NOKIA Bell Labs

Integrating Trust and Attestation in 5G, O-RAN and Edge Computing

Ian Oliver

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Trusted Computing Revisited

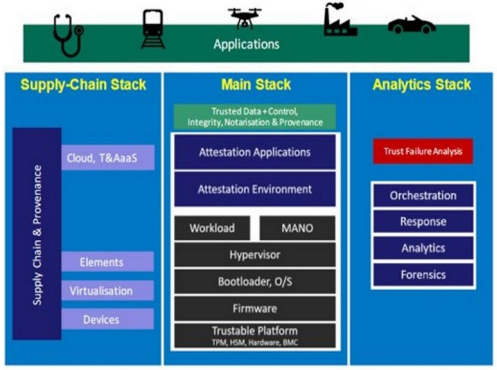
VNFs, VM Images, Containers, Clouds, Core, Edge, MEC, IoT, Sensors

Attestable? **Trustable?**

Object ⟶ Measurement ⟶ Claim ⟶ Result ⟶ Decision

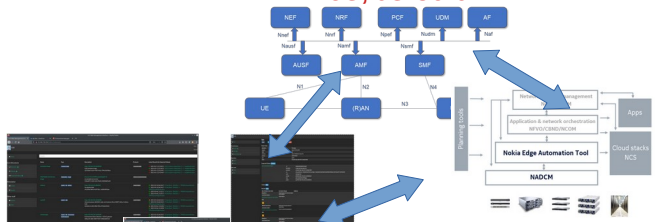
Trusted Computing “Architecture”

Case Studies:
Medical, Railways

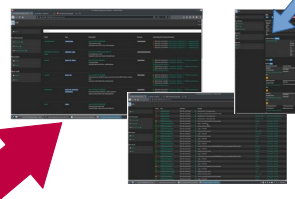


Trust Stack

5G, 6G Core



Deployment



Integration:
Remote Attestation Services
MANO, 5G Core, 6G Core
Attestation Applications, Data/Control Provenance

Montoring, Forensics and Analytics

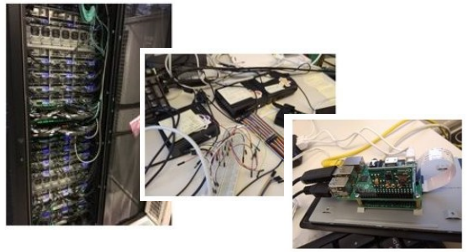
Conmtainer Identity/Integrity:
root-of-build-trust, provenance & lifecycle

kubernetes docker

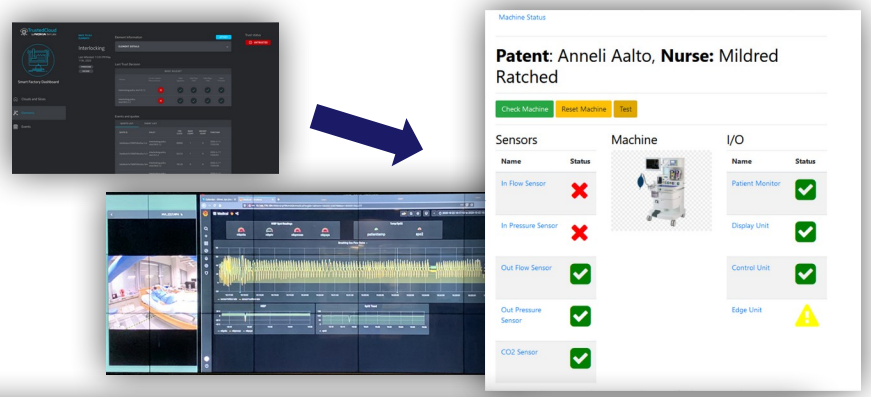
Notarisation:
TransparencyLog,
Blockchain, etc

