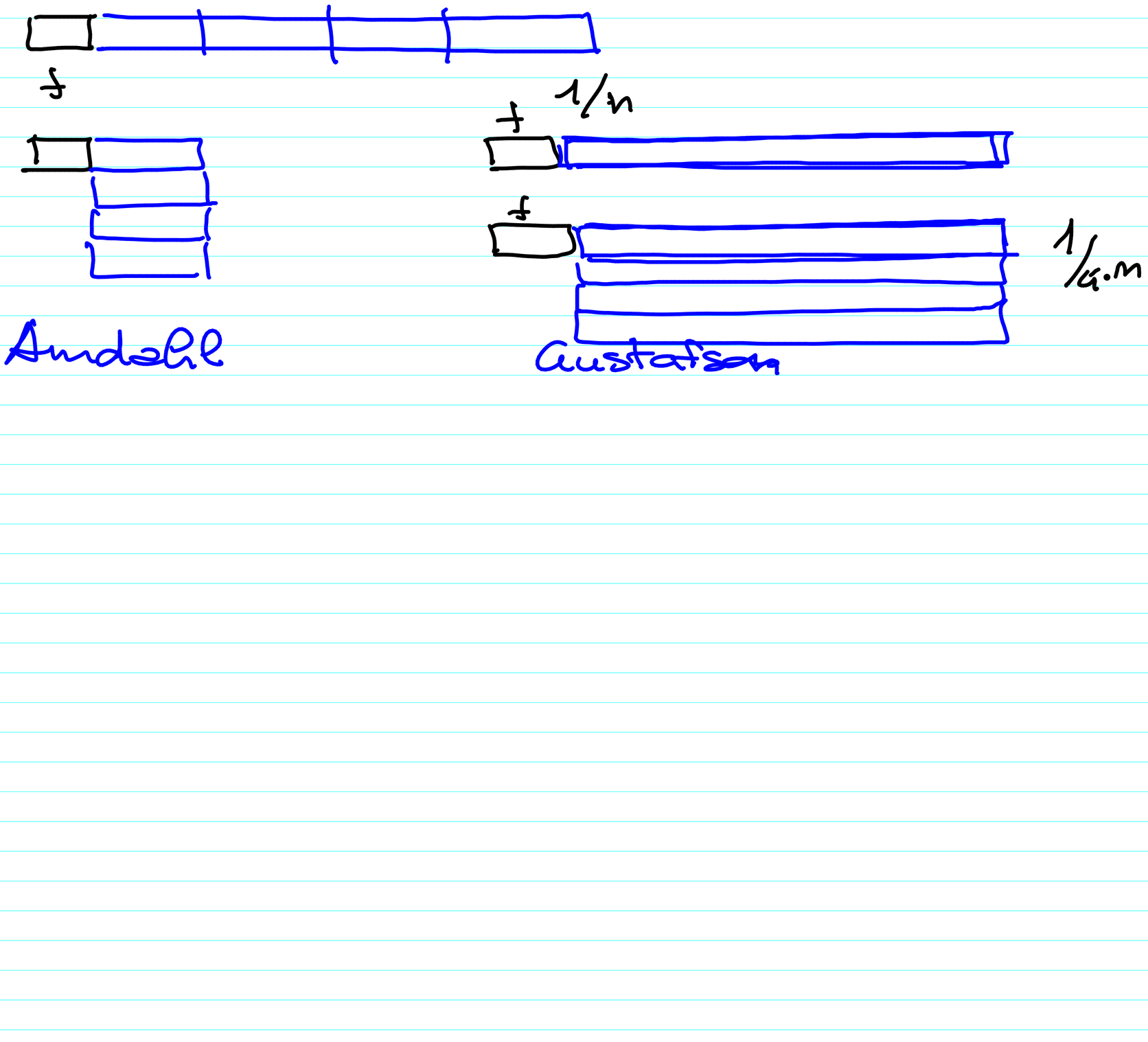


decent ε

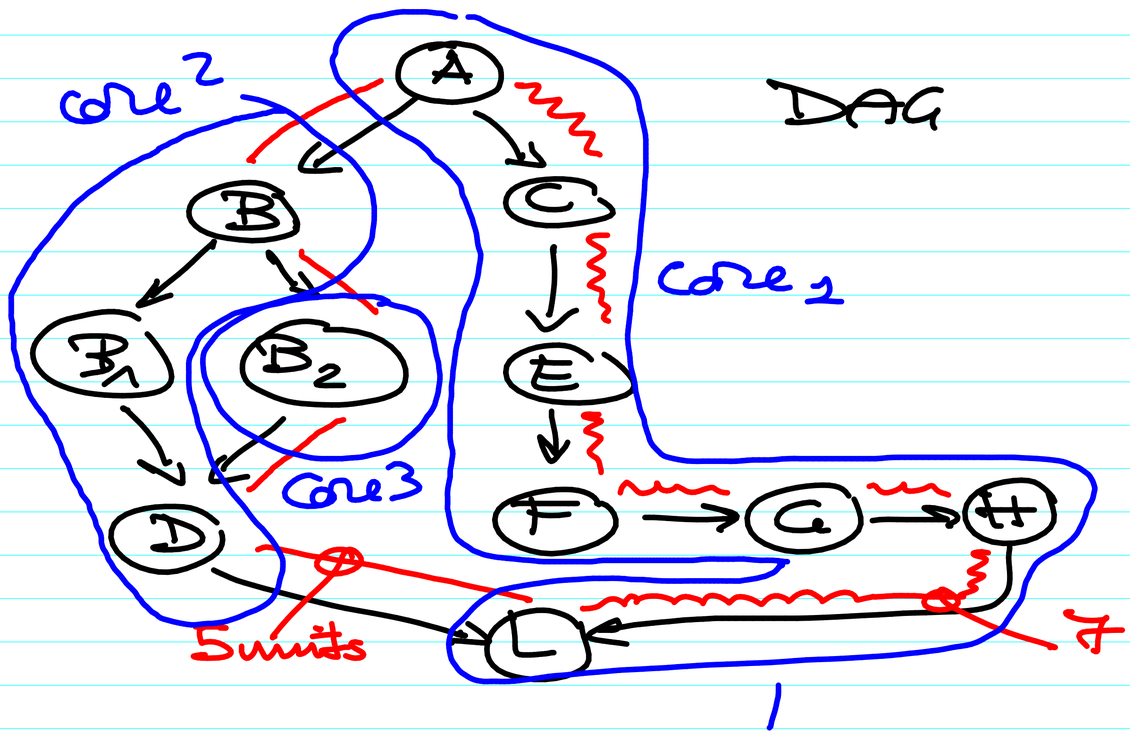
→ 90% ÷ 100%

85%

GUSTAFSON - BARSIS LAW



GRAPH of concurrent activities



DAG

WORK — 11 units of time to Complete

SPAN — (maximum length CRITICAL PATH)

$T(1)$ — work

$T(\infty)$ — span

$$\text{Speedup}(p) = \frac{T(1)}{T(p)} \leq \frac{T(1)}{T(\infty)} = \frac{\text{work}}{\text{span}} = \frac{11}{7}$$

