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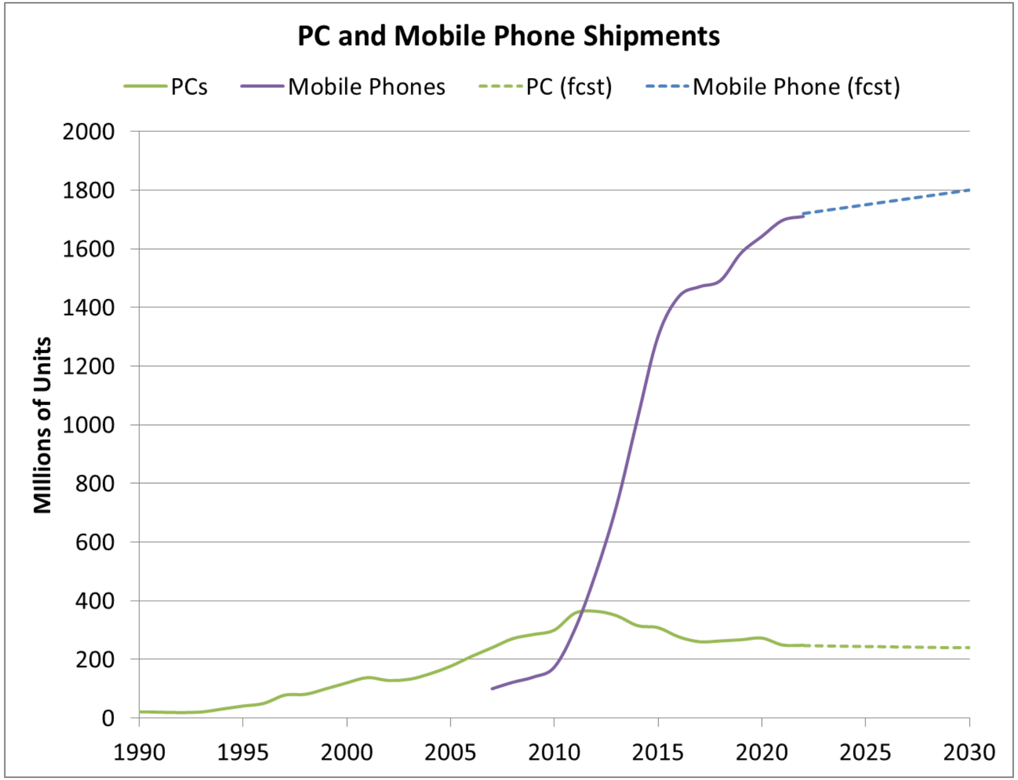
Is Big Data the next big thing for Semiconductor Test?

Rick Burns, VP Engineering

What is the next big thing?

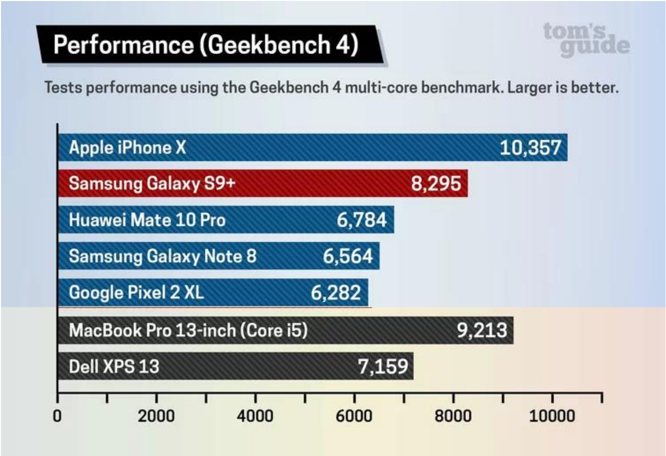


Source: Market Watch and Teradyne Internal Estimates

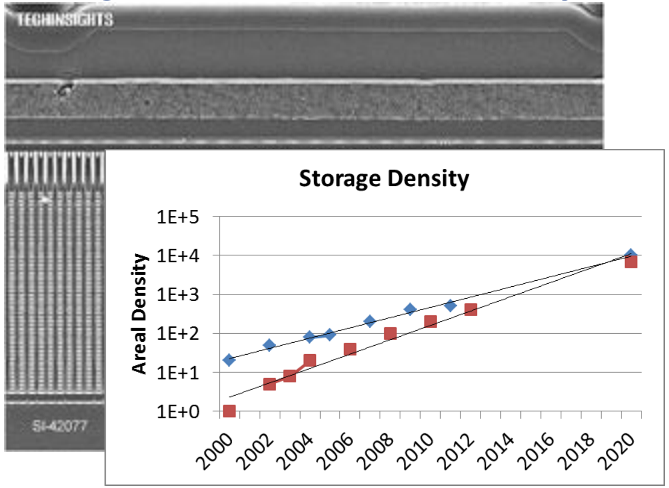
- From 1990 to 2008, the primary driver of the semiconductor industry was the personal computer
- From 2008 to 2020, the primary driver is the Mobile Phone
- But the period of explosive growth is behind us.
- What comes next?
- Is it big enough to sustain the growth of the semiconductor industry?

What else do you need from a smart phone?