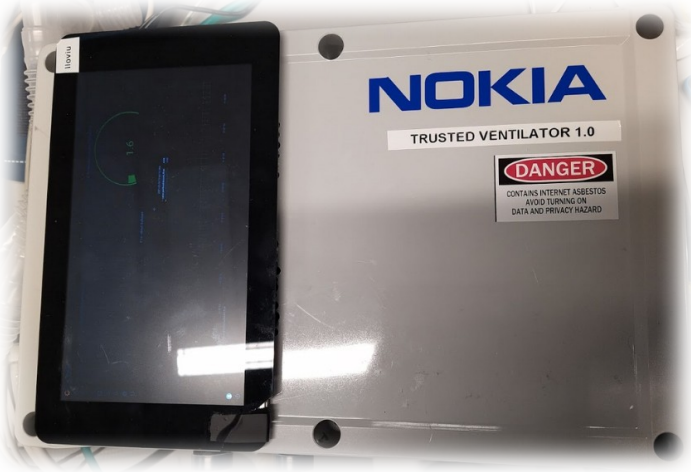
Supply-Chain/Load/Run-time Integrity:
Container Trust,
Cloud/Edge MANO Orchestration
Trusted Containers + Trusted Provenance of Containers

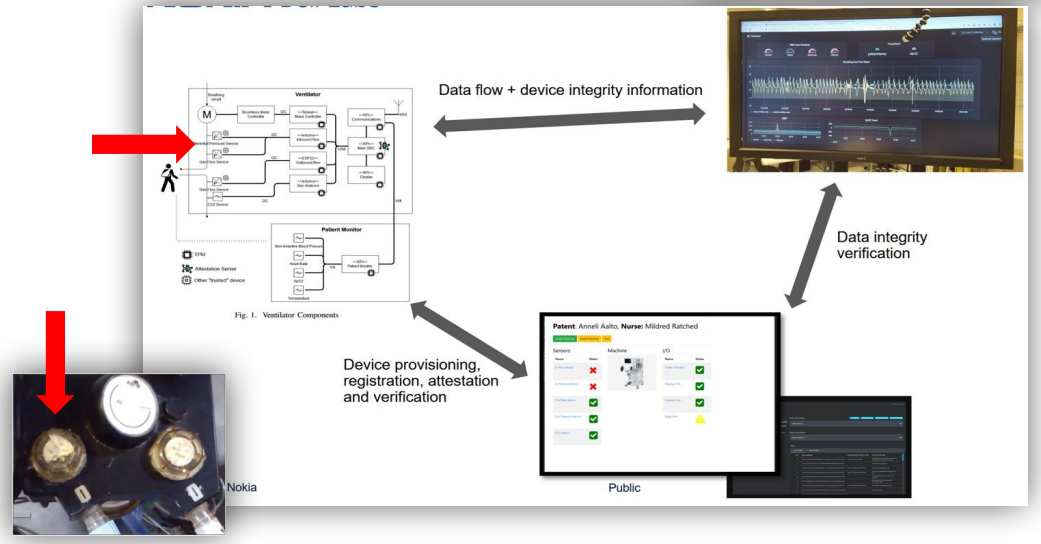
Deployment:
Servers, IoT, Edge, Far-Edge, UE, Sensors
Firmware supply-chain questions?



Trusted Computing: Medical Systems



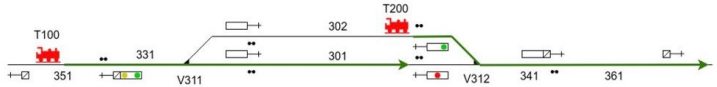




Trusted Computing: Railways

Trust Slices/Domains:

Low Speed Section → Passing Section → High Speed Section



Trust Slice Verification Rule Sets:

