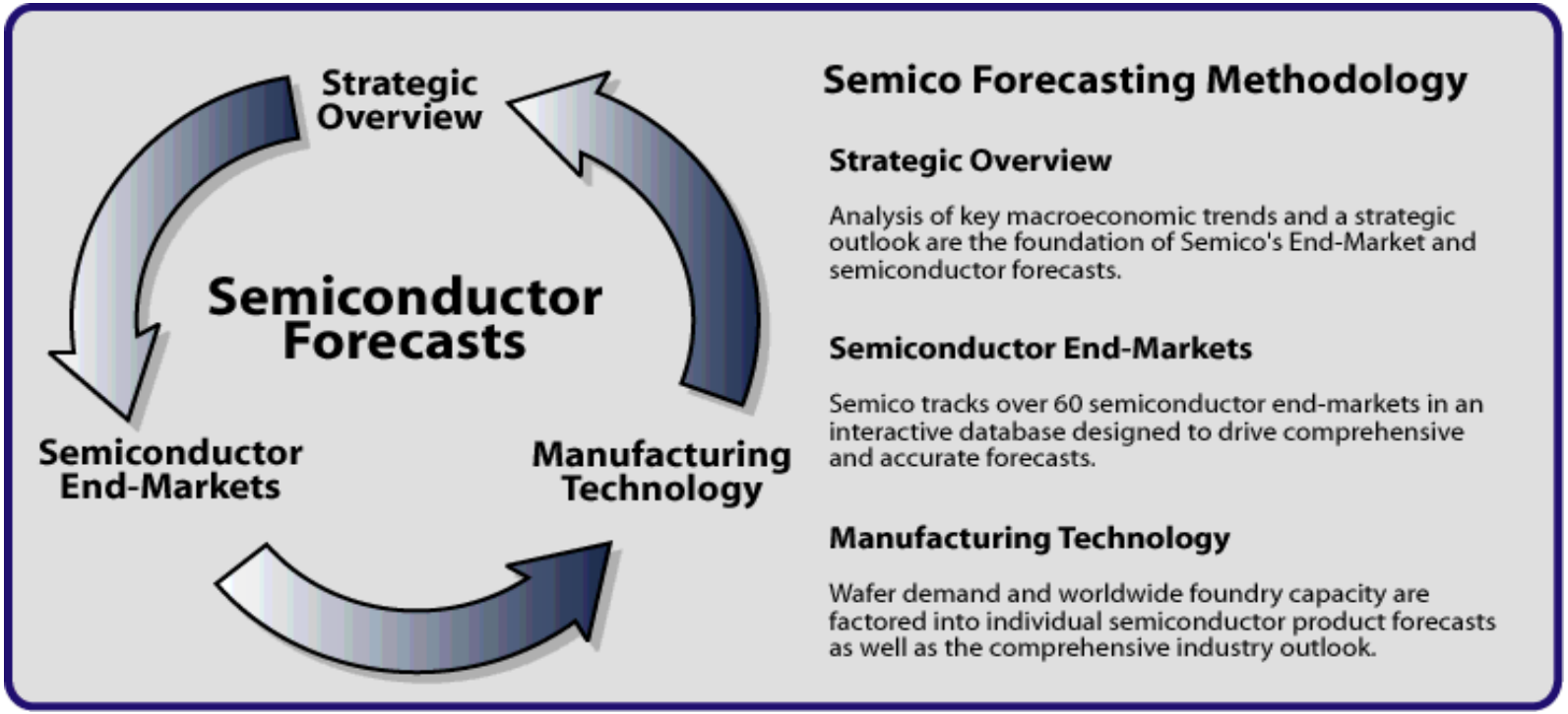
Market Dynamics Driving Future Semiconductor Demand

Semico Research Corp.
April 2018

Semico Forecast Methodology



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2018:Traditional Markets Slow Growth or Declining

-11%
65M Units

+1.4%
2.0 B Units

-2.1%
191M Units

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2018: Markets with Higher Growth Potential

Automotive 1.2%
123M

Server 18.6%
25.5M

Personal Assist
15% 30M

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Automotive
The Next Big Opportunity

Expectations in the Automotive Markets

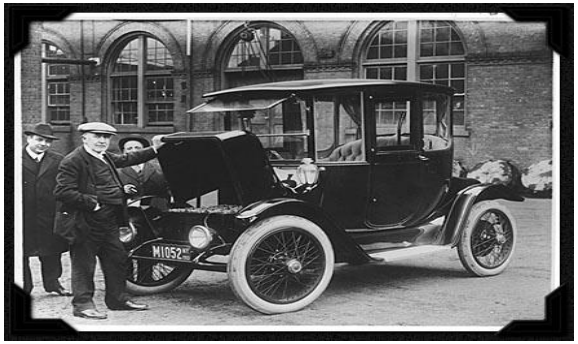
Connected vehicles

Electrification

Self driving car

Ideas That Didn't Take Off

Automaker Albert Augustus Pope and the electric car



Thomas Edison and the nickel-iron battery for electric cars

John DeLorean failed diecast, all-aluminum engine

2004 Versus 2017 Factory Installed Equipment

2004		2017	
• ABS	76.5%	• ABS	99.0%
• Power seats	53.9%	• Power seats	61.0%
• Auto headlights	52.1%	• Auto headlights	62.1%
• Anti theft	47.0%	• Anti theft	99.0%
• Side air bags	22.1%	• Side air bags	90.0%
• Stability control	16.7%	• Stability control	99.5%
• Traction control	14.9%	• Traction control	23.5%
• Rear object sensor	6.7%	• Rear object sensor	85.0%
• GPS	5.0%	• GPS	38.1%
• Drive by wire	0.7%	• Drive by wire	24.3%
• Heads up	0.6%	• Heads up	5.1%
• Blind spot sensor	0.0%	• Blind spot sensor	37.4%
• Tire Pressure	1.3%	• Tire Pressure	88.0%

Source: Semico Research Corp.

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Advanced Automotive Systems

GPS (global positioning system combined with readings from tachometers, altimeters and gyroscopes to provide the mo accurate positioning

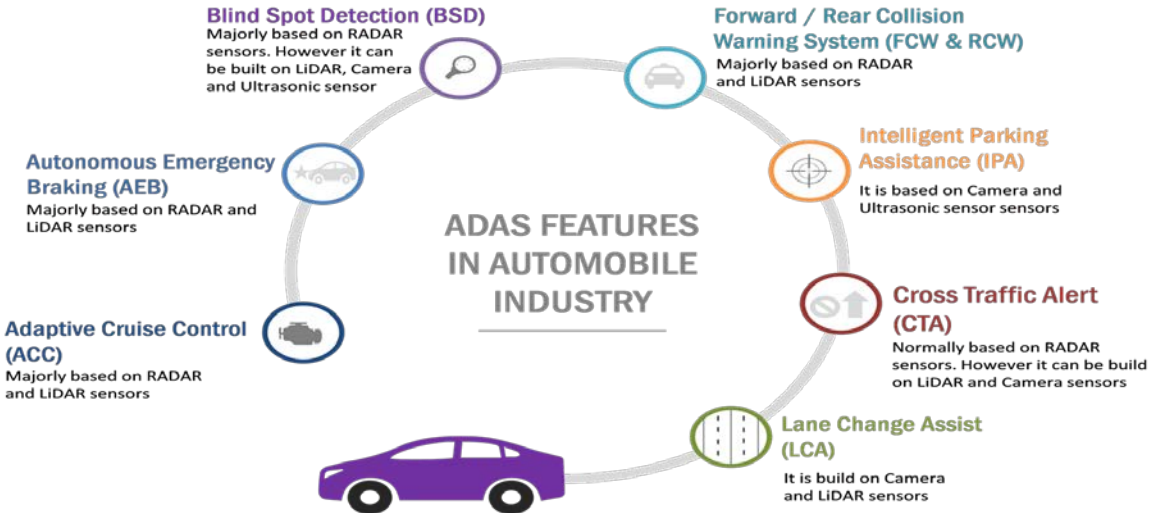
Ultrasonic sensors to measure the position of objects very close to the vehicle

