Topic V10

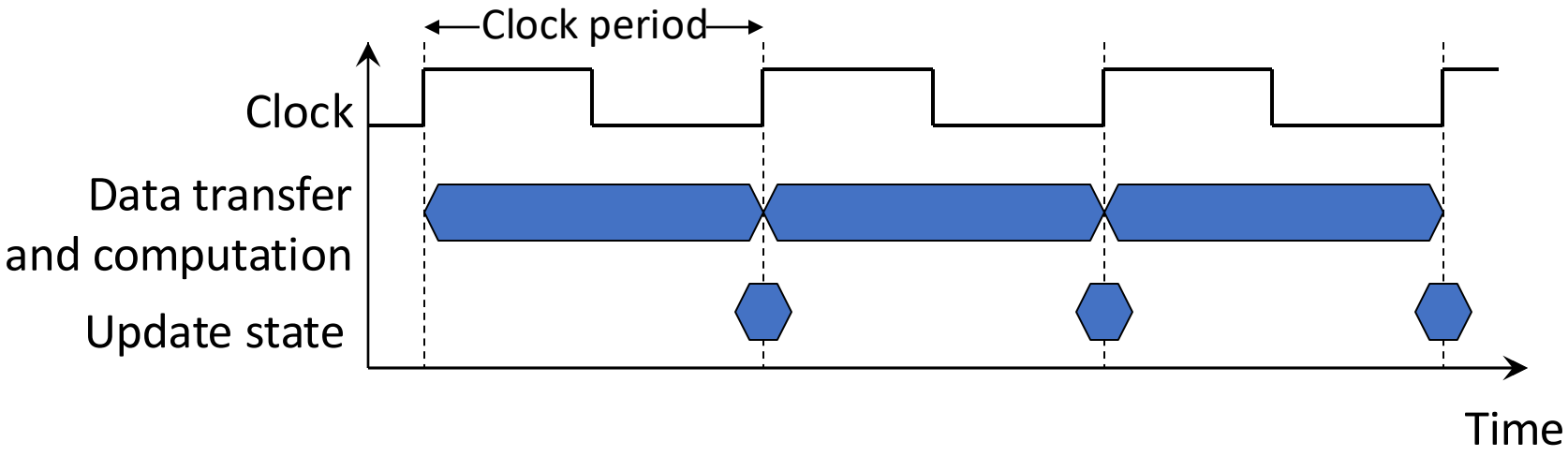
Clock and Frequency

Reading: (Section 1.6)

CPU Clocking

clock period ≡ duration of clock cycle

Example:
1 clock period = 250 *ps* (*pico*seconds)
1 clock period = 0.25 *ns* (*nano*seconds)
1 clock period = 250 × 10^{-12} *s* (seconds)



