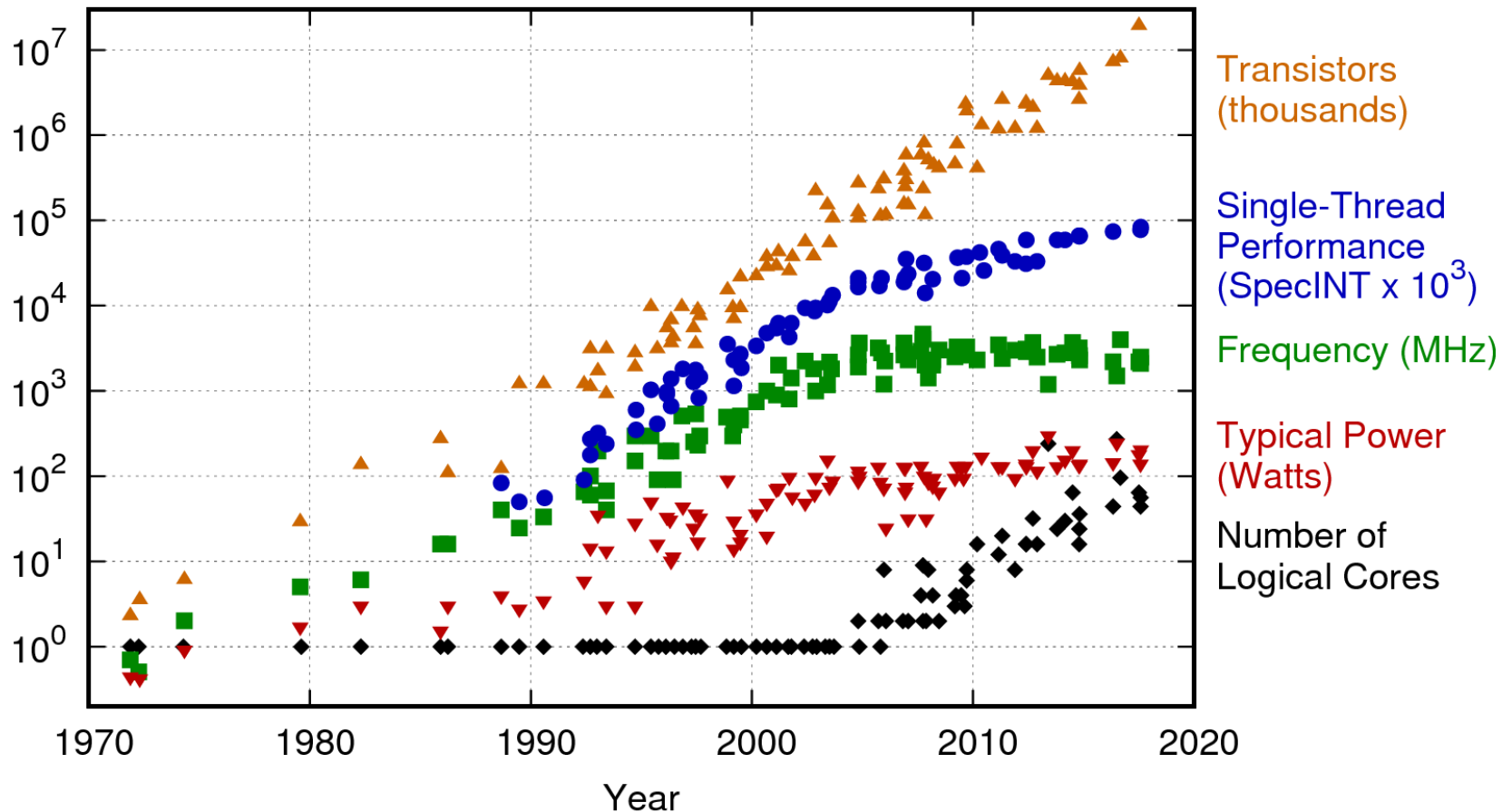


# Concurrent Computing

# Microprocessor Trends

42 Years of Microprocessor Trend Data



Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten  
New plot and data collected for 2010-2017 by K. Rupp

# Definitions

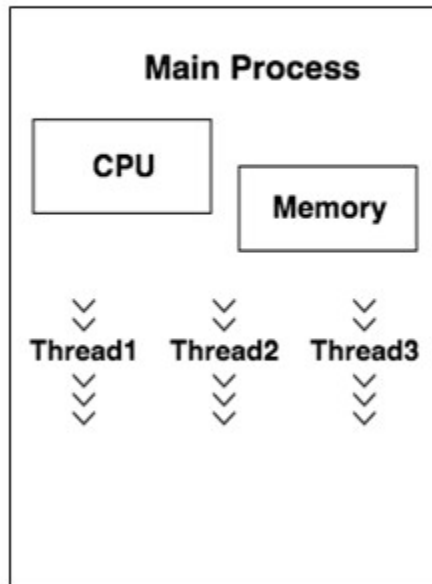
- **Concurrency** means that an application **is making progress** on more than one task at the same time (concurrently).
- **Parallelism** means that an application splits its tasks up into smaller subtasks which can be processed in parallel, for instance on multiple CPUs at the exact same time.

