



seL4 in Software-defined Vehicles: Vision, Roadmap, and Impact at NIO

Ning Qu @ NIO

seL4 Summit 2024

Oct 17, 2024

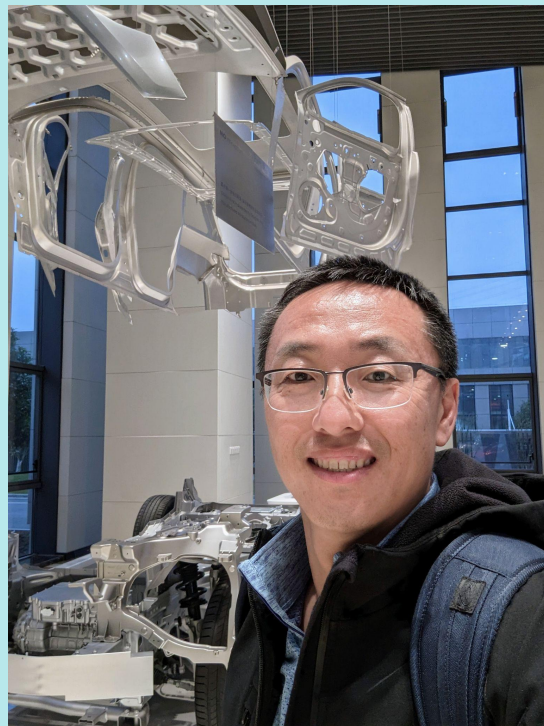
Ning Qu

Associate VP of Engineering at NIO, Global Head of Platform Software team (SkyOS).

SkyOS is comprehensive suite of platform software (including hypervisor, operating systems, and middleware) for Software Defined Vehicles, first announced at NIO IN 2023.

Prior to NIO, veteran in the autonomous driving industry leading Waymo's ML Runtime team and Baidu Apollo OS team.

B.S. and Ph.D in compute science from Peking University, Post-doc researcher at Carnegie Mellon University.



Agenda

SDV and SkyOS evolvement in NIO

Journey of seL4-based OS in NIO

Future Planning and Community Collaborations

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SDV and SkyOS evolution in NIO

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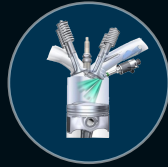
Future Planning and Community Collaborations

Automotive industry evolve into Smart EV + AI era

Mechanical
Era



Electric
Era



Digital
Era



Smart EV
Era



AI
Era



No OS or Minimum OS

Component based OS

?

For functional vehicles
OS is primarily tailored for component suppliers

The logo for AUTOSAR, featuring the word "AUTOSAR" in a bold, sans-serif font. The letter "O" is stylized with a horizontal line through its center, and the entire word is enclosed within a thin, white, rounded rectangular border.

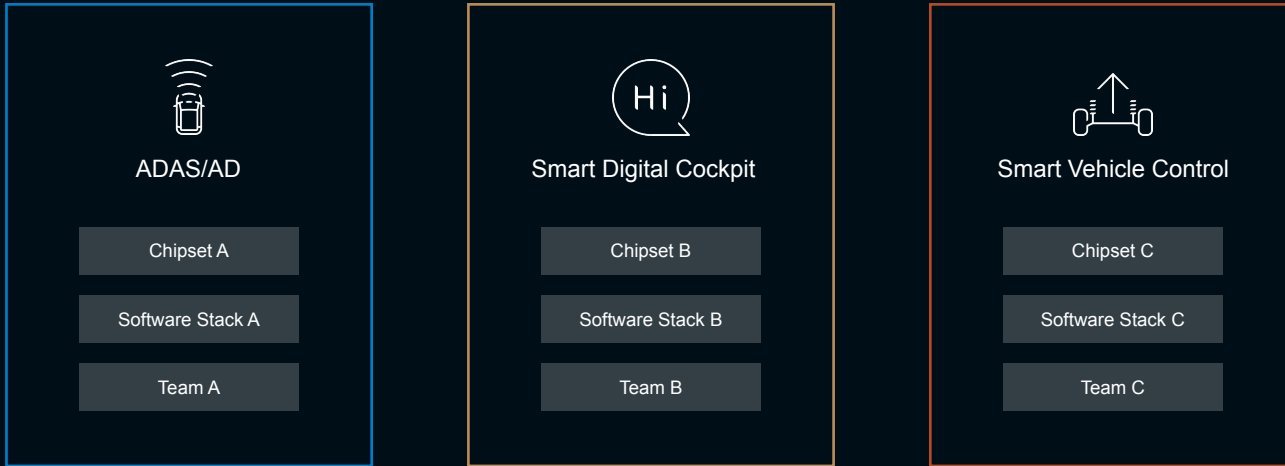
A type of 'acceptance criteria' that
OEMs impose on component
suppliers.

