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Platform Integrity Attestation at Scale

OCP GLOBAL SUMMIT
NOVEMBER 9-10, 2021

SECURITY

Platform Integrity Attestation at Scale

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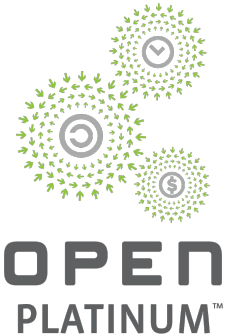

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NIST 800-193: Platform Firmware Resiliency

SECURITY

- **Protection** - Ensuring that Platform Firmware code and critical data remain in a state of integrity and are protected from corruption
- **Detection** - Detecting when Platform Firmware code and critical data have been corrupted or otherwise changed from an authorized state
- **Recovery** - Restoring Platform Firmware code and critical data to a state of integrity in the event that it is detected to have been corrupted

Integrating *detection* into machine fleets

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- **Policymaking** - Describing the platform's intended code and data configuration
- **Routing** - Exposing attestation signals to a verifier
- **Reaction** - Ensuring that appropriate action be taken when policies are violated

In the beginning, there was Titan

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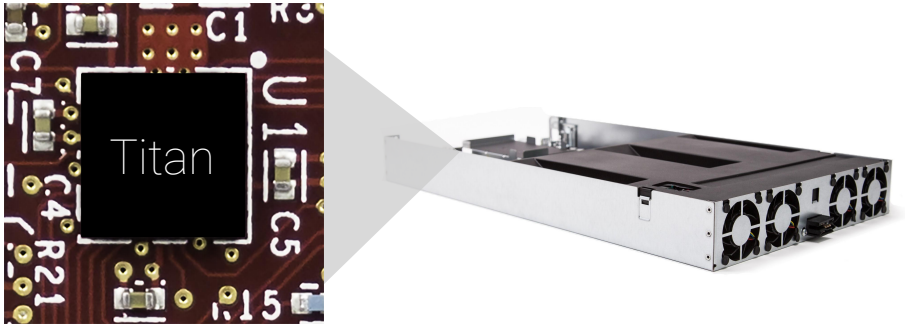
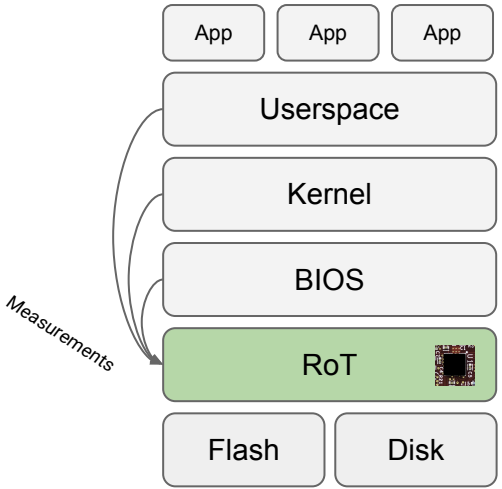


Complexity of yesterday



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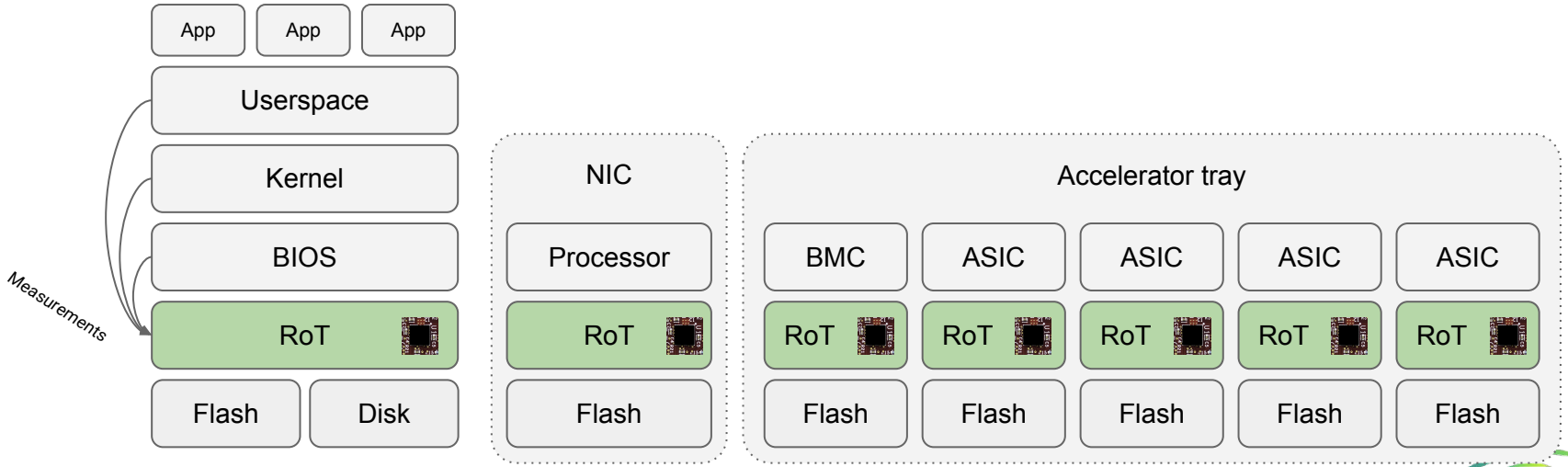
- **Root of trust (RoT)** - Secure element with a strong cryptographic identity
  - **Measurer** - Actively takes measurements of flash chip contents
  - **Attester** - Wields cryptographic identity to report trustworthy measurements
- Two strong assumptions:
  - **1:1 relationship between machines and RoTs**
  - **Everything of interest is measured into the single RoT**

