Your Vehicle, A Moving Computer

Kai Huang

Stanford Racing

- 2005 DARPA Grand Challenge: First place
- two quad-core Intel workstation

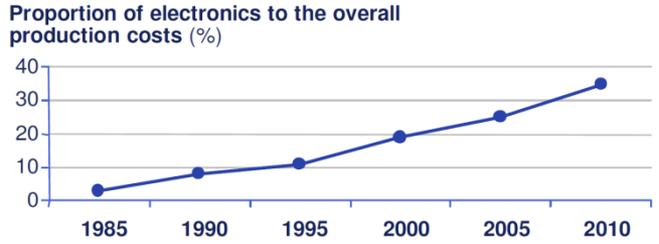http://cs.stanford.edu/group/roadrunner//old/index.html

CMU BOSS

- 2007 DARPA Urban Challenge: First place
- ten 2.16 GHz Core2Duo processors

http://www.tartanracing.org

Automotive Electronics

Proportion of electronics to the overall production costs (%)

Source: market and technology study automotive power electronics 2015

Level of dependency

1970
Electronic Injections
Check Control
Speed Control
Central Locking ...

1980
Electronic Gear Control
Electronic Air Condition
ASC Anti Slip Control
ABS
Telephone
Seat Heating Control
Autom. Mirror Dimming
...

1990
Navigation System
CD-Changer
ACC Adaptive Cruise
    Control
Airbags
DSC Dynamic Stability
    Control
Adaptive Gear Control
Xenon Light
BMW Assist
RDS/TMC
Speech Recognition
Emergency Call...

2000
ACC Stop&Go
BFD, ALC, KSG
42 voltage
Internet Portal
GPRS, UMTS
Telematics
Online Services
BlueTooth
Car Office
Local Hazard Warning
Integrated Safety System
Steer/Brake-By-Wire
I-Drive
Lane Keeping Assist.
Personalization
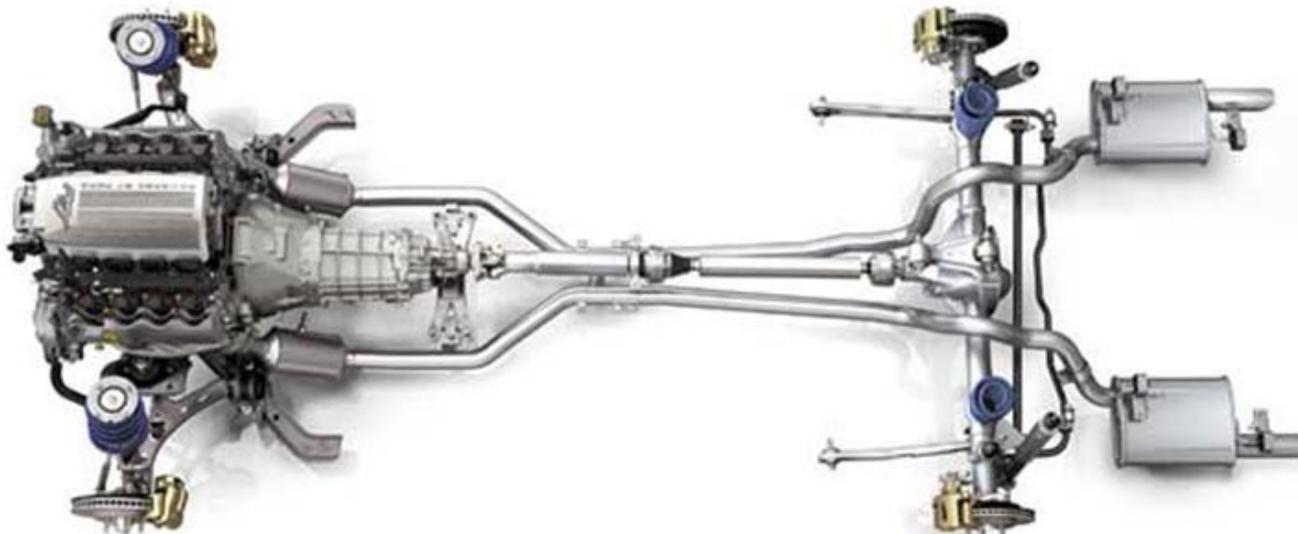Software Update
Force Feedback Pedal...