Odometry sensors to complement and improve GPS information

Central computer analyzes applies rules of the road and oper accelerator and brakes

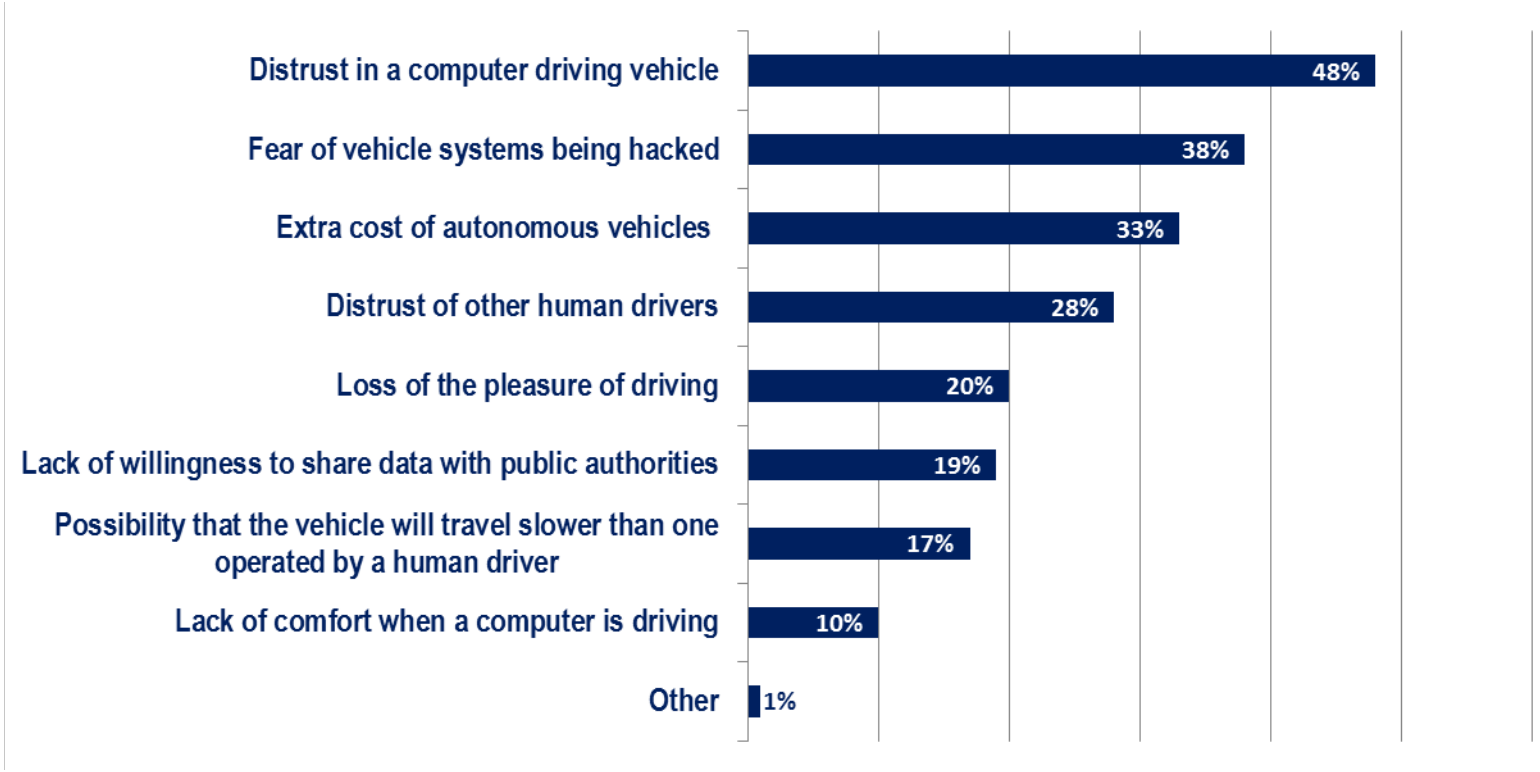
AUTOMOTIVE CHALLENGES

Leading-Edge Silicon for Self Driving Car



- Object Detection / Tracking
- Feature Recognition / Tracking
- 3D Scene Interpretation

Consumer Concerns About ADAS



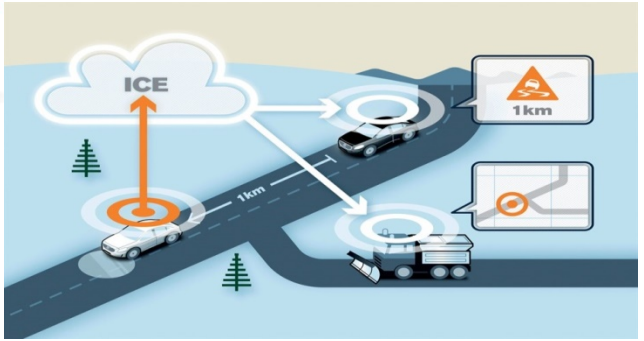
Source: McKinsey

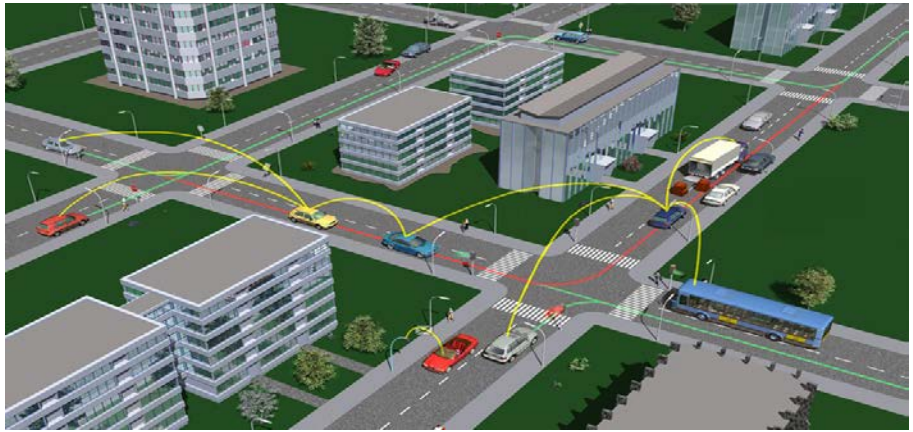
SAE Automated Vehicle Classifications

Classification	Description
Level 0:	Automated system has no vehicle control, but may issue warnings.
Level 1:	Driver must be ready to take control at any time. Automated system may include features such as Adaptive Cruise Control (ACC), Parking Assistance with automated steering, and Lane Keeping Assistance (LKA) Type II in any combination.
Level 2:	The driver is obliged to detect objects and events and respond if the automated system fails to respond properly. The automated system executes accelerating, braking, and steering. The automated system can deactivate immediately upon takeover by the driver.
Level 3:	Within known, limited environments (such as freeways), the driver can safely turn their attention away from driving tasks.
Level 4:	The automated system can control the vehicle in all but a few environments such as severe weather. The driver must enable the automated system only when it is safe to do so. When enabled, driver attention is not required.
Level 5:	Other than setting the destination and starting the system, no human intervention is required. The automatic system can drive to any location where it is legal to drive.

