# What is computer engineering?

by

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Updated 2024 by Dr. W. Craig Scratchley



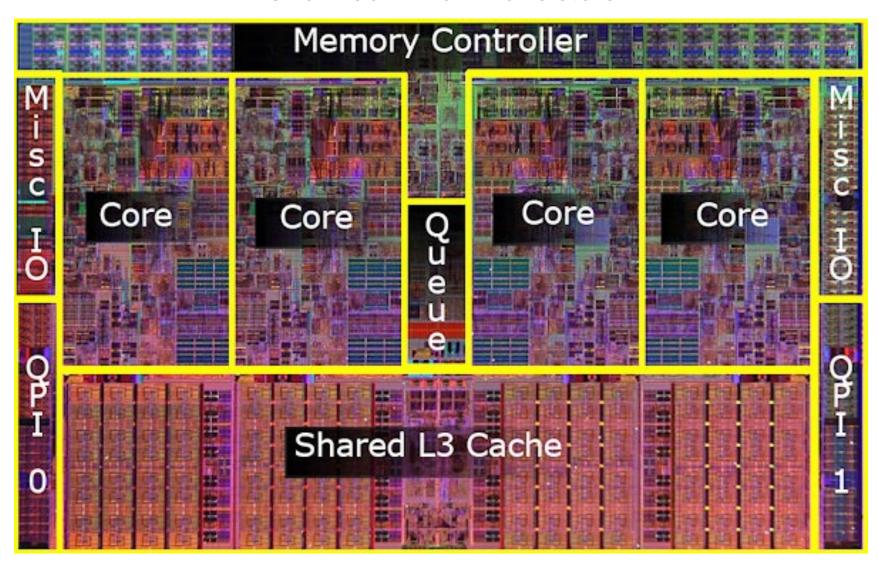
# Traditional Thinking ...

# Intel i7



# Intel i7

Over 730 Million Transistors



### Intel Pentium Prescott

Trace Cache Access. next Address Predict

Trace Cache Branch Prediction Table (BTB), 1024 entries.

Return Stacks (4 x16 entries)

Trace Cache next IP's (4x)

### Instruction Decoder

Up to 4 decoded uOps/cycle out (from max. one x86 instr/cycle) Instructions with more than four are handled by Micro Sequencer

Raw Instruction Bytes in

Data TLB, 64 entry fully associative, between threads dual ported (for loads and stores)

Front End Branch Prediction Tables (BTB), shared, 4096 entries in total

Instruction TLB's 128 entry. fully associative for 4k and 4M pages. In: Virtual address [47:12] Out: Physical address [39:12] + 2 page level bits

Instruction Fetch from L2 cache and Branch Prediction

Front Side Bus Interface, 533..800 MHz

### Instruction Trace Cache

L2 Cache

Block

### **Execution Pipeline Start**



### Buffer Allocation & Register Rename

Instruction Queue (for less critical fields of the uOps ) General Instruction Address Queue & Memory Instruction Address Queue (queues register entries and latency fields of the uOps for scheduling)

### uOp Schedulers

Parallel (Matrix) Scheduler for the two double pumped ALU's

General Floating Point and Slow Integer Scheduler: (8x8 dependency matrix)

FP Move Scheduler: (8x8 dependency matrix)

Load / Store Linear Address Collision History Table

Load / Store uOp Scheduler: (8x8 dependency matrix)

### FP, MMX, SSE1..3

Floating Point, MMX, SSEL... Renamed Register File 256 entries of 128 bit.

### Integer Execution Core

- (1) uOp Dispatch unit & Replay Buffer Dispatches up to 6 uOps / cycle
- (2) Integer Renamed Register File 256 entries of 32 bit (± 6 status flags) 12 read ports and six write ports
- (3) Databus switch & Bypasses to and from the Integer Register File.
- (4) Flags, Write Back
- (5) Double Pumped ALU 0
- (6) Double Pumped ALU 1
- (7) Load Address Generator Unit
- (8) Store Address Generator Unit
- (9) Load Buffer (96 entries)
- (10) Store Buffer (48 entries)

(13) Databus multiplexing

L2 Phys.

