



DORNERWORKS

Throwing seL4 on the Throwbot® 3 Robot

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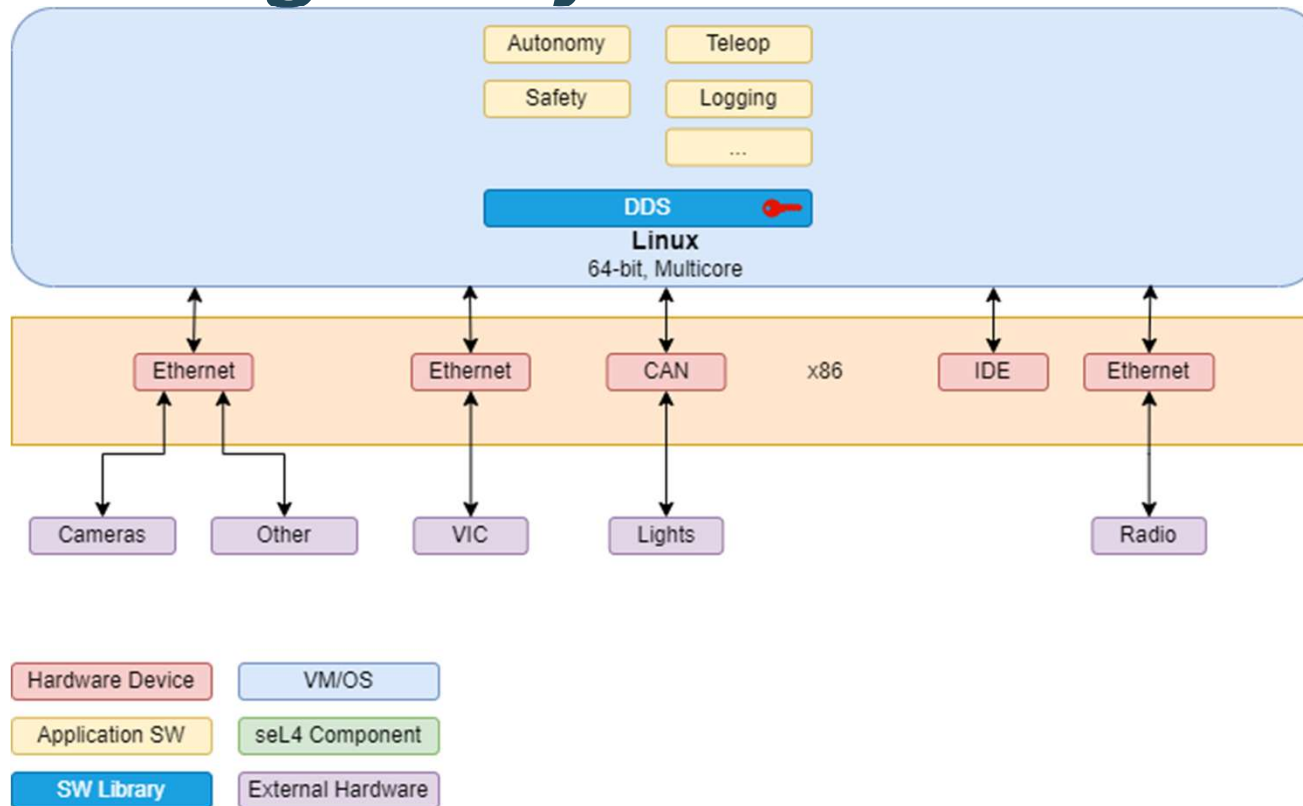
Agenda

- Background
- Throwbot® 3 Robot
- Throwbot® 3 Robot Cyber Retrofit
- Demo
- Other Results
- Related Work
- Future Work

