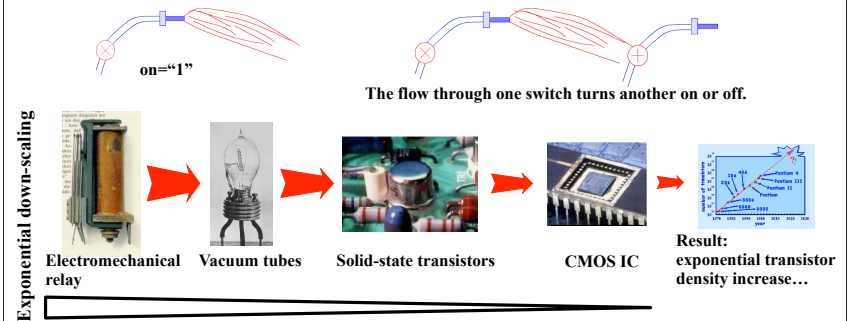


Lecture 28 Introduction to Parallel Processing

A little history... Zuse's paradigm

- Konrad Zuse (1938) Z3 machine
 - Use binary numbers to encode information
 - Represent binary digits as on/off state of a current switch



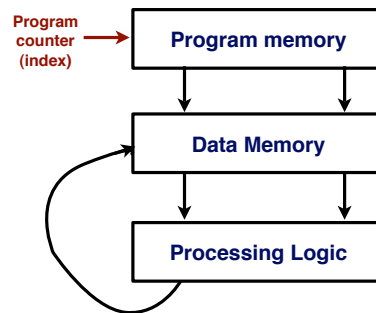
A little history... programs

- Stored program model has been around for a long time...

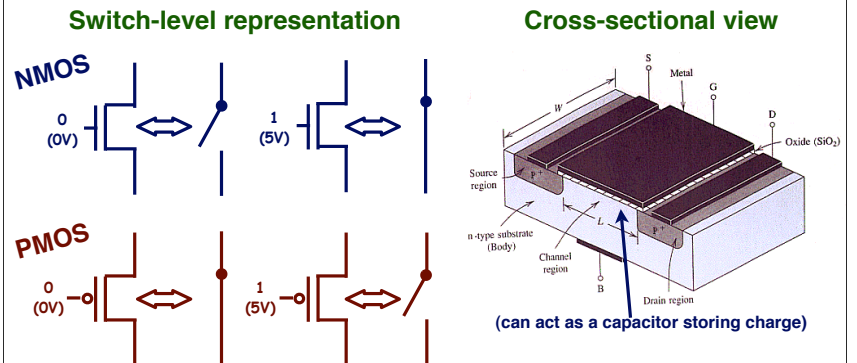
First Draft of a Report
on the EDVAC
by
John von Neumann

Contract No. W-670-ORD-4926
Between the
United States Army Ordnance Department
and the
University of Pennsylvania

Moore School of Electrical Engineering
University of Pennsylvania
June 30, 1945



Transistors used to manipulate/store 1s & 0s



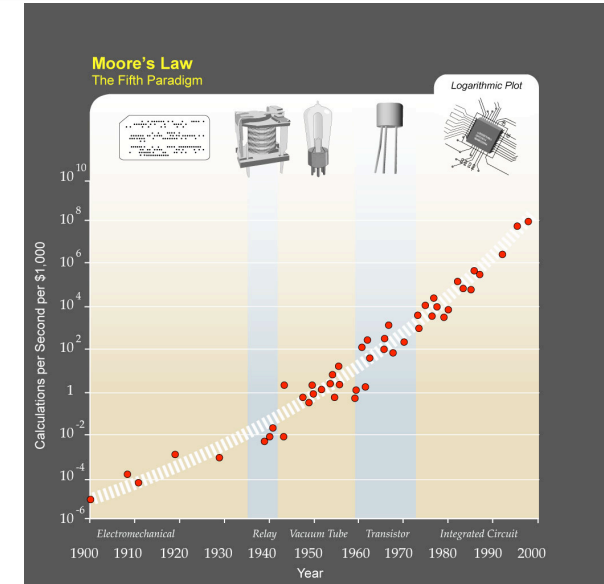
Using above diagrams as context, note that (with NMOS) if we
(i) apply a suitable voltage to the gate & (ii) then apply a
suitable voltage between source and drain, current will flow.