2020
You name it !

source: BMW

Brief history of ICT in the Automobile

- Up to ca. 1990, no or minimal use of ICT in the car (with the exception of the radio), control of the energy flow by the driver
- Three threads of development:
  - Controllers for automatic transmissions
  - Electronic fuel injection EFI
  - Antilock Braking System ABS

Brief history of ICT in the Automobile: EFI

- (Mechanical) fuel injection, Introduction in aircraft in Germany in the 1930's, Bendix Corp. Introduced it for cars in the USA in the beginning of the 50's

- First cars with EFI: 1958 Chrysler's sport models D300, Adventurer, D500 and Fury with Bendix Electrojector

- First German car with EFI (Bosch D-Jetronic): VW Type 3 (1600 E), 1967, first Bosch ECU (analog)

http://www.ch300imp.com/bendix_us.htm
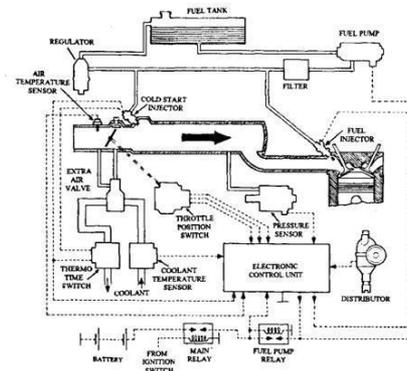
Brief history of ICT in the Automobile: ABS

- First presentation of electronic ABS by Mercedes-Benz in 1970
- Introduction in 1978 S-Class
- First digital ECU, basis of digitization of ICT in the car

Characteristics of today's ICT in the car

- Historically grown structures, mapped to (and clotted into) the development and production processes in the automotive industry

- More or less firm (and static) coupling between (software) function and (hardware) execution unit

- High complexity of the design of new or "overarching" functions (involving more than one execution unit)

→ Concepts for new architectures inevitably needed when additional sets of complex functions are added, e.g., energy/battery management and thermal management for EVs

State of the art

- "Hard wired" architecture with distributed ECUs
- Dedicated bus systems
- Evolutionary grown architecture that is increasingly interconnected
  - Over 70 electronic control units (ECU)
  - Divided into different domains (Chassis, Body, Drivetrain, Infotainment)
  - 5 different communication systems
  - 6 CAN buses (different speed / domains)
  - 22 LIN buses (connecting sensors / actuators)
  - 1 FlexRay bus (Chassis/drive train / motor control)
  - 1 MOST bus (Infotainment/Multimedia)
  - Ethernet (Point to point)
- Complexity of integrating new functions increases dramatically
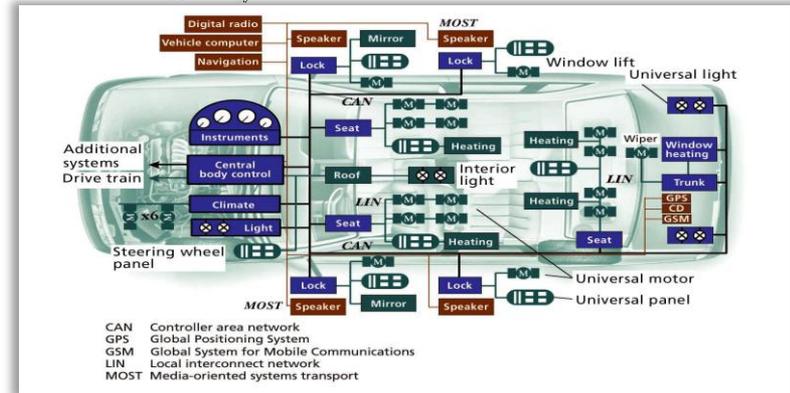
Complexity Keep Increasing

