SOFTWARE AND HARDWARE SYSTEM ARCHITECTURE FOR NEXT GENERATION VEHICLES

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MISSION

We create stunning, driver focused supercars that deliver exhilarating performance with maximum control and safety—on road and track.

DRAKO

https://www.youtube.com/watch?v=b_OIP_qzezQ

THE GROWTH OF VEHICLE ELECTRONICS

Modern luxury vehicles have 50-150 ECUs
source: Strategy Analytics, IHS Markit

Global ECU market $63.6 billion (2018)
source: grandviewresearch.com

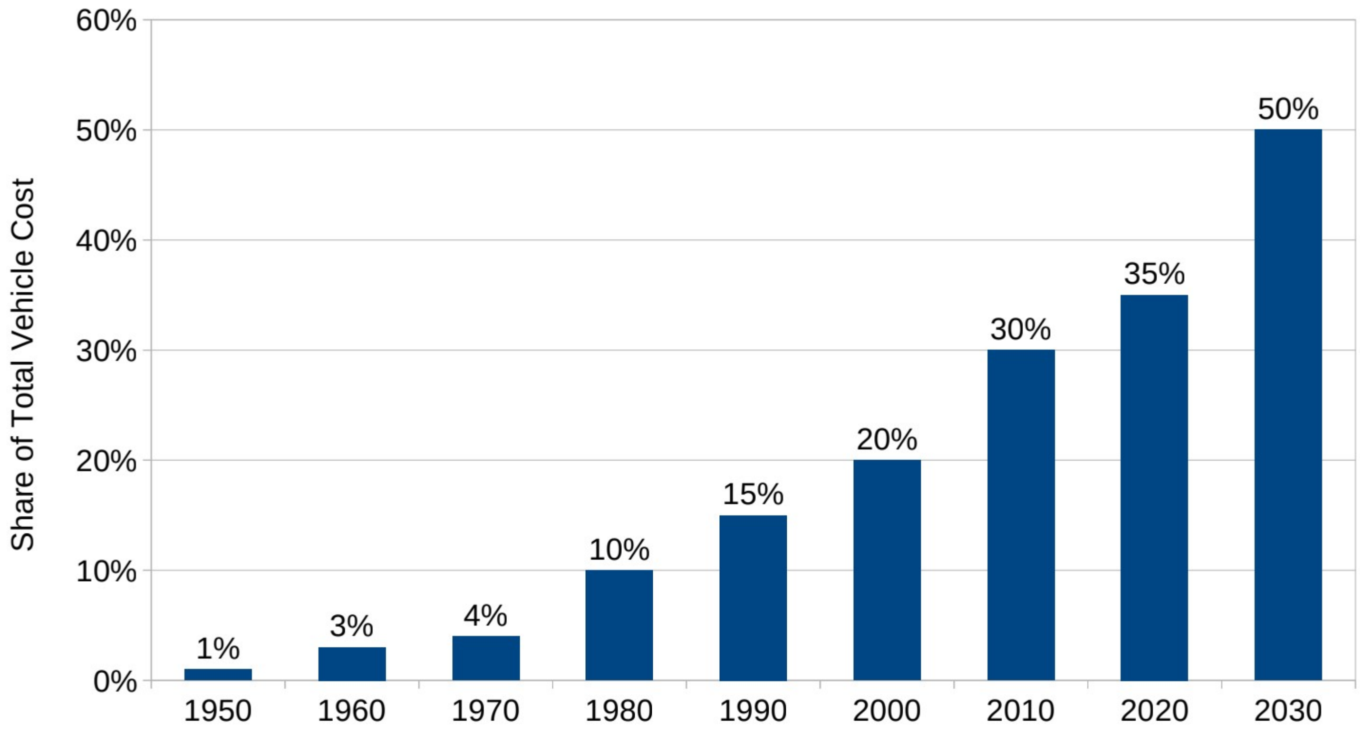
ADAS, HEVs and BEVs driving costs of electronics in vehicles

HEV + BEV ECUs 3% market in 2018

+ Potential rise to 15% by 2030
+ Continental & Bosch have 28% ECU market

source: eenewsautomotive.com 2018

ELECTRONICS SHARE OF TOTAL VEHICLE COST



source: Statista 2017

HARDWARE EVOLUTION

EMBEDDED MCUs
8→ 16→ 32 bit microcontrollers
Single core, single function
low performance, low power

SIMPLE RTOS
Compute / memory limited
Low communication bandwidth
High cost for functional safety