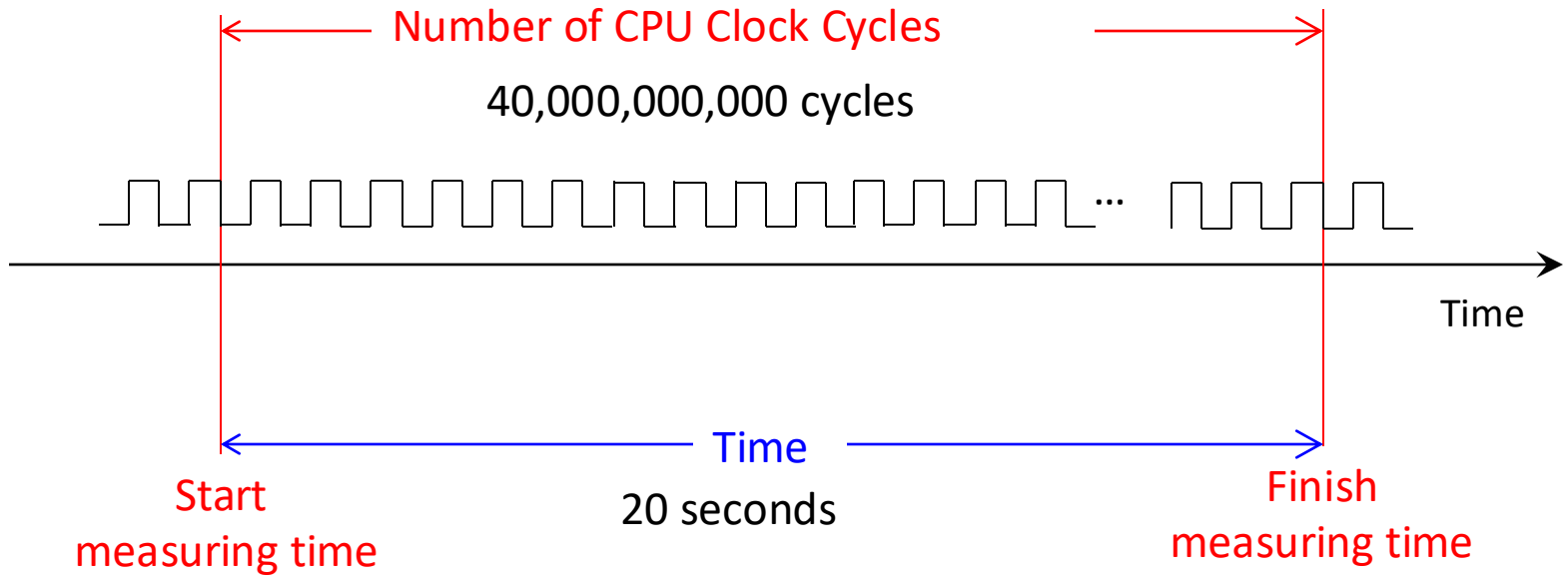
clock frequency ≡ clock rate

number of clock cycles per second

Example:
4.0 *GHz* (*Giga*Hertz)
4000 *MHz* (*Mega*Hertz)
4.0 × 10^{9} *Hz*

Frequency

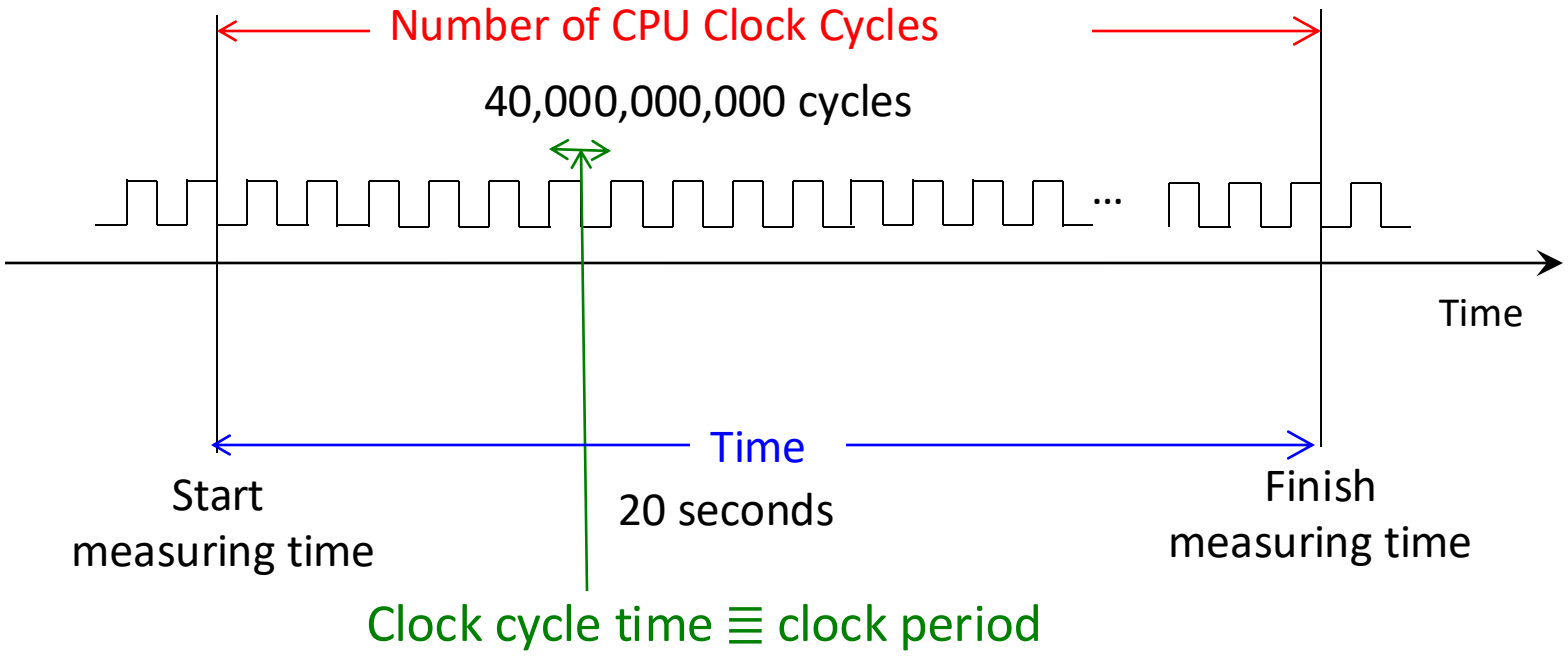
$$\text{Frequency} = \frac{40{,}000{,}000{,}000 \text{ cycles}}{20 \text{ seconds}} = 2 \times 10^9 \frac{\text{cycles}}{\text{seconds}} = 2 \text{ GHz}$$