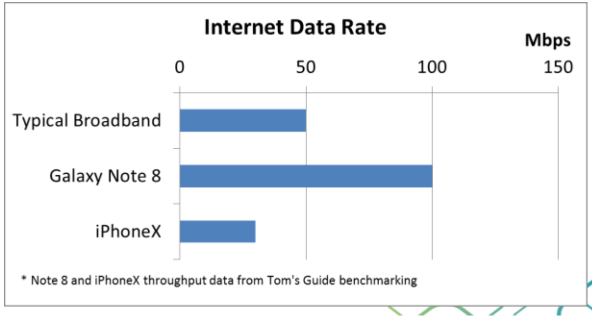
Incredibly Fast Processors



Huge, Fast Flash Memory



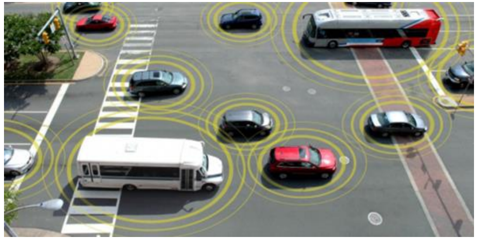
Gigabit Network Speeds



Emerging applications

Natural Language Processing

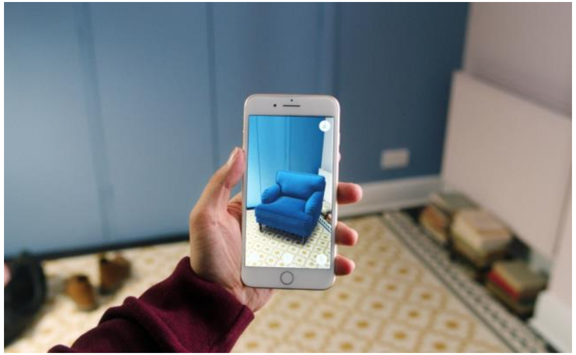
Autonomous Vehicles



Personal Medicine

Facial and Image Recognition

Augmented Reality



These applications need:

- Processing power
- Storage
- Network bandwidth

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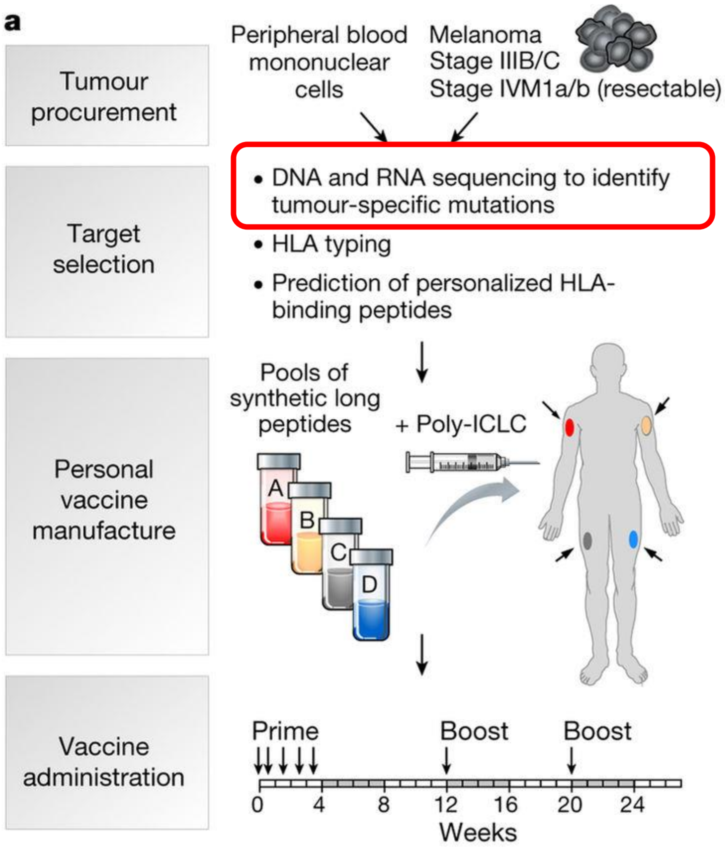
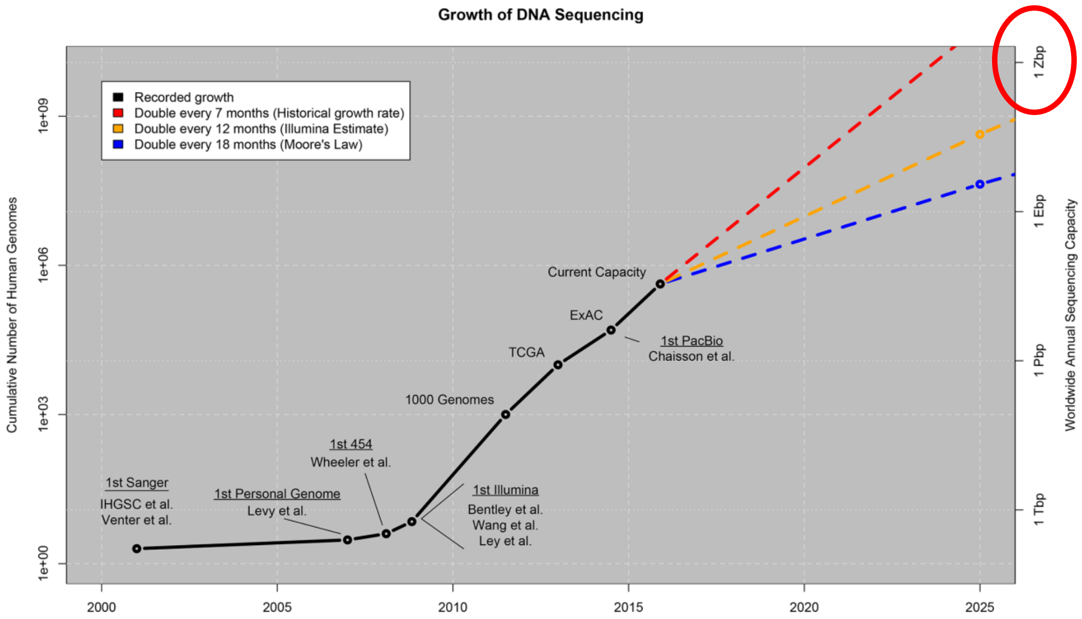
Personalized Cancer Vaccine – Drives Storage