The logos for BlackBerry and QNX. The BlackBerry logo consists of a stylized "B" made of dots followed by the word "BlackBerry" in a serif font. The QNX logo consists of the letters "QNX" in a bold, sans-serif font. A vertical line separates the two logos.

Adapt into OS for vehicle domain
(e.g. digital cockpit)

OS is introduced to enhance the reusability of components

Software are developed for each ECU domain



Fragmented and Disconnected

What sets SkyOS apart as full domain vehicle OS

Transition EE Arch from
Distributed Computing arch into
Centralized Computing arch

Redesigned based on SOA:
Cross-domain scheduling
Seamless cross-domain
integration

Break ECU domain boundaries
==
Break departmental boundaries

High Reliability
Low Latency
and High Bandwidth

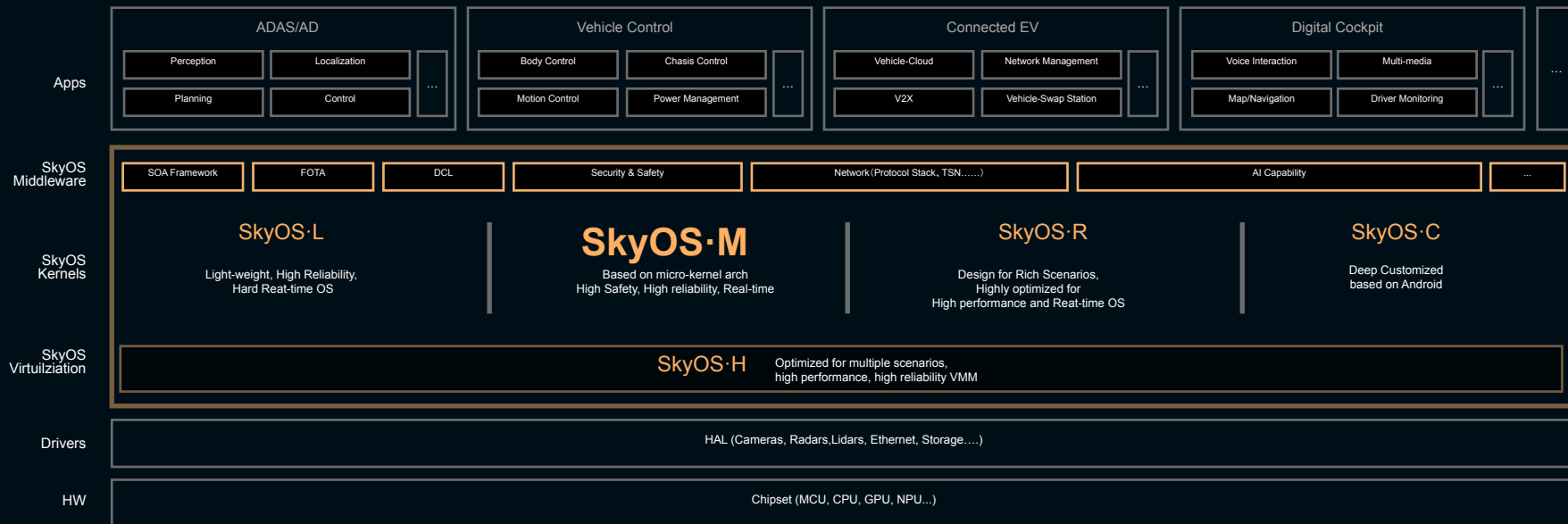
Chipset Support
Toolchain

Shift in supply chain cooperation model

Technical Level

Org Level

An unified vehicle OS that: consolidates and orchestrates computational resources while efficiently managing and integrating all subsystems



Production Timeline of SkyOS



Deployments:

- Over 600K+ NIO vehicle deployed to date
- Rapid expansion continues with both NIO and sub-brand ONVO

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ONVO L60 equipped with seL4 based OS

Mass production in Sep, 2024



How seL4 aligns into NIO's long-term vision.

Vision of SkyOS-M:

- Deliver a state-of-the-art **safety** vehicle OS with best-in-class **performance** and **reliability**.
- Support a wide feature spectrum for various application scenarios: vehicle body control, cockpit, edge AI, as well as autonomous driving.

Leveraging seL4's proven strengths in safety-critical systems and formal verification.



Developing SkyOS-M based on seL4

Timeline and milestones for the SkyOS-M development.



Challenges of developing SkyOS-M

Develop essential
core OS service



Process Server

Device Server

Memory
management

Network Server

FS Server

...

Challenges of developing SkyOS-M

Support a necessary subset of Posix interfaces



Process &
Threads

Signals

FS

IPC

Sockets

...