Frequency: number of clock cycles per seconds

Clock Cycle Time

$$\text{Clock cycle} = \frac{20 \text{ seconds}}{40{,}000{,}000{,}000 \text{ cycles}} = 0.5 \times 10^{-9} \frac{\text{seconds}}{\text{cycle}} = 0.5 \text{ ns}$$



What is the duration of a clock cycle?

Relation Between Clock Cycle Time and Frequency

$$\text{Frequency} = \frac{40{,}000{,}000{,}000 \text{ cycles}}{20 \text{ seconds}}$$

$$\text{Clock Cycle Time} = \frac{20 \text{ seconds}}{40{,}000{,}000{,}000 \text{ cycles}}$$

$$\text{Clock Cycle Time} = \frac{1}{\text{Frequency}}$$

Example

Question 5: The current processor commercialized by *TinyProc Inc* is the TP500 that runs at a 500 MHz frequency ($1\text{MHz} = 10^6$ Hz). The most important application that runs in the TP500

500 MHz Frequency

$$\text{Clock Cycle Time} = \frac{1}{\text{Frequency}} = \frac{1}{500 \times 10^6} = 2 \times 10^{-9}\ s = 2\ \text{ns}$$

Because we Know Algebra…

$$\text{Clock Cycle Time} = \frac{1}{\text{Frequency}}$$

$$\text{CPU Time} = \#\text{ of CPU Clock Cycles} \times \text{Clock Cycle Time}$$

fewer clock cycles ⇒ better performance

$$\text{CPU Time} = \frac{\#\text{ of CPU Clock Cycles}}{\text{Frequency}}$$

faster clock ⇒ better performance

Example

Computer A

Renders explosion in 10 s

Frequency: 2 GHz

Computer B

Goal: render explosion in 6 s

Faster clock but needs 1.2 × # clock cycles

What should be the frequency of Computer B?

$$\text{Clock Rate}_B = \frac{\#\text{Clock Cycles}B}{\text{CPU Time}B} =$$

Example

Computer A

Renders explosion in 10 s

Frequency: 2 GHz

Computer B

Goal: render explosion in 6 s

Faster clock but needs 1.2 × # clock cycles

What should be the frequency of Computer B?