Core/Basic LoA

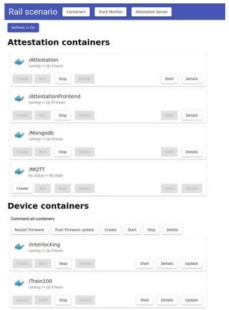
TPM 2.0 Quote Rules	Attestation Timeliness Rules	History/Assurance Rules
Is it a quote?	Did the device respond to the quote request in a timely manner?	
Signed and matches the qualified signer?	Did the device process the quote request in a timely manner?	
Nonce + additional data correct?		
Does the attested value match the known good value?	-	
Is the device running the correct firmware?	-	-
Has the device been rebooted?	-	-
Is the clock increasing correctly?	-	-
	-	-

Intermediate LoA

TPM 2.0 Quote Rules	Attestation Timeliness Rules	History/Assurance Rules
Is it a quote?	Did the device respond to the quote request in a timely manner?	
Signed and matches the qualified signer?	Did the device process the quote request in a timely manner?	
Nonce + additional data correct?	Was the response consistent with network latencies (where applicable)?	
Does the attested value match the known good value?	-	
Is the device running the correct firmware?	-	-
Has the device been rebooted?	-	-
Is the clock increasing correctly?	-	-
Was the device shutdown correctly?	-	-

Critical LoA

TPM 2.0 Quote Rules	Attestation Timeliness Rules	History/Assurance Rules
Is it a quote?	Did the device respond to the quote request in a timely manner?	Has the device changed in any way since the last quote?
Signed and matches the qualified signer?	Did the device process the quote request in a timely manner?	...and for what properties?
Nonce + additional data correct?	Was the response consistent with network latencies (where applicable)?	Does the device verify against the selected rules for its LoA ?
Does the attested value match the known good value?	-	What set of PCRs is required for a minimum LoA?
Is the device running the correct firmware?	-	-
Has the device been rebooted?	-	-
Is the clock increasing correctly?	-	-
Was the device shutdown correctly?	-	-

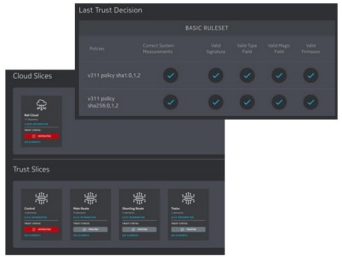


Administration

Attack Injection

Operator Response & Security Procedures

Operator & Simulation Control



Attestation

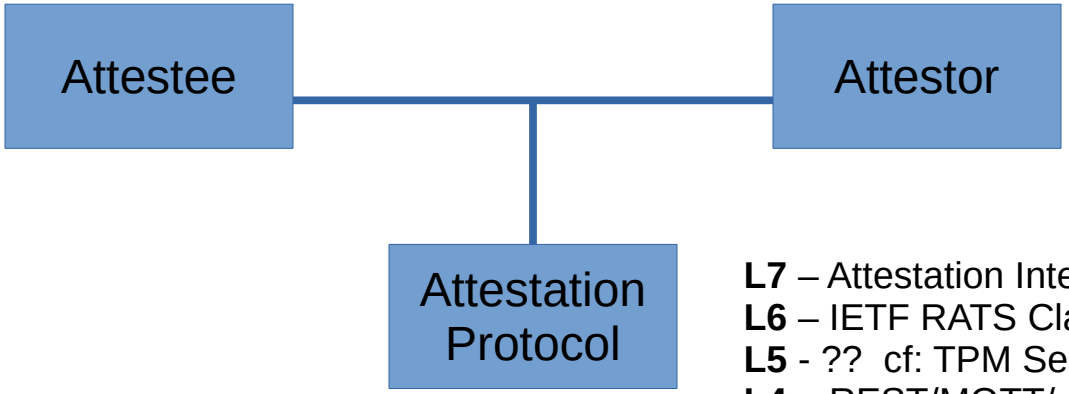
Communication Infrastructure

Device ID
Signalling Devices as 5G/6G UEs
Integrity and Identity of Components
Control and Data Plane Trust/Provenance

Eurobalise picture: Public Domain, Wikipedia https://commons.wikimedia.org/wiki/File:Siemens_Eurobalise.jpg 15 June 2004
Train Picture: © 2021 Ian Oliver