SOFTWARE EVOLUTION

Simple firmware

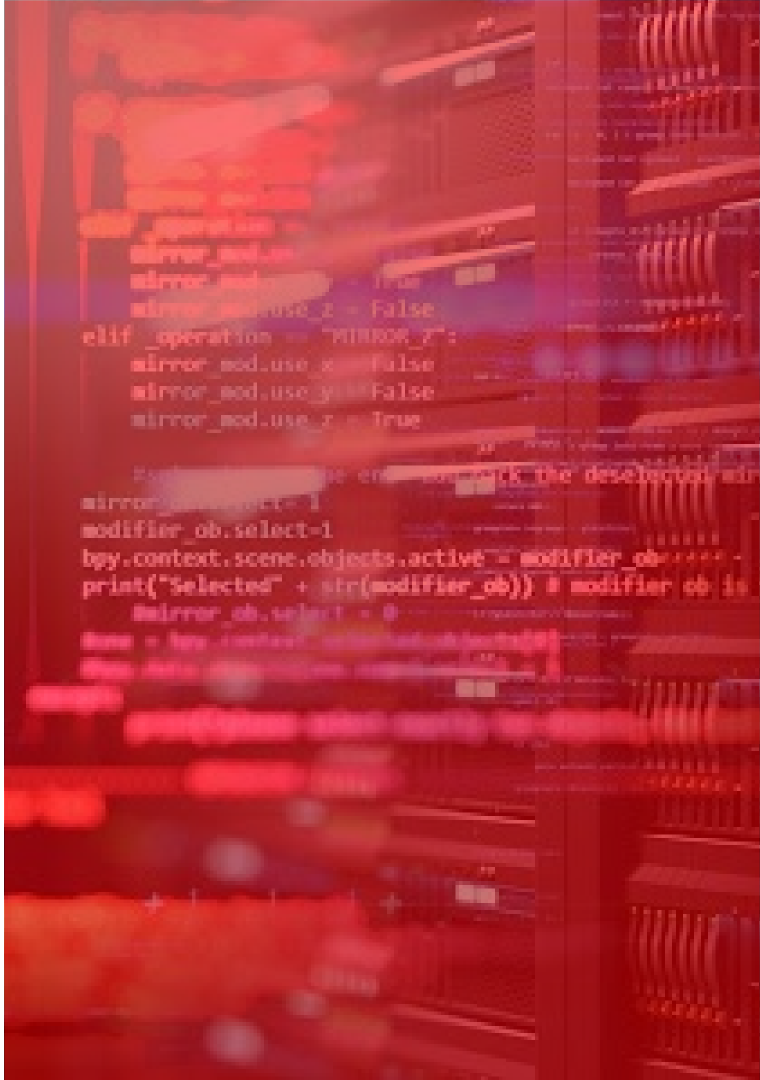
Model-based design

MATLAB, Embedded C/C++ single threaded code

Separate hardware for different software criticality/integrity levels (ASIL A-D)

Linux / Windows for low-criticality infotainment

RTOS for high-criticality vehicle control



VEHICLE COMMUNICATIONS NETWORKS

I2C, CAN, LIN, Flexray, MOST

Bandwidth-limited (typically <1Mbps)