$$\text{Clock Rate}_B = \frac{\#\text{Clock CyclesB}}{\text{CPU TimeB}} = \frac{1.2 \times \#\text{Clock Cycles}_A}{6\ s}$$

$$\#\text{Clock Cycles}_A = \text{CPU Time}_A \times \text{Clock Rate}_A$$
$$= 10\text{s} \times 2\ GHz = 20 \times 10^9 \text{ cycles}$$

$$\text{Clock Rate}_B = \frac{1.2 \times 20 \times 10^9}{6\ s} = \frac{24 \times 10^9 \text{ cycles}}{6\ s} = 4\ GHz$$

fewer clock cycles ⇒ better performance

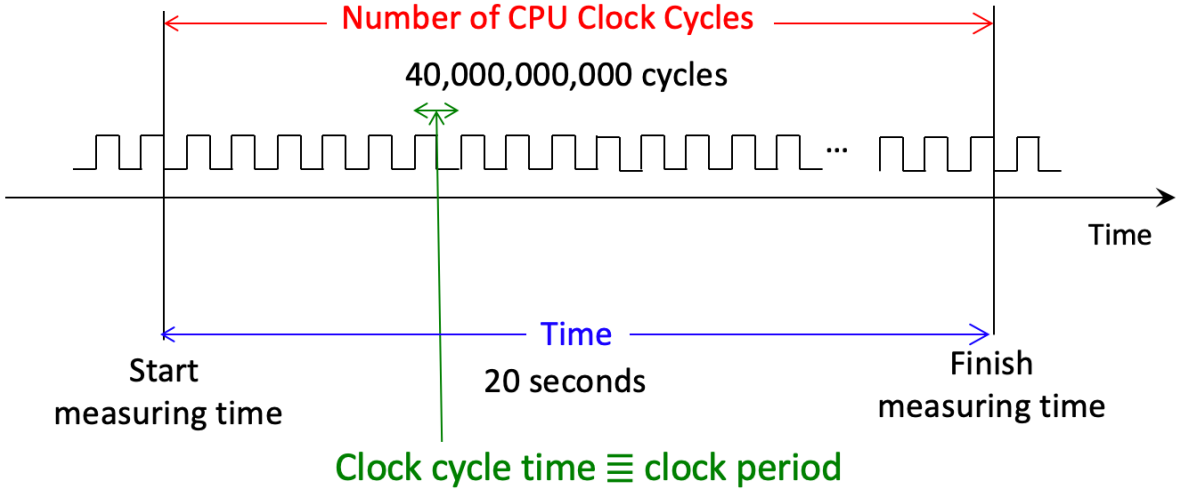
$$\text{CPU Time} = \frac{\text{\# of CPU Clock Cycles}}{\text{Frequency}}$$

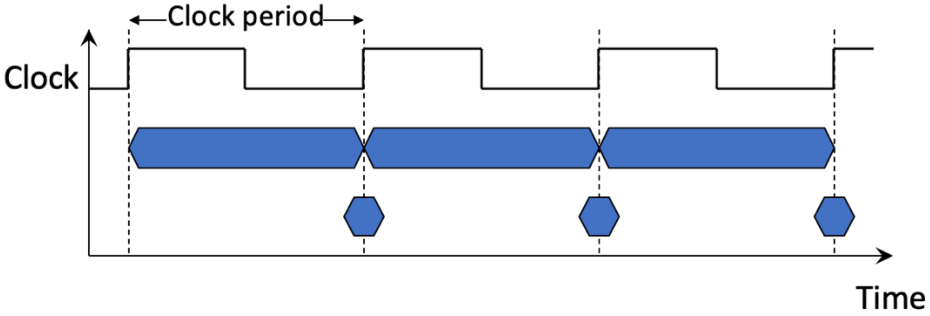
faster clock ⇒ better performance

Example

Computer A

Computer B





Recap