Moore's Law

- “Cramming more components onto integrated circuits.”
- G.E. Moore, Electronics 1965
- **Observation: DRAM transistor density doubles annually**
 - Became known as “Moore's Law”
 - Actually, a bit off:
 - Density doubles every 18 months
 - (in 1965 they only had 4 data points!)
- **Corollaries:**
 - Cost per transistor halves annually (18 months)
 - Power per transistor decreases with scaling
 - Speed increases with scaling
 - Reliability increases with scaling
 - Of course, it depends on how small you try to make things
 - » (I.e. no exponential lasts forever)

Remember these!

Moore's Law



Moore's Law

- **Moore's Curve is a self-fulfilling prophecy**
 - 2X every 2 years means ~3% per month
 - I.e. $((1 \times 1.03) \times 1.03) \times 1.03 \dots$ 24 times = ~2
 - Can use 3% per month to judge performance features
 - If feature adds 9 months to schedule...it should add at least 30% to performance
 - $(1.03^9 = 1.30 \Rightarrow 30\%)$

A bit on device performance...

- One way to think about switching time:
 - Charge is carried by electrons
 - Carrier velocity is proportional to the lateral E-field between source and drain
 - i.e. $v = mE$
 - $m =$ carrier mobility (and can be thought of as a constant)
 - Electric field defined as: $E = V_{ds}/L$
 - Time for charge to cross channel = length/speed
 - (i.e. meters / (meters/s) = seconds)
 - $= L/v$
 - $= L/(mE)$
 - $= L/(m^*(V_{ds}/L))$
 - $= L^2/(mV_{ds})$
- Thus, to make a device faster, we want to either increase V_{ds} or decrease feature sizes (i.e. L)

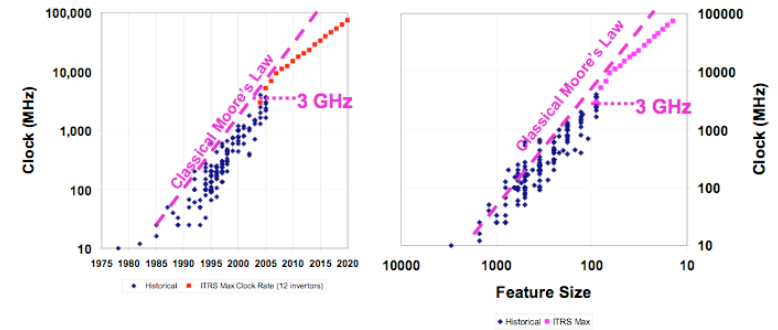
Some more important relationships

- What about power (i.e. heat)?
 - First, need to quickly discuss equation for capacitance:
 - $C_L = (\epsilon_{ox}WL)/d$
 - ϵ_{ox} = dielectric, WL = parallel plate area, d = distance between gate and substrate
 - Then, dynamic power becomes:
 - $P_{dyn} = C_L V_{dd}^2 f_{0-1}$
 - Dynamic power is a function of the frequency of 0 to 1 or 1 to 0 transitions (as this involves the movement of charge)
 - » Note frequency in this context is NOT clock frequency
 - Note that as W and L scale, C_L decreases which in turn will cause a decrease in P_{dyn} .
 - Note that while an increase in V_{dd} will *decrease* switching time, it will also cause a quadratic *increase* in dynamic power.

A funny thing happened on the way to 45 nm

•Speed increases with scaling...

Remember these!

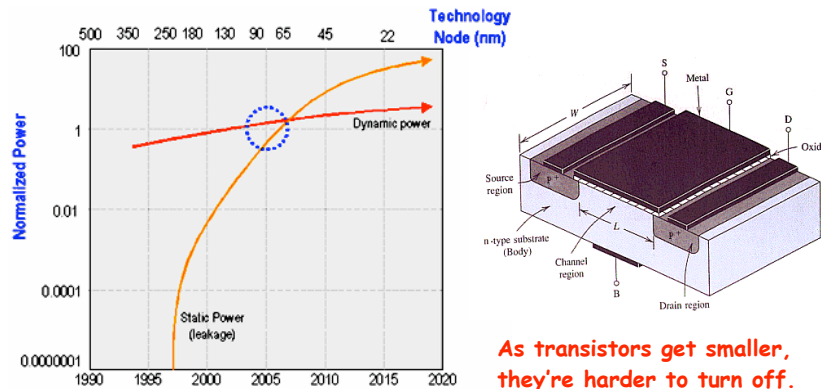


2005 projection was for 5.2 GHz - and we didn't make it in production. Further, we're still stuck at 3+ GHz in production.

