EE309 Advanced Programming Techniques for EE

Lecture 24: Modern systems

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[Slides from 15-213: Introduction to Computer Systems at CMU]

Systems

- A *system* is any collection of components combined to create an entity that is intended to accomplish some **particular task(s) or goal(s).**

- Three properties
  - Correctness: To accomplish the goal
  - Performance: To accomplish the goal *with many users*
  - Security: To accomplish the goal *with even malicious users*

What we have studied

- Files IO
- Allocation
- Buffer overflow
- Network programming
- Concurrent programming
- Cryptography

Moore’s Law Origins

April 19, 1965

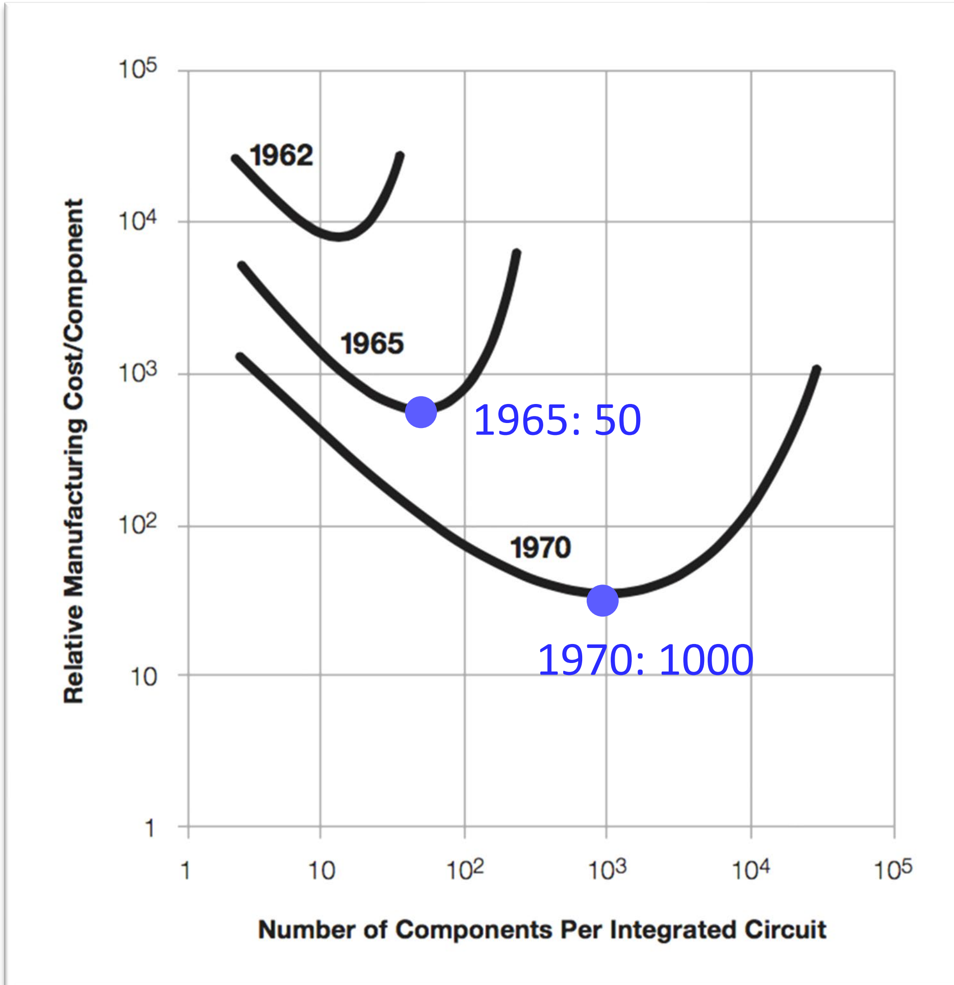
Cramming more components onto integrated circuits