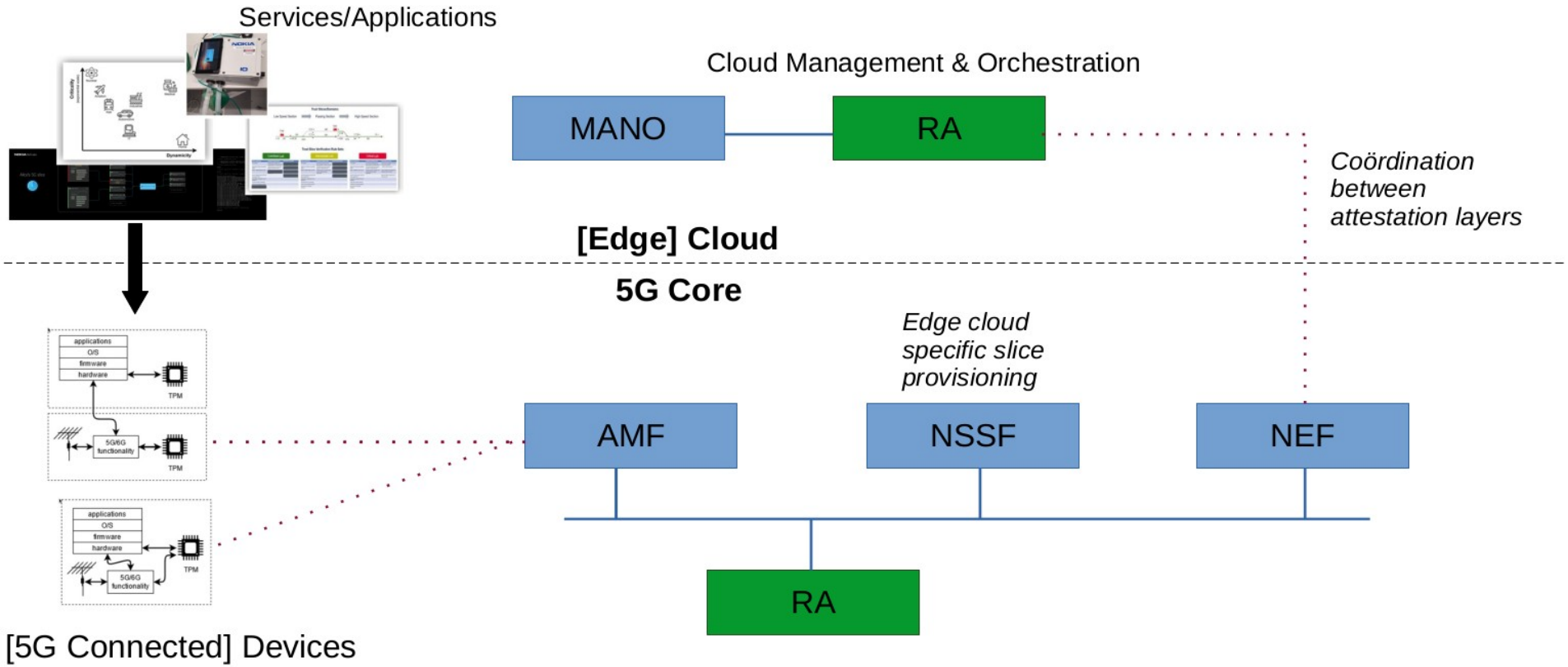
Generic Model

H/W TPM 2.0
CNF/VNF
Other...

