Virtualization and Shared Graphics on i.MX6
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5. Shared GPU
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1. About OpenSynergy
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Short Profile

• Located in Germany (Berlin – Headquarter) and United States (San Diego)

• Worldwide customers and partners

• Focused on automotive embedded software

• Approximately 65 employees (Q1 2014)

• Excellent expertise in AUTOSAR, Infotainment, Car2I, Mobile device integration, Linux in automotive, Bluetooth software
List of Automotive Customers

COQOS & Services

Blue SDK
Pricing pressure requires multiple functions integrated on a single ECU.
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The product COQOS contains all orange modules.
It is based on PikeOS technology.
• Infotainment framework
• Virtualized environment
  • Linux
  • Android
  • AUTOSAR
  • POSIX, bare metal
• Shared graphics (framebuffer, GPU, touch)
• Fast-booting rear-view camera (1.6s)
• Bluetooth stack
• Safety and security

• Real-time applications
• Certified hypervisor
COQOS is the best way to take advantage of Linux and still satisfy automotive requirements!

The product COQOS contains all orange modules. It is based on PikeOS technology.
Single Chip for Application (Linux), CAN-Communication, Higher Layer Communication

- Best cost solution based on single SoC
- Open framework for online services in Linux
- Separation of software partitions for security
- ECU state management in separate partition for safety support
- AUTOSAR basic software for automotive integration
- Linux framework for middleware and applications
- Automotive communication framework (ACF) for inter-partition communication
# Supported Platforms

<table>
<thead>
<tr>
<th>Hardware Platform</th>
<th>Consumer OS</th>
<th>Automotive OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freescale i.MX 35</td>
<td>Linux</td>
<td>AUTOSAR CAN-Stack</td>
</tr>
<tr>
<td>PDK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freescale i.MX 53</td>
<td>Android 2.3 or Linux 2.6.35 / GenIVI</td>
<td>AUTOSAR CAN-Stack</td>
</tr>
<tr>
<td>SABRE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freescale i.MX 6D/Q (SABRE ai)</td>
<td>Android 4.2 or Linux 3.0</td>
<td>AUTOSAR CAN-Stack</td>
</tr>
<tr>
<td>Freescale i.MX 6 solo</td>
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Major hardware blocks

CPU

- Core 1
- Core 2
- Core 3
- Core 4

CPU processing time

Memory

Interrupts

I/O

- Ethernet
- Graphics
- ...

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Partitioning

Linux | other OS | services | AUTOSAR

controlled communication

partitioning

hypervisor

CPU
Supervisor with multiple resource partitions

- Linux guest OS #1
  - Linux Userland
  - Direct I/O
    - Linux Kernel

- Linux guest OS #2
  - Linux Userland
  - Secure I/O
    - Linux Kernel

- Service partition
  - Watchdog
  - Shared drivers

- Hypervisor System Software
- Configuration Data

- Hypervisor Kernel in supervisor mode

- CPU

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Global scheduling of the threads inside the partitions in the hypervisor through a real-time scheduler:

- **time-partitioning** mechanism (deterministic sharing of ECU between partitions)
- Pre-emptive **priority-based scheduler** (highest priority ready thread runs) within time-partition
i-Core Scheduling

- SMP Linux
- Single core Linux
- System Partition
- AUTO SAR

COQOS

Core 0
Core 1
Core 2
Core 3
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AUTOSAR BSW

Linux  other OS  ...

services  AUTOSAR

COQOS

CPU

Hardware block
e.g. Ethernet, CAN, Graphics

Concurrent read, write, configure
Drivers in local partition – exclusive access

Virtualized Linux with selective Direct Hardware Access

- Graphics
- Audio
- Video
- USB
- Ethernet

Fully Virtualized Linux

AUTOSAR

CAN Driver

COQOS

CPU

- Graphics
- Audio
- Video
- USB
- Ethernet

CAN
Virtualized Linux with selective Direct Hardware Access

- X Server
- NFS Server
- ... (Graphic, SSD, IP stack)

Fully Virtualized Linux

- X Client
- NFS Client
- ... (Graphic, SSD, IP stack)

COQOS

CPU

Share through high-level frameworks
e through low-level frameworks

Partition 1

File Provider
(Sharing Logic)
Driver

Partition 2

Driver Proxy
File Client

Partition 3

Driver Proxy
File Client

Device

COQOS

CPU

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Case: Cockpit

Cluster 1 (Speed indicator)

Cluster 2 (Information)

Head Unit

hypervisor

SoC
Use Case: Multi Linux on Head Unit

- Navigation (Linux 1)
- Multimedia (Linux 2)

hypervisor

SoC
Use-Cases:
- run ADAS (e.g. rear-view camera) in its own fast-booting partition
- drive 2 displays (e.g. instrument cluster and central head-unit display) from a single SoC
- combine critical (time-critical or safety-relevant) and uncritical information on a single display
1. Shared framebuffer

2. Shared GPU

3. Shared touch
ed Frame-Buffer

Client 1 (sees virtual frame-buffer)
Graphics client driver

Client 2 (sees virtual frame-buffer)
Graphics client driver

... shared memory + events

Graphics Server
with Window Positioning/Layering Control

COQOS

IPU

Display 2

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• Capturing touch events from device (UART, SPI...)
• Decide on partition based on current window/layer setup
• Forward events “active” to partition
• Virtual touch driver in each partition
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sharing + framebuffer sharing

Client Application using OpenGL

OpenGL-ES2 libraries

Linux Kernel

Virtual framebuffer

Virtual GPU driver

Client App

OpenGL lib

Kernel

VFB

VGPU

Access Control

Windowing Control

COQOS

shared memory + events

i.MX6

GPU

IPU

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Major reasons for the approach:

- **User space remains untouched;** applications, libraries (or even root fs) can be reused
- **Better performance** compared to userspace virtualization, uses DMA
- **GPU vendor’s IP** of OpenGL libs is protected (no chance to legally modify anything there)
- **Security:** protected component to control the GPU server services (access and timing).
- **GPU scheduler plug-in** interface (driver level) for further improvements available.
• **Hypervisor**
  • Linux / Android / AUTOSAR / POSIX / real-time partitions; system partition
  • Multi-core / SMP
  • separation
  • Time partitioning & priorities; Fixed schedules, switchable
  • Interpartition communication: shared memory, pipes, virtual Ethernet, ACF, etc

• **Shared devices**
  • Ethernet, UART, storage
  • Graphics (framebuffer, GPU, touch)
  • Other or request

• **Rear-view camera (RVC)**
  • Analog camera
  • Based on boot-optimized linux partion
  • API for guiding lines

• **Fast-boot**
  • Hypervisor + AUTOSAR boot in <200ms
  • Hypervisor + AUTOSAR + RVC boot in about <2s
COQOS maturity

- In series production in a telematics unit
- Integrated into upcoming platforms at multiple Tier-1s
- Development projects for series production have just started
- Android based head-unit A-sample for an OEM
- Many PoC projects

OpenSynergy

- Independent company
- Development & support in Berlin
- Automotive company
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Demo on Freescale i.MX6Q
Thank you!

Questions?
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