CURTISS-WRIGHT

Defense Solutions Division

Hybrid Processors: Cores & Threads and Why You Should Care

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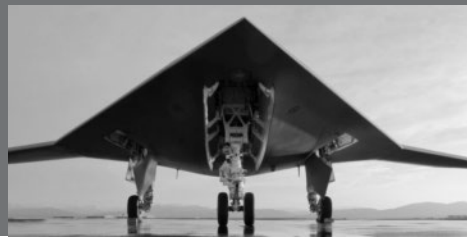
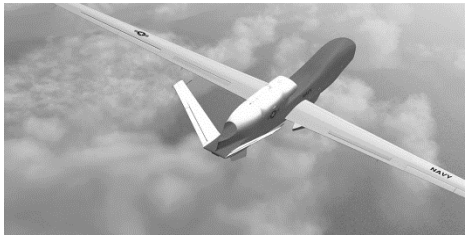
ETT, January 2024





TRUSTED PROVEN LEADER

CURTISS-WRIGHT

WHO uses a Laptop Computer?

WHAT’s inside your Cell Phone?

What about Embedded Technology in a Smart Kitchen or Car?

Consumer "Computer" vs. Embedded Systems – Why We Care

Consumer computing world is about "good enough"

- We hit SAVE and don't care what happens
- Few consequences if the SAVE takes 2-seconds or 3-seconds or a few more milliwatt-hours of power

Embedded is different

- An embedded system is designed to perform a specific function, either as an independent system or as a part of a large system
- Different than "using a computer" – embedded systems perform pre-determined functions
- RELIABLE and PREDICTABLE and ENERGY EFFICIENT

WE tightly control embedded designs to ensure they perform as expected

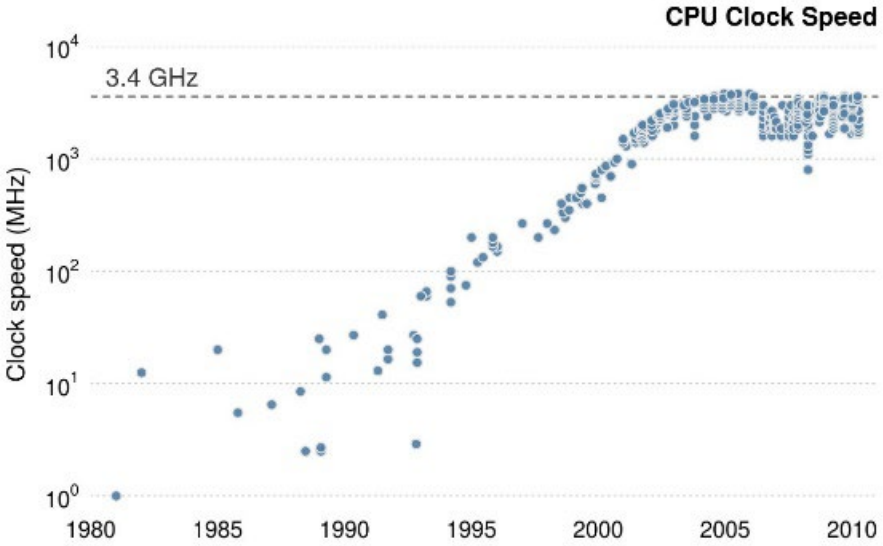
That's why we care about the details….

What's Changing for Embedded Systems?

Processor clocks approached their peaks in the 2000's

Single-Tasking became Multitasking

A new approach was needed to do more in less time



The answer to "faster" lies in a better ability to multitask

Hardware Solutions for Multi-Tasking

2000 IBM introduced a dual-core processor: Power4

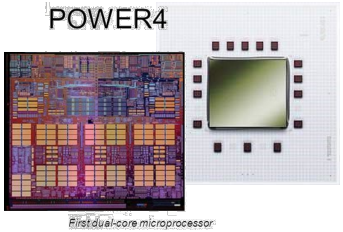
- AMD followed with Opteron then Intel followed with Core2

2002 Intel created their hyper-threading architecture

- PowerPC mimicked with their multi-threading cores
- Arm remains a single threading processor

2011 Arm introduced big.LITTLE

- Claiming up to 70% energy savings for common workloads
- LITTLE cores take up less silicon space
  - estimated 75% less than a big core



HYPER THREADING TECHNOLOGY
intel

arm
big.LITTLE

Intel Hybrid Architecture

INTEL® CORE™ PROCESSORS WITH INTEL® HYBRID TECHNOLOGY

2020 Intel creates the Hybrid Architecture

- Performance/Efficient (P/E) architecture began in 2020 with Lakefield
- Hits the mainstream with 12th gen Core "Alder Lake"
  - Performance = traditional high-performance hyper-threading – up to 8x → **P-cores** for primary "time-important" applications
  - Efficiency = lower performance, single-threading – up to 8x → → **E-cores** for less time-important processes

Intel's research on consumer processing:

- Majority of workloads do not scale beyond 4 cores
- Some workloads can scale to 8 cores but not higher
- Very few workloads can scale higher than 10 cores and continue to scale with core count

More Cores, More Threads: What could go wrong?