Complexity of today

SECURITY



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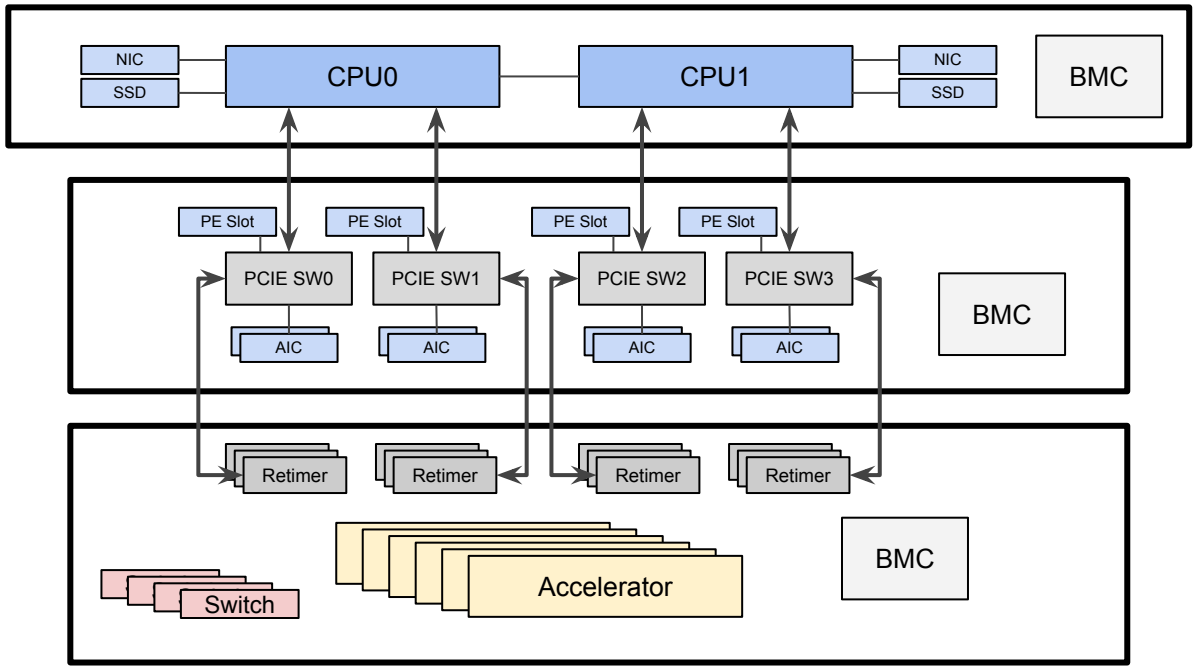
Complexity of tomorrow