Comm Chips Another Key Opportunity

Vehicle-to-Cloud
and
Vehicle-to-Vehicle





5G

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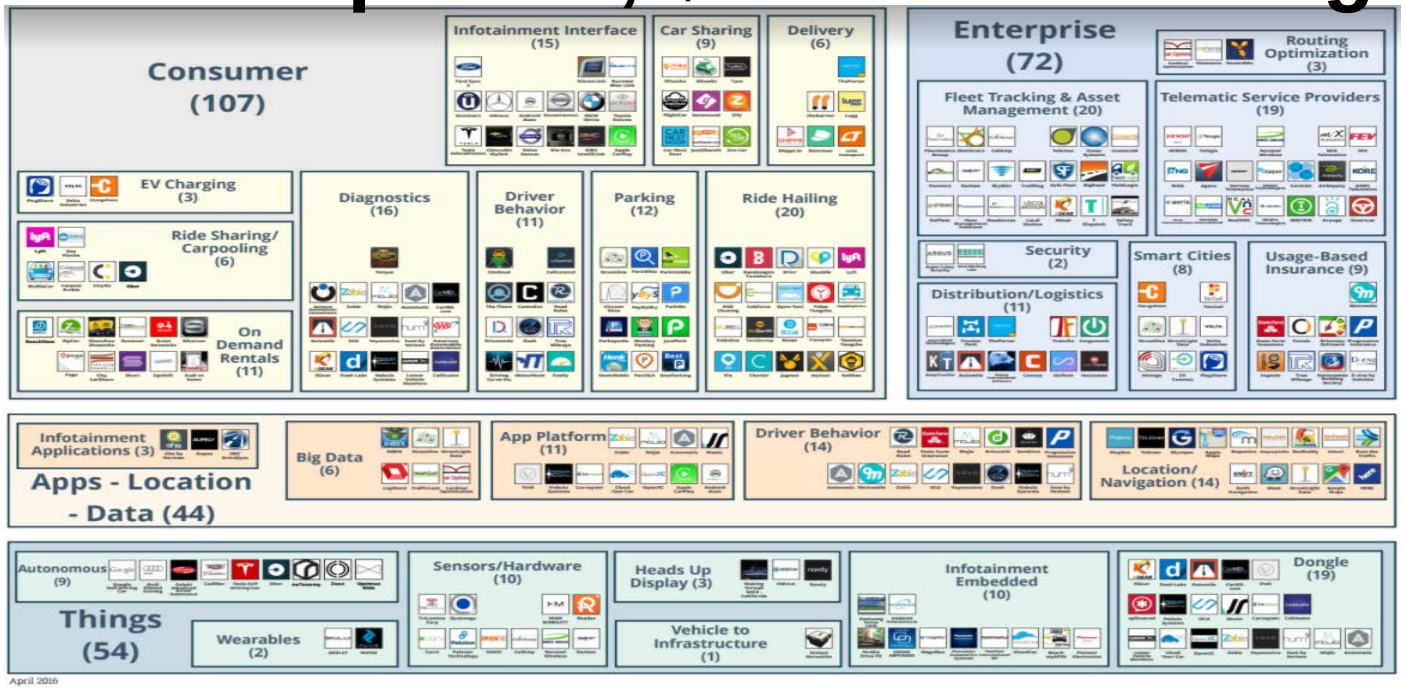
Connected Car Landscape

250 companies, $38.7B in funding



Source: VentureBeat

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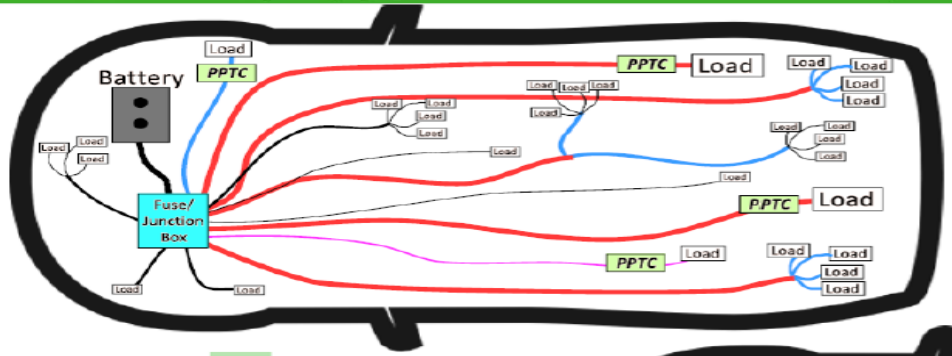
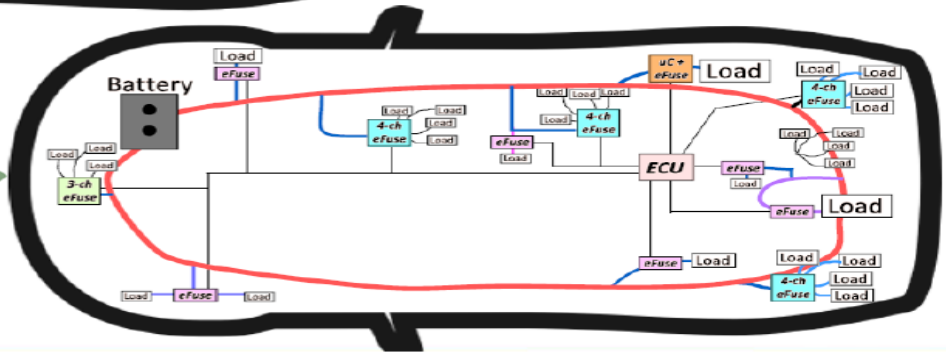
New Innovations Require New Solutions

How an eFuse Reduces Weight – a Key Benefit



Huge Ancillary Benefit to the OEM's:
Significant Weight Reduction via Copper Wire Removal



Distributed with intelligent eFuse

2004 Technology for Automotive ICs

N^{-9} N^{-8} N^{-7} N^{-6} N^{-5} N^{-4} N^{-3} N^{-2} N^{-1} N

Process Technology

Source: Semico Research Corp.

Down the Road: Technology for Auto ICs

Source: Semico Research Corp.