Analogy: driving cars on the freeway

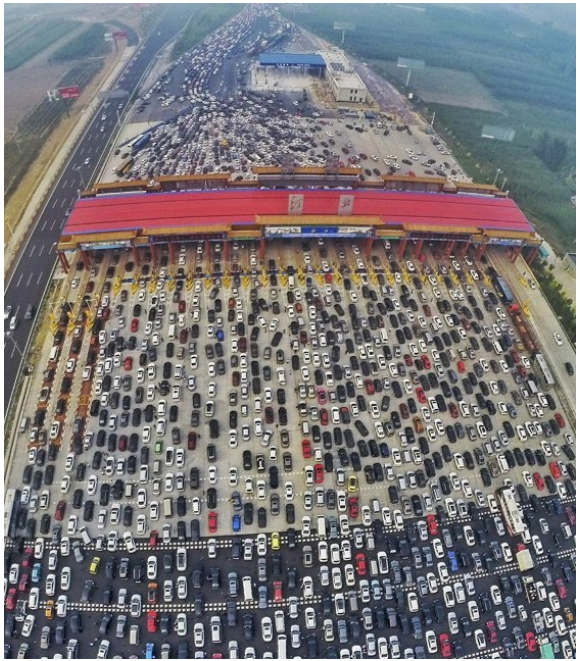
- GOAL: transport more people
- SOLUTIONS
  - Add more traffic lanes
  - Put more cars on the road
- Should scale, right?

TRAFFIC slows us down

- SHARED RESOURCES: we all use same roads, same on/off ramps, etc
- BOTTLENECKS exist

Processors with more cores will have more shared resource conflicts

- Cache memory, DRAM memory, storage, I/O interfaces, etc
- A 2-core processor will rarely ever beat 2 separate processors



MORE cores is better, but not N times faster for N-cores

The Magic of Marketing

Details Matter for the Embedded Designer

Will More Cores Make You Faster???

My previous laptop was a quad-core Intel i5

- No hyper-threading = 4 concurrent threads

New laptop is a 16-core Intel Alder Lake hybrid-core processor

- 16 physical cores, 8 of which are hyper-threading
- 24 logical cores to the OS

I am not 4x or 6x faster

Performance Details

How do you measure Performance?

Which laptop would you prefer?

- 1-core processor operating at 60 GHz?
- 4-core processor operating at 15 GHz?
- 20-core processor operating at 3 GHz?

All provide 60G “core Hz” performance

Confused?

Applications Matter

- When running a single task application, the super-fast 1-core would produce the answer quicker
- When running a real-world multitasking application in a multitasking operating system, the 4-core or 20-core would be a better choice

Embedded designers must consider software architectures

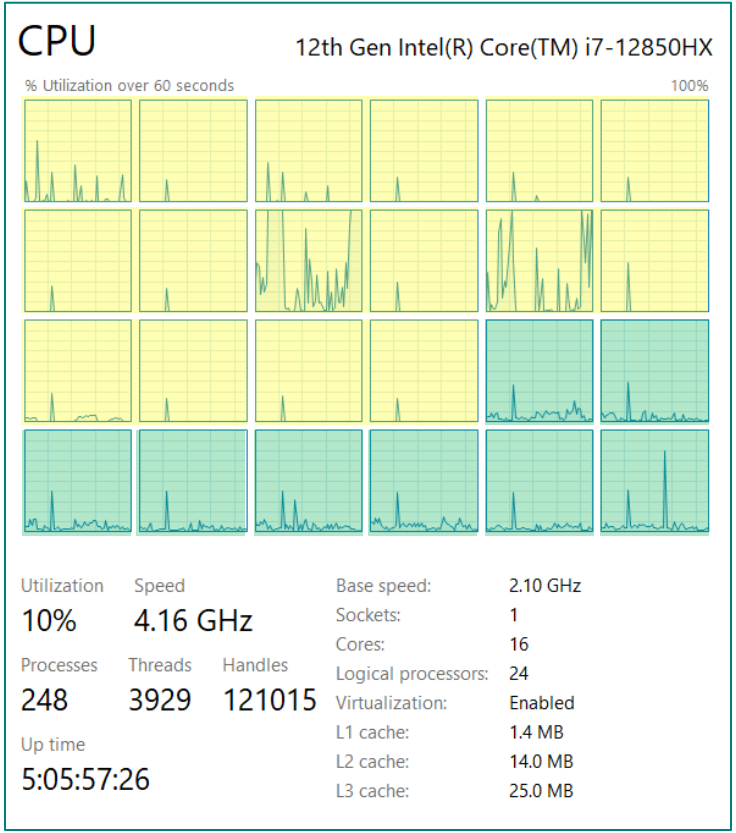
Applications Matter – General Purpose Computing

My Windows desktop ➔

- 16-core processor with 24 threads
  - 8x P-cores (16-threads)
  - 8x E-cores (8-threads)
- 248 processes, 3,929 threads!