Tags

(14) Cache Line Read / Write Transferbuffers and 256 bit wide bus to and from L2 cache

Transfer

Buffers

(11) ROB Reorder Buffer 4x64 entries (12) 16 kByte Level 1 Data cache

L2 Cache

Block

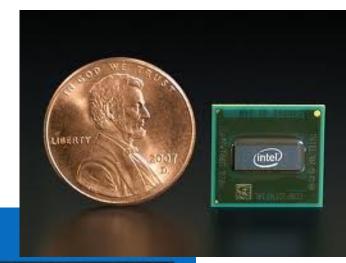
four way set associative. 1R/1W

April 19, 2003 www.chip-architect.com

## Intel Atom

**47.2 million transistors** 

### Sea-of-FUBs Chip Layout





7.8 mm

### SCHEMATIC TRANSISTORS:

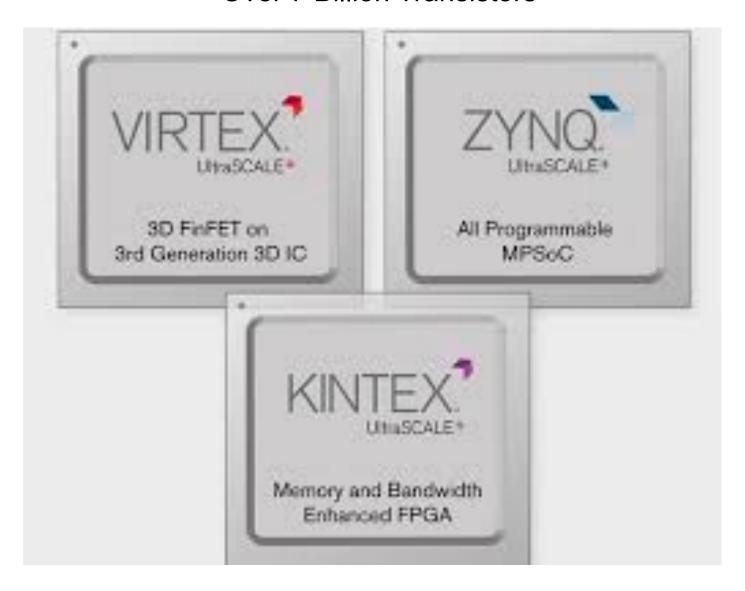
Core: 13,828,574 Uncore: L2 & L2 tag: TOTAL: 47,212,207

	Area %	
Core	28%	
Uncore	72%	
BIU	9%	
L2	22%	
IO FSB	35%	
PLL+FUSE	7%	
Total	100%	

Туре	unique	instances
Random Logic Synthesized	92	92
Structured Data Paths	88	140
L2 sub-arrays	2	40
Custom	18	19
Repeater Stations	-	317
TOTAL	200	608

# Xilinx UltraScale+

### Over 7 Billion Transistors



[Update: Blackwell GPUs are packed with 104 billion transistors on each die, unified as one chip with 208 billion transistors. Mar 22, 2024]

However, that really does not cover it

We are <u>technology experts</u> that work to enable or improve the realization of applications and services

### The COVID years were difficult

But Computer Engineering contributions enabled:

- Remote working and studying
- Remote shopping
- Telemedicine
- Accelerated medical sample testing
- Synthetic vaccine design

### These contributions have

- Kept people in touch when travel was not allowed
- Allowed people to work and study when we were in lockdown
- Kept our economy going, enabling the government to fund CERB, etc and other the benefits that have helped struggling individuals and companies
- Enabled us to exit the pandemic faster with fewer deaths

### Typically, Computer Engineers

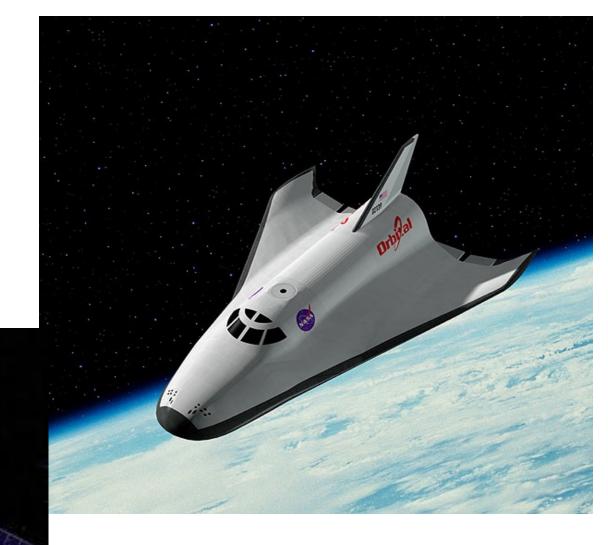
- Work with application experts to realize challenging designs
- Work on applications involving sound, image or video processing
- Try to make things lower power, smaller, faster, more reliable, more secure