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip

By Gordon E. Moore

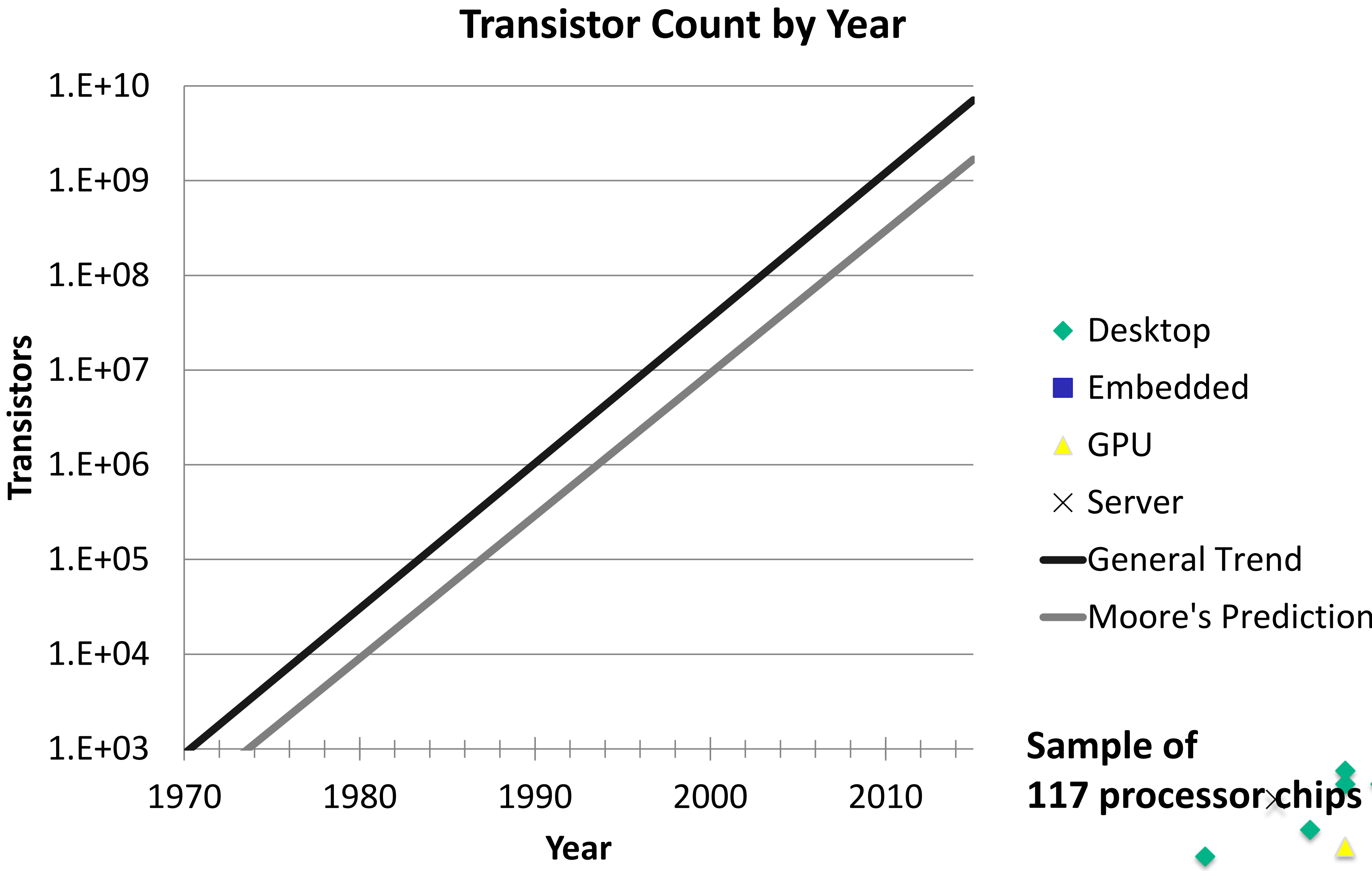
Director, Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.

Moore's Law Origins



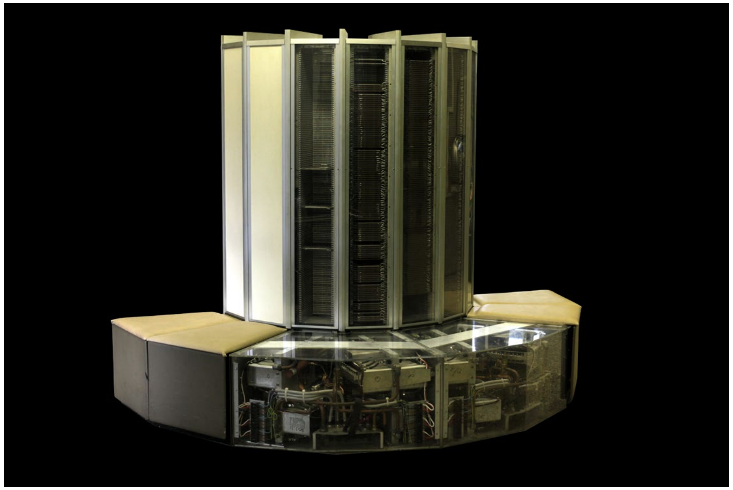
- **Moore's Thesis**
  - Minimize price per device
  - Optimum number of devices / chip increasing 2x / year
- **Later**
  - 2x / 2 years
  - "Moore's Prediction"

Moore’s Law: 50 Years



Sample of 117 processor chips

What Moore's Law Has Meant



- **1976 Cray 1**
  - 250 M Ops/second
  - ~170,000 chips
  - 0.5B transistors
  - 5,000 kg, 115 KW
  - $9M
  - 80 manufactured

- **2014 iPhone 6**
  - > 4 B Ops/second
  - ~10 chips
  - > 3B transistors
  - 120 g, < 5 W
  - $649
  - 10 million sold in first 3 days