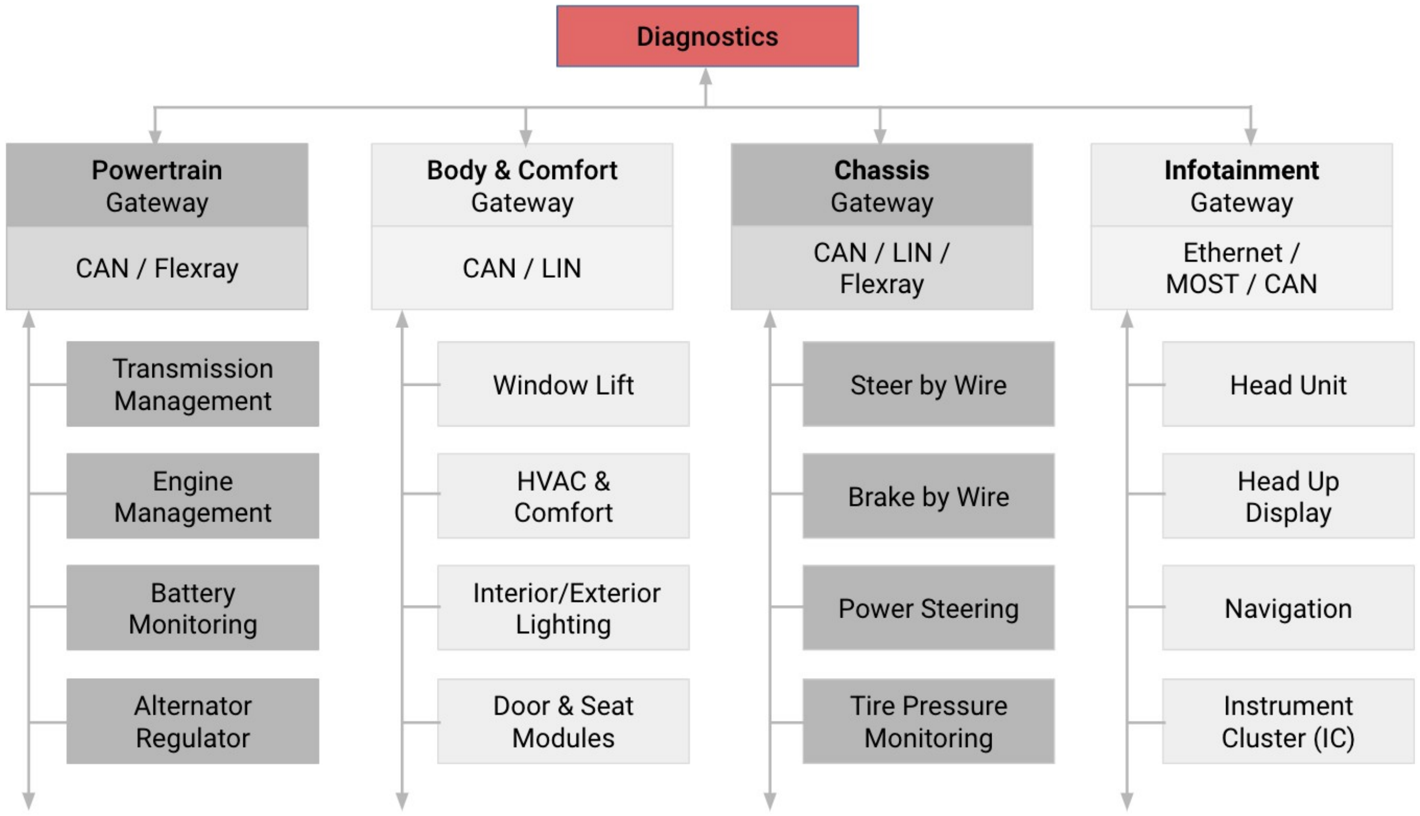
ETHERNET

Real-time challenges, jitter, no bandwidth reservation

Time-triggered Ethernet not yet commonplace

Switched architecture

TODAY'S ECU VEHICLE NETWORK



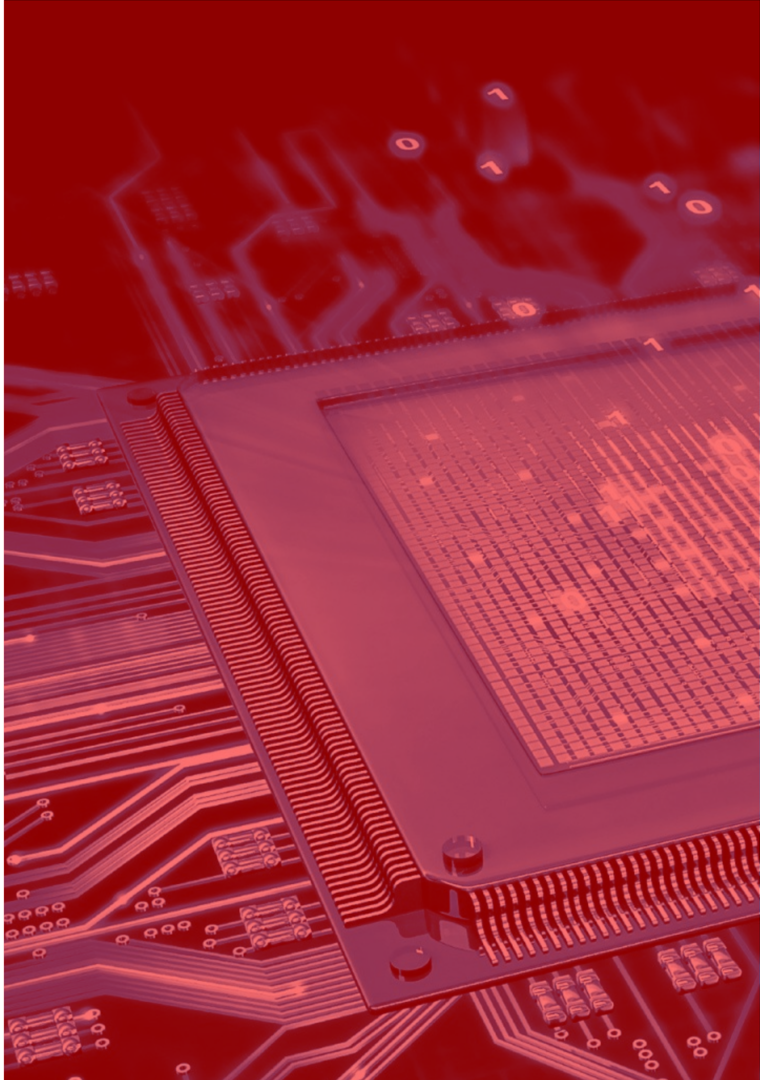
SEMICONDUCTOR EVOLUTION

Compute, memory & I/O challenge addressed by increasing count of MCUs/ECUs

More complex ECUs for BEVs (ADAS, battery mgmt, vehicle dynamics, IVI, IC, V2V, V2I,…)