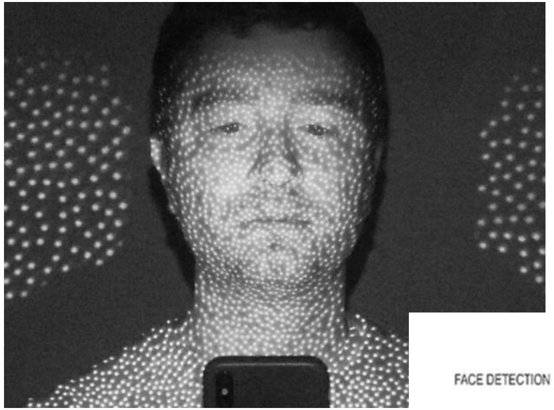




From: An immunogenic personal neoantigen vaccine for patients with melanoma
Patrick A. Ott, Zhuting Hu[…]Catherine J. Wu
Nature 547, 217–221 (13 July 2017)

Human Genome → 3Gbp per cell
3 Gbp → 1Gbyte
14 million new cancer cases per year
Up to 1Zbp of sequencing per year
Or 0.5 ZB of storage per year

Facial Recognition – Needs Processing Power



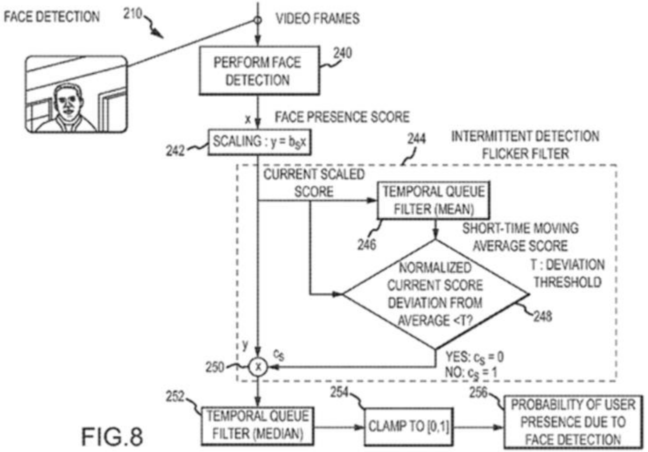
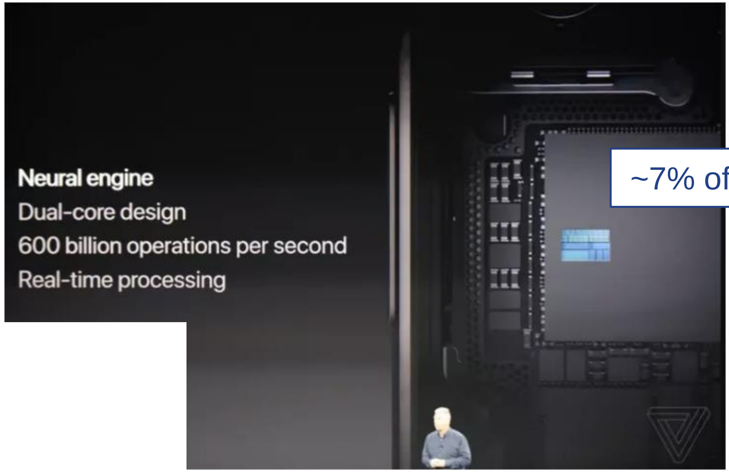
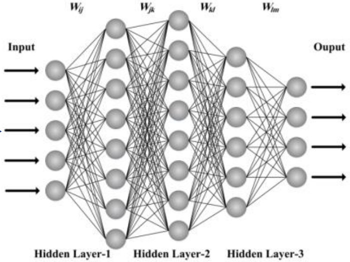


FIG.8



~7% of die area



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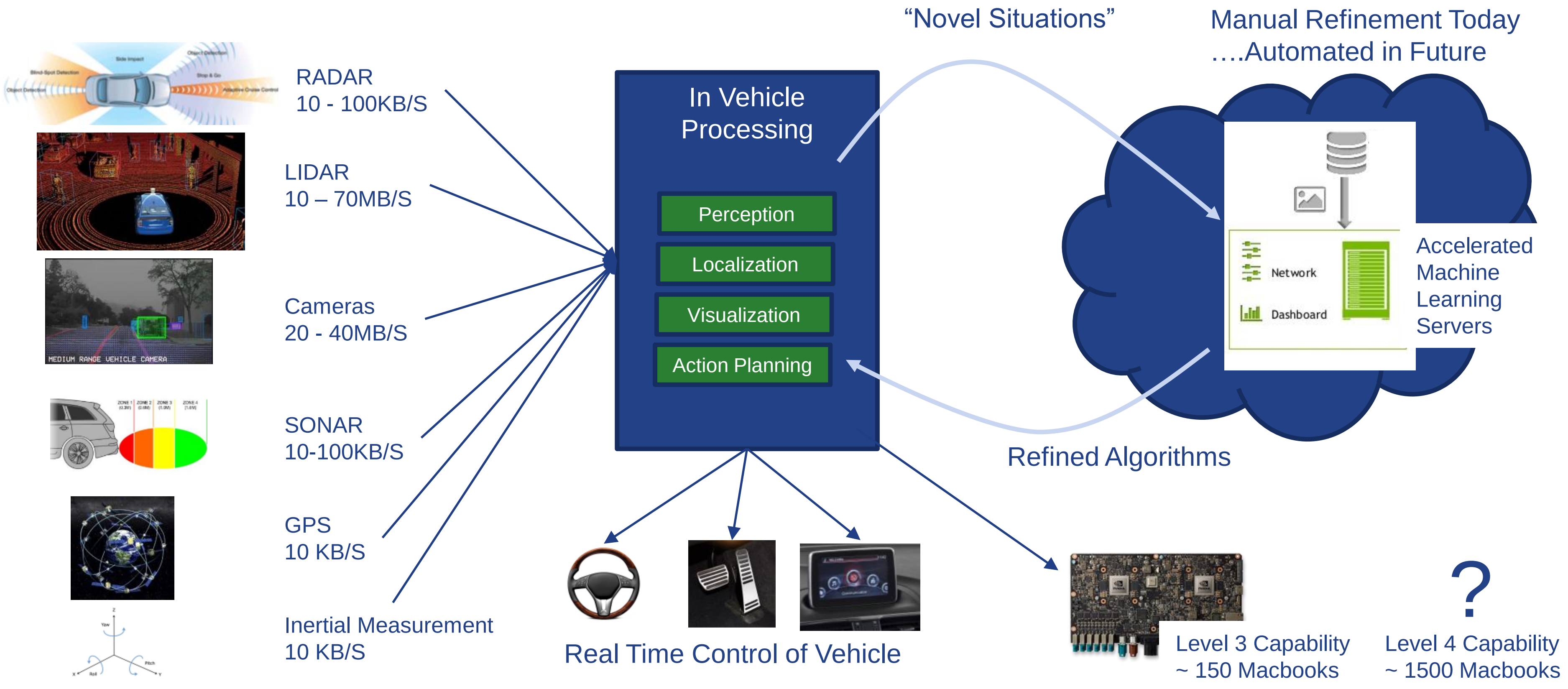
Autonomous Driving = Rolling Big Data Centers