What Moore's Law Has Meant

- **1965 Consumer Product**

- **2015 Consumer Product**

Apple A8 Processor
2 B transistors

What Moore's Law Could Mean

- **2015 Consumer Product**

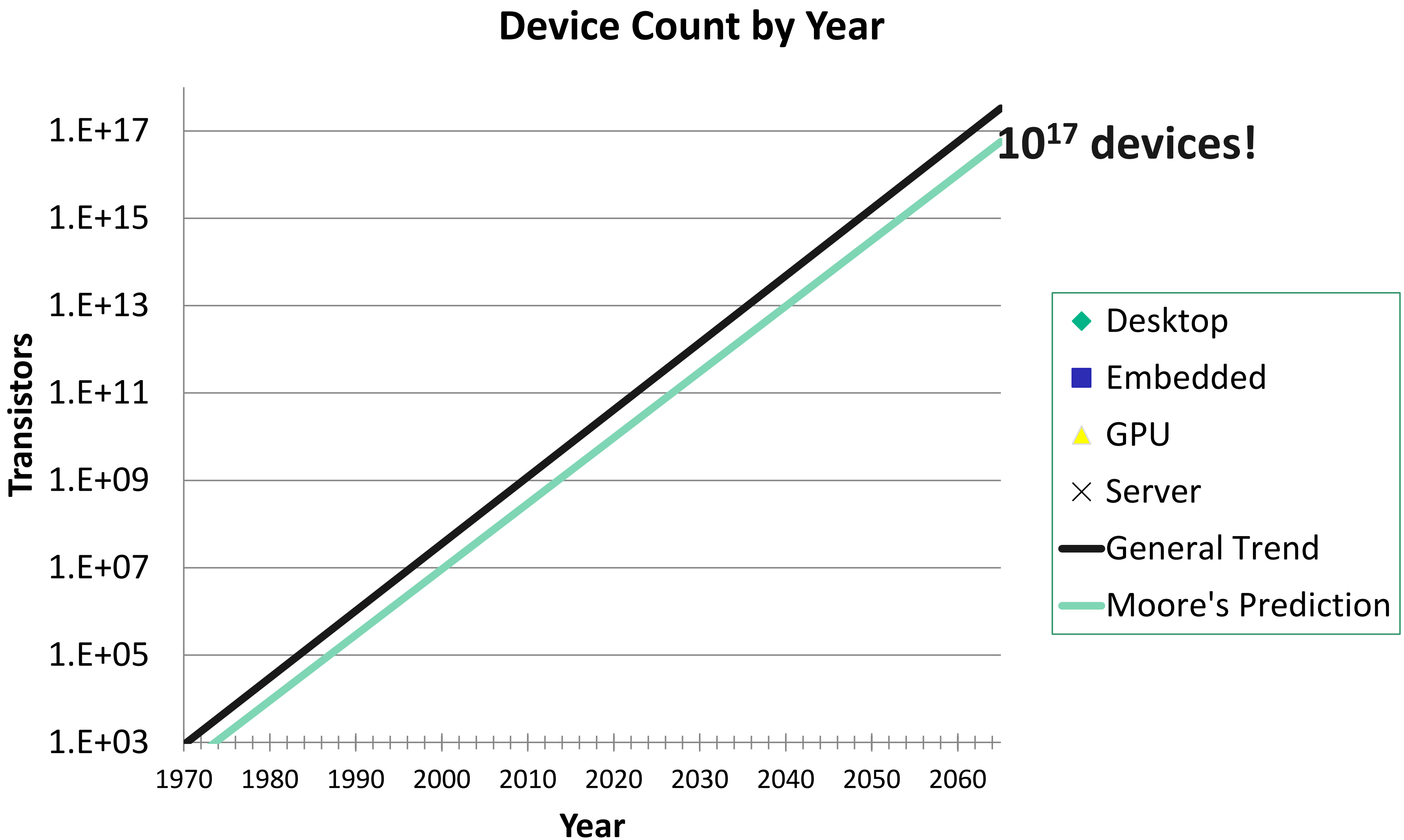
- **2065 Consumer Product**

  - Portable
  - Low power
  - Will drive markets & innovation

Requirements for Future Technology

- **Must be suitable for portable, low-power operation**
  - Consumer products
  - Internet of Things components
  - Not cryogenic, not quantum
- **Must be inexpensive to manufacture**
  - Comparable to current semiconductor technology
    - O(1) cost to make chip with O(*N*) devices
- **Need not be based on transistors**
  - Memristors, carbon nanotubes, DNA transcription, ...
  - Possibly new models of computation
  - But, still want lots of devices in an integrated system

Moore's Law: 100 Years



Visualizing 10^{17} Devices

If devices were the size of a grain of sand

$0.1\ m^3$
3.5×10^9 grains

1 million m^3
0.35×10^{17} grains

Increasing Transistor Counts

1. **Chips have gotten bigger**
   - 1 area doubling / 10 years
2. **Transistors have gotten smaller**
   - 4 density doublings / 10 years

Will these trends continue?

Reaching 2065 Goal

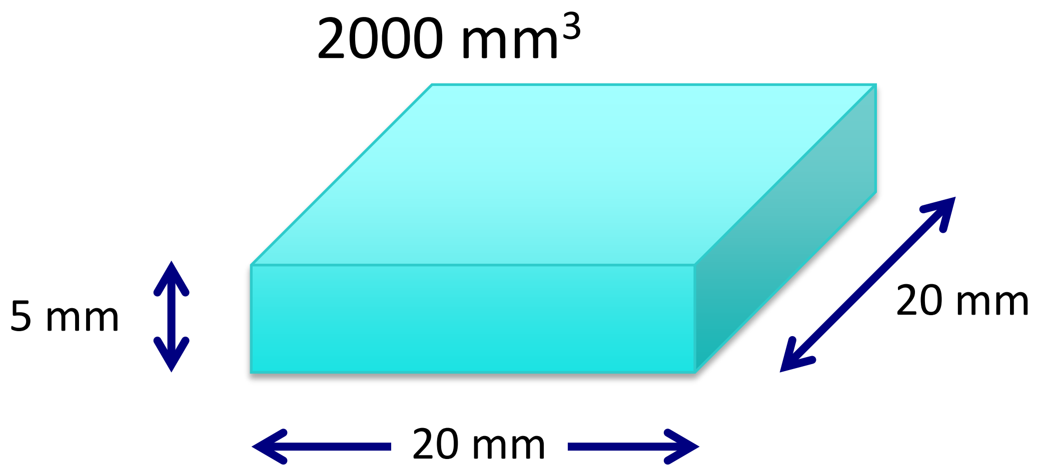
- **Target**
  - 10^{17} devices
  - 400 mm^2
  - L = 63 pm

- **Is this possible?**

No!