C. Buckl, A. Camek, G. Kainz, C. Simon, L. Mercep, H. Stähle, A. Knoll. The Software Car: Building ICT Architectures for Future Electric Vehicles. 2012 IEEE International Electric Vehicle Conference, Greenville USA, March 2012
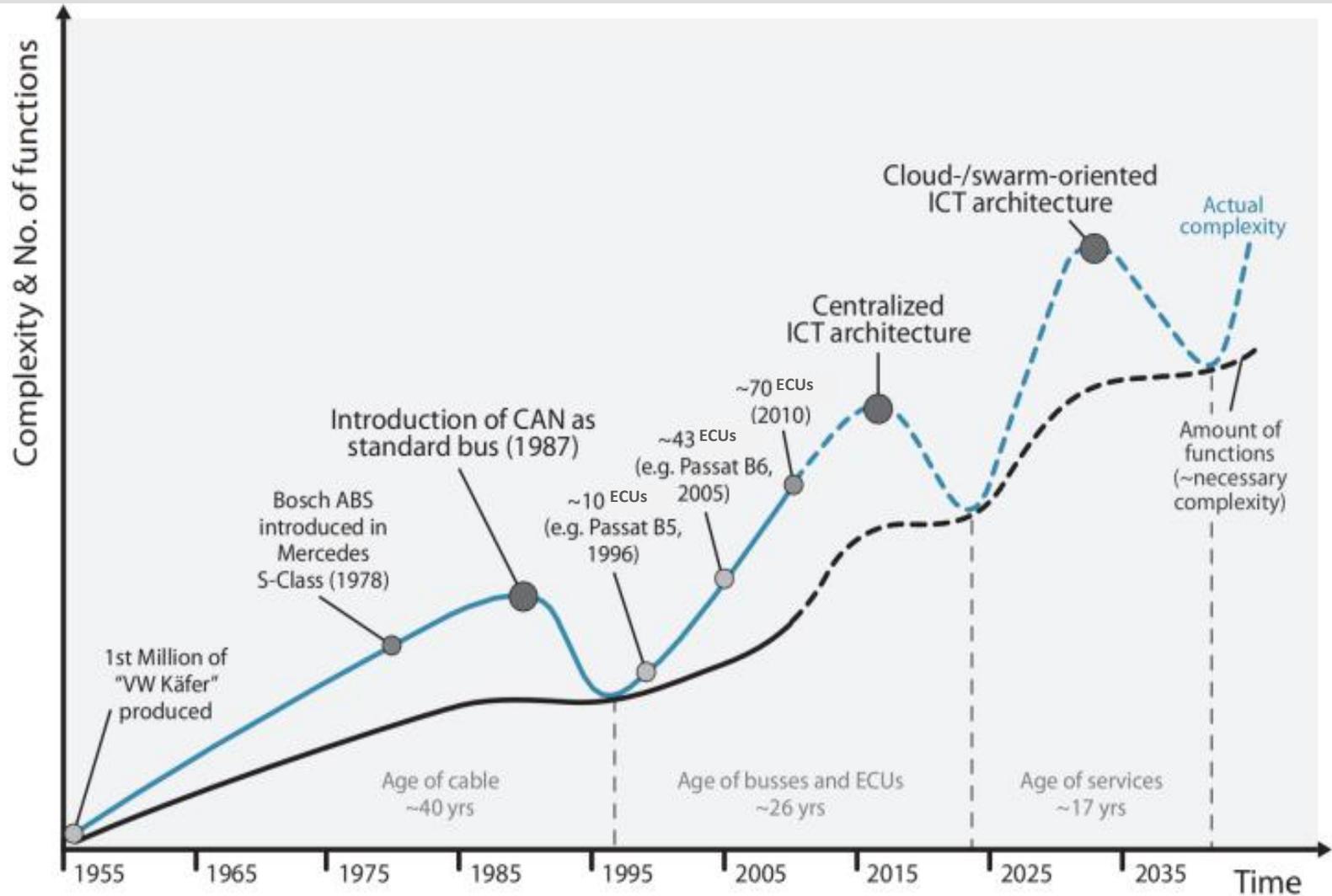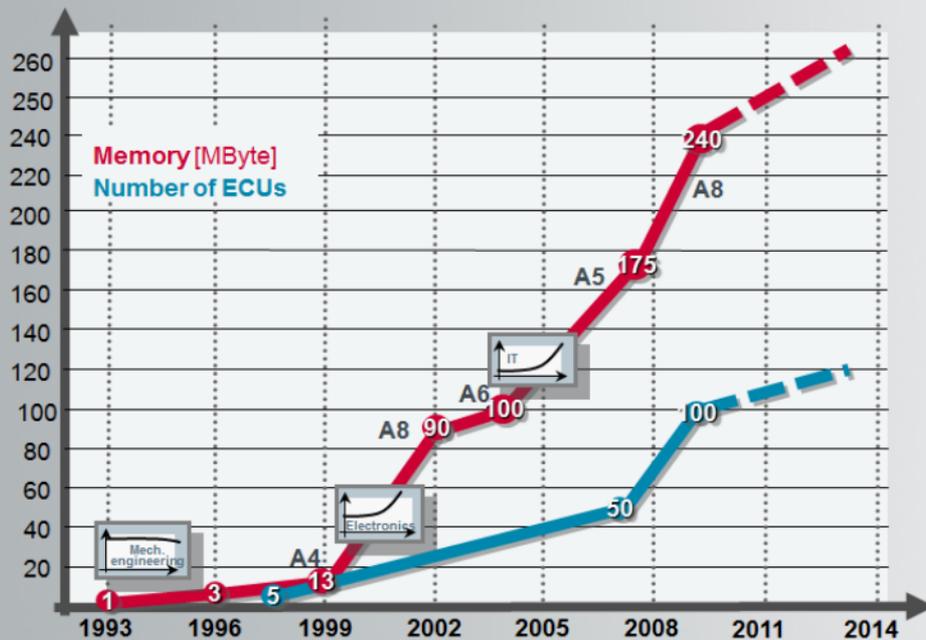
DENSO's View
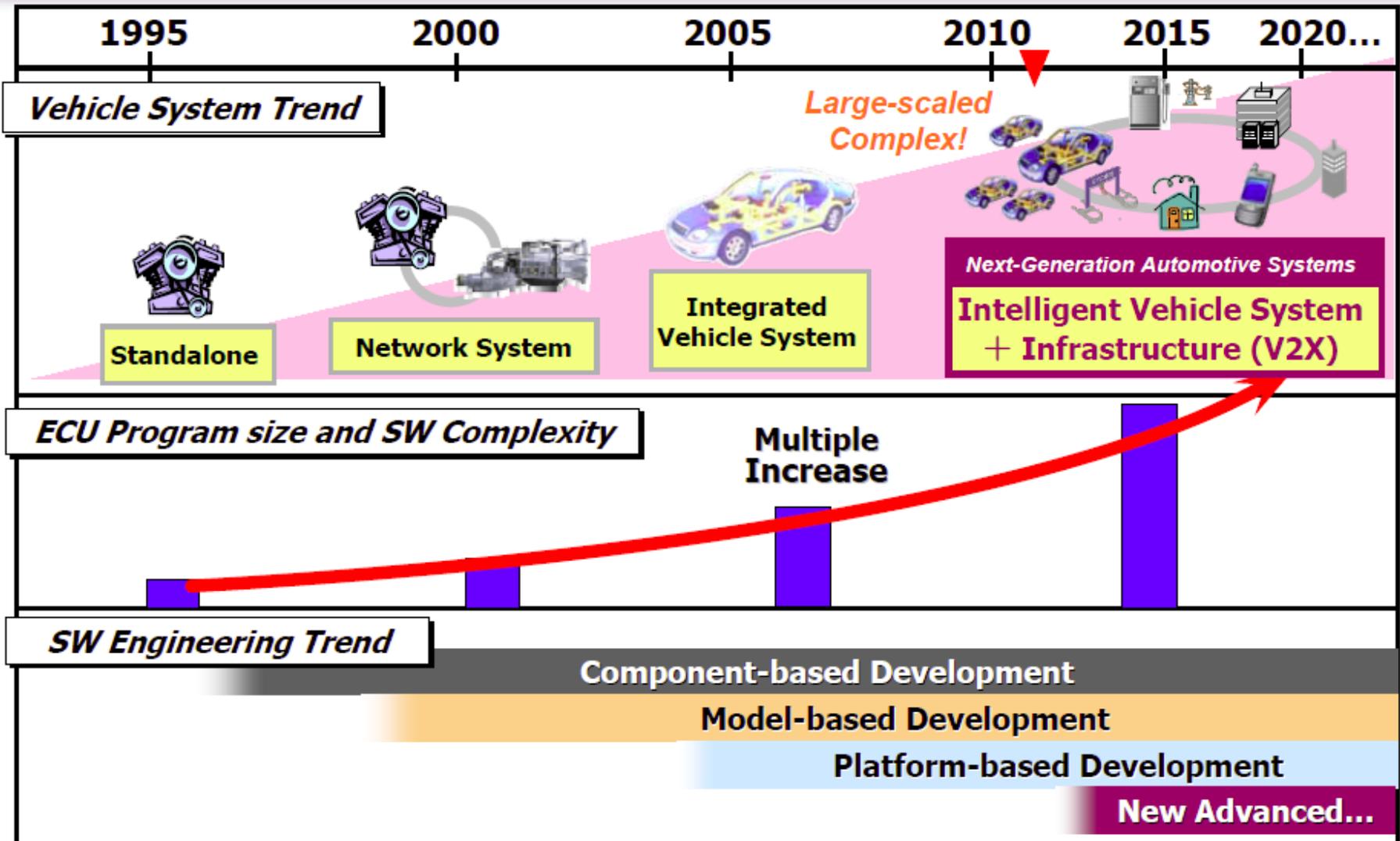
Data from car manufacturers