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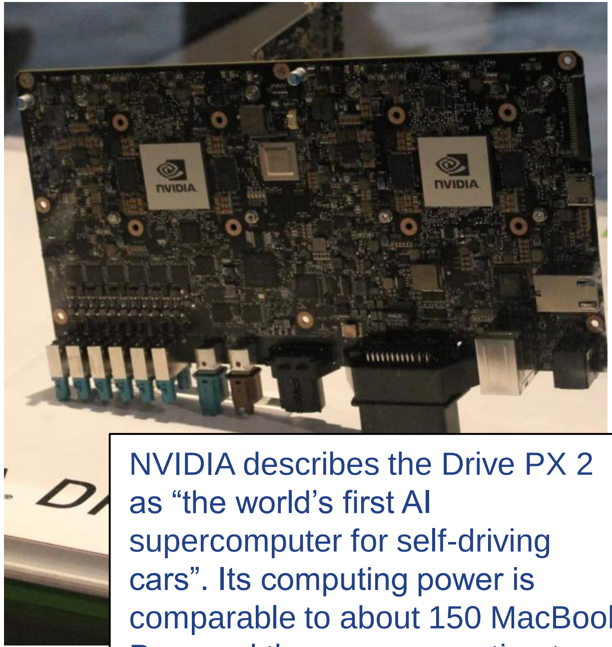
Rapid development of in-Vehicle Processors

Today



NVIDIA describes the Drive PX 2 as "the world's first AI supercomputer for self-driving cars". Its computing power is comparable to about 150 MacBook Pros and the company estimates that one can support a level 3 self-driving system

Tomorrow

electrek

Automakers | Alt. Transport | Autonomous Driving | Energy

Tesla to make its own custom SoC (System on Chip) for self-driving cars built by Samsung, report says

In what could now possibly be a confirmation of the rumor, a report from South Korea suggests that Samsung Electronics signed a contract with Tesla to build an ASIC (Application-Specific Integrated Circuit) system – meaning to build its System on Chip with Samsung semiconductors.

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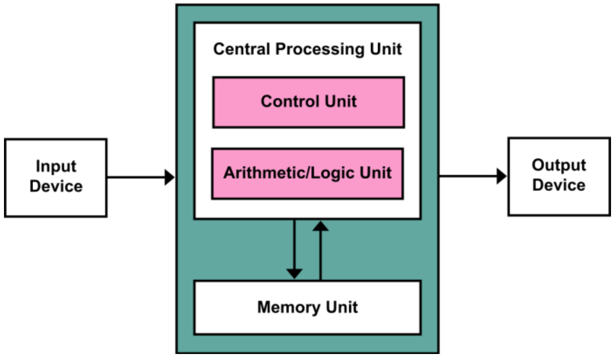
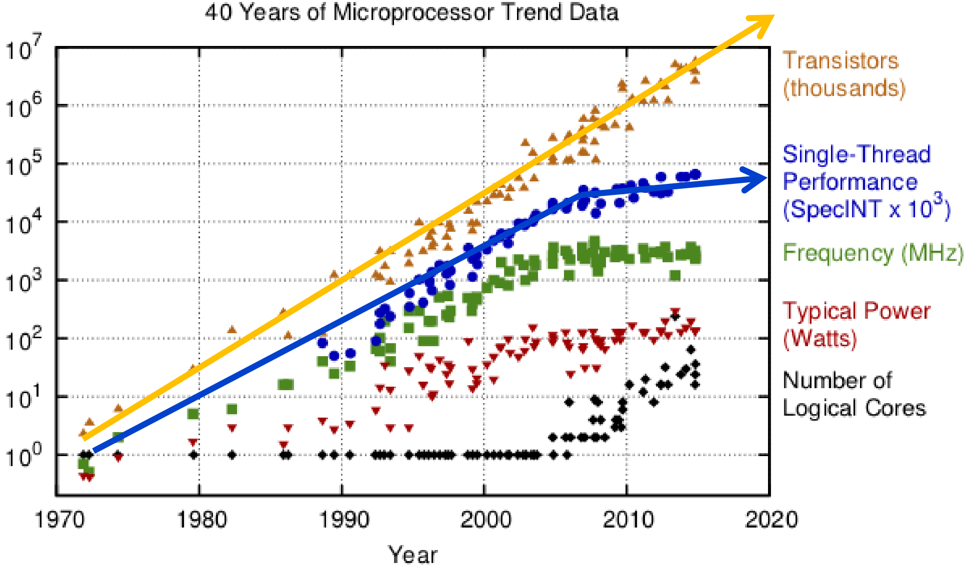
Processing Speed Bottleneck