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Self-Driving Car Timeline

- GM: 2018
- Ford: 2021
- Honda: 2020
- Toyota: 2020
- Renault Nissan: 2020, 2025
- Volvo: 2021
- Hyundai: Highway 2020, Urban 2030
- Daimler: Early 2020s
- Fiat Chrysler: 2021
- BMW: 2021
- Tesla: 2017
- Volkswagen: 2020

Big Opportunities for Big Rigs

Motiv

Tesla

Toyota

Nikola One

Thor Truck

Daimler 2019

Cummins 2019

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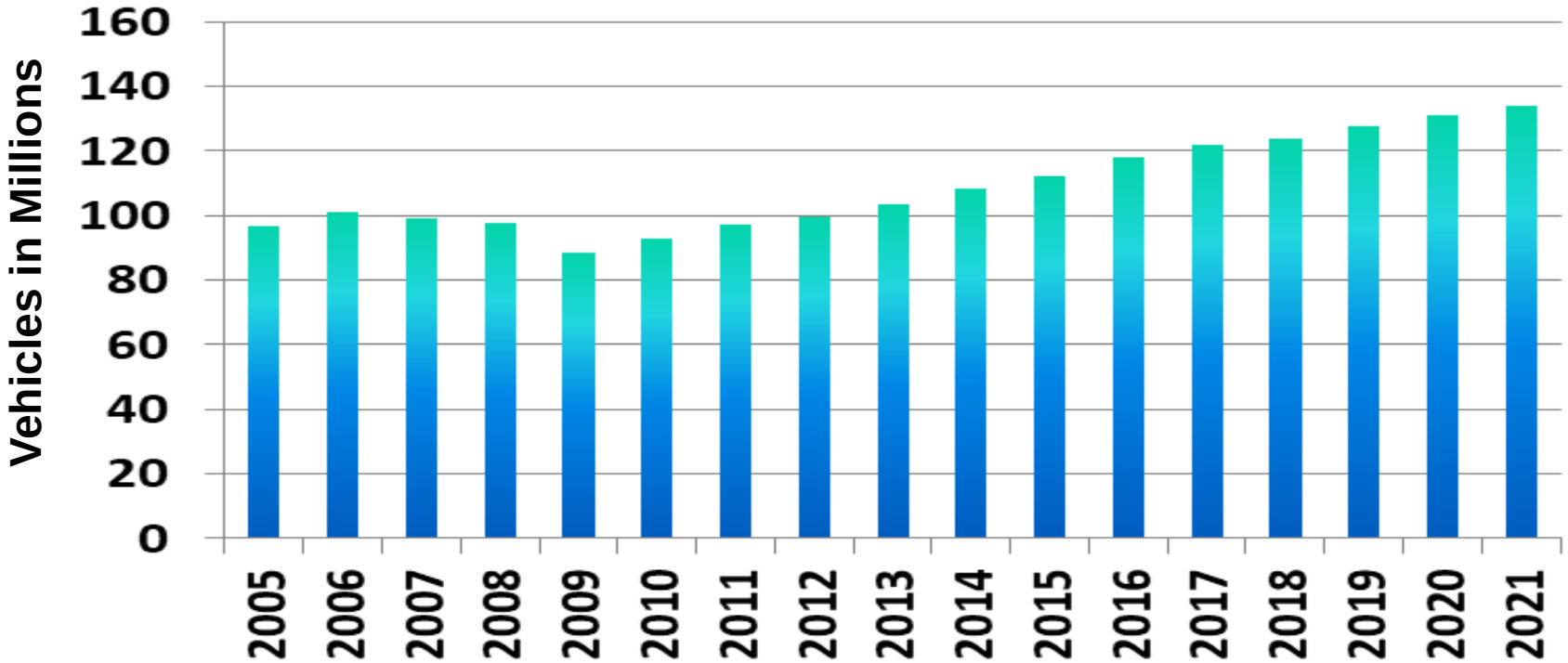
Automotive Forecast



Source: Semico Research Corp.

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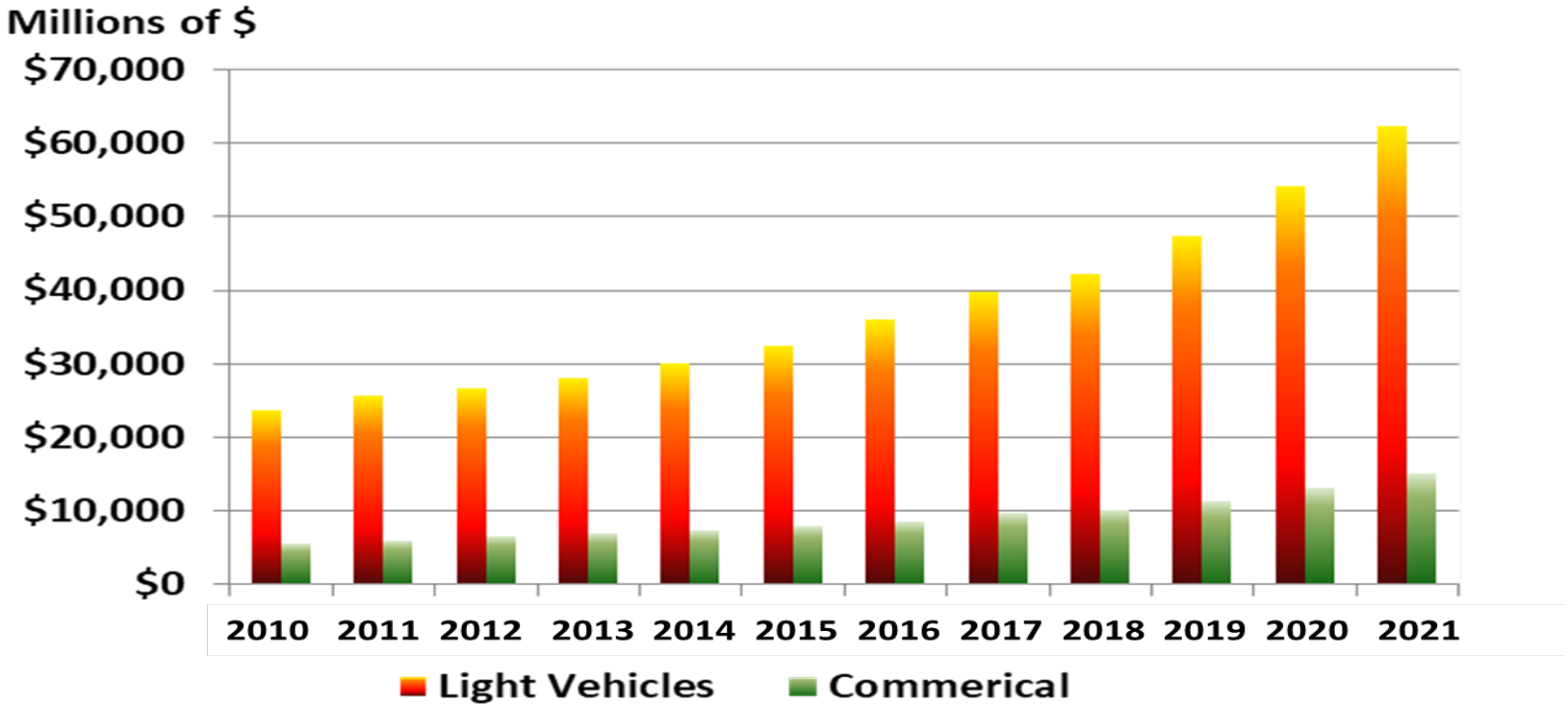
Automotive Semiconductor Forecast



Source: Semico Research Corp.