That may not sound like much, but

# Computers and Computer Engineers are everywhere...

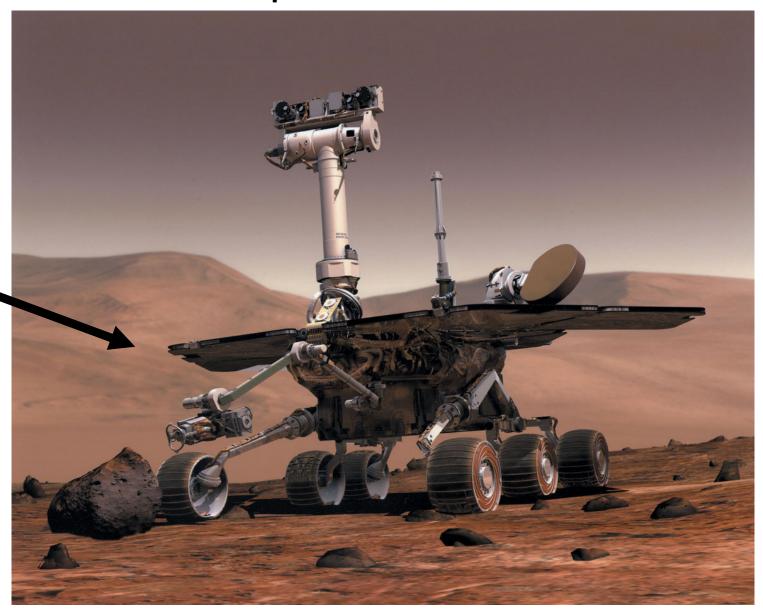


# In Outer Space – Orbitting the Earth



### In Outer Space - Mars Rover

Xilinx FPGAs Here



### In the Air...



### At Sea



# On the road...







### On the road...

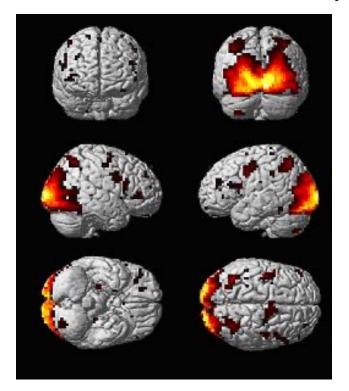




Just a few examples:

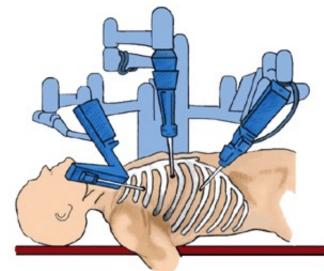
Airbag control,
window control,
radio system,
automatic steering,
Automatic parking
Collision impact warning
Powertrain control module
Sunroof module
Automatic breaking

### In Medicine (i.e. Biomedical Applications)





Remote Surgery



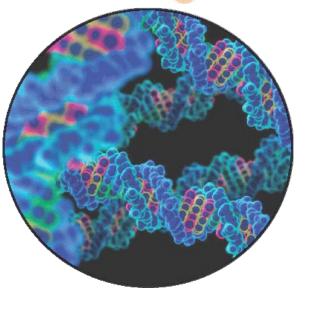
**Prosthetics** 







Molecular
Dynamics and
Gene Mapping



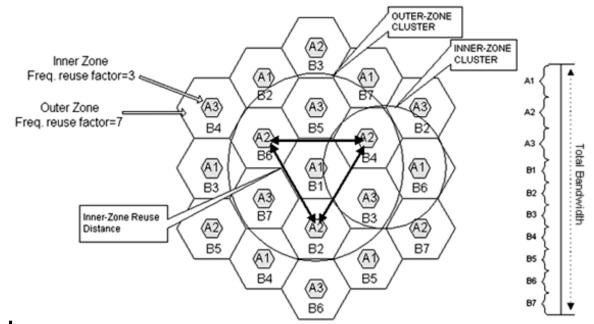
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ENSC 251: Lecture Set 0