Not with 2-d fabrication

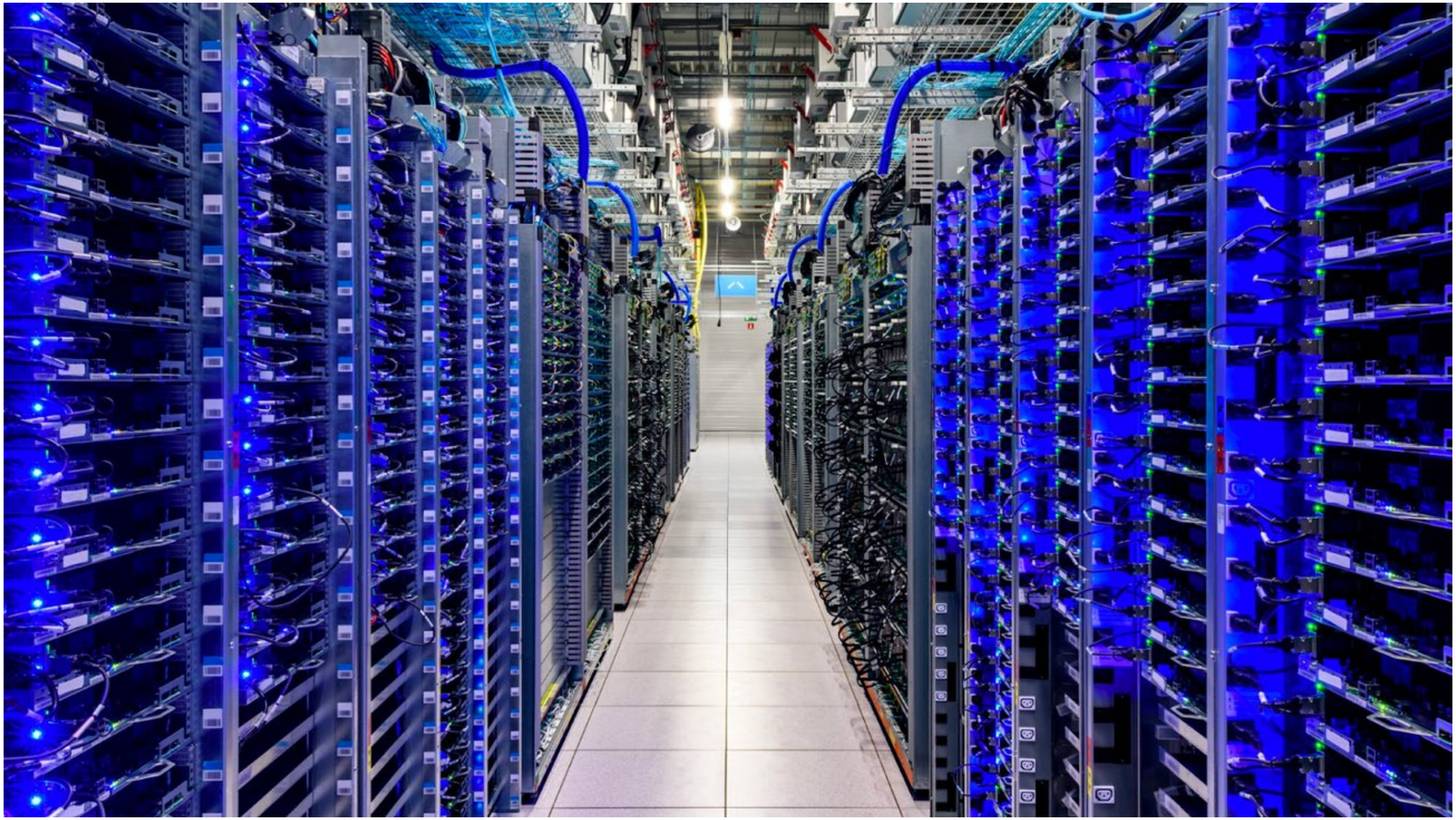
Fabricating in 3 Dimensions



- **Parameters**
  - 10^{17} devices
  - 100,000 logical layers
    - Each 50 nm thick
    - ~1,000,000 physical layers
      - To provide wiring and isolation
  - *L* = 20 nm
    - 10x smaller than today