Source:
Paul Milbredt, AUDI AG, EFTA 2010
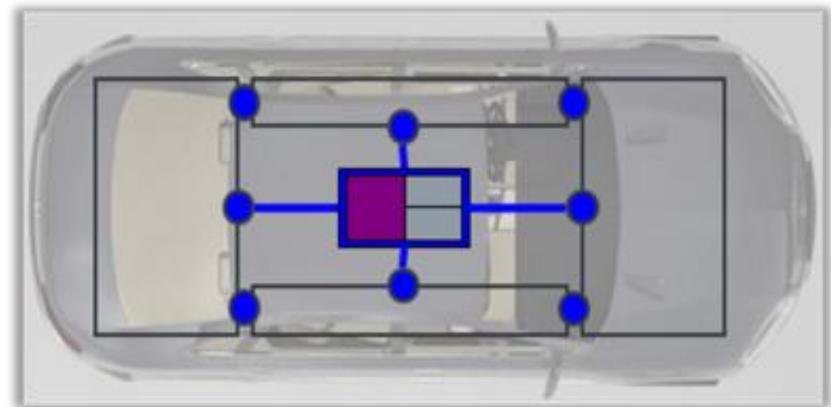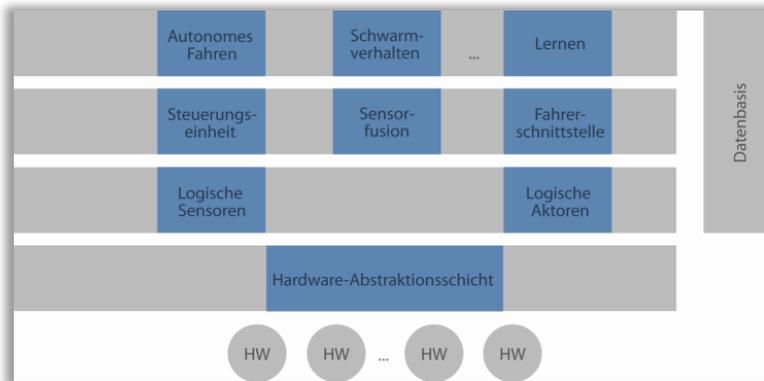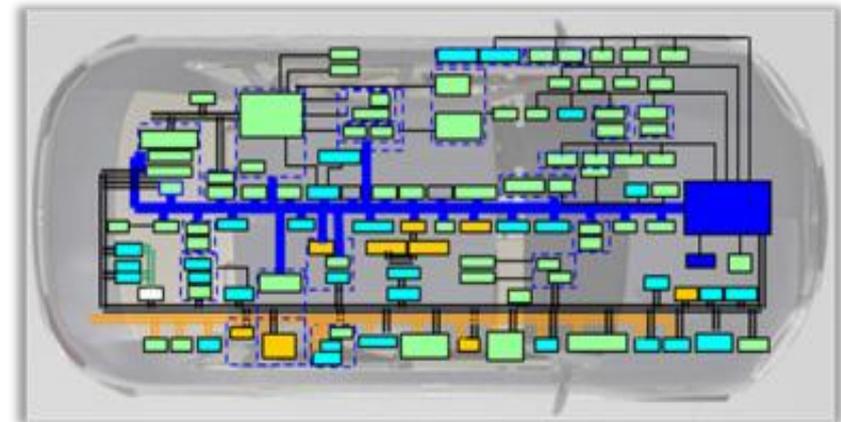Switched FlexRay: Increasing the Effective Bandwidth and Safety of FlexRay Networks
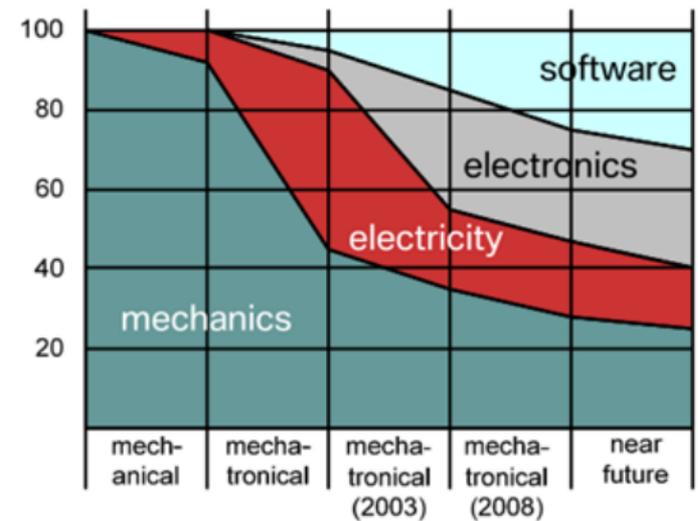
Source:
BMW Group, FTF 2010 Orlando
Energy Saving Strategies in Future Automotive E/E Architectures