A funny thing happened on the way to 45 nm

•Power decreases with scaling...

Remember these!



As transistors get smaller, they're harder to turn off.

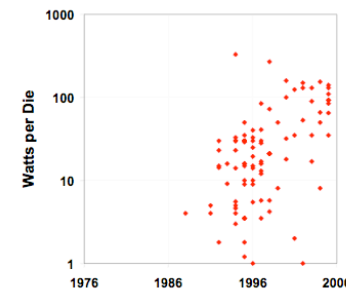
A funny thing happened on the way to 45 nm

• Speed increases with scaling...

• Power decreases with scaling...

Remember these!

Why the clock flattening? POWER!!!!

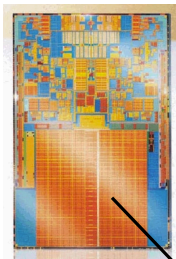


Recall...

- $P_{dyn} = C_L V_{dd}^2 f_{0-1}$
 - Dynamic power is a function of the frequency of 0 to 1 or 1 to 0 transitions (as this involves the movement of charge)
 - » Note frequency in this context is NOT clock frequency

Other reasons too, but this should give you a good feel for technology...

Transistors used for memory too...



Saw earlier, that transistors used for *on chip* memory too...

Problem: Program, data = bigger + power problem isn't going away...



- Why? Put faster memory closer to processing logic...
 - SRAM (logic): density +25%, speed +20%
 - DRAM (memory): density +60%, speed +4%
 - Disk (magnetic): density +25%, speed +4%

Solution?

High art meets high-tech.

Lincoln's latest project, titled "CLOSE," is a 10" x 10" translucent structure outfitted with video cameras, uniquely combining sculpture, portraiture and architecture. With Intel® Centrino® processor technology inside, a notebook becomes many other things as well — portable studio, camera, digitization tool.

Top 5 Must-Haves

- POWERFUL PROCESSOR**
A portrait of performance. "My generative portraits are demanding on the processors in my laptop, as they continuously manipulate video," says Lincoln. Thankfully, the dual-core performance of Intel Centrino processor technology can handle intensive tasks with flying colors.
- BUZZING TRANSFER SPEEDS**
Art is 90 frames per second. Data transferring up to 30% faster* allows Lincoln to shoot footage from 24 video cameras with lightning speed.
- WIRE-SPEED WIRELESS**
Always Connected. With up to twice the range and 5x the speed when connected to a Wireless N home network,¹ Lincoln can download music or shoot for art books anywhere, anytime.
- ENHANCED VIDEO**
High-def broadcast. Lincoln can view his generative portraits with "gallery-like" clarity, thanks to stunning multimedia performance for a super-enhanced high-def video experience.
- INDEPENDENT BATTERY LIFE**
The power of art. Lincoln's infinitely reconfiguring images are ultimately presented on a 15.5-inch screen powered by his computer — so reading power is not an option. Thanks to Intel's exclusive power-saving features, he conserves energy by using it only when he needs it.

Deeper. Richer. Faster.
Log on to drivewywhatinside.com for access to exclusive multimedia content to keep you up-to-date on the latest tech trends — faster. To take advantage of this high-tech, multimedia masterpiece, make sure your computer has Intel Centrino processor technology.

Motivation:
Processor complexity is good enough, transistor sizes scale, we can slow processors down, manage power, and get performance from...

Parallelism

Top 5 Must-Haves

- POWERFUL PROCESSOR**
A portrait of performance. "My generative portraits are demanding on the processors in my laptop, as they continuously manipulate video," says Lincoln. Thankfully, the dual-core performance of Intel Centrino processor technology can handle intensive tasks with flying colors.

(i.e. 1 processor, 1 ns clock cycle vs. 2 processors, 2 ns clock cycle)