Ideas That Didn’t Take Off

The 3-wheel car with rear mount V8

Car with one door in the front

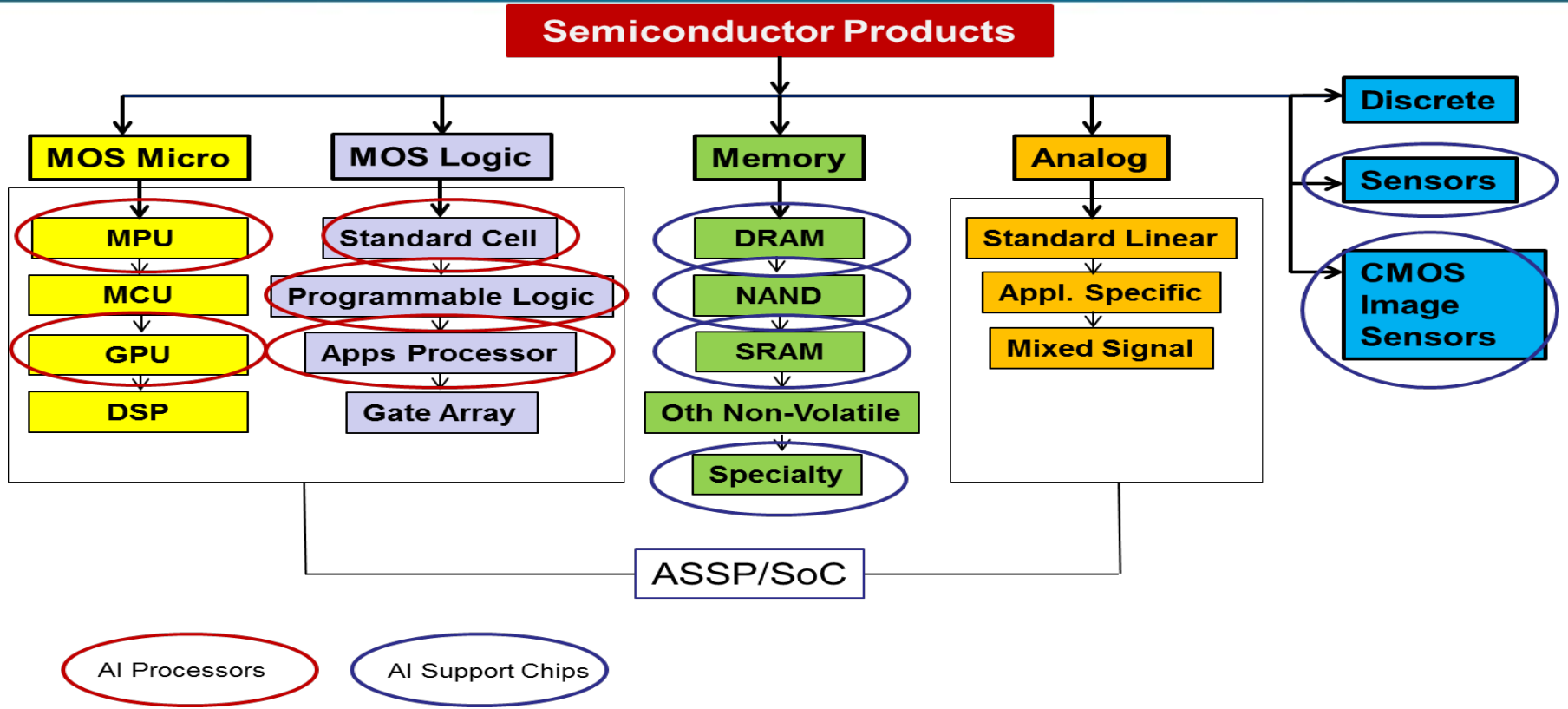
Combination office and dining car

AI
Intelligence Everywhere

Where is AI Today?

- Has become a focus for all companies
- Two different facets
  - Training: run millions of data inputs through a system to recognize specific patterns
  - Inference: after training is completed, an algorithm is created to duplicate the same results
- Innovation and development is moving fast

Semiconductor Market Landscape



Source: Semico Research Corp.