New applications need 100x or more increase in performance

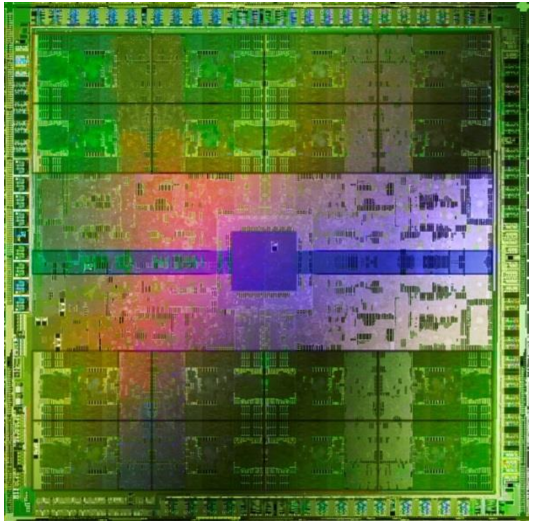
Von Neumann Architecture



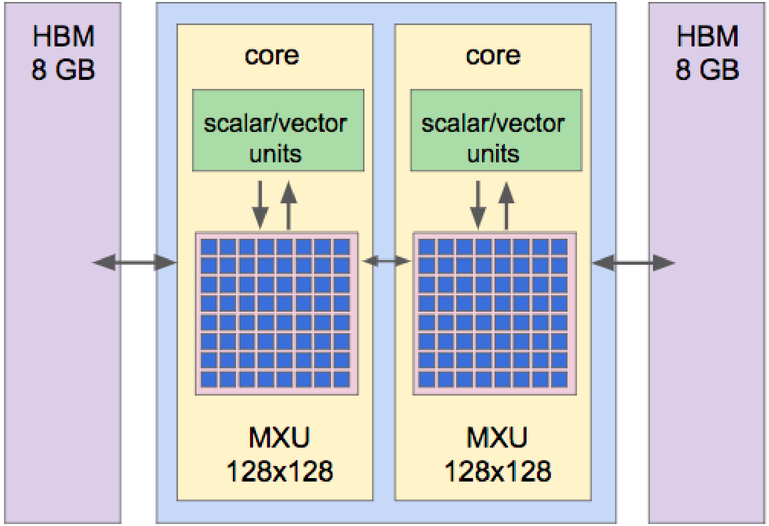


Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2015 by K. Rupp

New computational strategies need a LOT more transistors



nVidia Volta
12nm process
21B Transistors
4992 CUDA cores
14.8 TFLOPS
815 mm^2 (250W)



Google Tensor Processor (2nd gen)
2 die
7nm process
2 x 16384 floating point multipliers
45 TFLOPS

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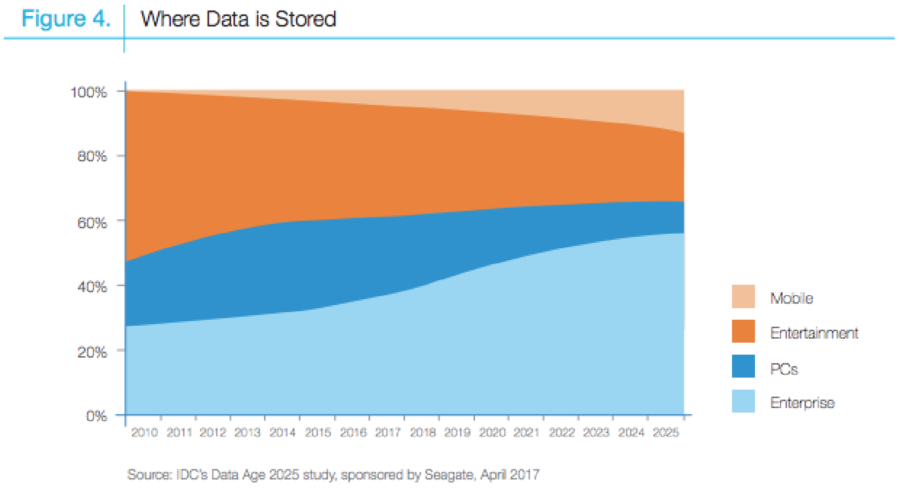
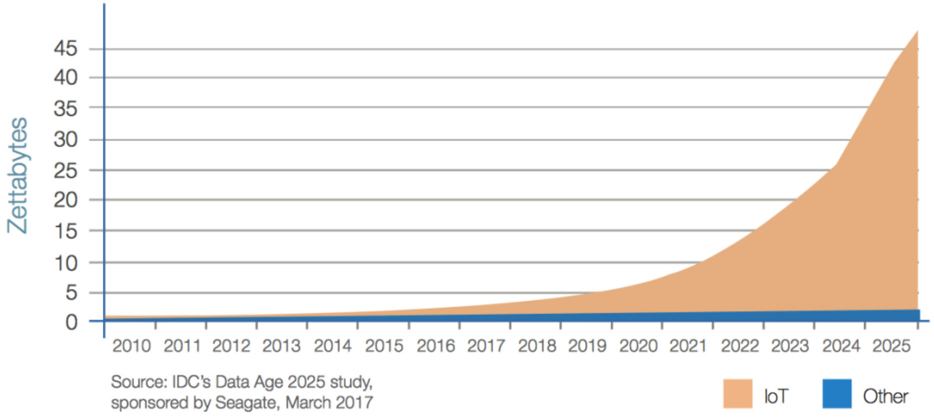
Storage Trends: Cloud and Real Time





<u>50ZB will be real time data by 2025</u>

- Cars
- Planes
- Health care
- Factories

What is a Zettabyte?