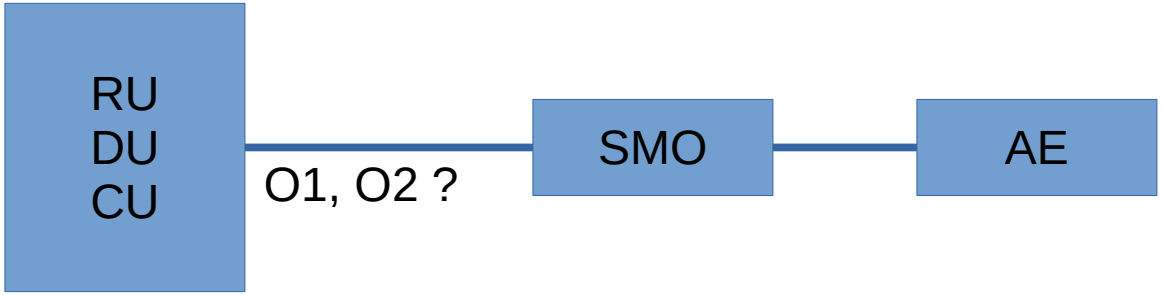


L7 – Attestation Intents
L6 – IETF RATS Claims
L5 - ?? cf: TPM Sessions?
L4 – REST/MQTT/... over IP/RAN7...