Intel Thread Director helps the OS choose the right core for the job

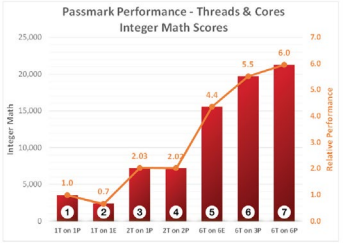
- Foreground vs. background
- Tasks with I/O bottlenecks
- Task QoS settings
- AC .vs. battery power

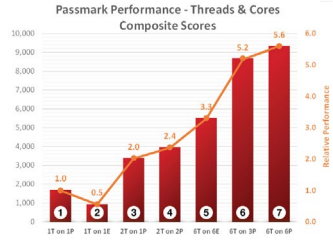


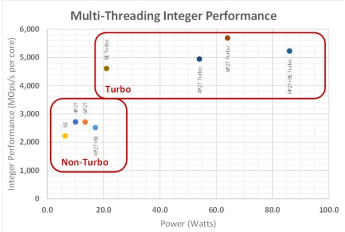
Performance Details

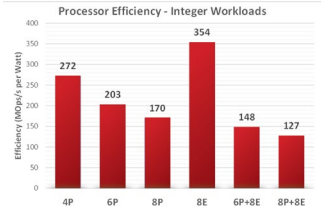
Compared to a single core

- Hyper-threading cores perform slightly less than 2x
- Multiple independent cores also perform slightly less than 2x
- E-cores offer ~70% performance at 50% power consumption
  ➔ higher power efficiency









Intel Core Generation	Family Name	Processor SKU	Core Config.	Threads
4th Gen Core	Haswell	i7-4700EQ	4P	8
5th Gen Core	Broadwell	i7-5850EQ	4P	8
5th Gen Xeon D	Broadwell DE	Xeon D-1559	12P	24
9th Gen Core	Coffee Lake	E-2276ME	6P	12
10th Gen Ice Lake Xeon D	Ice Lake D	D-1700 (LCC) D-2700 (HCC)	10P 20P	20 40
11th Gen Core	Tiger Lake	W-11865MRE	8P	16
13th Gen Core	Raptor Lake	i7-13800HRE	6P+8E	20

Benefits of Hybrid Processors

Your phone lasts all day

- Approx 70% of today's smartphones run on Arm big.LITTLE
- Even though it's constantly "on" and most of the time - there's no active user…

Your laptop lasts longer

- More efficient use of power when running on battery power

Consumer Processing

- Intel will continue with Hybrid processors offering choice of CPU mix
  - All P-core, all E-core, hybrid mix of P and E cores

Embedded Systems

- Ability to run in low-power modes until performance is needed
- More deterministic performance for foreground activities
- Embedded designers can choose the most appropriate cores for tighter control over performance and power

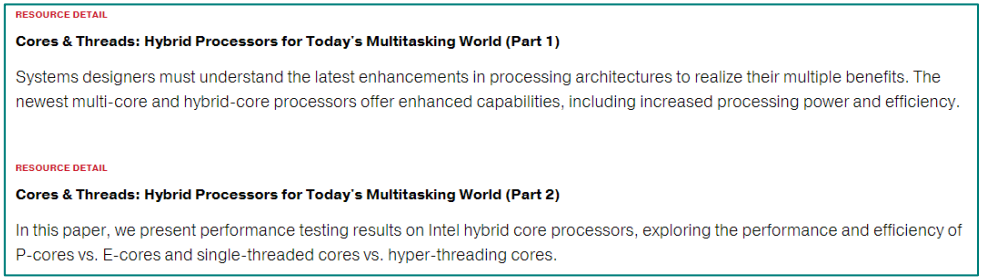
Cores & Threads: Hybrid Processors for Today's Multitasking World

2-part white paper

- https://www.curtisswrightds.com/resources/white-papers/cores-threads-hybrid-processors-multitasking-world-part-1
- https://www.curtisswrightds.com/resources/white-papers/cores-threads-hybrid-processors-multitasking-world-part-2

OR

- www.curtisswrightds.com
  and search for “cores & threads”



RESOURCE DETAIL

Cores & Threads: Hybrid Processors for Today's Multitasking World (Part 1)

Systems designers must understand the latest enhancements in processing architectures to realize their multiple benefits. The newest multi-core and hybrid-core processors offer enhanced capabilities, including increased processing power and efficiency.

RESOURCE DETAIL

Cores & Threads: Hybrid Processors for Today's Multitasking World (Part 2)

In this paper, we present performance testing results on Intel hybrid core processors, exploring the performance and efficiency of P-cores vs. E-cores and single-threaded cores vs. hyper-threading cores.

The End

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Q&A

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