- 1 Zettabyte is 1E+21 bytes
- It takes 1 billion terabyte drives to hold a Zettabyte of data

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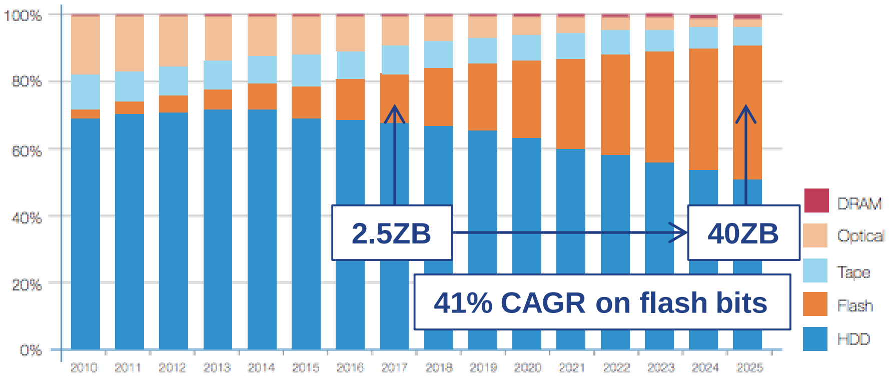
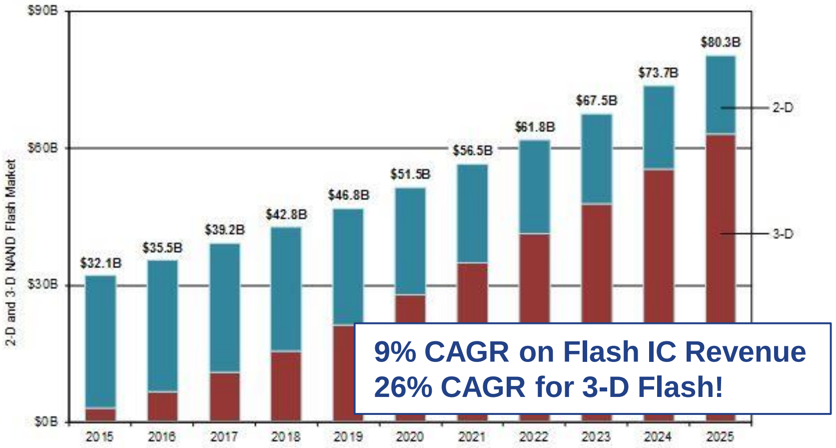
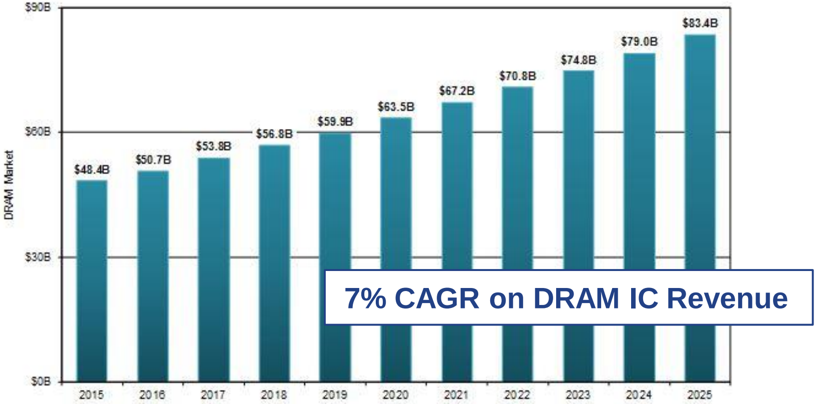
The future of storage is Flash

% of Global Storage



Source: IDC's Data Age 2025 study, sponsored by Seagate, April 2017





Push for more processing power is driving DRAM market hard:

- Higher Density
- Higher Speed Interfaces (LP-DDR5)

Source: SEMI Estimates

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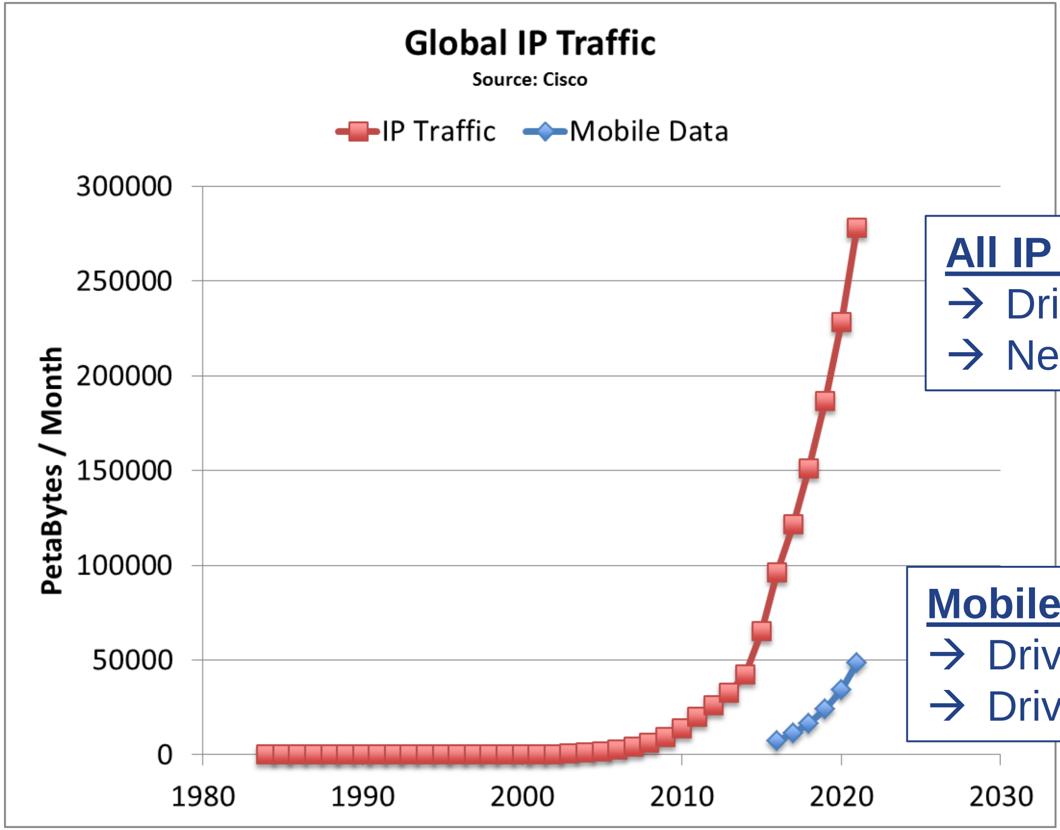
Global IP Traffic Growth