### On the phone

Cellphone Networks

&







### Checking the Weather

Doppler Weather Radar





## Financial & Entertainment Applications



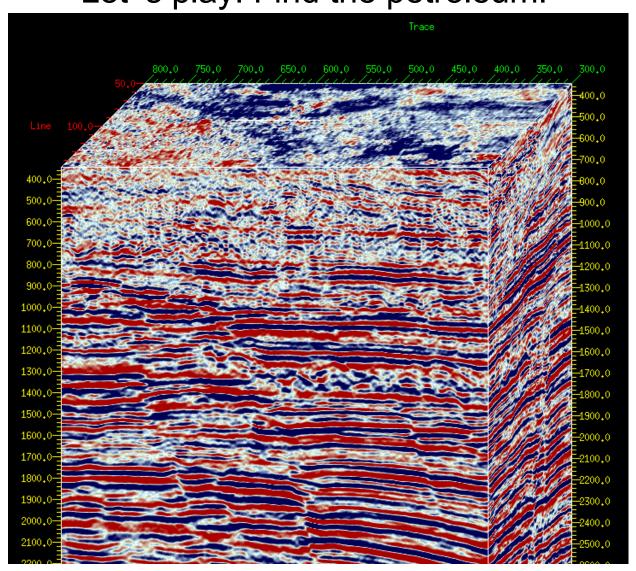






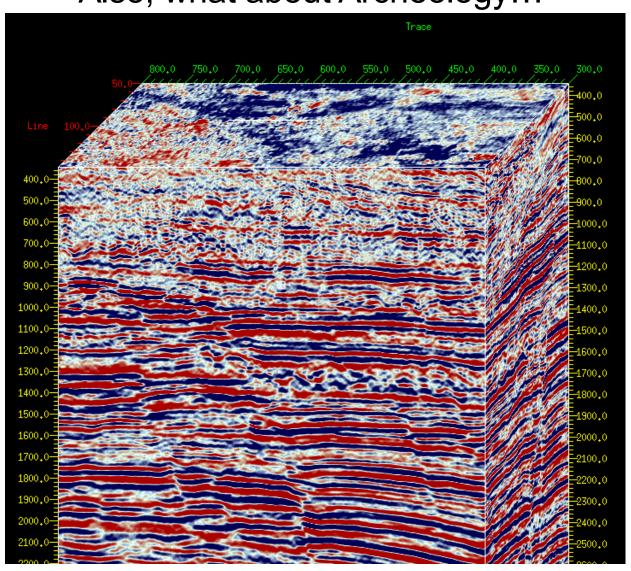
### Seismic Imaging

Let's play: Find the petroleum!



### Seismic Imaging

Also, what about Archeology...

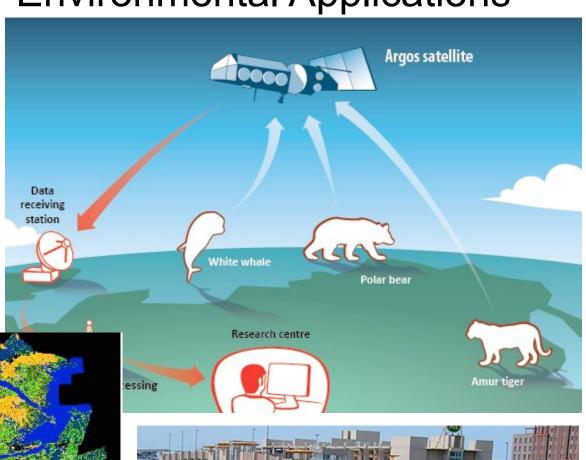


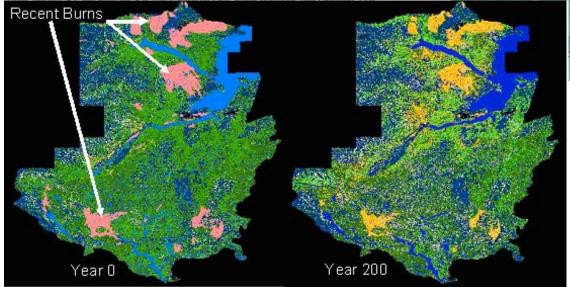
### 3-D Seismic Imaging At Work

Hydrophones streaming from a 3-D seismic ship record the reflection of sound waves as they bounce back from subsalt surfaces.