2065 mm^3

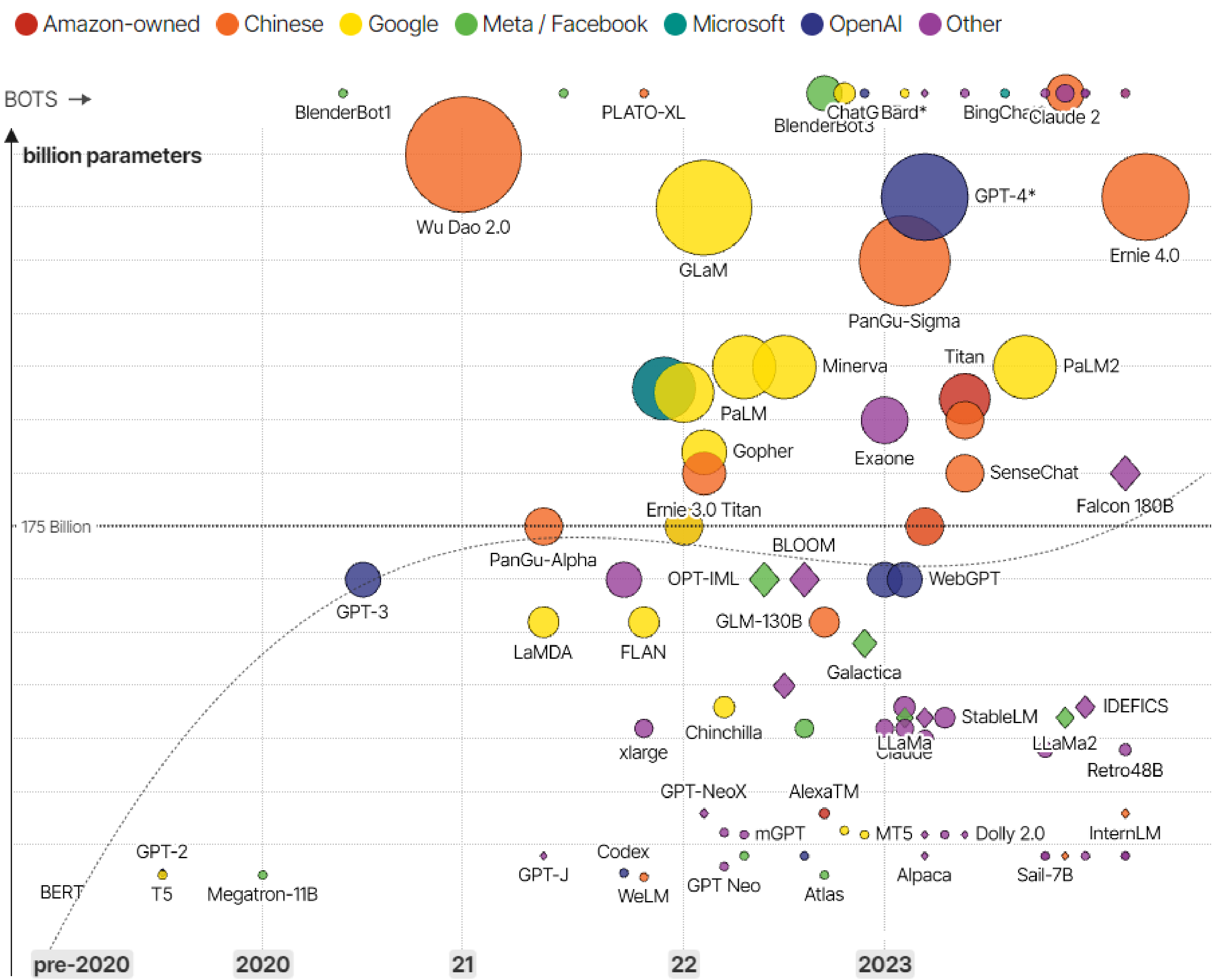
Towards scalability



Distributed system

The Rise and Rise of A.I. Large Language Models (LLMs) & their associated bots like ChatGPT

KAIST



David McCandless, Tom Evans, Paul Barton

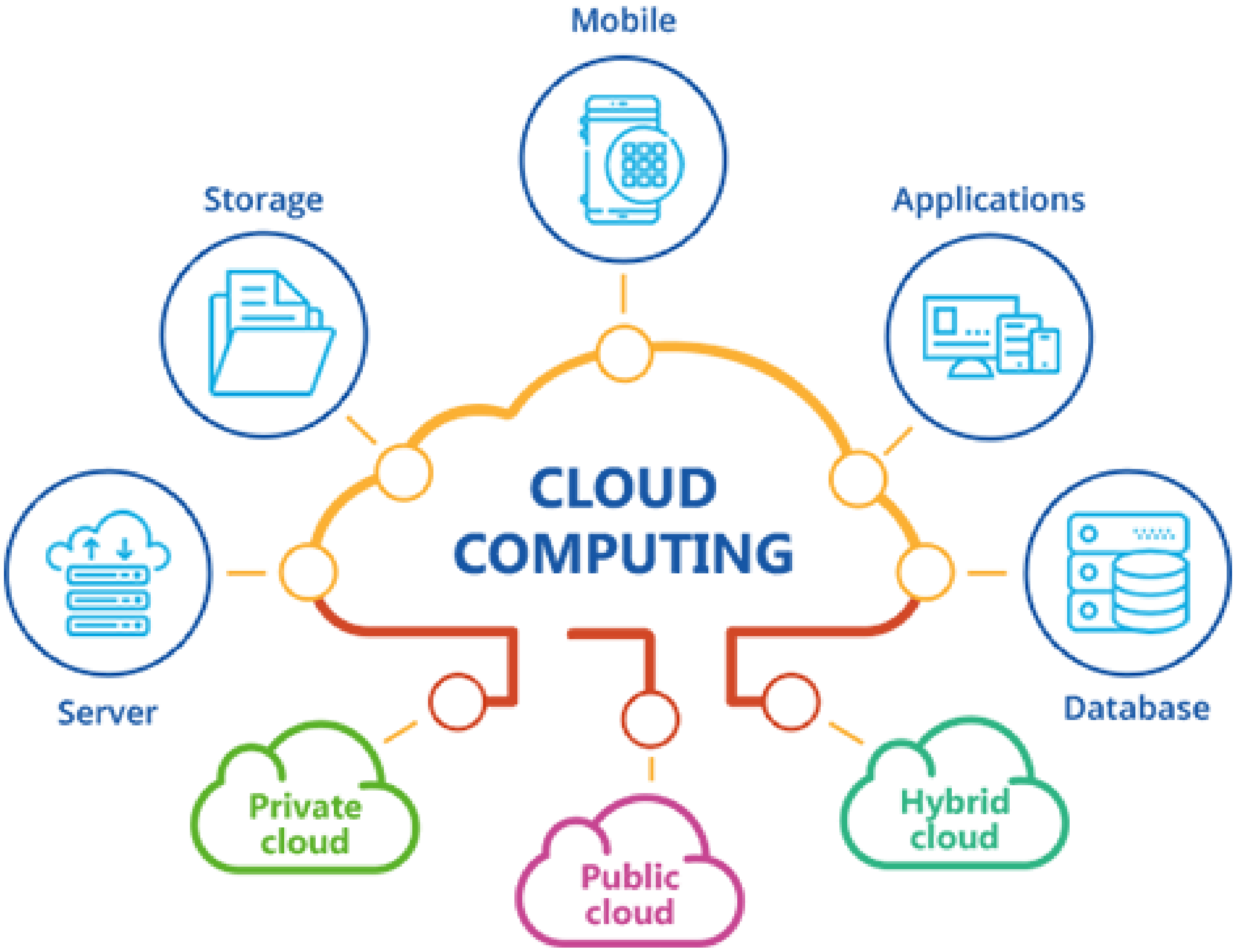
Information is Beautiful // UPDATED 2nd Nov 23