Develop essential core OS service



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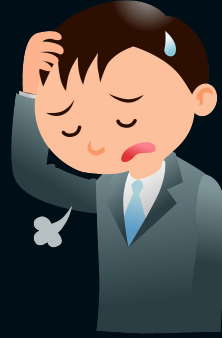
FS Server

...

Tooling & SDK Support

(sys monitoring, logging, etc)

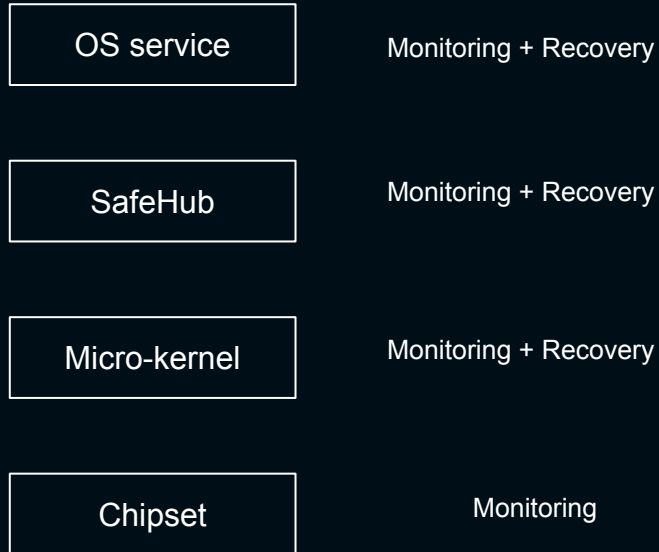
Challenges of developing SkyOS-M



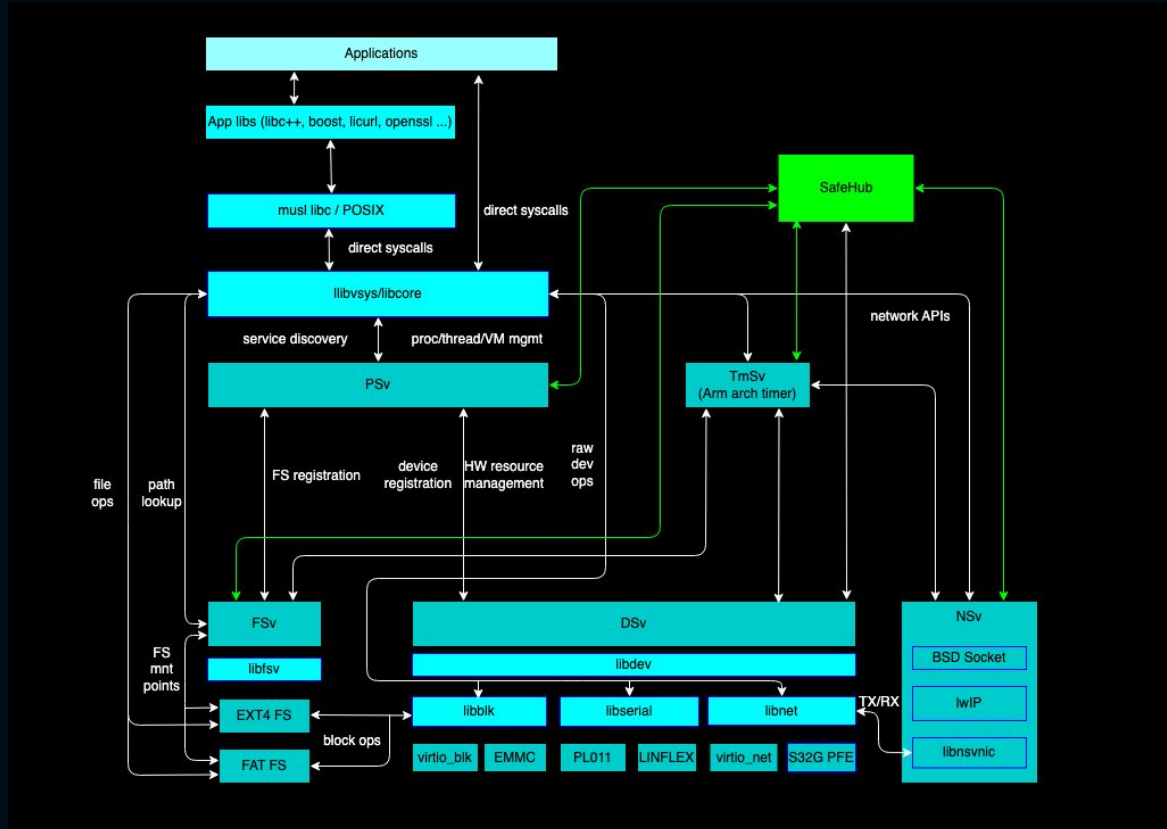
A shortage of developers experienced with microkernel-based systems presents an ongoing challenge

Hierarchical safety design implemented from the ground up ...