# Three Types of Task

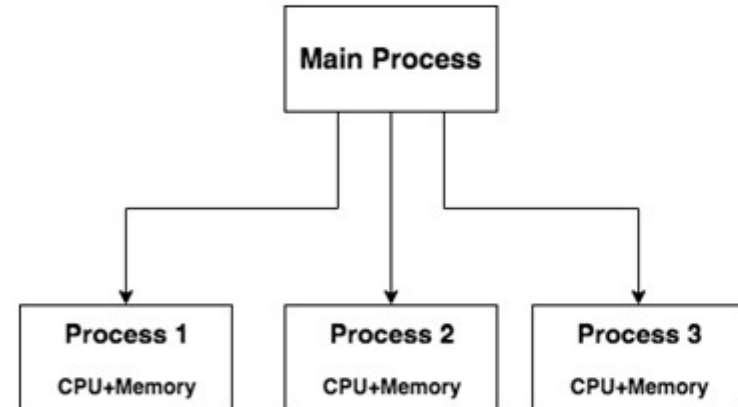
- **I/O Bound** - situation where the time it takes to complete a computation is determined principally by the period spent waiting for **input/output** operations to be completed.
- **CPU Bound** - situation where the time it takes to complete a computation is determined principally by speed of the CPU.
- **Memory Bound** - situation where the ability to complete a computation is limited by availability of memory.

# Threads and Processes

## Multithreading



## Multiprocessing



# Serial Processing (IO Bound Task)



# Serial Processing (IO Bound Task)

Req 1   Wait 1   Store 1



# Serial Processing (IO Bound Task)

Req 1	Wait 1	Store 1	Req 2	Wait 2	Store 2
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# Serial Processing (IO Bound Task)