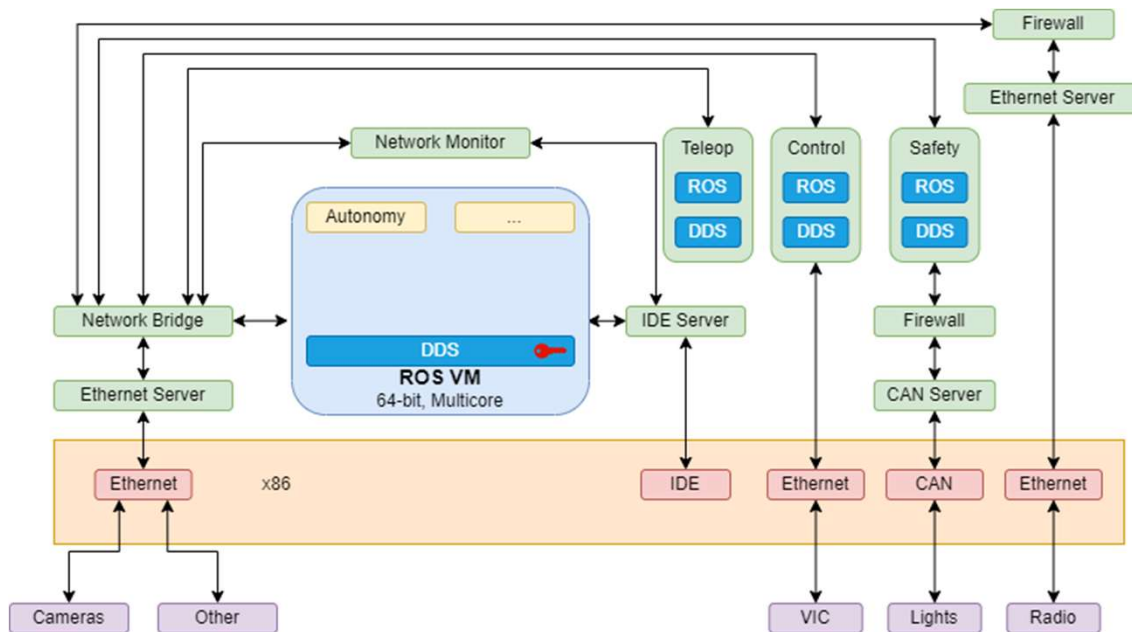


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Original System



Original Goal



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Original Results



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Recap

Results

- Ported Micro-XRCE DDS to seL4
- Ported Micro-ROS to seL4
- Migrated several ROS nodes from VM to native seL4 threads

Recommended Next Steps

- DDS Improvements
 - Security
 - etc...
- ROS2
- Zenoh
- MicroKit (sDDF) Conversion
- Verified Userspace Components
- Additional I/O:
 - Cameras
 - etc...
- Additional Architectures:
 - ARM
 - etc...



MRZR

- Large Vehicle
- x86 Industrial PC Controller
- Teleop and Guarded Teleop
- Complex Autonomy Stack



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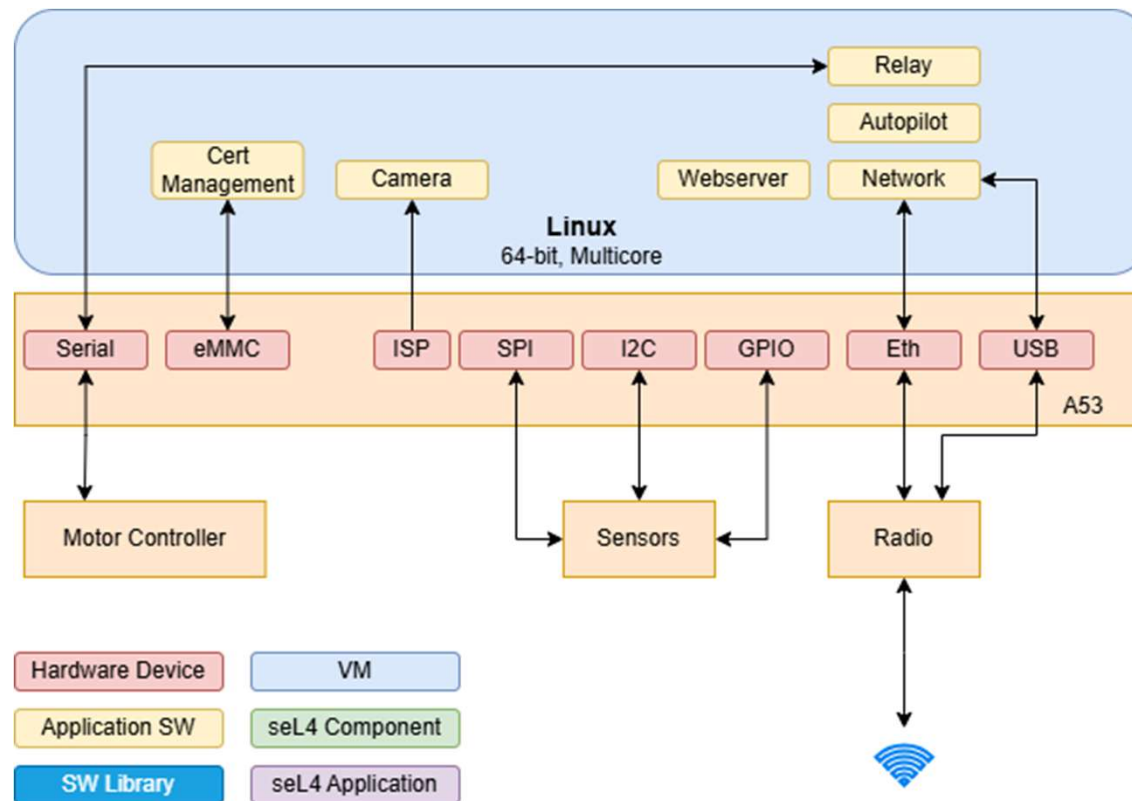
Throwbot® 3 Robot