Custom processors and SoCs

Cost explosion for OEMs



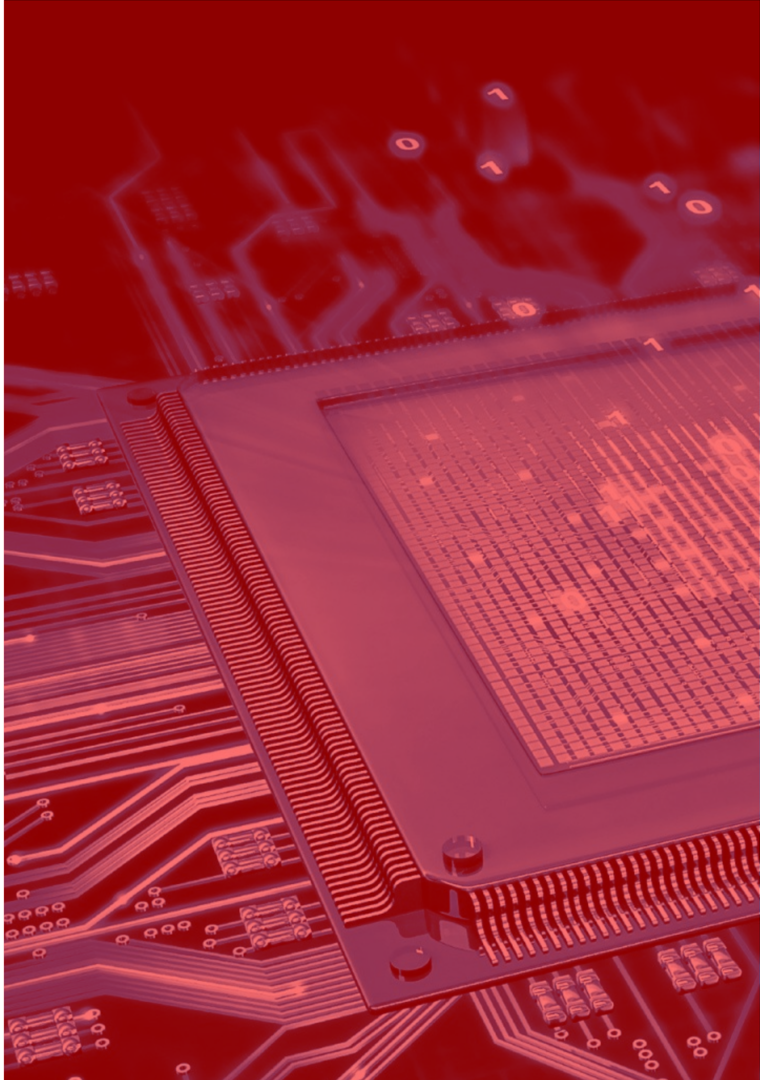
SEMICONDUCTOR EVOLUTION

From MHz to GHz

Clock speed scaling now over

Future is multicore

+ Already embraced outside automotive domain
+ Smartphones, tablets, laptops, desktops, servers
+ 8 cores on smartphones, 64+ on servers
+ Hardware virtualization features to separate functional components



FUNCTIONAL CONSOLIDATION

AIM: break the 1:1 mapping of vehicle functions to ECUs (minimize ECUs)

Replace hardware ECU functionality with software

- + N > 1 software functions per core
- + Easier to reconfigure
- + Easier to update
- + Easier to extend
- + Extend vehicle life and capabilities – Lower cost

AUTOMOTIVE OS REQUIREMENTS

Management of software functions

- Tradeoffs in timing and safety criticality
- Mixed-criticality functionality on single platform
  - e.g., ABS, torque vectoring vs infotainment
- Time and space isolation (security)
- ASIL requirements