AI Architectures: Nvidia

Nvidia Volta Family

TESLA V100

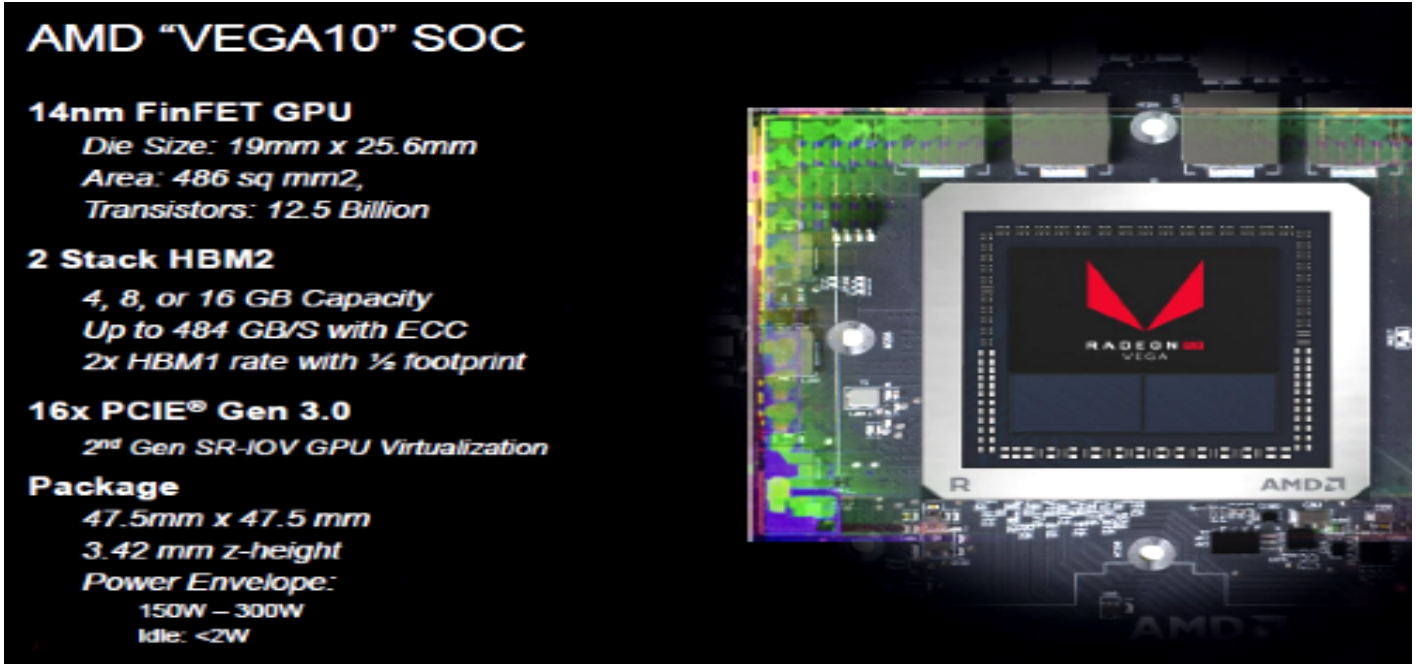
21B transistors
815 mm²

80 SM
5120 CUDA Cores
640 Tensor Cores

16 GB HBM2
900 GB/s HBM2
300 GB/s NVLink

Source: NVIDIA Corp.,

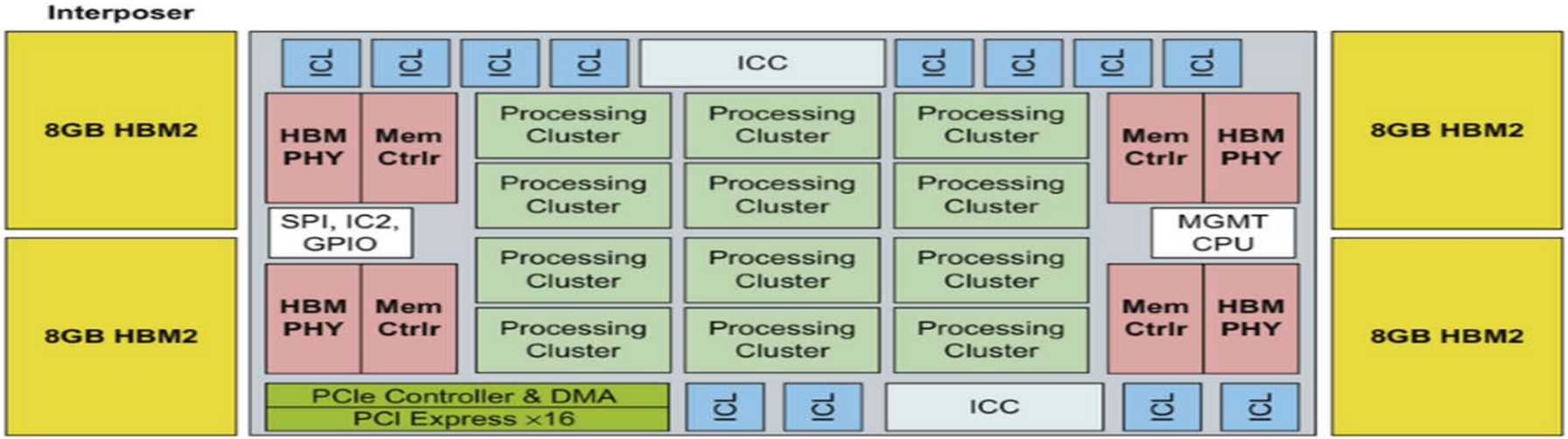
AMD Vega Architecture



Source: AMD

AI Architectures: Intel

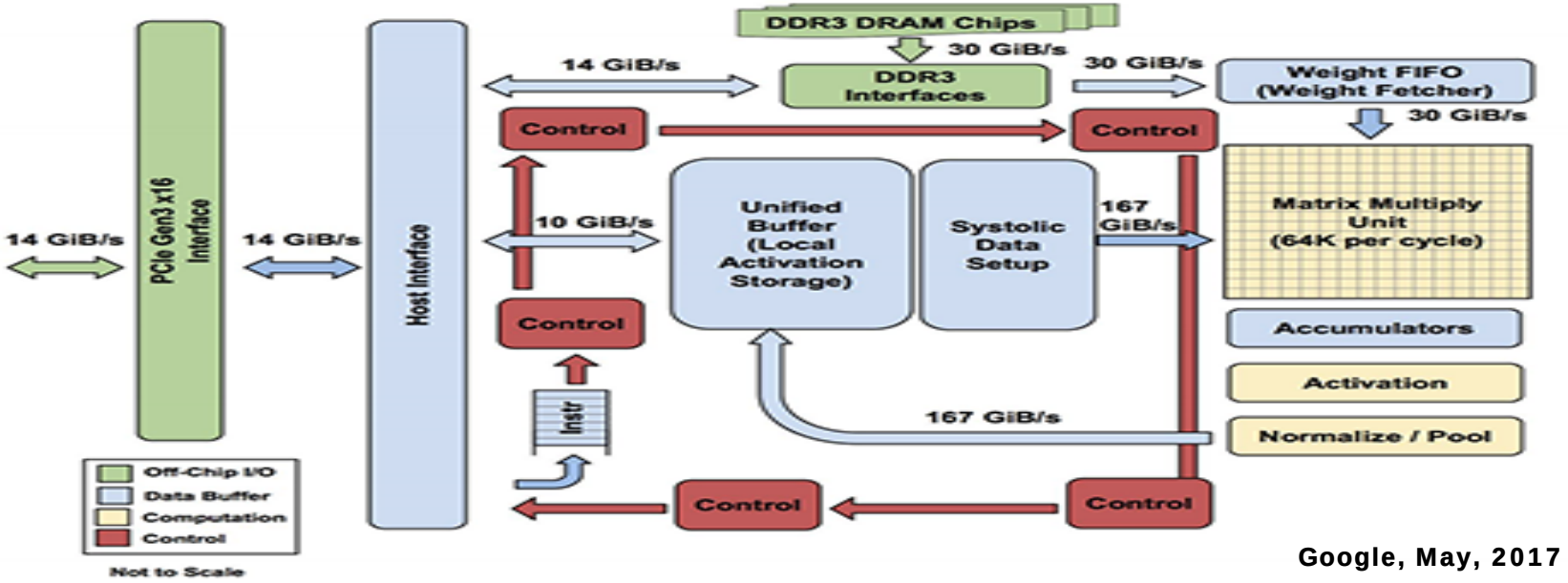
Intel Nervana (Lake Crest) Deep Learning Architecture



Source: Intel Corp.