- Small Form Factor
- ARM SoC Based
- MAVLink Controller
- Teleop
- Minimal Autonomy



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Throwbot® 3 Robot - Design



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Throwbot® 3 Robot Threats

1. Hijacking
2. Certificate Extraction



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VM Lift

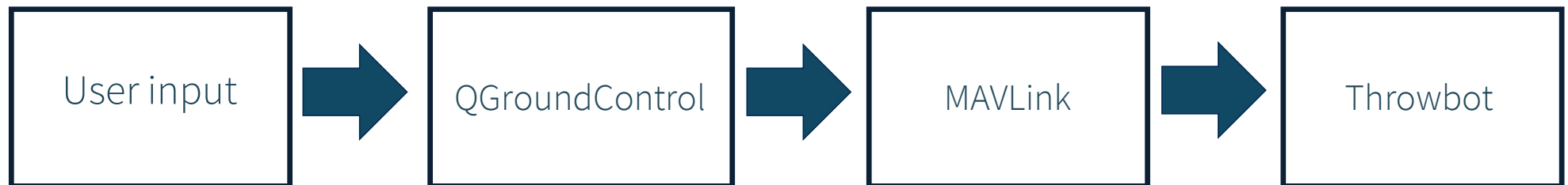
- Added Throwbot® 3 Robot platform to seL4
- Built CAmkES project with Throwbot applications
- Passed TB3 devices through to VM
 - I2C
 - SPI
 - Ethernet
 - USB
 - GPIO
 - PWM
 - Camera
 - UART
 - USB C
 - Host MMC
 - Motor Controller
 - Thermal Camera – WIP?
 - VPU – WIP?
 - GPU – WIP?



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Command Pipeline

1. GUI or game controller generates user input
2. QGroundControl converts inputs to MAVLink message
3. MAVLink messages are transmitted and received via Microhard radios
4. Messages are processed on the Throwbot® 3 Robot