Real-time vs non-real-time functions

Low cost

Fast Boot

Power Management

Drako DriveOS™

Uses PC-class hardware for the car

Multicore

Hardware virtualization

Integrated high-bandwidth I/O

Combine RTOS capabilities with legacy services for e.g., infotainment, ADAS

Drako DriveOS™

Leverage the Quest-V real-time partitioning hypervisor

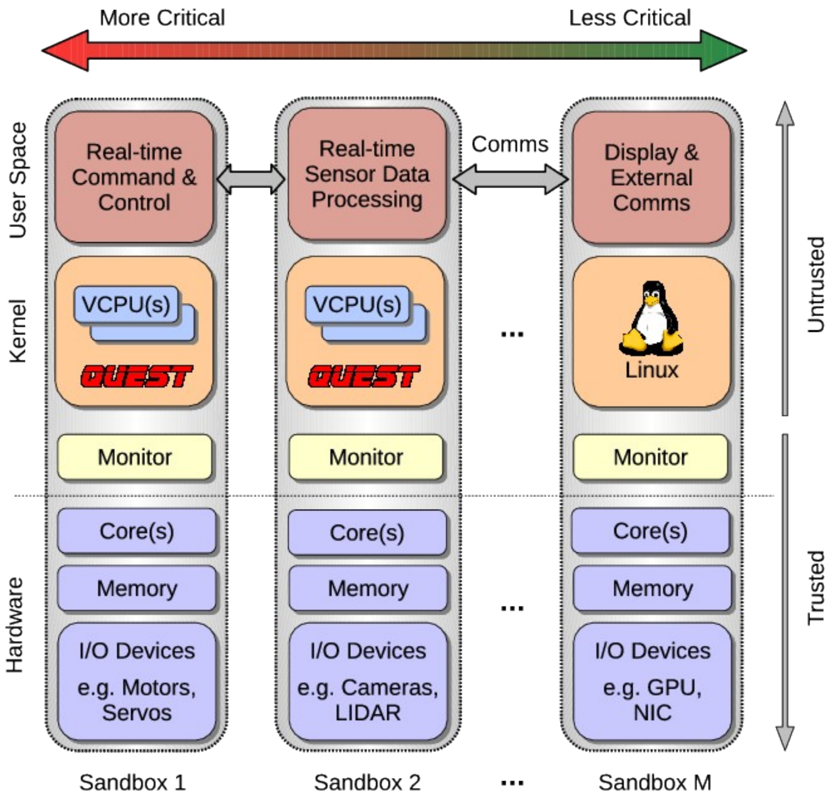
- Open Source

Co-locate Quest RTOS with Linux and Android guests on same hardware

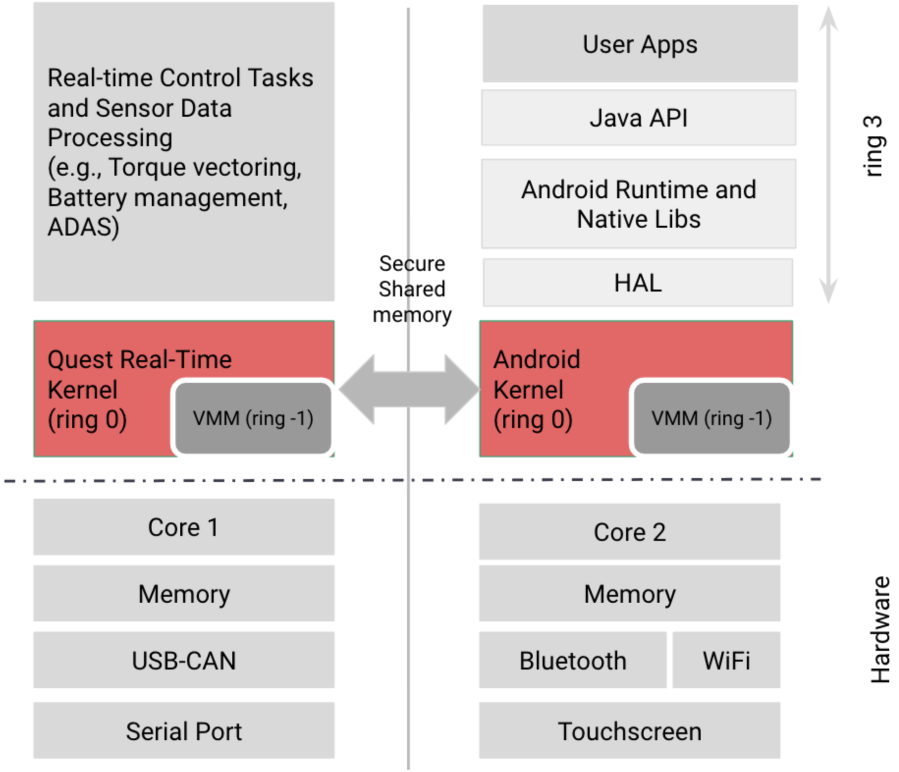
Real-time USB-CAN interface for communication with simple ECUs