Centralized Architecture Reduces Complexity
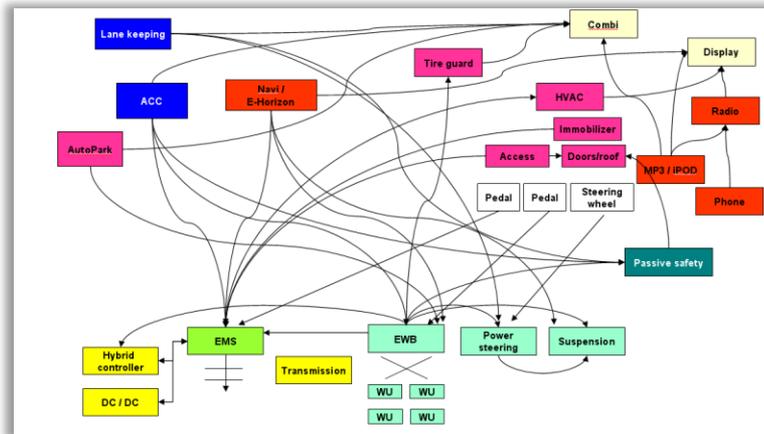
Required Technology for Centralised ICT

High performance

Scalability

Energy efficiency

Safety and Reliability

Computation-Intensive Lane Detection

- Need a Nividia GeForce GTX 285 (1G DDR3, 1476MHz) to get 24 frames/second for a 600*480 resolution video
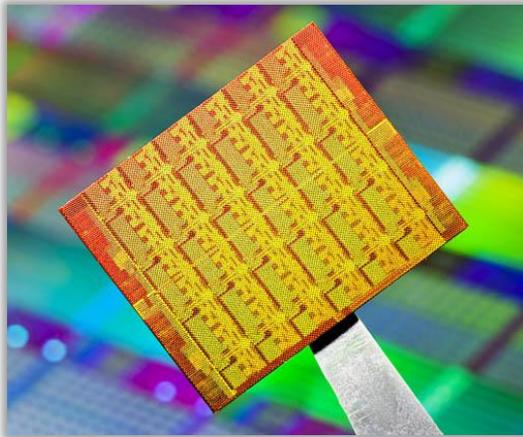
Current Automotive Controllers

Infineon 8 bit, 16 bit, 32 bit chips

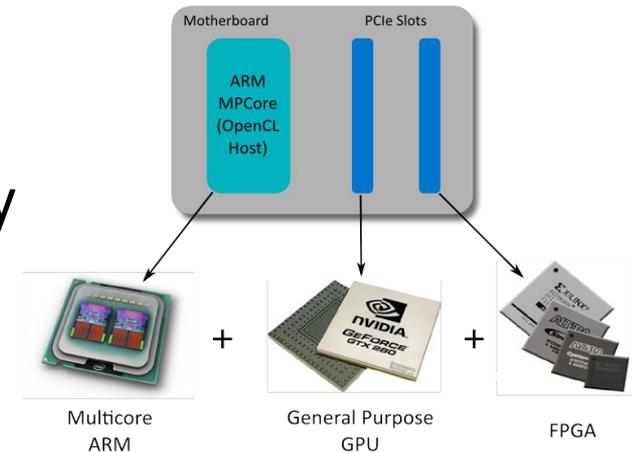Freescale 16bit, 32 bit chips

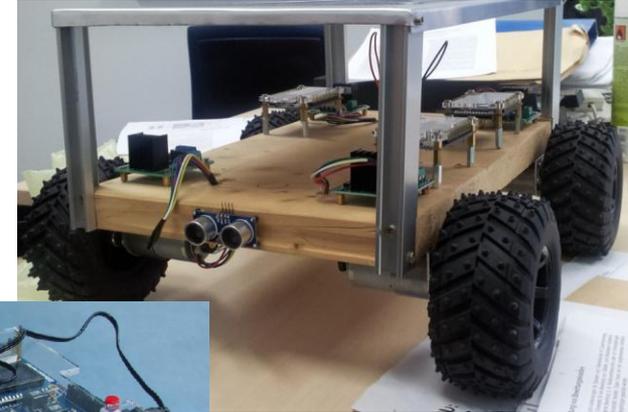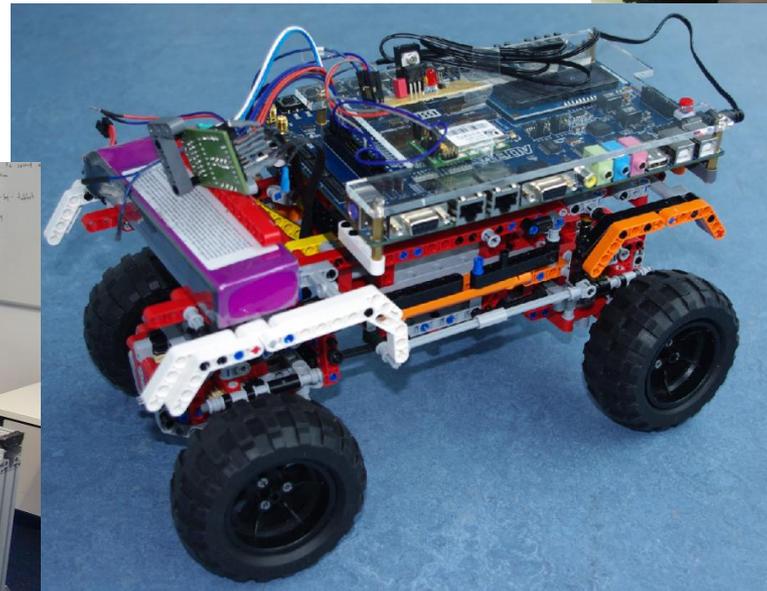# What is Needed