# Multithreading (IO Bound Task)

Thread 1

Thread 2

Thread 3



# Multithreading (IO Bound Task)

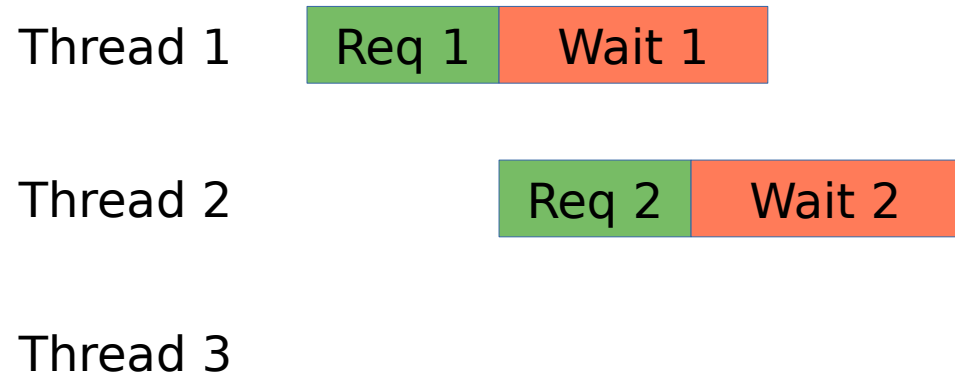
Thread 1    Req 1    Wait 1

Thread 2

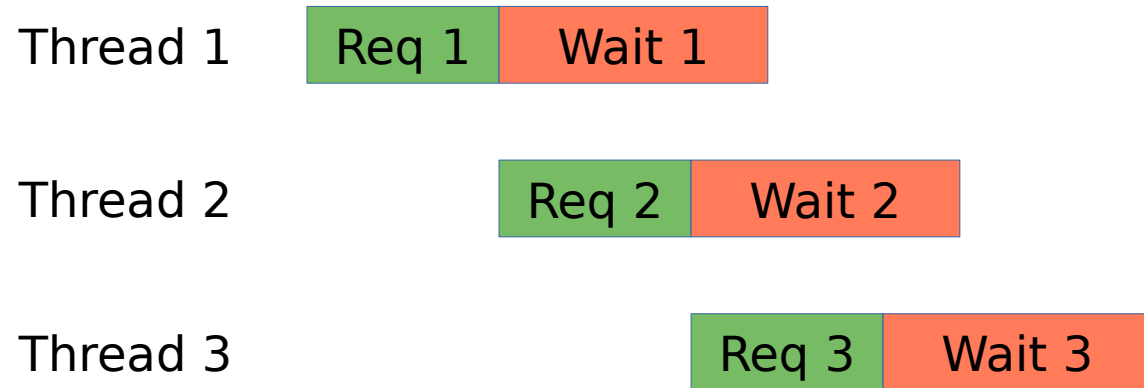
Thread 3



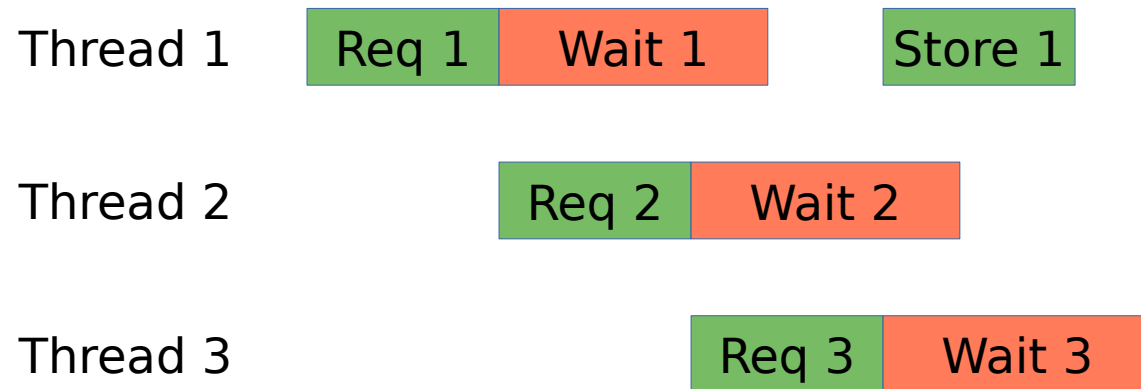
# Multithreading (IO Bound Task)



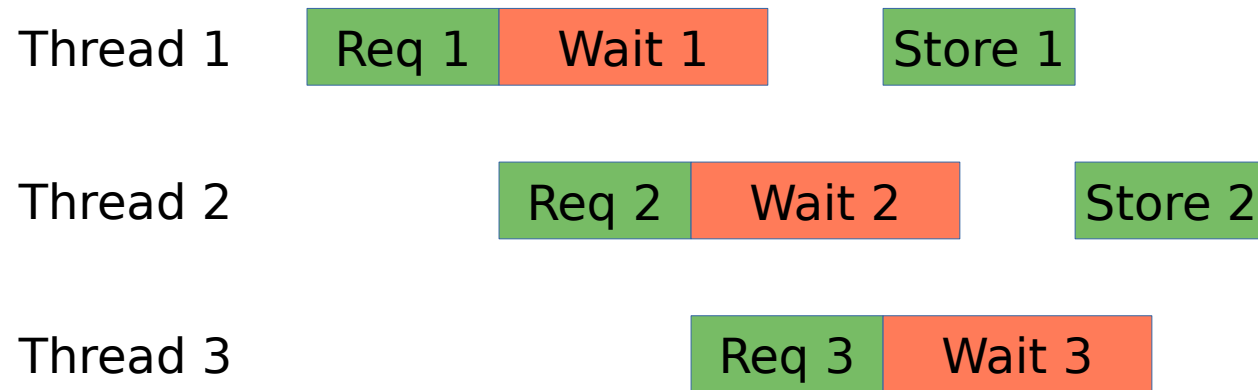
# Multithreading (IO Bound Task)



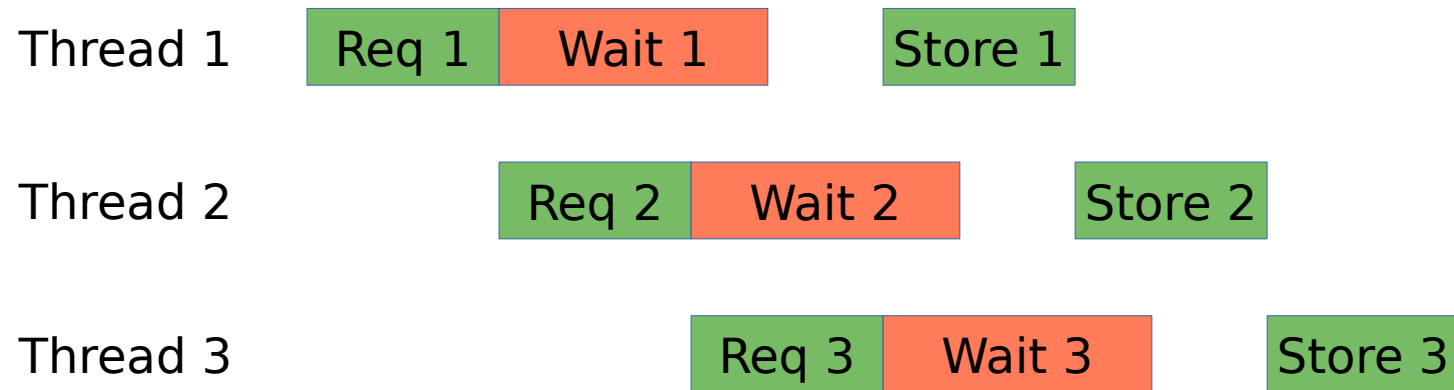
# Multithreading (IO Bound Task)