+ Processing moved to PC, while ECUs communicate, sense and respond to data

QUEST-V PARTITIONING HYPERVISOR

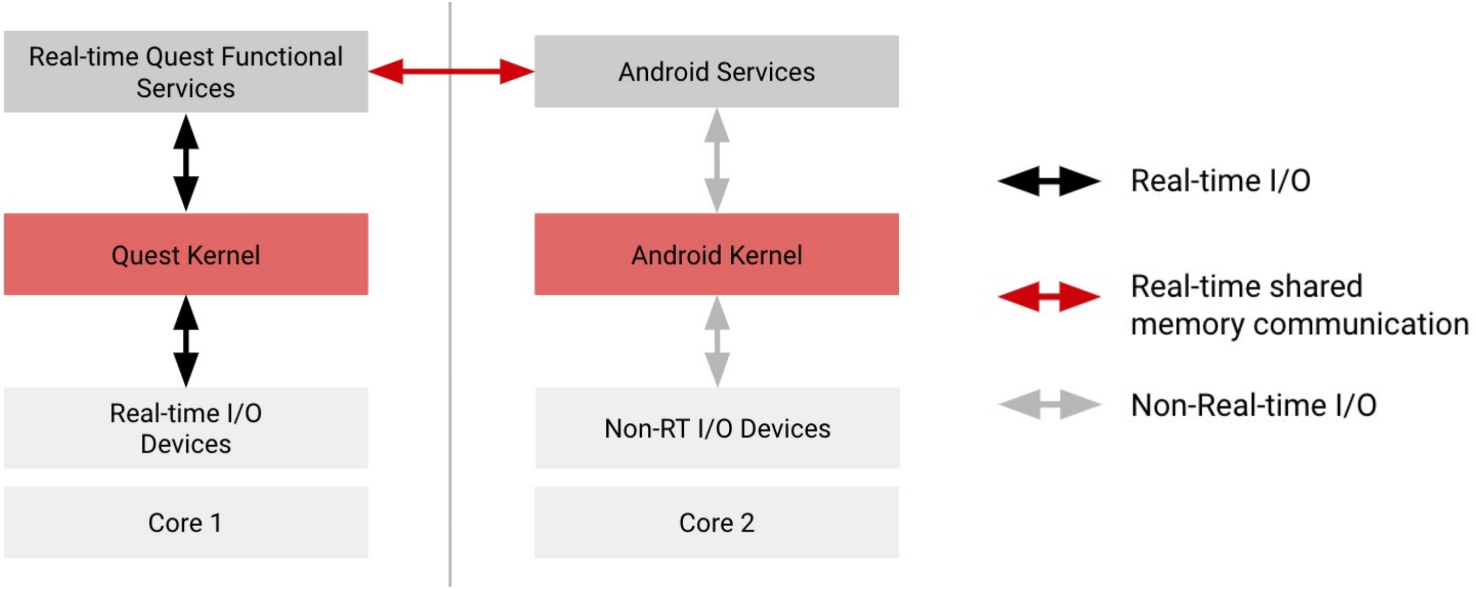


EXAMPLE: DriveOS FOR NEXT-GEN IVI

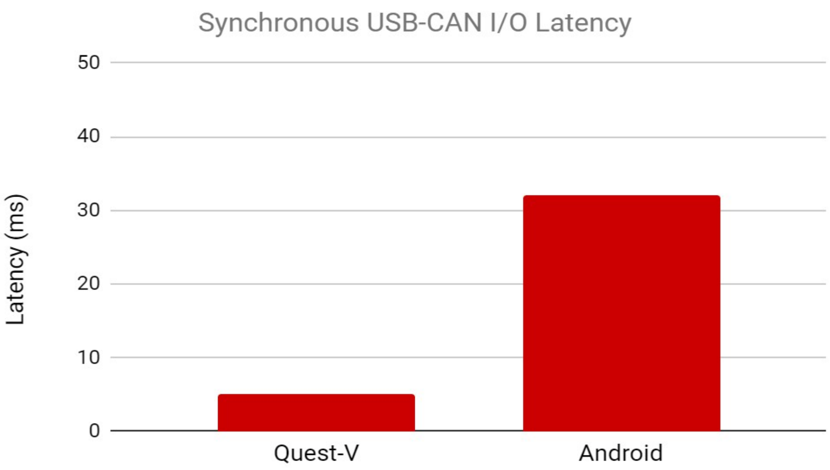


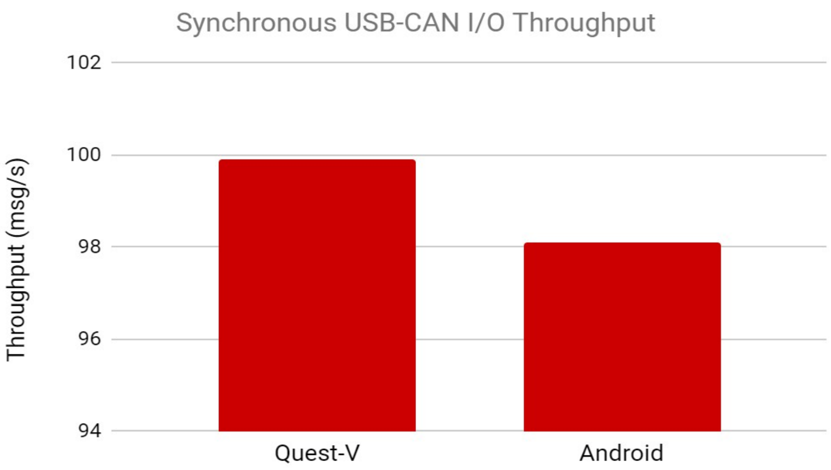
DriveOS: SUPPORT FOR ANDROID IVI

Provide Android interface to securely configure vehicle & exchange data in real-time