What does a Petabyte per month mean?

- 1 Petabyte is 1E+15 bytes
- 2.592E+6 seconds in a month
- 1 PB / Mon = 386MB / Sec
- 278,000 PB / Mon = 107 KB / nSec

All IP Traffic → 24% Annual Growth

→ Drives network infrastructure

→ New technologies for Data Comm (PAM)

Mobile IP Traffic → 48% Annual Growth

→ Drives transition to mmWave 5G

→ Drives Mobile Infrastructure buildout

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5G is about a lot more than mobile phones

World's First 5G-Connected Cars Demo'd in Korea

By Philip E. Ross
Posted 16 Nov 2016 | 13:00 GMT

The world's first 5G hologram call just happened and the future is officially here

By
Joe Roberts
April 6, 2017

Verizon and Korean Telecom (KT) have held what they say is the world's first live hologram international call over the two company's trial 5G networks.

The demonstration saw a KT employee in Seoul use a monitor in the firm's headquarters to converse with a live hologram of a Verizon employee in New Jersey.

A 5G connection will someday enable self-driving cars to brake in unison. If my car's AI sees an obstacle as it rounds a bend, it could hit the brakes on both my car and your car, following just behind me. Of course, vehicle-to-vehicle talk won't be enough: We'll also need sensor-festooned cars capable of knitting together various kinds of data to make split-second decisions as good as a human driver's.

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5G includes multiple parts of the RF Spectrum

A unified 5G design for all spectrum types/bands

Addressing a wide range of use cases and deployment scenarios

Licensed Spectrum	Shared Licensed Spectrum	Unlicensed Spectrum
Cleared spectrum	Complementary licensing	Multiple technologies
EXCLUSIVE USE	SHARED EXCLUSIVE USE	SHARED USE

Below 1 GHz: longer range for massive Internet of Things

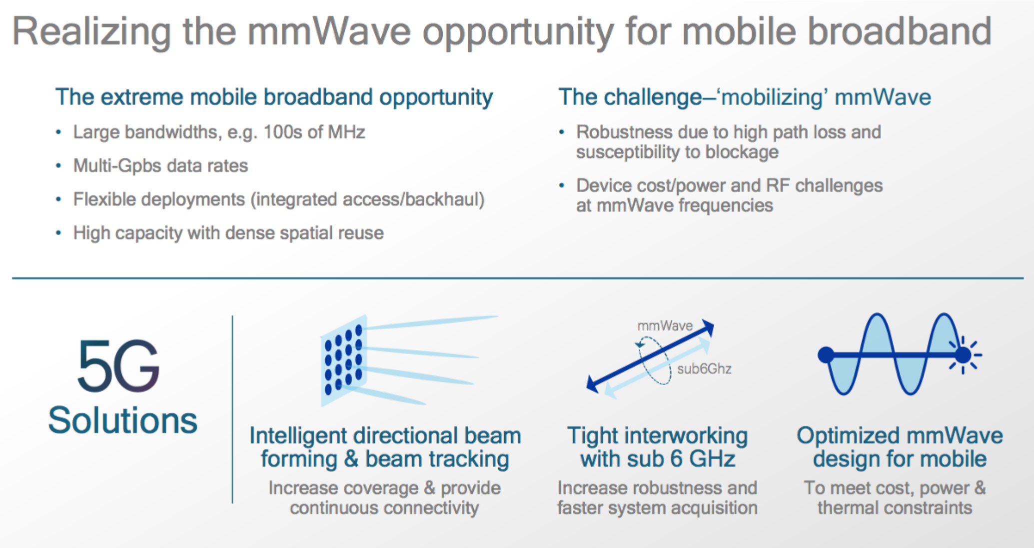
1 GHz to 6 GHz: wider bandwidths for enhanced mobile broadband and mission critical

Above 6 GHz, e.g. mmWave: extreme bandwidths, shorter range for extreme mobile broadband