Manycore

FPGA

GPU

- Use the combination of state-of-art Semiconductor techniques to achieve high performance and energy efficiency
- Use customized board to scale the number of chips to use

Scalability Demos
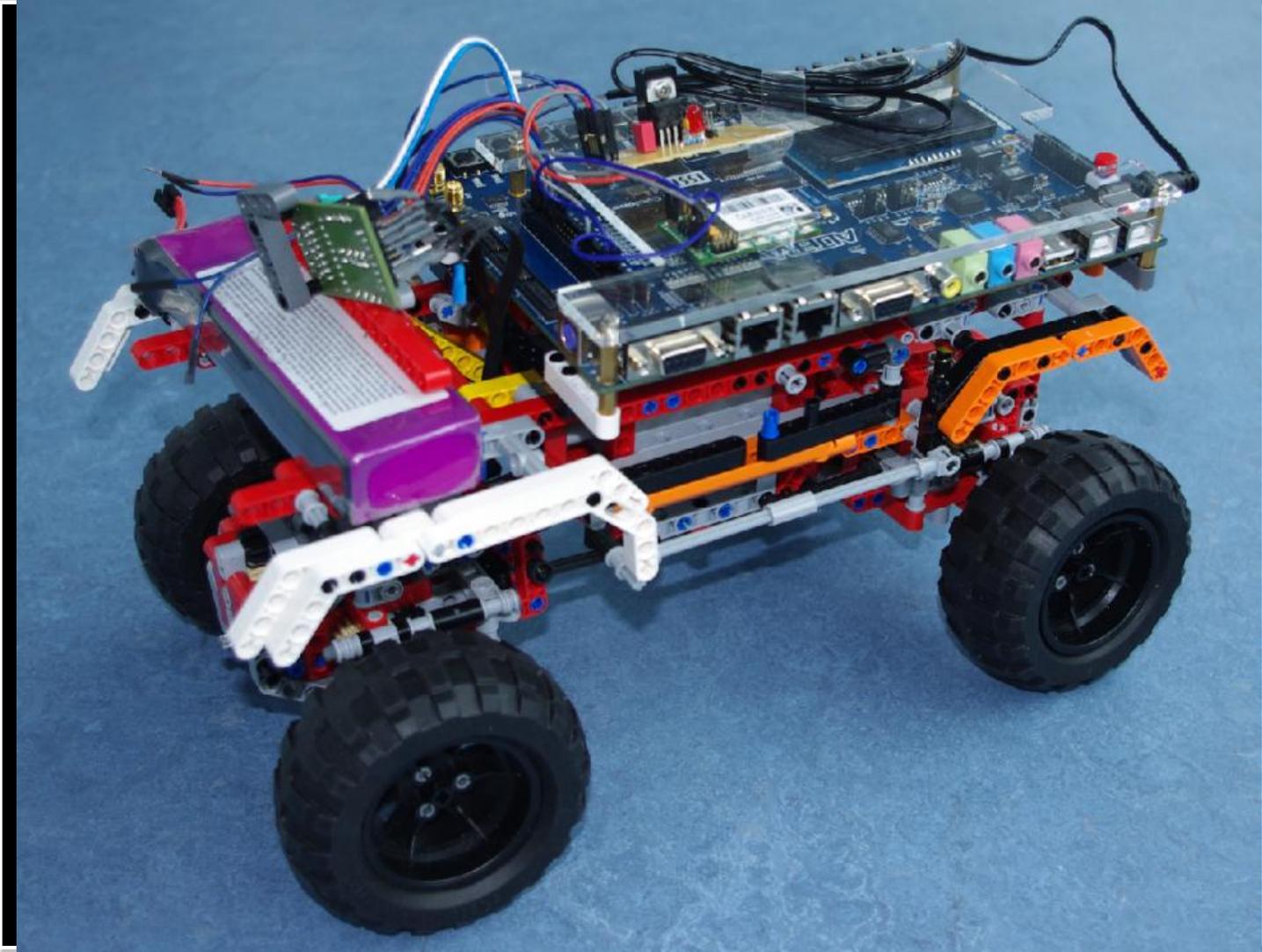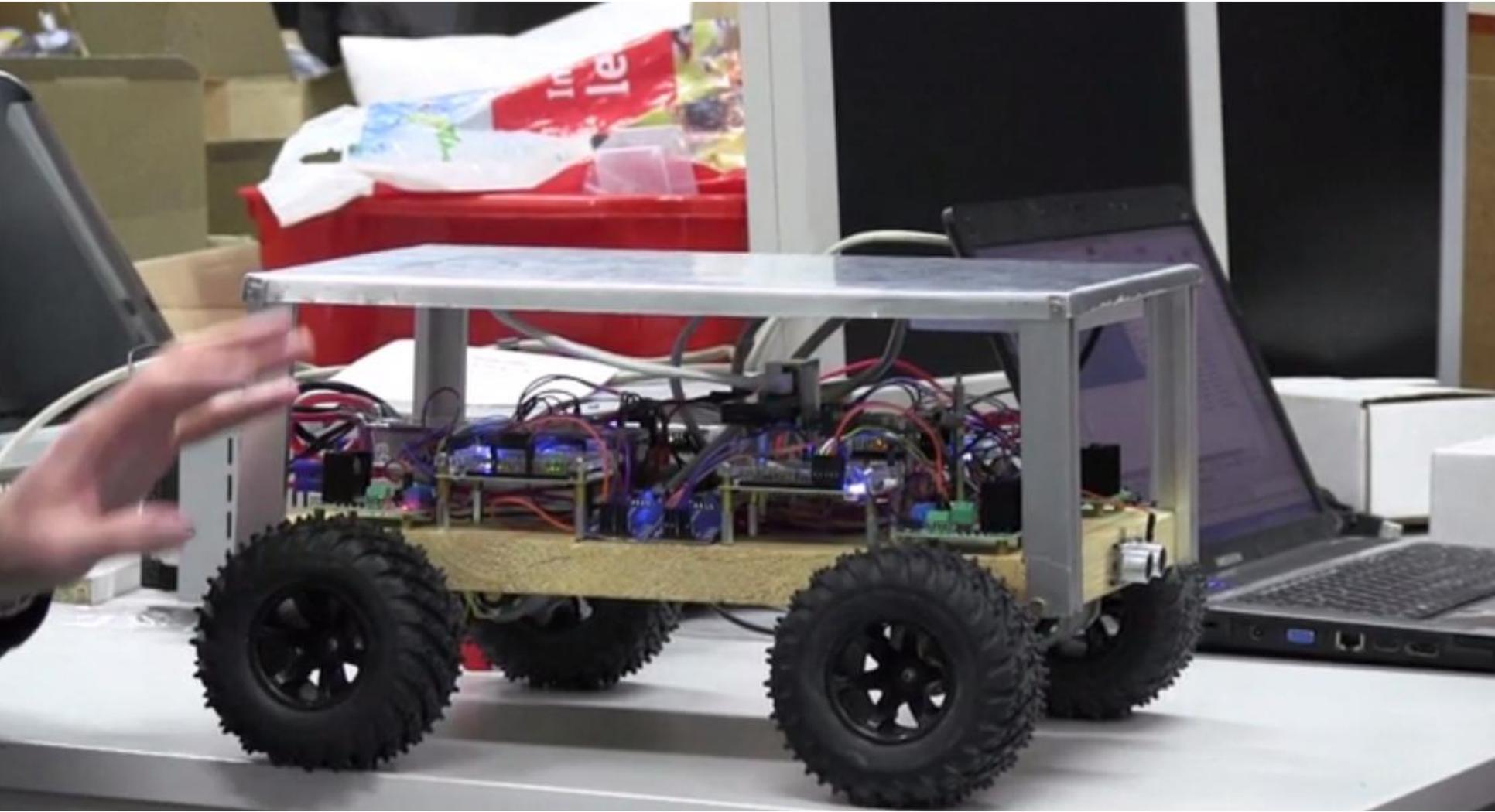
fortiss eCar

Lab Car 1: LEGO E-Corner

Lab Car 2: LEGO

Lab Car 2: Collision Avoidance

TUM Lab Car: Climbing the Tube

Video 5: Mercedes S-class

MISC

- AUTOSAC (http://www.autosar.org/)

- GENIVI (http://www.genivi.org/)

Ford reveals solar-powered car

- Fully charged the car could travel for up to 21 miles powered just on electricity.

- Research from the company suggests that in future the sun could power up to 75% of all trips made by an average user in a solar hybrid vehicle.