Drako DriveOS™: QUEST-V VS NATIVE ANDROID



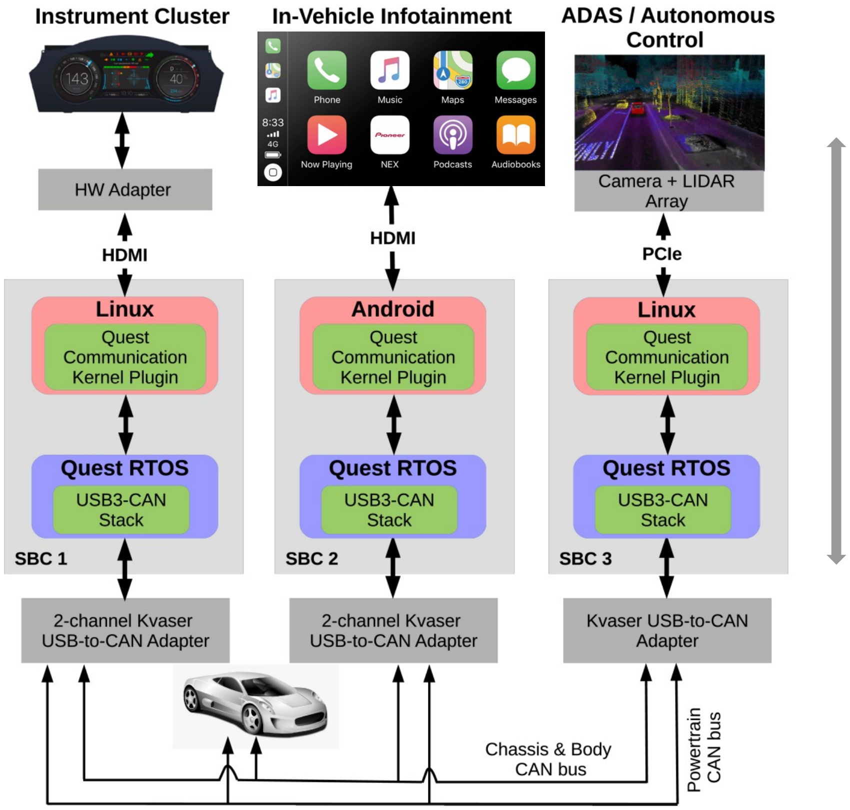


Quest-V tuned pipes empowers Android

- More predictable communication (less jitter)
- Greater throughput and lower delay

Single x86 multicore PC Solution

Can map all services to a single car PC



Real-time I/O via Quest-V Tuned Pipes

Drako DriveOS™: TUNED PIPES

Like POSIX pipes but guarantee throughput and delay on communication

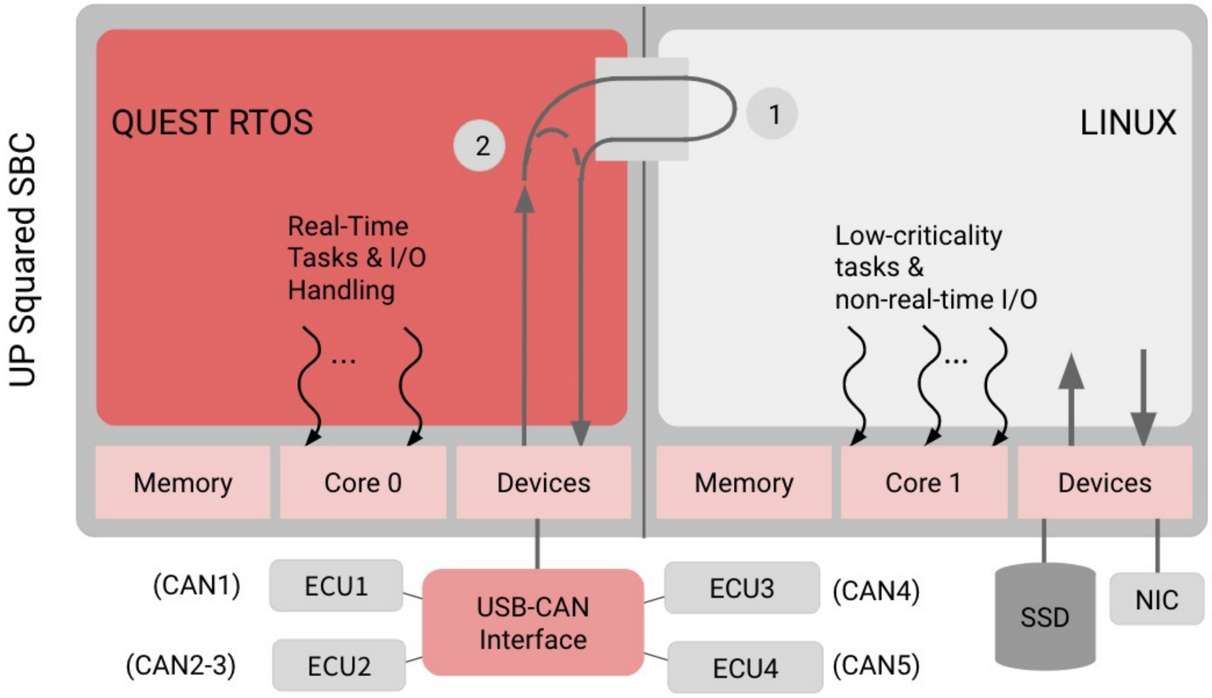
Boomerang I/O subsystem supports real-time I/O across Quest RTOS and legacy OSes