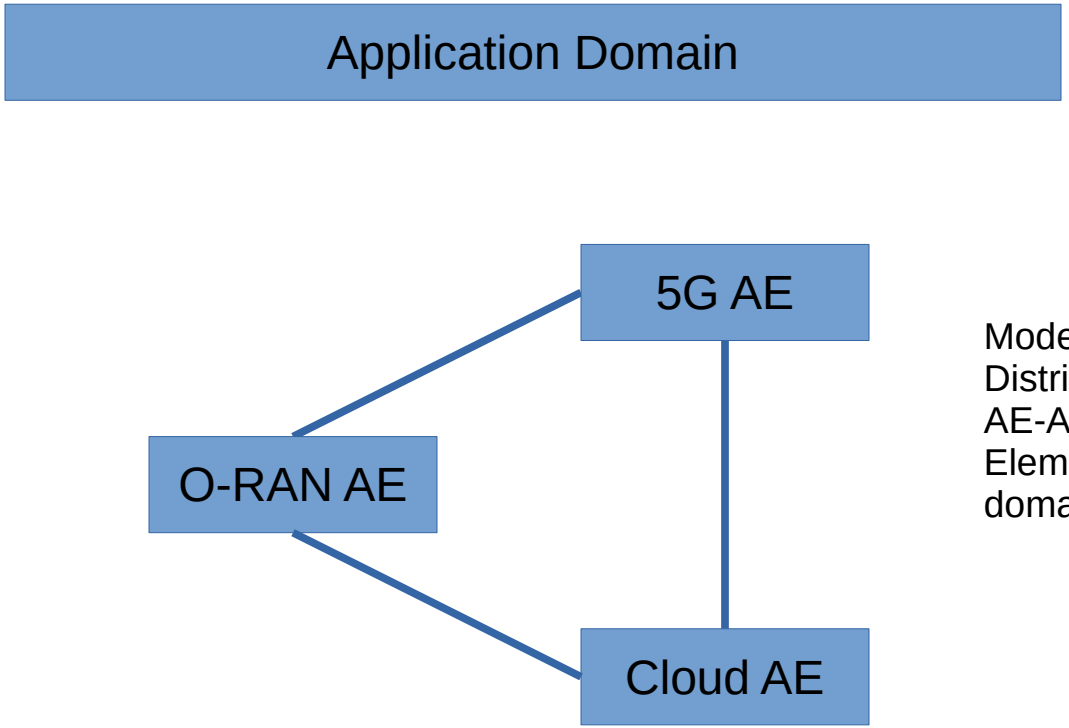
5G



O-RAN

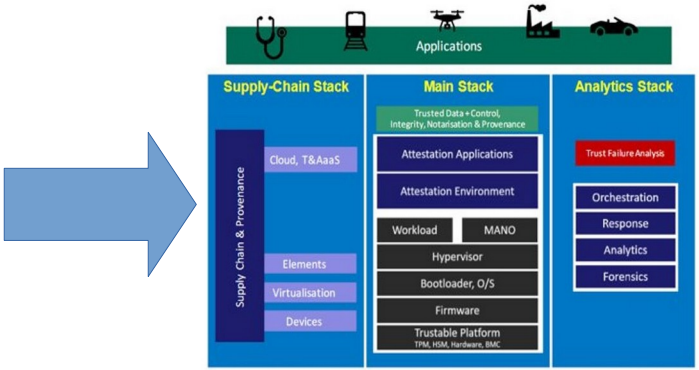


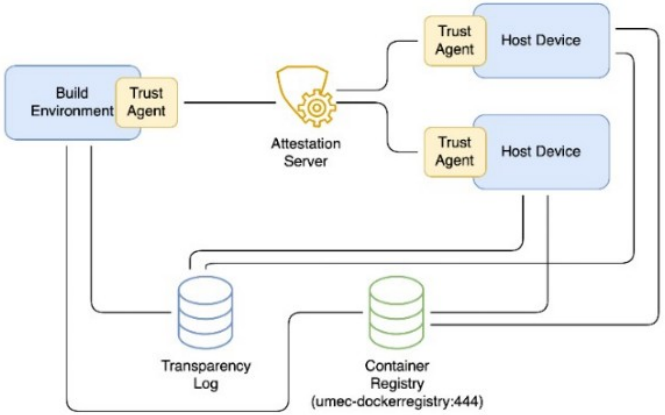
O-RAN+5G+Cloud+Domain



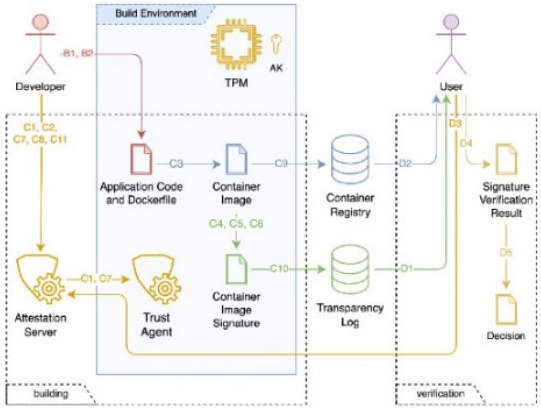
Model of Trust?
Distribution of Responsibilities
AE-AE Protocols
Element Identity across infrastructure domains and application domains