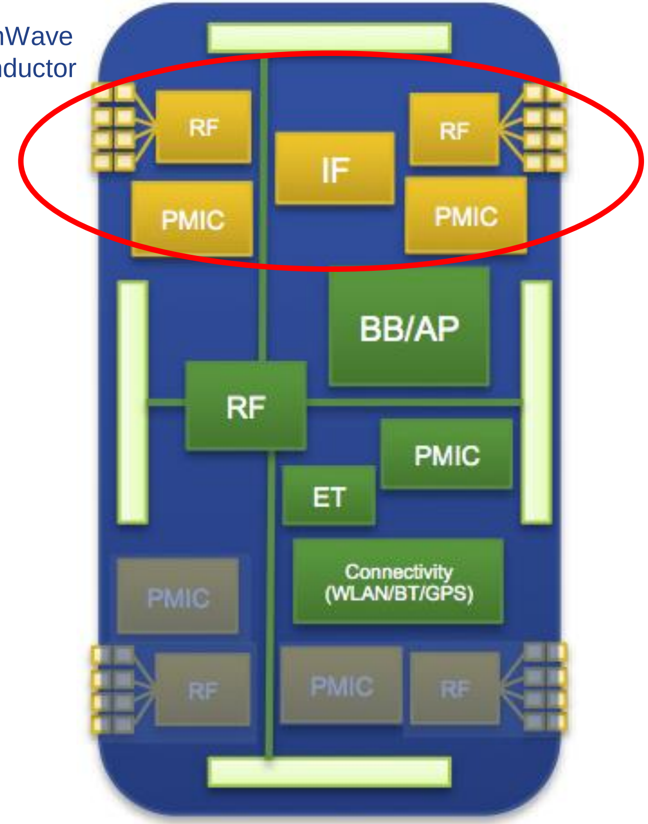
From wide area macro to local hotspot deployments

Also support diverse network topologies (e.g. D2D, mesh)

Critical new technology for 5G → Millimeter wave



New mmWave Semiconductor Content



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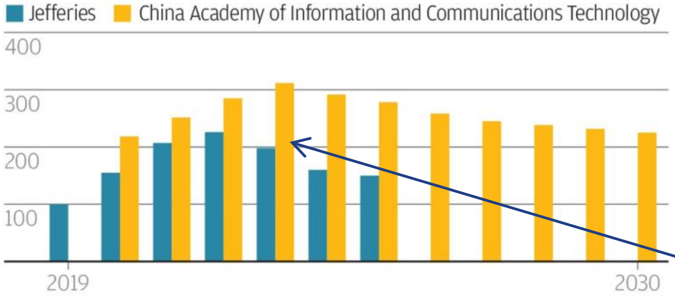
5G will drive Huge Infrastructure Investment

KT to start deploying 5G ahead of the 2018 Winter Olympics

By Juan Pedro Tomás on SEPTEMBER 19, 2017 5G, APAC, Carriers

Estimates for 5G capital expenditure in China (b yuan)



Sources: China Academy of Information and Communications Technology, Jefferies SCMP

~$50B in 2023

How Much Will 5G Cost? No One Has a Clue

MORRIS LORE
IAIN MORRIS,
News Editor

6/15/2017

COMMENT (3)

LONDON -- 5G World -- Uncertainty hovers above 5G like a swarm of fleas over a mangy dog, and perhaps the greatest uncertainty of all is how much the whole thing will cost.

A few numbers have been bandied around. A Barclays report last year estimated that blanketing the US with a 5G network would cost about $300 billion. Deutsche Telekom AG (NYSE: DT) CEO Timotheus Höttges says doing the same across the whole of Europe will require investments of between €300 billion ($335 billion) and €500 billion ($558 billion). But Ovum Ltd. analyst Daryl Schoolar thinks T-Mobile US Inc. may be facing a bill of about $25 billion to construct a nationwide 5G network. And a 5G action plan from the European Commission reckons 5G upgrades across the region will cost about €57 billion ($64 billion), according to the Financial Times. (See DT Plots 5G Across Entire Footprint andT-Mobile 5G Plan Could Drive Capex to Record Highs.)

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High performance Computing Challenges

- DUT Power: 1mV Accuracy, Wide Bandwidth
  - Teradyne improved accuracy of power supplies 3x to meet 1mV requirements
- Higher complexity drivers deeper scan patterns
  - Teradyne doubles memory depth for UltraFLEX
- High Test Cost driving need for more parallel test
  - Teradyne is developing innovating “MLO” based interfaces to make high site count processor interfaces economically feasible
  - Teradyne is developing solutions to support “Scan plus SLT”. Opportunity to radically reduce scan test times on ATE for processor devices.

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Memory Challenges

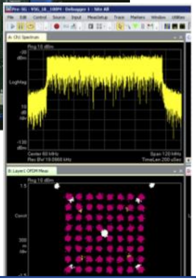
- Flash Interface Technology Evolving Rapidly
  - Speeds increasing to >7Gbps
  - Complex protocols required
  - Teradyne Strategy
    - “Near DUT Test”: Move pin electronics to TIU
    - Flexible protocol support
  - Benefits
    - Highest signal fidelity for highest yield
    - Supports incremental standards with FW changes to extend asset life
    - Major new protocols supported with only TIU changes to minimize upgrade cost
- LP-DDR5 data rates require new test approach
  - DRAM HS pincount requirements are radically higher than for Protocol Flash
  - Is “Near DUT Test” architecture required to achieve signal integrity requirements?

RF / Millimeter Wave Challenges

- Challenges for high volume mmWave device test
  - Device interfacing is lossy, fragile and expensive
  - mmWave device technology is too expensive and bulky for ATE instruments
  - mmWave port counts are 2x to 10x current RF devices.
- Large gap between target COT and current capability
  - Teradyne has complete solutions for characterization and initial production today
  - Teradyne is working with customer partners to reduce CoT
    - Scalable instrumentation
    - Leverage Device BIST
    - Over the air testing

CZ and Initial Production Test
For 802.11ad/ay, 5G mmWave and UWB

Production Test for mmWave 5G on UltraFLEX



28 GHz EVM
Loopback Test

2GHz IF capability for
802.11ay and UWB

Litepoint 5G OTA solutions

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Conclusion

- The future in semiconductors beyond smart phones is bright
- The critical drivers are:
  - High performance processing in novel architectures
    - Thousands of cores
    - Neural Networks
  - Huge growth in storage, especially Flash
    - Mostly in the cloud and mobile
  - Demand for high data rate RF Communications
    - expanding in millimeter wave with 5G
- Teradyne is ready to solve the challenges that the Big Data Era will bring for the semiconductor industry