+ Empowers legacy OSes (Linux, Android) with real-time capabilities

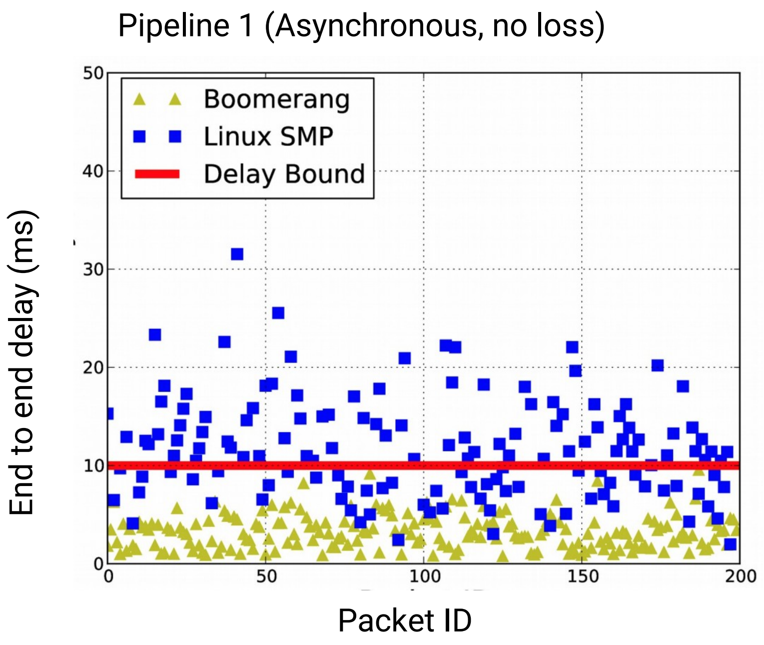
EXAMPLE SINGLE BOARD COMPUTER

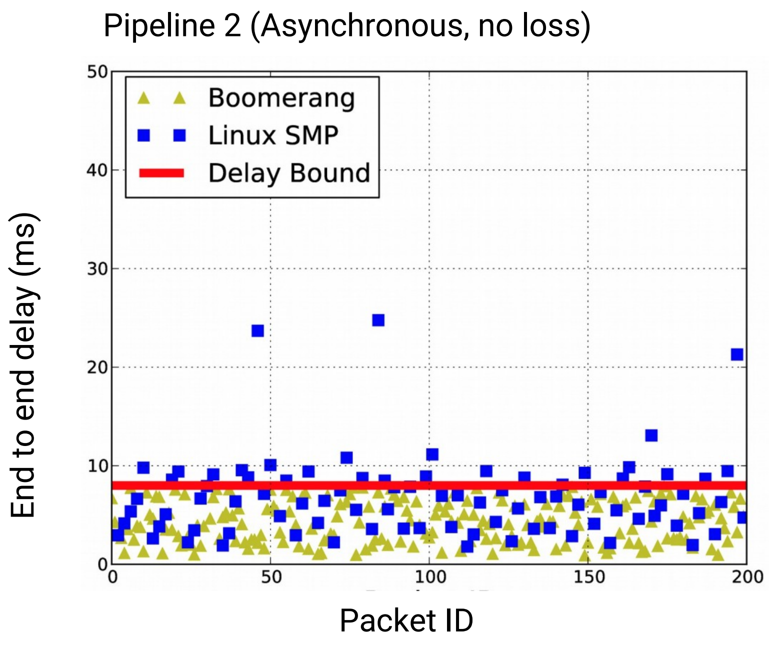
Boomerang tuned pipe path (1) spans Quest + Linux + USB-CAN

Boomerang tuned pipe path (2) spans Quest + USB-CAN



Drako DriveOS™: BOOMERANG RESULTS





Boomerang sub-system in DriveOS meets communication timing guarantees
A Linux SMP (multicore) OS with real-time extensions cannot perform I/O predictably

CONCLUSIONS

Next-generation automotive systems require ECU functional consolidation

Automotive PC-class hardware a low-cost viable option

Need for a vehicle OS that integrates real-time and non-real-time mixed-criticality services

DriveOS™ uses hardware virtualization for real time temporal and spatial isolation

+ Uses Quest-V: World's first real-time partitioning hypervisor with guaranteed I/O throughput and delay across criticality domains

QUESTIONS