source: news reports, LifeArchitect.ai

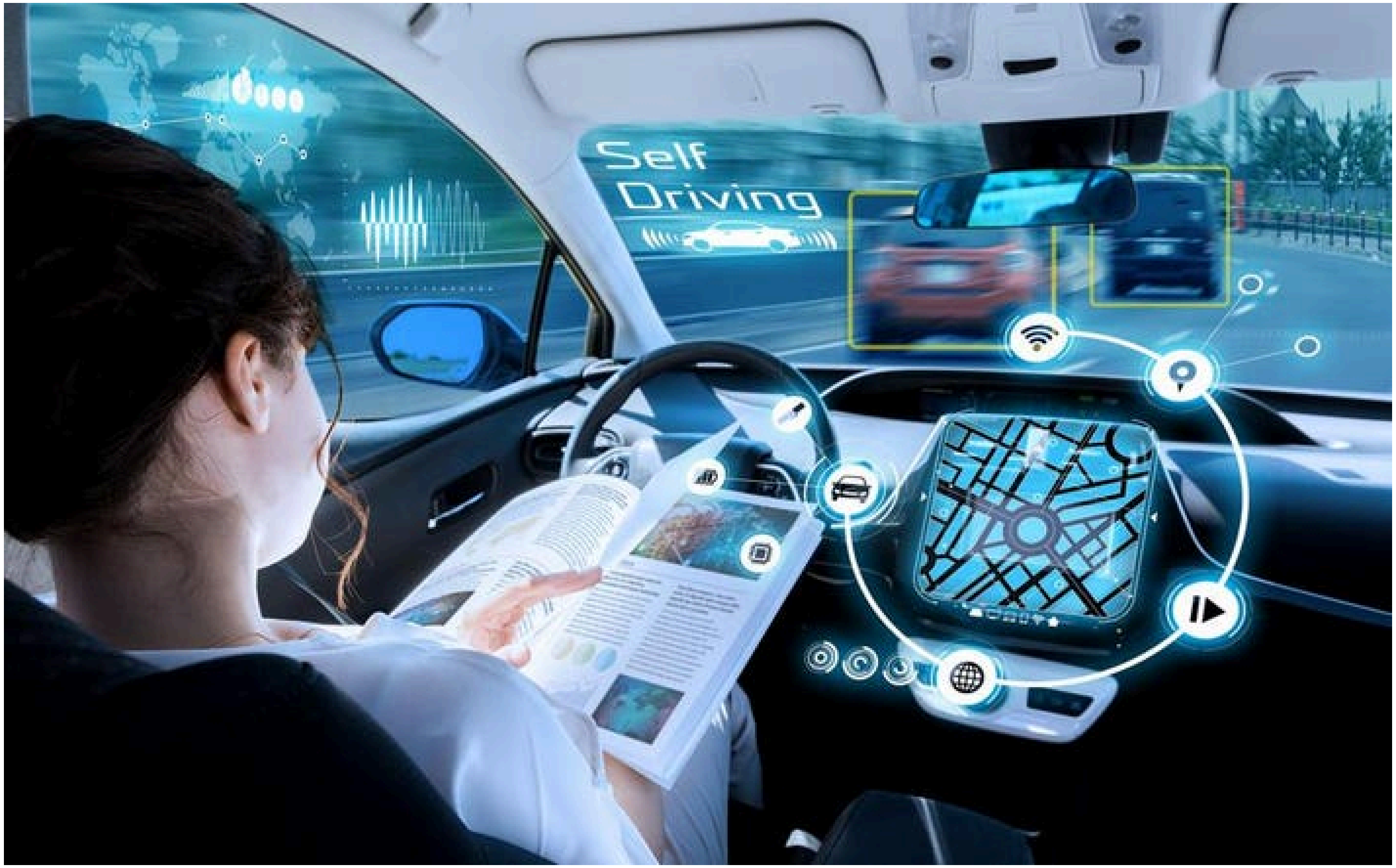
* = parameters undisclosed // see the data