4 Tier Monitoring + 3 Tier of Recovery System



SkyOS-M Architecture



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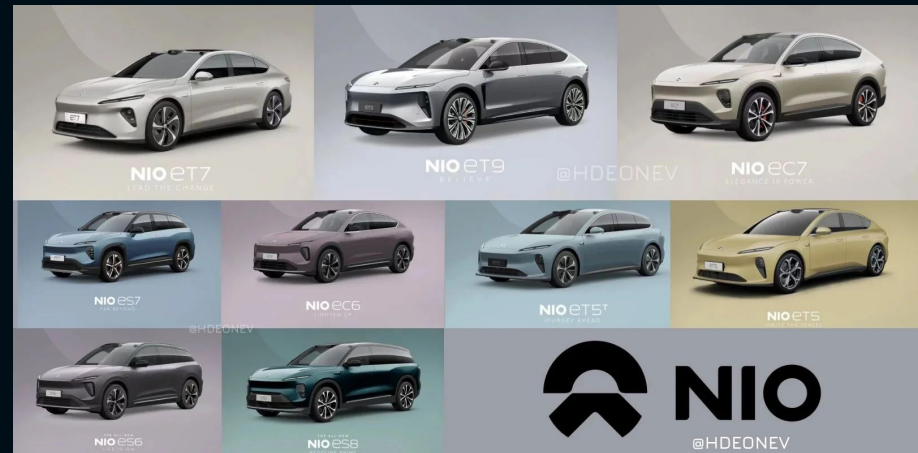
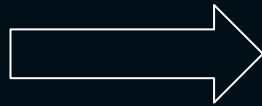
Journey of seL4-based OS in NIO

Future Planning and Community Collaborations

This is just the beginning ...

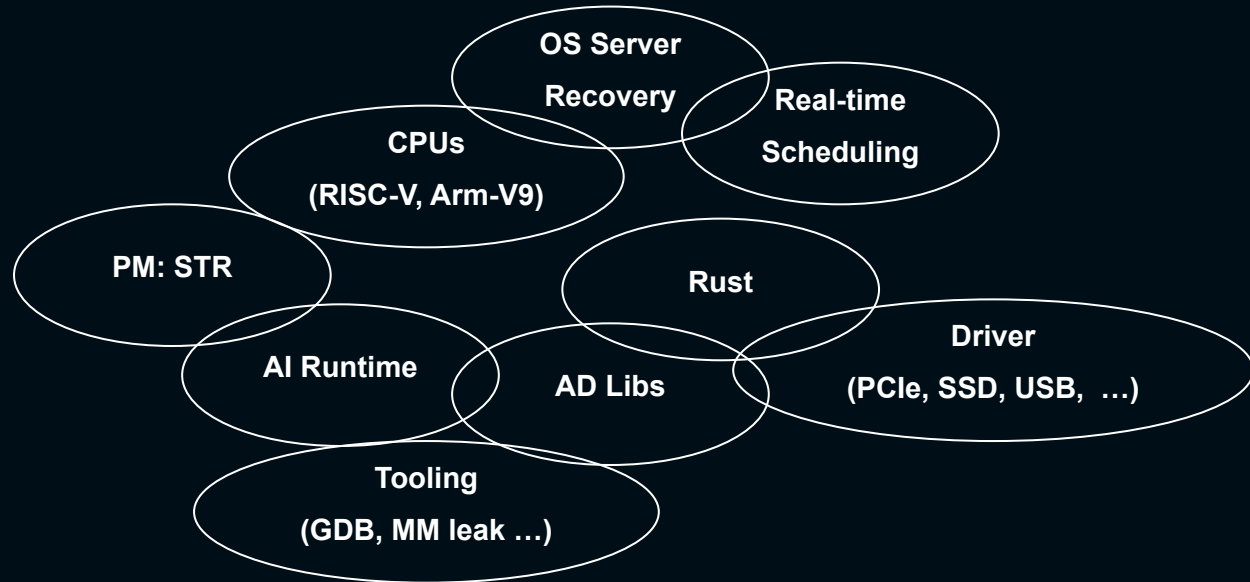
SkyOS's long-term vision within the broader SDV landscape.

- Expansion of microkernel-based architectures in more automotive domains
- How seL4 and SkyOS will adapt to next-generation vehicle platforms.



Future considerations

- **Extending SkyOS-M with seL4 beyond the current vehicle body control to additional domains**
- **Performance optimization and capability expansion**
- **Safety certification for core services**



Opportunities for seL4 Community Collaboration

Proud of our active contributions to the open-source seL4 community:

- **Premium member of seL4 Foundation**
- **Silver Sponsor for seL4 summit since 2023**
- **Sponsor of Lion OS initiative**

Looking ahead, excited to foster deeper technical collaborations with broader seL4 ecosystem.



Thank you!





Q&A