State-of-the-art in robot security

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This work has been supported by the Austrian Research Promotion Agency in the program ”ICT of the Future” (grant no. 861264) and the Austrian Ministry for Transport, Innovation and Technology (bmvit).

Cyber threats in robotics

- Classically, robots have worked in isolation
- Modern robots work in highly interconnected environments
- Industry-grade robots are not harmless machines
- Robots pose risks to property and life
- Insecure robots may be manipulated remotely
- Industrial security is breached frequently [Byres et al., 2004, Cheminod et al., 2013, Stouffer et al., 2015, Karnouskos, 2011, Nelson, 2016, Fairley, 2016]

Security in ROS

- ROS has no built-in security [McClean et al., 2013]
- Missing authentication, authorization and confidentiality functions
- ROS is an easy target
  - Exploit XMLRPC-API used to interact with ROS master
  - Use stealth publisher attack to inject data or isolate subscribers
  - Use service isolation for DoS
  - Parameter manipulation

Attacks on ROS [Dieber et al. 2019]

- Stealth publisher attack
  - Isolate a node within the ROS application, feed with fake data
- Service isolation attack
  - Make the rest of the application think that a service is no longer available
- Malicious parameter attack
  - Modify rosparam server

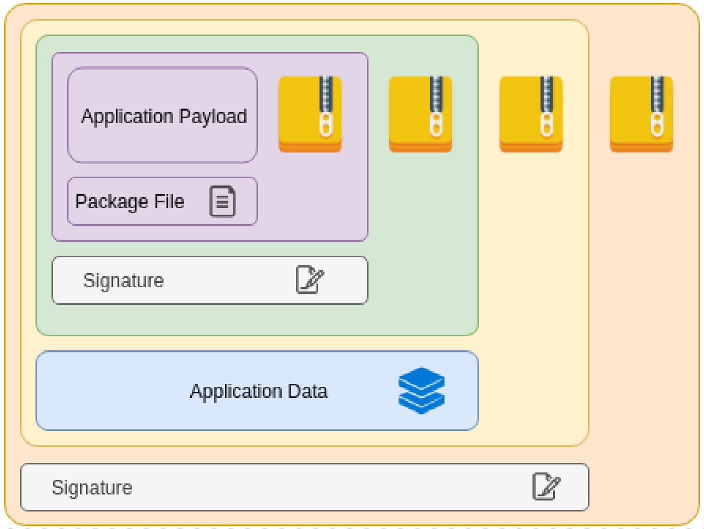
- Tools
  - roschaos
    - https://github.com/ruffsl/roschaos
  - RosPenTo
    - https://github.com/jr-robotics/RosPenTo

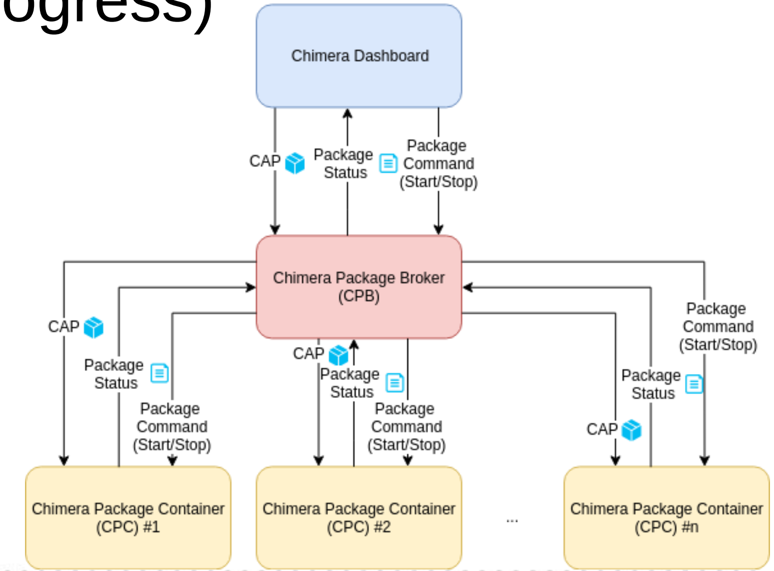
Countermeasures

- Application-level security [Dieber et al. 2016]
  - Use dedicated authentication server
- SROS1 [White et al. 2016]
  - Using TLS and AppArmor
  - Python only, TCP only
- Secure ROS core [Breiling et al. 2017]
  - Using TLS
  - C++, TCP and UDP
- SRI secure ROS [http://secure-ros.csl.sri.com/]
  - Uses IPSec

Security is more than applied cryptography

- Workflows for accessing secured devices [Dieber et al. 2017]
- Security architecture for mobile manipulators [Dieber and Breiling 2019]
- Secure deployment (work in progress)




Chimera Dashboard
CAP
Package Status
Package Command (Start/Stop)
Chimera Package Broker (CPB)
CAP
Package Status
Package Command (Start/Stop)
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Package Status
Package Command (Start/Stop)
Package Command (Start/Stop)
Package Status
CAP
Chimera Package Container (CPC) #1
Chimera Package Container (CPC) #2
...
Chimera Package Container (CPC) #n

Security in ROS2

- ROS2 builds on DDS
- DDS has security mechanisms based on proven techniques
  - https://www.omg.org/spec/DDS-SECURITY/1.1/
- SROS2 project makes DDS security accessible to ROS2
  - https://github.com/ros2/sros2
- Access provisioning for SROS2 integrated in build process [White et al. 2018]

If everything else fails

- Storing forensically usable evidence on robot incidents
- Robot black box [Taurer et al. 2018]
  - Account for elevated security risks in autonomous systems
  - Separate device or dedicated software module
  - Cryptographic scheme to ensure CIA
- Work in progress of White et al.
  - Blockchain-based

Literature

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