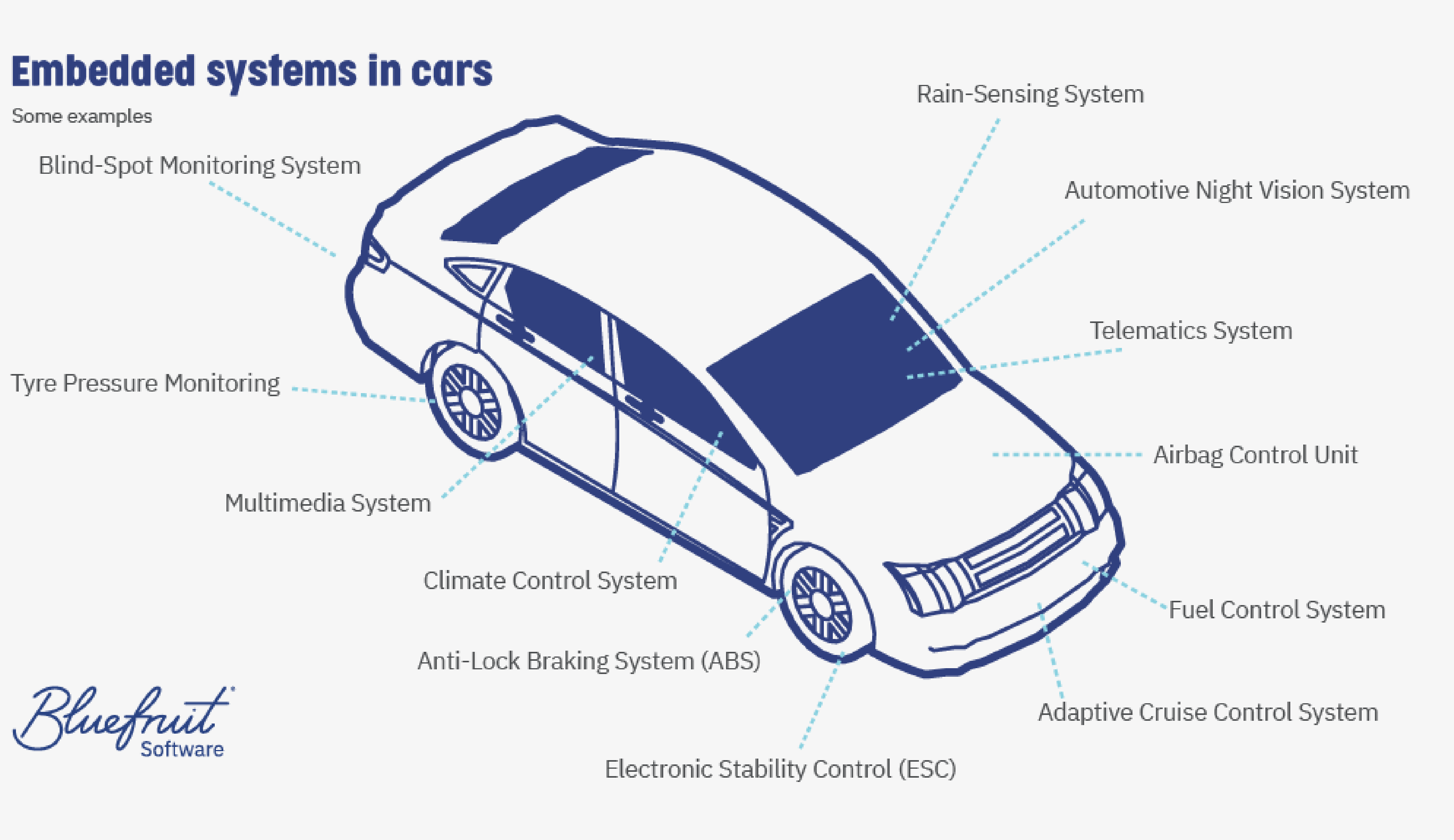
MADE WITH VIZsweet

Cloud computing

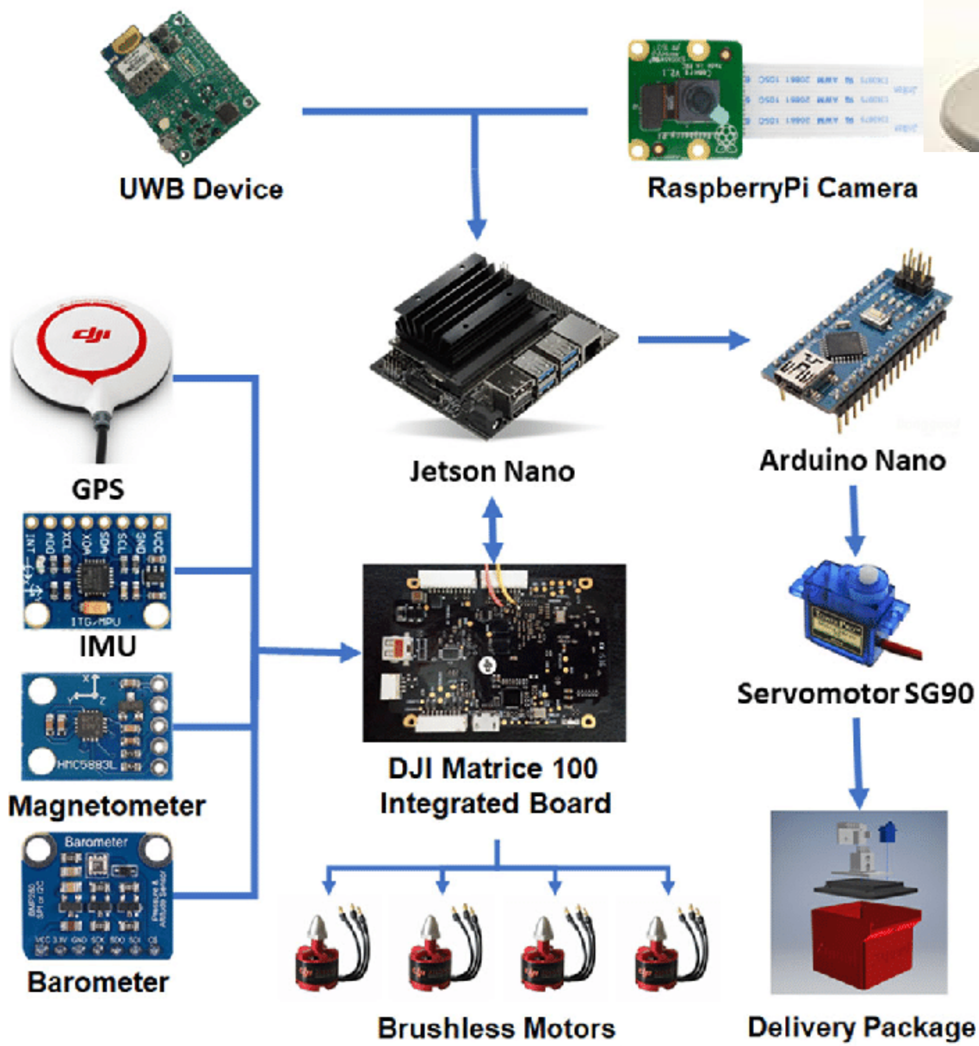


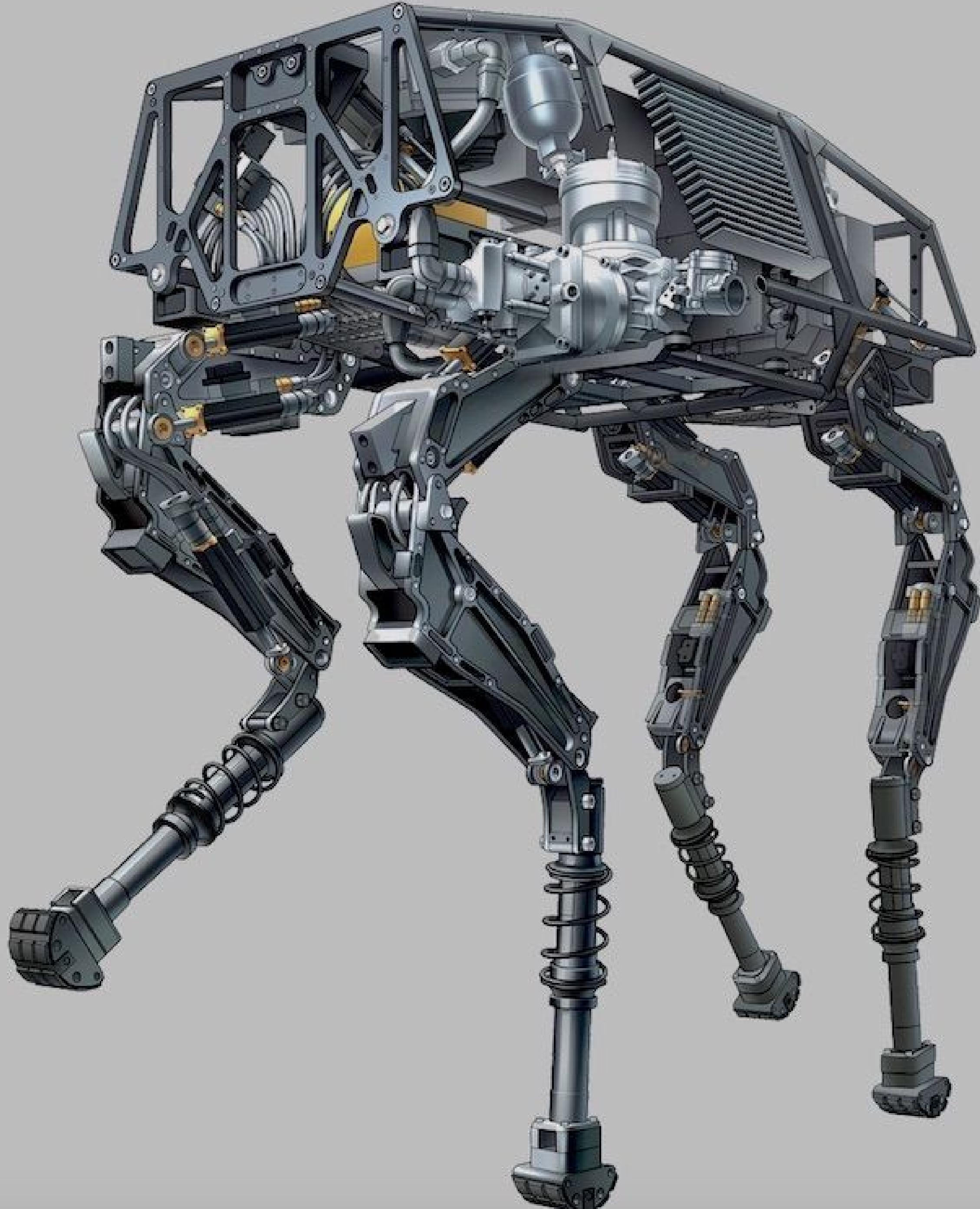
Cyber Physical Systems




Embedded systems in cars
Some examples
Blind-Spot Monitoring System
Rain-Sensing System
Automotive Night Vision System
Telematics System
Tyre Pressure Monitoring
Airbag Control Unit
Multimedia System
Climate Control System
Fuel Control System
Anti-Lock Braking System (ABS)
Adaptive Cruise Control System
Electronic Stability Control (ESC)
Bluefruit Software

Cyber Physical Systems





Operating system

Next courses?

- EE323: Computer network
- EE324: Network programming

- EE412: Introduction to Big Data analytics
- EE414: Embedded system

- EE415: Operating system for Electrical engineering