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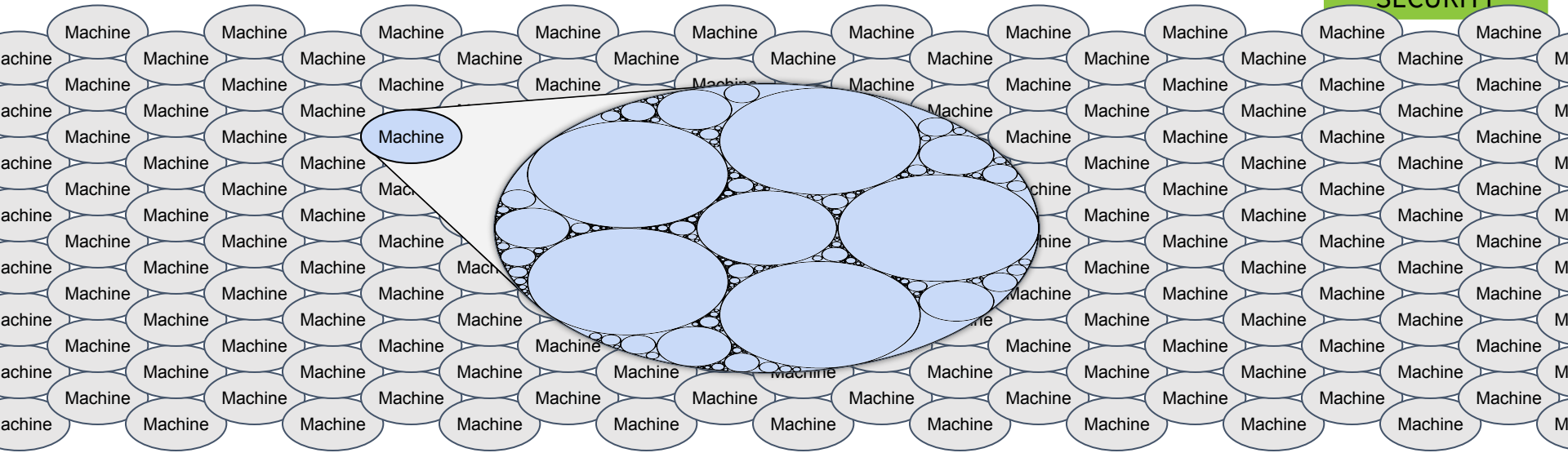
~20× RoTs

3x BMCs & power domains

AIC = Arbitrary Add-in Card

Attestation "at scale"



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So what are we sharing today?

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- **Design constraints** - If they sound familiar, this scheme might be right for you
- **Our attestation solution** - Scalable middleware for attesting complex machines
- **Some standards gaps** - What we invented ourselves to get it to tick

Google fleet management philosophy

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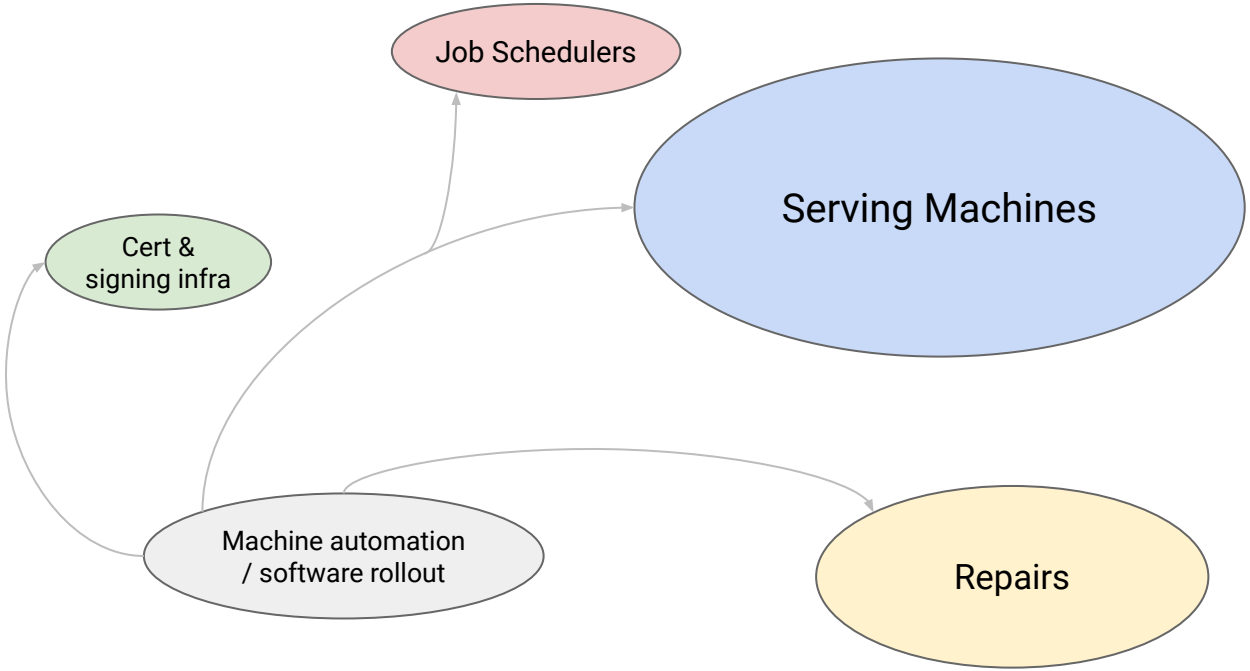
- **Production is in a constant state of flux**
  - Software always rolling out, machines breaking, getting fixed...
  - Nothing is perfect: sometimes updates don't take, machines are incorrectly repaired, etc.