Supply-Chain, CD/CI, DevOps



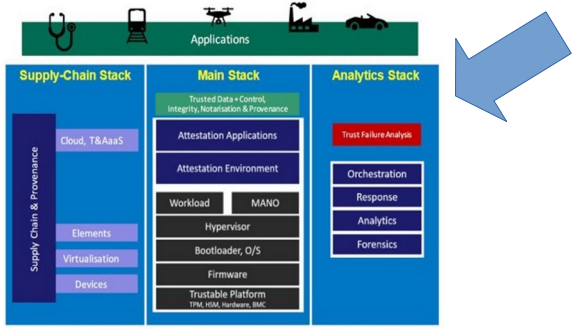


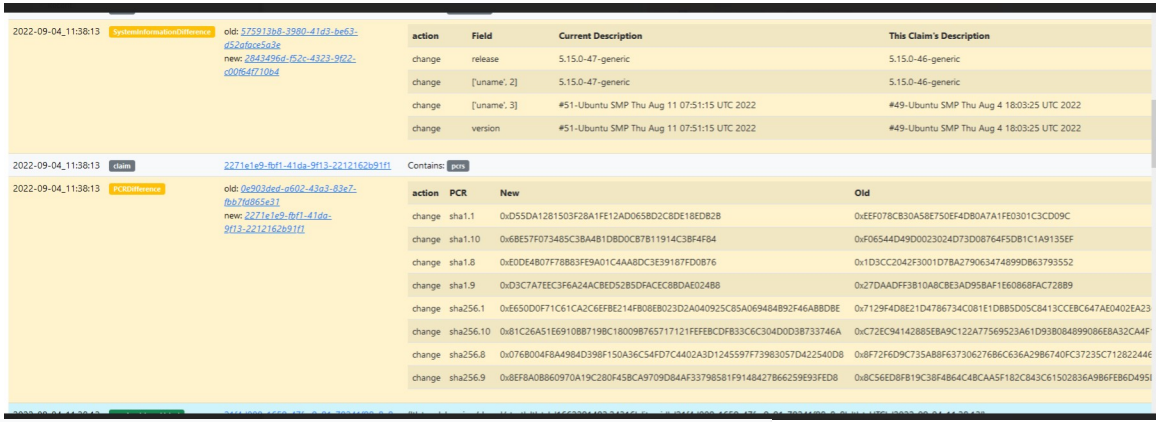
[Core,Edge,Far-Edge] RAS Architecture

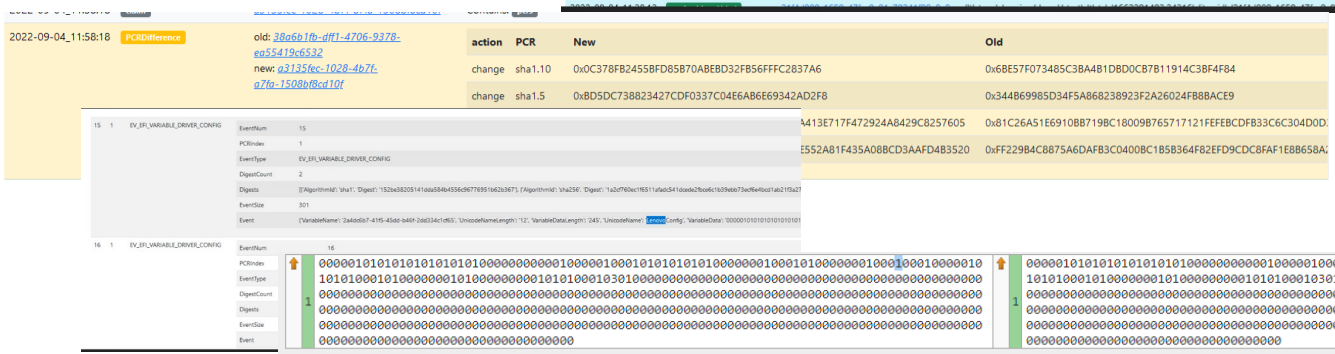


Container Attestation

Forensics-Analytics-Response-Orchestration



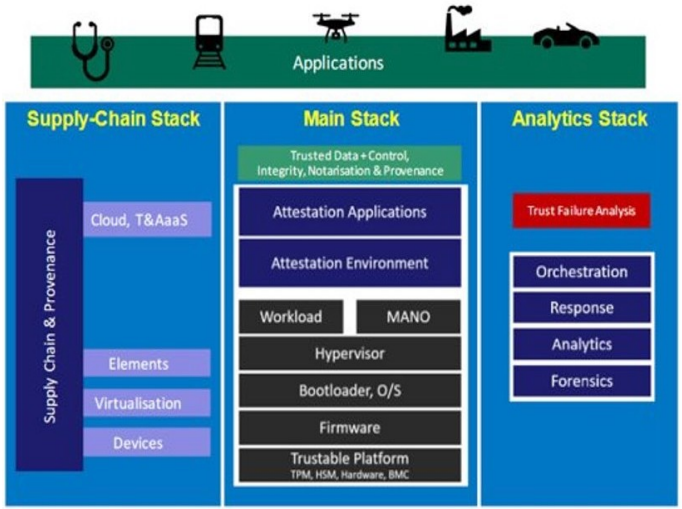




Summary

Grand Challenge

- Where the attestation takes place
- How and when(!) the attestation communicates with the element being attested
- Interface definitions and requirements
- Trust loss, Detection, Response and Orchestration



Thanks & Demo

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Kiti Muller, Aalto University (Neurobiology)


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