# Multithreading (IO Bound Task)

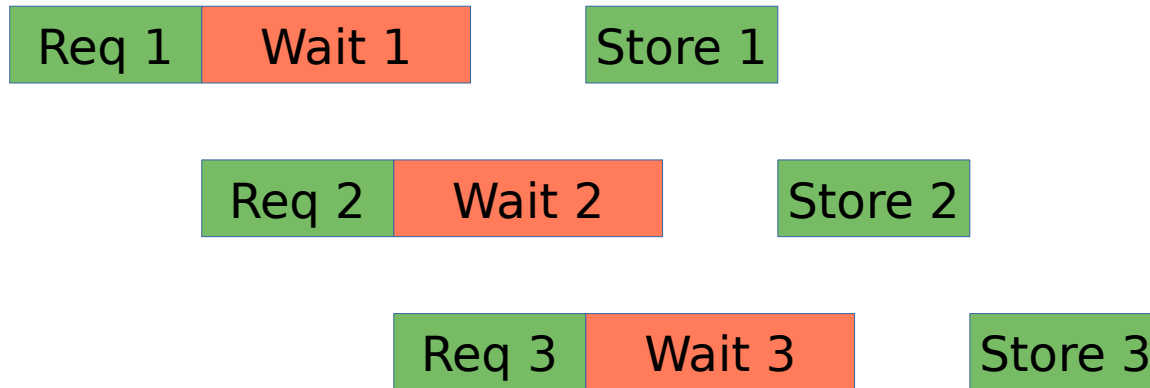


# Multithreading (IO Bound Task)





# Serial vs Multithreading (IO Bound Task)



# Serial Processing (CPU Bound Task)



# Serial Processing (IO Bound Task)

Compute 1

Store 1

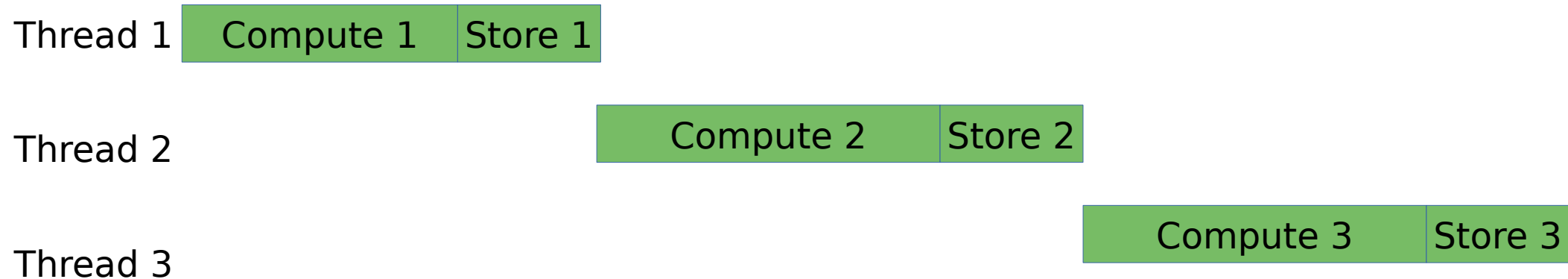
Compute 2

Store 2

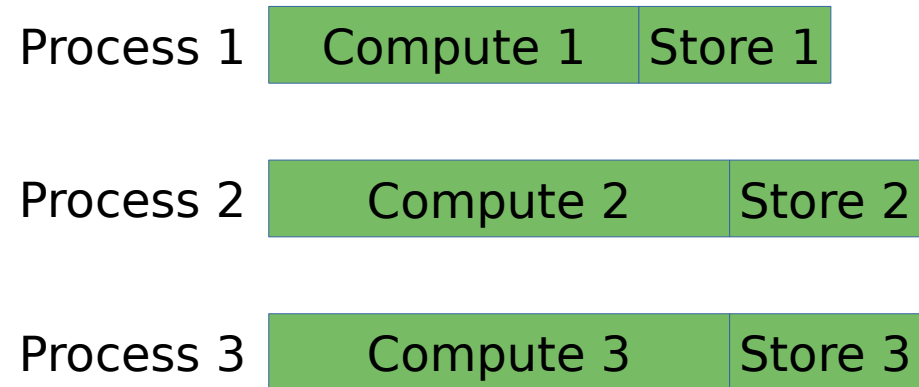
Compute 3

Store 3

# Multithreading (CPU Bound Task)



# Multiprocessing (CPU Bound Task)



# Distributed Computing