AI Architectures: Google

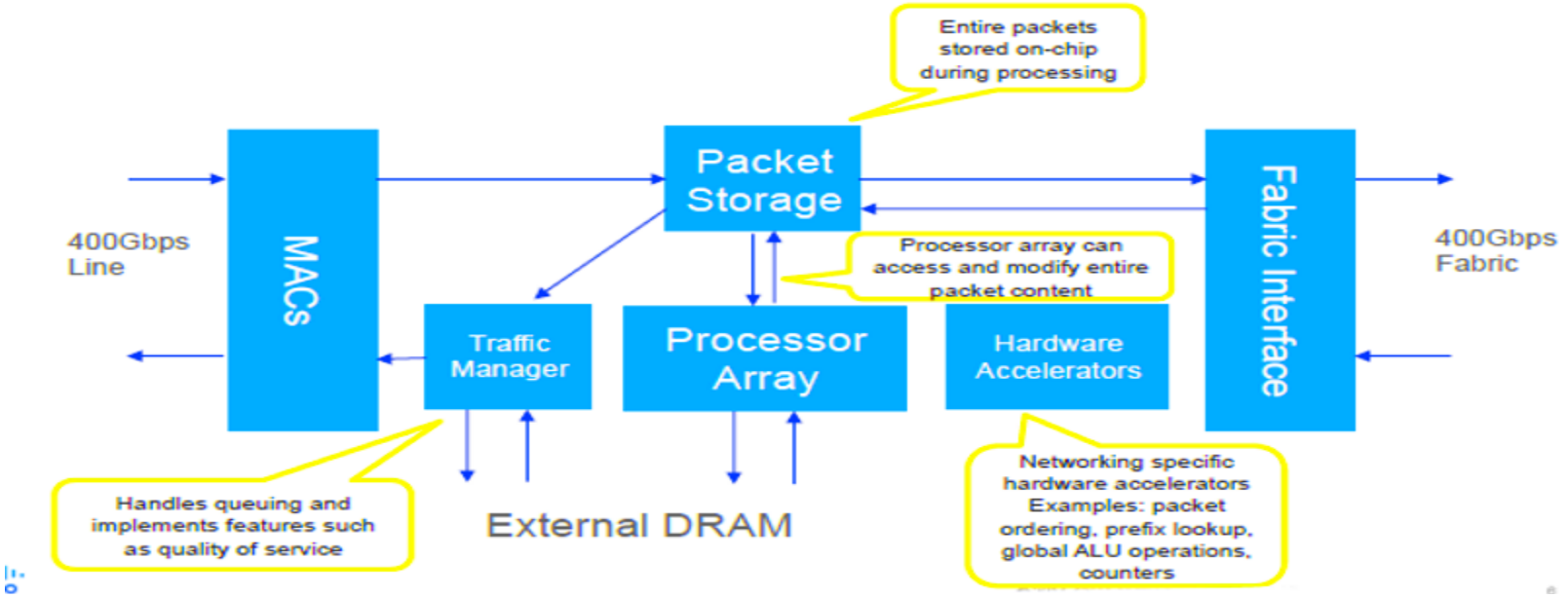
Google TPU Architecture



Google, May, 2017

AI Architectures: Cisco

Cisco Architecture

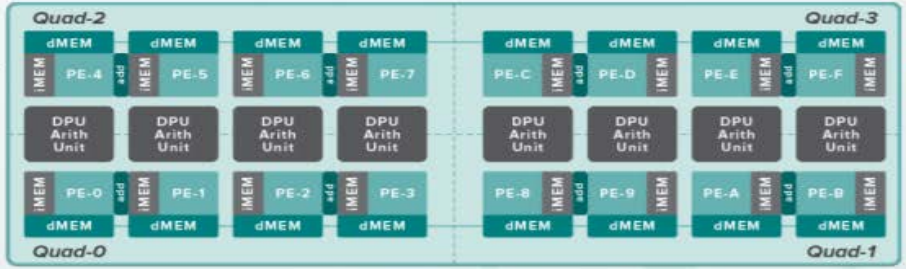


Source: Cisco

AI Architectures: Wave Computing

Wave Computing DPU Architecture

Processing Element (PE)



Cluster (16 PE's)

- ***16 Processor CLUSTER: a full custom tiled GDSII block***
- **Fully-Connected PE Quads with fan-out**
- **8 DPU Arithmetic Units**
  - Per-cycle grouping into 8, 16, 24, 32, 64-b Operations
  - Pipelined MAC Units with (un)Signed Saturation
  - Support for floating point emulation
  - Barrel Shifter, Bit Processor
  - SIMD and MIMD instruction classes
  - Data driven
- ***16KB Data RAM***
- ***16 Instruction RAMs***
- ***Full custom semi-static digital circuits***
- ***Robust PVT insensitive operation***
  - Scalable to low voltages
  - No global signals, no global clocks

Source: Wave Computing

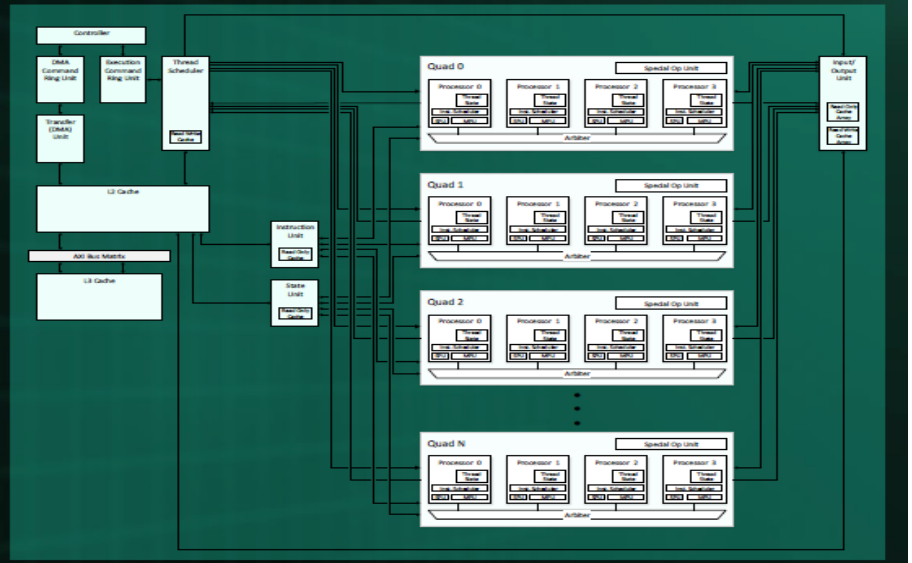
AI Architectures: ThinCI

ThinCI Architecture

Fine-Grained Thread Scheduling

thinci

- Thread Scheduler
  - Aware of data dependencies
  - Dispatches threads when:
    - Resources available
    - Dependencies satisfied
  - Maintains ordered behavior as needed
  - Prevents dead-lock
- Supports Complex Scenarios
  - Aggregates Threads
  - Fractures Threads



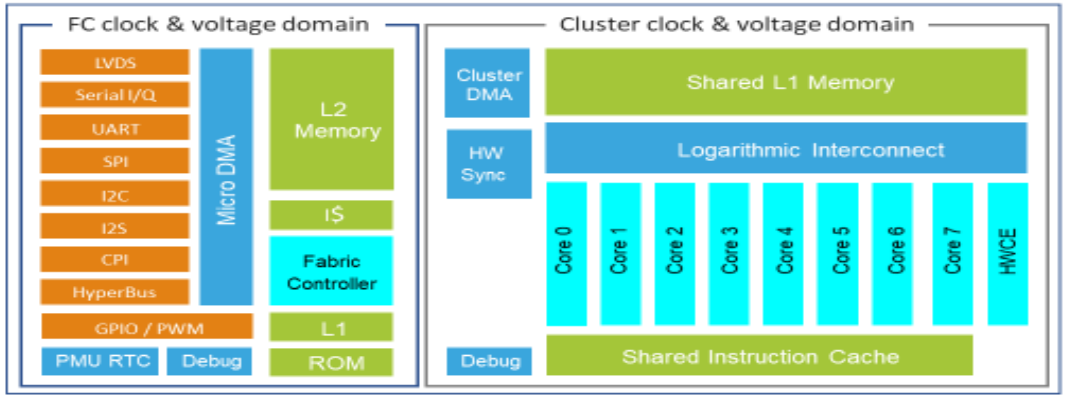
Source: ThinCI

AI Architectures: GreenWaves Technology

GreenWaves Architecture

GAP8 – An IoT Application Processor

Two independent clock and voltage domains, from 0-133MHz/1V up to 0-175MHz/1.2V



MCU Function
Extended RISC-V core
Extensive I/O set
Micro DMA
Embedded DC/DC converters
Operation and memory security model / e-fuses

Computation engine function
8 extended RISC-V cores
Fully programmable
Efficient parallelization
Shared instruction cache
HW synchronization
HW convolution Engine (3 * 3x3)

