REAL – TIME HD

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“Ready, Fire, Aim - 20 years of hits & misses at Hot Chips”

Major Technology Misses of the 80’s and 90’s

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RISC Revolution of the 80's and 90's

- **Most computers in 1980 were built with bipolar small scale integration**
  - Fast transistors but a large penalty for their interconnect
  - Perhaps up to 20k transistors per bipolar chip
- **CMOS allowed up to 200k transistors for the first time on a single chip**
  - Bipolar defect densities were 4x CMOS resulting in poor yields
- **Simple machines called RISC machines were able to be built on a single chip because of high CMOS yields**
  - Interconnect was a small part of the overall delay
    - Gates were relatively slow
  - Simplicity of ISA allowed a good clock rate
    - Clock rates were in the 20 to 33MHz range were achieved
  - Very low cost systems could be built
  - Very low power was achieved
- **Many of these projects were underway**
  - Sun, MIPS, Fairchild, National, IBM, etc
  - Performance (clock rate & IPC) drove technology decisions

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Technology Options in the 80's and 90's

- **ECL**
  - Well understood, around a long time
  - Very High frequency transistors
  - All the fastest main frame computers and super computers used ECL
  - Poor yield compared with CMOS
  - Very high power
- **CMOS**
  - New technology replacing NMOS
  - 2U process node in ~1985
  - Slow compared to bipolar
  - Very low power
- **GAS**
  - New technology
  - NMOS, no complimentary transistor
  - 3x the mobility of Si
  - Low power compared with bipolar
  - High power compared with CMOS

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ECL & GAS Risc machines of the 80's and 90's

- **Why did all of these companies try ECL or GAS projects**
  - Fear CMOS would not scale because of the wavelength of visible light and frequency would be limited
    - UV, Deep UV, OPC……
- **Companies that tried ECL projects**
  - Sun, MIPS, Intergraph, MicroUnity, Exponential, BIT, others??
- **Companies that released products**
  - Almost none
- **Why for ECL?**
  - Cost was high compared with CMOS
  - Power was high
  - Density was low
  - Killer! CMOS delivered on Moores law
- **Why for GAS?**
  - Power was high
  - CMOS manufacturing was more mature than GAS
  - Killer! CMOS delivered on Moores law

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Sun Sparc example

- **BIT SPARC processor**
  - 1989-ECL
  - 4- chips
  - 80MHz
  - 1.2 U process, 3 layer metal, 4/8U metal pitch
  - IU = 125k transistors, FPC=36k transistors
  - 20W
  - Some may have been used by Floating Point Systems
  - No real production, 0.8U CMOS killed it!
- **Prisma Supercomputers**
  - 1989-GAS
  - Gigabit (old Rockwell?)
  - Sub micron technology (GAS foundries were always one generation ahead of CMOS, Marketing hype)
  - 250MHz
  - 112 pin chips, 5mm x 4mm
  - 49 chips at 500 Watts
  - Never completed

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Intergraph Example

- **E1 processor 1988, 2U ECL**
  - 48 ECL GA
  - 15 GA types
  - 500 W
  - 150MHz
  - No production, C4 @ 0.8U CMOS ran at 100MHz
  - Power, Cost not competitive

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Microunity Example

- **CML processor 1995**
  - 300 W
  - 1GHz
  - 0.35 U Bipolar in-house fab
  - No prototype, design only
  - No manufacturing yield
  - Power, Not able to manufacture

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MIPS example

- **R6000**
  - ECL
  - Made by BIT
  - 60MHz
  - A few may have been used by CDC in their servers
  - Overshadowed by R4000 in 1991 which was CMOS and ran at 100MHz
    - Cheaper, faster, lower power

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Foundries in 1990

- **GAS Foundries**
  - Fujitsu (now only for communications)
  - Rockwell (sold)
  - Vitesse (Communications products)
  - IBM (I think research only)
- **ECL Foundries**
  - Fujitsu
  - Fairchild
  - Hitachi
  - IBM

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Conclusion

- **Things that were not understood in the late 80's**
  - Moore's Law would continue for the foreseeable future
  - CMOS yield and ease of scaling was much better than other technologies
  - Up until the 80's computers were expensive
    - Everyone thought that they would stay expensive
    - Cost became important
    - Power became important
  - At higher speeds interconnect problems dominated so high density was important
    - Older ECL technologies like the Cray computers with SSI (small scale integration) were very powerful at low clock rates but could not scale to higher frequencies