# Drill ship 3-D seismic ship Hydrophones Salt Oil and gas Salt Oil and gas Solt Oil miles

### **Environmental Applications**





# Forest Type Black Spruce Pin Cherry Non Spruce-Fir White Birch Wat Balsam Fir Birch Aspen Und

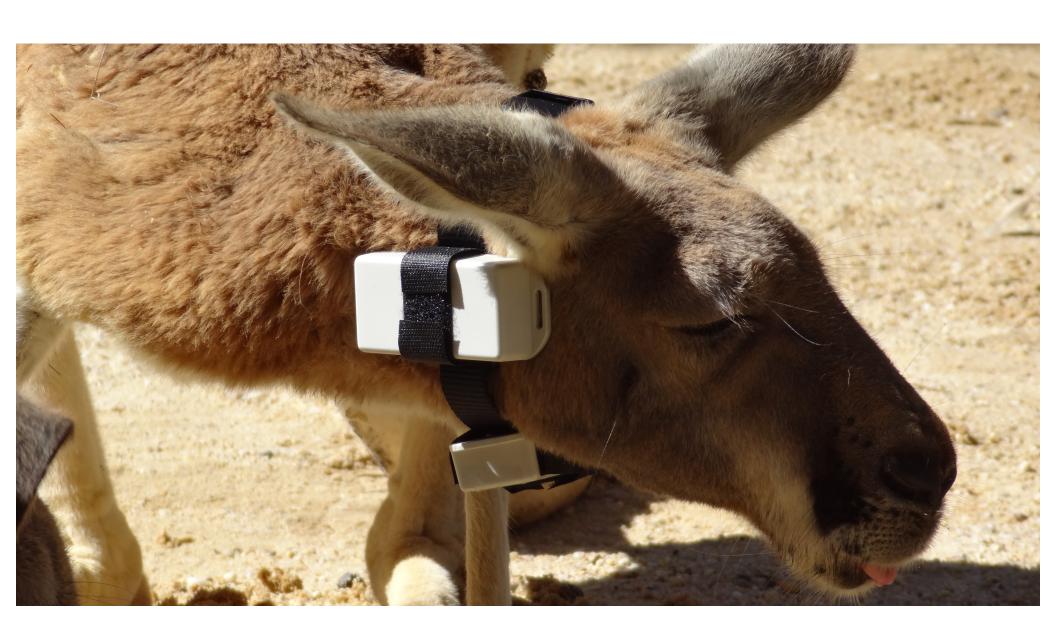
Spruce Bog

Lichen Woodland

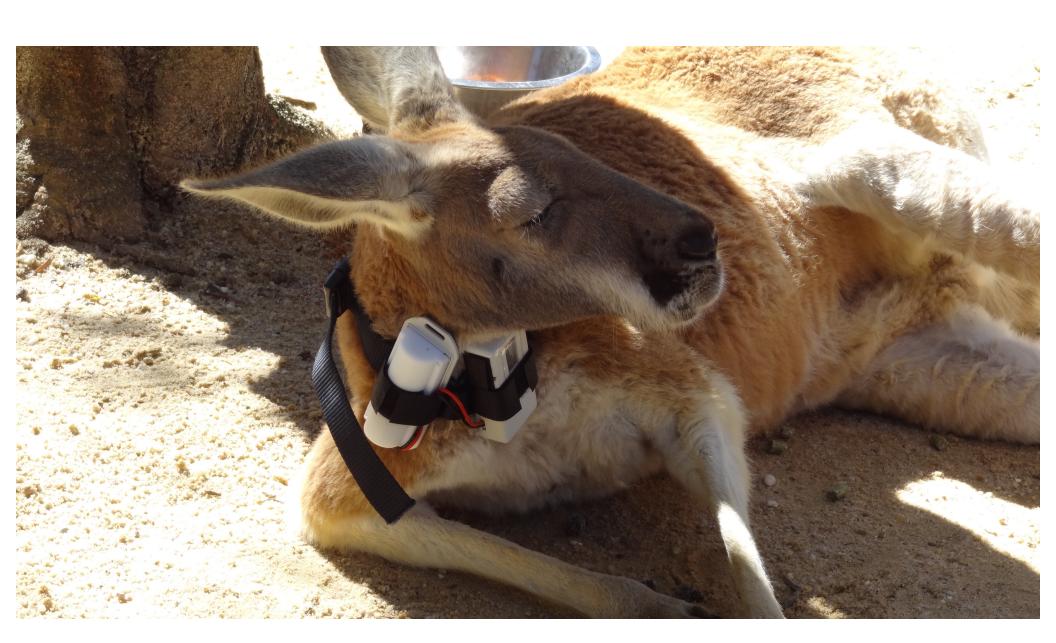


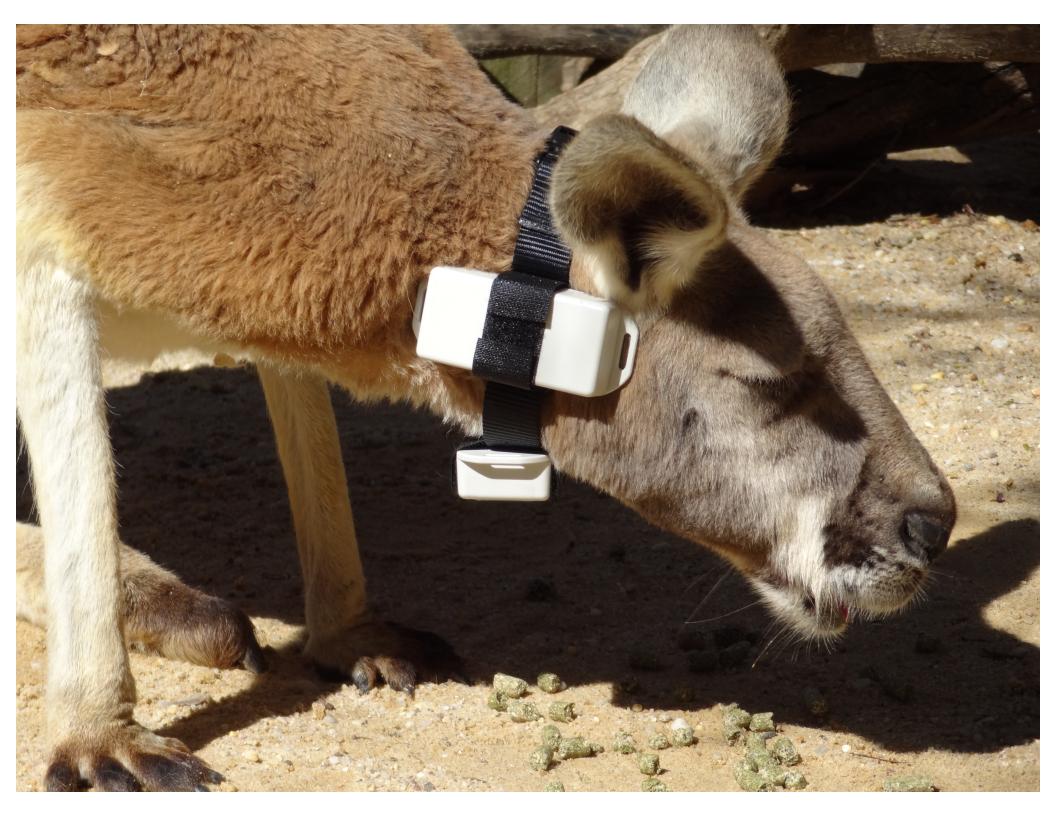


# At the zoo...



# Kangaroos and Nutritional Ecology







### And so much more...

- Kinesiology
- Graphics
  - Movie special effects
  - Video Games
- Sound Effects
- Finance
  - The banks (day trading, etc)
- Law
  - Patents
- The Environment









### And so much more...

- Basically anything you can imagine
  - And probably things you cannot



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  - And probably things you cannot

**QUESTIONS?** 

