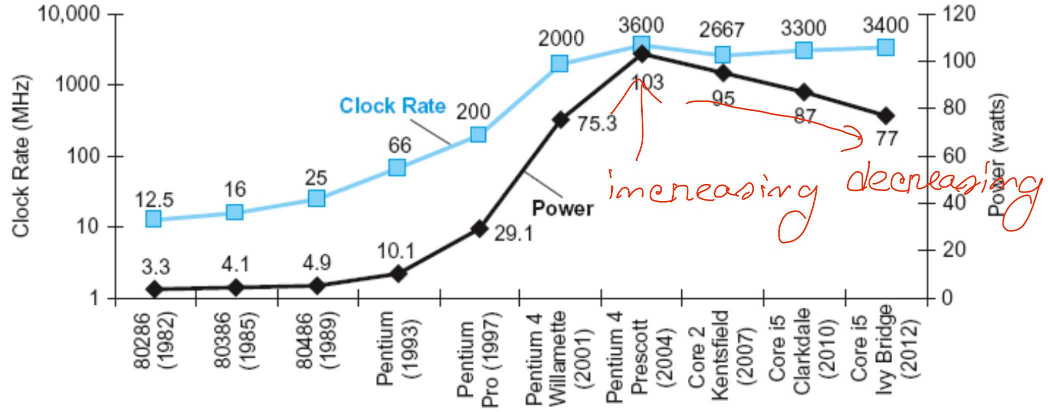
CPU can use upto a limited amount of power.
If given more than that, it generates too much heat.

Power Trends



- In CMOS IC technology

$$\text{Power} = \text{Capacitive load} \times \text{Voltage}^2 \times \text{Frequency}$$

Reducing Power

- Suppose a new CPU has
  - 85% of capacitive load of old CPU
  - 15% voltage and 15% frequency reduction

$$\frac{P_{new}}{P_{old}} = \frac{\underbrace{C_{old} \times 0.85}_{C_{new}} \times (\underbrace{V_{old} \times 0.85}_{V_{new}})^2 \times \underbrace{F_{old} \times 0.85}_{F_{new}}}{C_{old} \times V_{old}^2 \times F_{old}} = 0.85^4 = 0.52$$

$P_{new} = 0.52 \times P_{old}$

$= \frac{1}{2} \times P_{old}$

$= \frac{P_{old}}{2}$

- The power wall
  - We can't reduce voltage further
  - We can't remove more heat
- How else can we improve performance?

Microarchitecture Enhancement:
- Cache optimization – increase the size & efficiency of cache
- Specialized execution units – GPUs for specific task.

Software optimization :

Energy efficient Computing:
- power gating – turn off the unused component of CPU

Heterogeneous Computing:
- Combine different types of cores. (high perf. + energy eff.)

Advanced cooling and packaging.

SPEC — Corporation

Evaluation

Standard

Performance

SPEC CPU Benchmark is a standardized set of tests used to measure and compare the perform. of computer processors.

$$\text{Spec ratio} = \frac{\text{Reference time}}{\text{Execution time}}$$

$$\text{Geometric mean} = \underbrace{(S.R1 \times SR2 \times \dots \times SRn)}^{\frac{1}{n}}$$

this value tells that, on average the CPU is about x times faster than the reference system across the tested workloads.

Amdahl's Law

this law helps us to understand the overall performance improvement gained by optimizing a single part of a system.

$$T_{improved} = \frac{T_{affected}}{\text{improvement factor}} + T_{unaffected}$$

Mips

Millions of Instructions per second

1 Mips

= 1 million instructions executed per second.

12 ins. executed in 24 s

$\Rightarrow$ 24 s —— 12 ins

1 s —— $\frac{12}{24}$ ins.

$= 0.5$ "

10,00000 ins = 1 Million ins

$\therefore$ 1 " $= \frac{1}{1000000}$ "

$\therefore$ 0.5 " $= \frac{0.5}{1000000} = \frac{0.5}{10^6}$