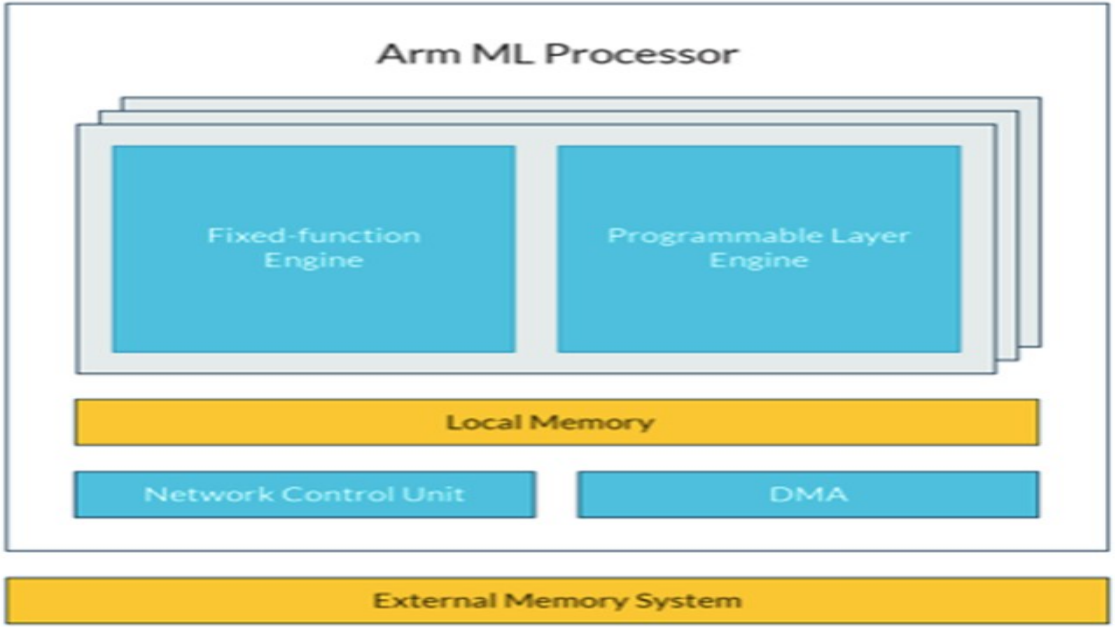
An integrated, hierarchical architecture

Deep sleep	Asleep	Retentive	Acquisition	Pre-analysis	Inference
70nA	3µA	3µA+x*8µA	40µWs + peripheral	1mWs	few 10mWs

GREENWAVES TECHNOLOGIES

Source: GreenWaves Technology

Project Trillium



Source: ARM

AI Players

	Training	Inference	Cost	Sell Systems	Sell Services	Sell Silicon
Intel	X	X	High	X		X
Google	X		High		X	
NVidia	X		High	X		X
ThinCI	X	X	Low			
Wave	X	X	High	X		
Graphcore	X		Low			X
Cambricon		X	Low		X	X
GreenWaves		X	Low			X
MediaTek	X	X	Low			X
Amazon	X		High		X	X*
Cisco	X		High	X	X	
IBM	X		High	X	X	
Huawei	X		High	X	X	
Apple		X	Low	X	X	
Facebook	X		High		X	
Samsung	X	X	Low	X		X
Xilinx	X	X	Low			X
Qualcomm	X	X	Low			X
AMD	X	X	High			X
Microsoft	X		High		X	

* Company has stated they **may** sell their silicon to 3rd Parties

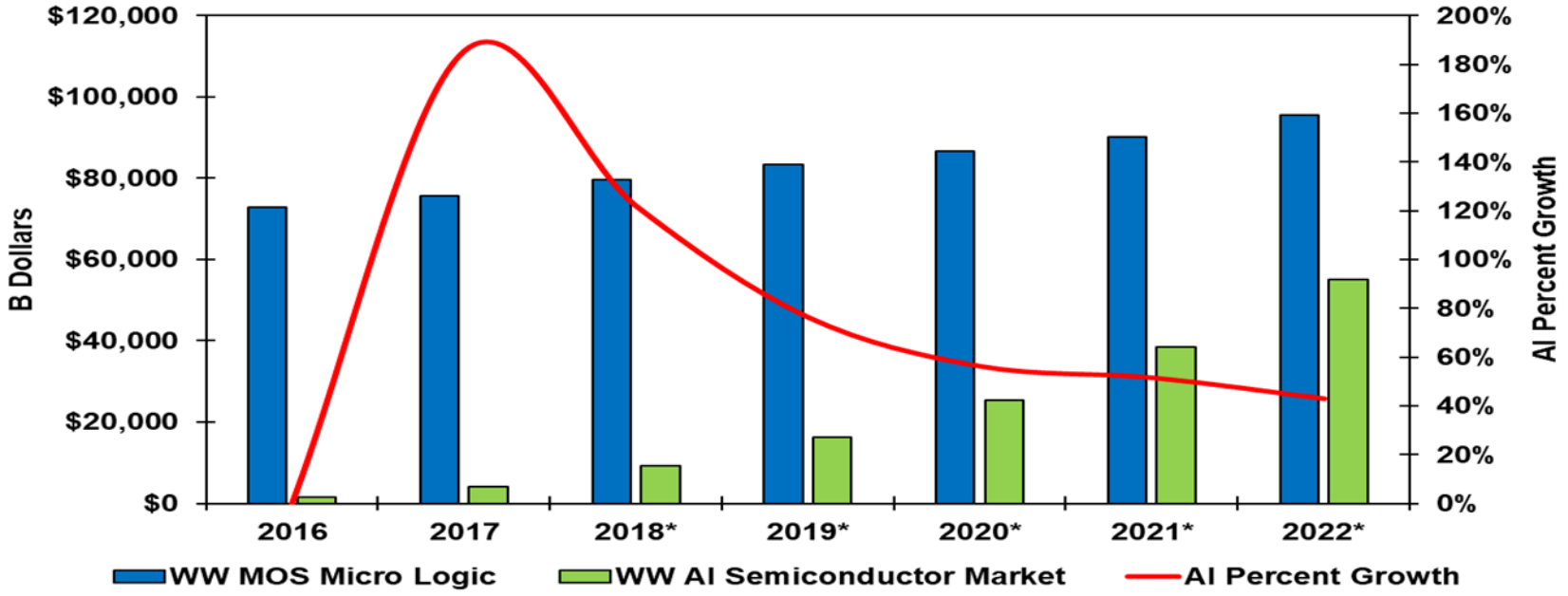
Source: Semico Research Corp.

Future of AI: Ubiquitous

Industry	AI Applications	Performance	Cloud vs. End Point
Agriculture	Crop mgmt, pest control, livestock mgnt	Mid range	Cloud
Automotive	Autonomous driving, object detection/avoidance, etc	High	Both
Finance & Banking	Fraud detection, facial / voice recognition, AI mobile teller	High	Both
Govt./Military	Threat detection, assessment & analysis, security, logistics	High	Both
Healthcare	Diagnosis, pharmaceutical, radiology image analysis, home care	High	Cloud
Industrial / Mfg	Logistics/warehouse mgnt, inventory analysis, workflow analysis, preventative maintenance, design tools	Mid range	Cloud
Infrastructure	Energy demand, Smart Cities (traffic flow, crime prevention, lighting, etc), disaster prediction (earthquake, tsunami)	Mid to High	Both
Research	Material research analysis, physical sciences, resource exploration	High	Cloud
Retail	AR, theft detection, perishable product detection, customer movement analysis, inventory control/logistics	Mid to High	Both
Robotics	Drones, home assistant	Mid to High	Both
Telecom	Cyber security, predictive resource analysis, anomaly detection	High	Both

Source: Semico Research Corp.

Semiconductor Forecast for AI



Source: Semico Research Corp.

The Paradigm Shift

Computing

→ **Artificial Intelligence**

Questions for Semico