$$T(p) = \frac{(T(1) - T(\infty))}{p} + T(\infty)$$

Hp $T(\infty) << T(1)$

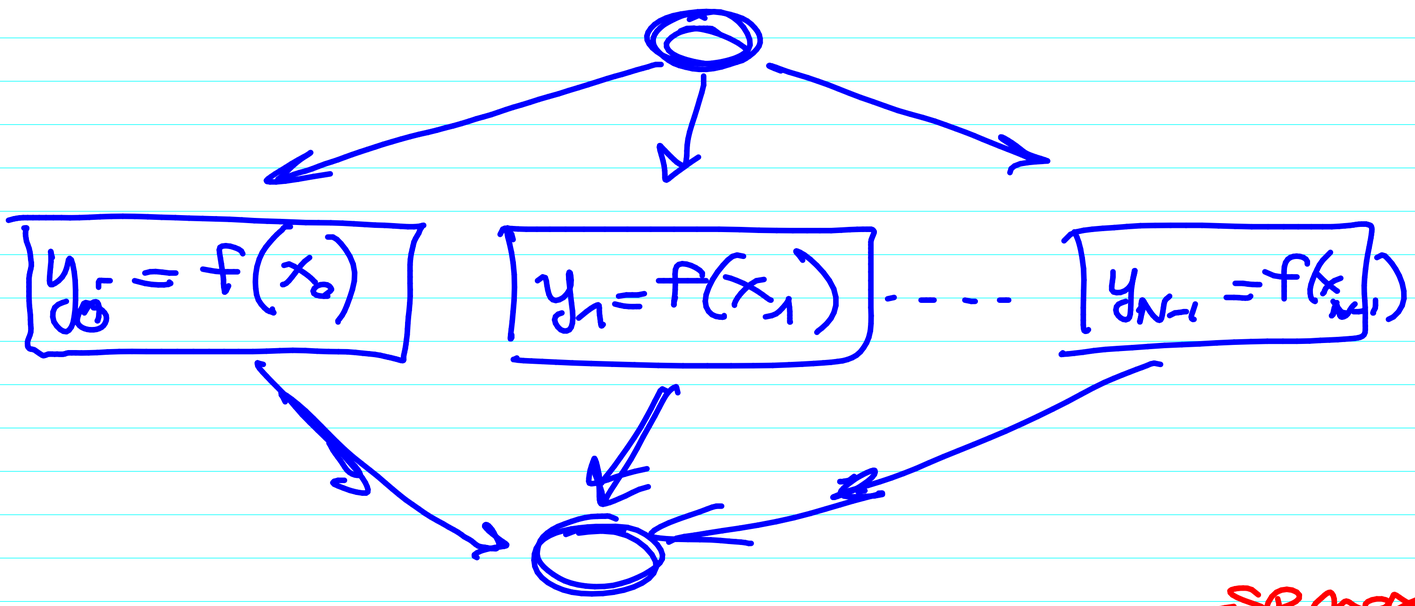
$$T(p) \approx \frac{T(1)}{p}$$

data structure (collection)

$\forall$ items x_i in collection : new collection with item y_i

$y_i := f(x_i)$

N elements in collection x



$$sp\,max = \frac{N + \cdots}{1 + \cdots}$$

work $N+2$

span 3

$$Sp\,max = \frac{N+2}{3} = \frac{N}{3}$$

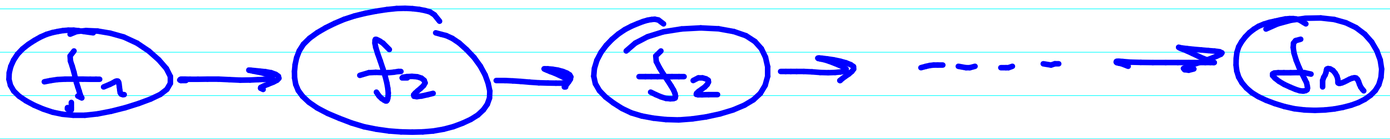
$$work = \sum_{\forall N} pesi \qquad span = \sum_{\substack{nodi \\ nel \\ CRITICAL\ PATH}} pesi$$

1

collezione di funzioni

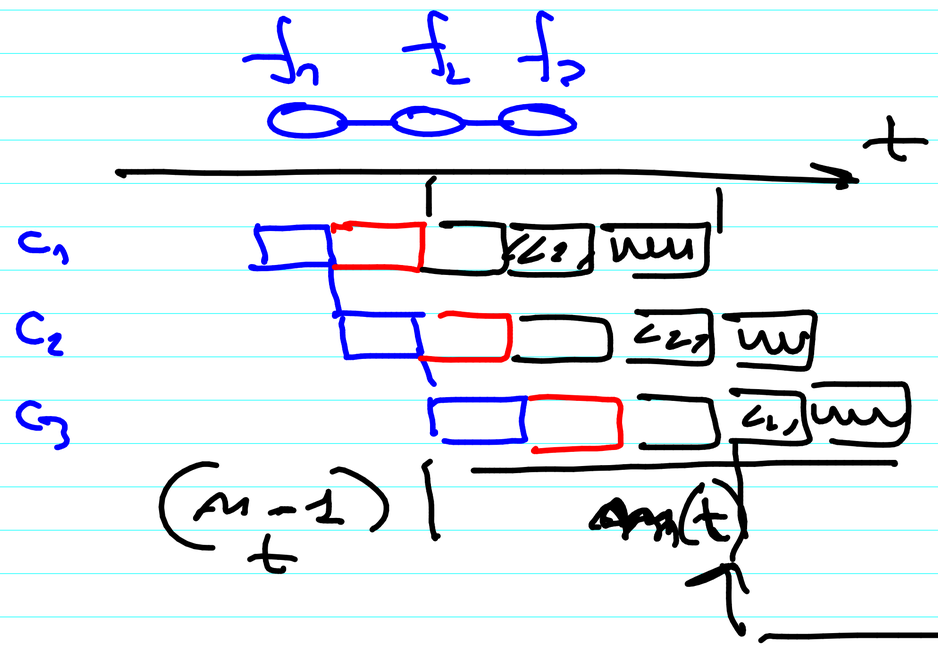
$f_1\ f_2 \cdots f_n$

$\forall$ input $f_n(\cdots f_2(f_1(x))\cdots)$



n input n "stadi"

$n >> n$ $\quad T(n) \approx \frac{n}{n} = n\left(\frac{T_{seq}}{n}\right)$



$t(f_1)+t(f_2)+t(f_3) = T_{seq}$