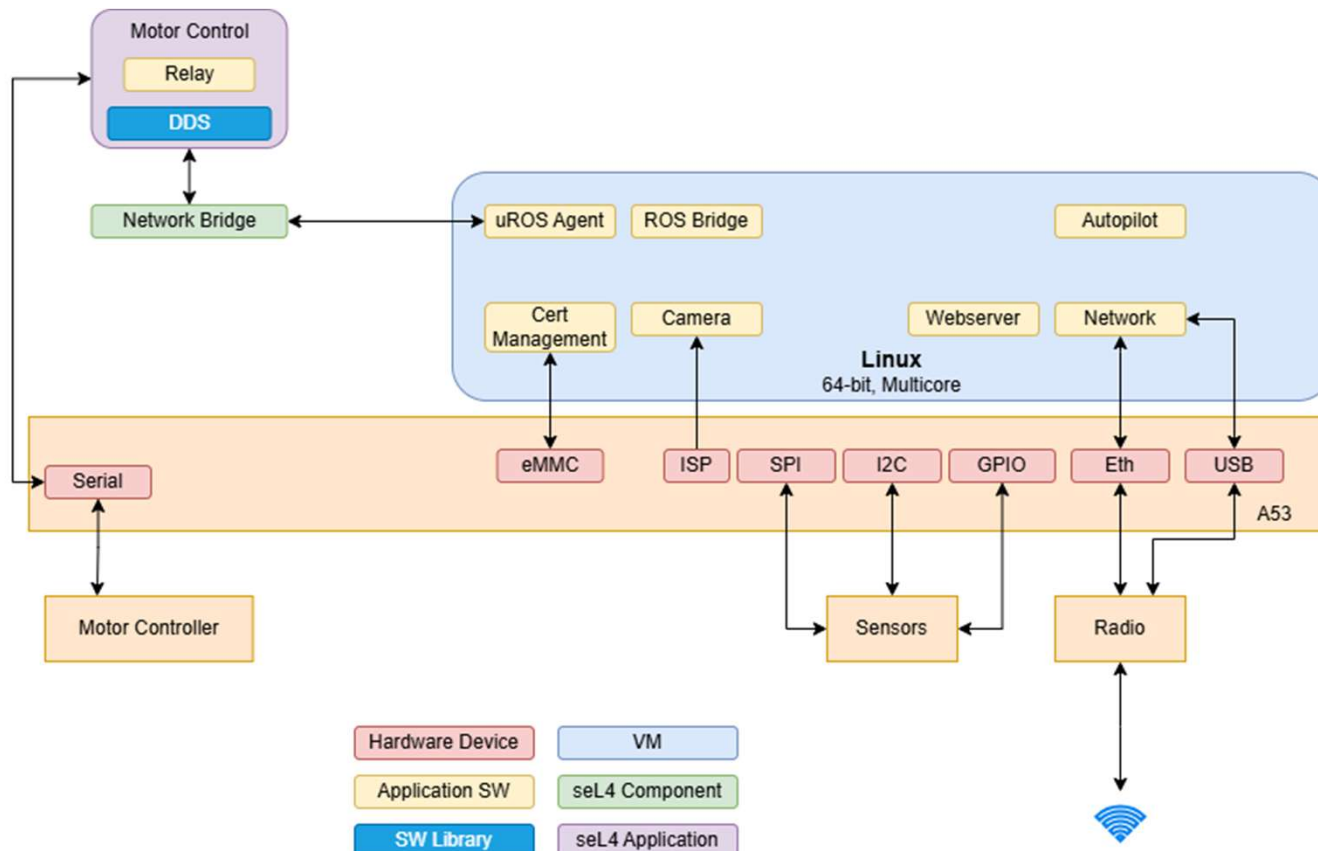
MAVLink to ROS conversion

- Ported CAmkES seROS application to ARM
- Added MAVLINK to ROS Bridge to VM
- Added uROS agent to VM
- Add ROS functionality in seL4 Threads

Motor Control Disaggregation

- Move motor control application into seL4 Thread
- Isolates motor control
 - Protection from faults on other components
 - Increased security against hijacking

Throwbot® 3 Robot Current



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Demo



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Other Results

- Microkit Conversion
 - Ported XCRE-DDS to Microkit
 - seROS running on LionsOS
- Basic C++ Library
 - Added to seL4 to support FastDDS
- FastDDS
 - Static FastDDS Build
 - ROS support being built on top of this
- ROS
 - Staticly building ROS
 - Ported uROS application from x86 to ARM
- Open-Source Release

Future Work

- Throwbot® 3 Robot
 - Complete Disaggregation
 - Complete Microkit Conversion
 - Camera Support
- DDS Improvements
 - Security
 - Performance
 - Scaling
 - etc...
- Complete ROS2 Support
- Remove Static Build Dependencies
 - Lions OS Shared Object Loader
- Remove Static Config Dependencies
 - DDS/ROS File-Based Configuration
 - MicroPython Launch Files
- Open Source Release

Related Work

- Directly Sponsored
 - Galios – Network Driver Verification
 - KSU – ROS/uROS HAMR Backend
- Encouraged
 - Riverside – Multi-core x86 Verification
- Related
 - TrustedST -ARSENAL

U.S. ARMY Questions?



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THANK YOU

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