- **Risk of outages must be minimized**
  - E.g., machines must not brick themselves en masse
  - Where possible, prefer complexity in the control plane rather than on-machine

- **"Machines are cattle, not pets"**
  - Individual machines are allowed to die, but we like to know what killed them
  - Automate, automate, automate

Google's production fleet



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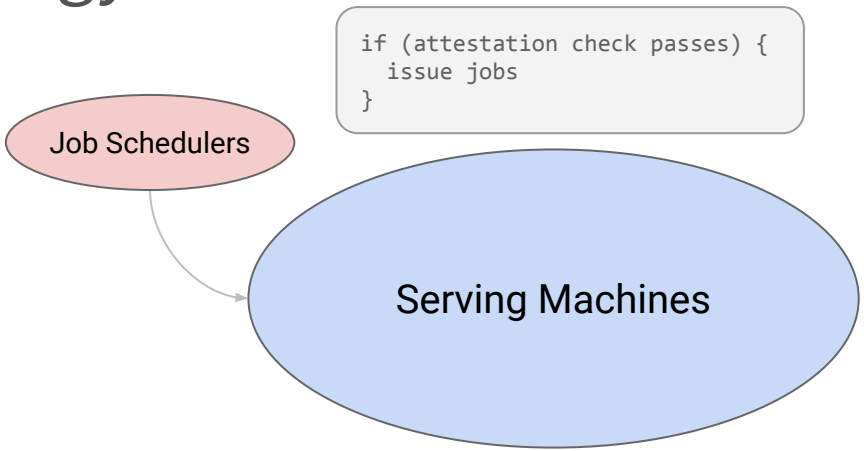
(Not drawn to scale)

Attestation strategy



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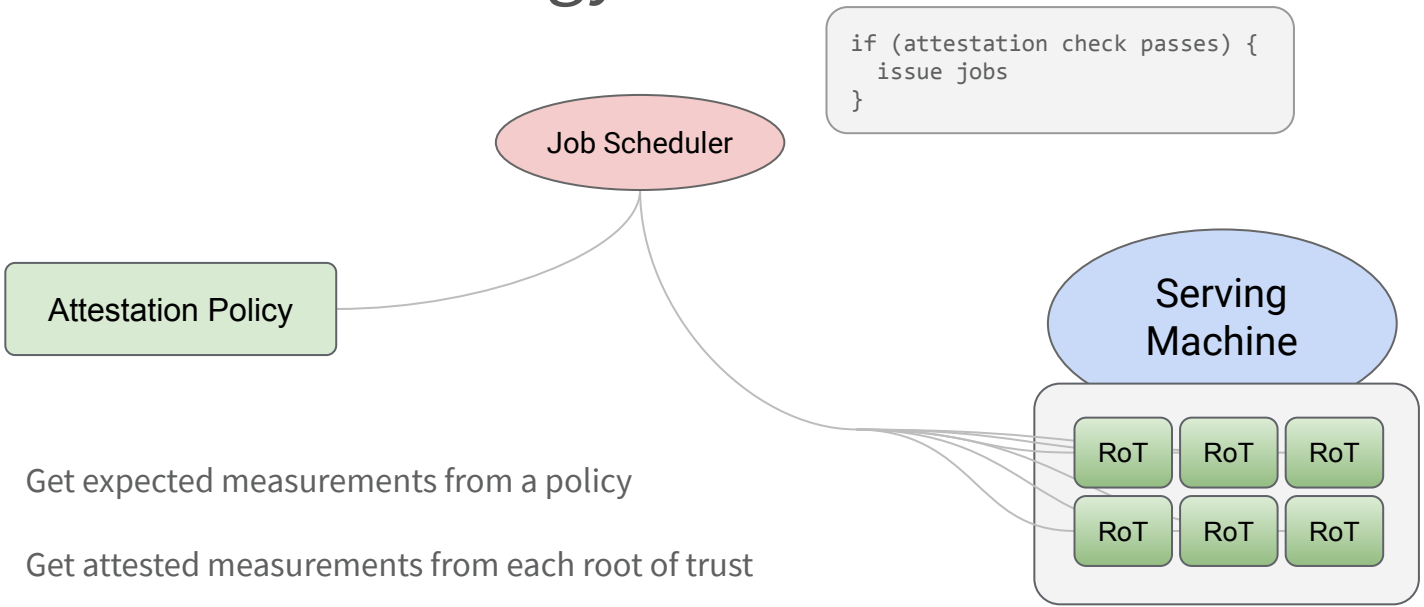
- **Desired property**: Jobs only run on machines booting intended firmware
- **Strategy**: Job schedulers issue attestation challenges to machines
  - Only issue jobs and data on successful attestation

Attestation strategy



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1. Get expected measurements from a policy
2. Get attested measurements from each root of trust
3. Compare attestations to expectations

Why not enforce the policy on-machine?

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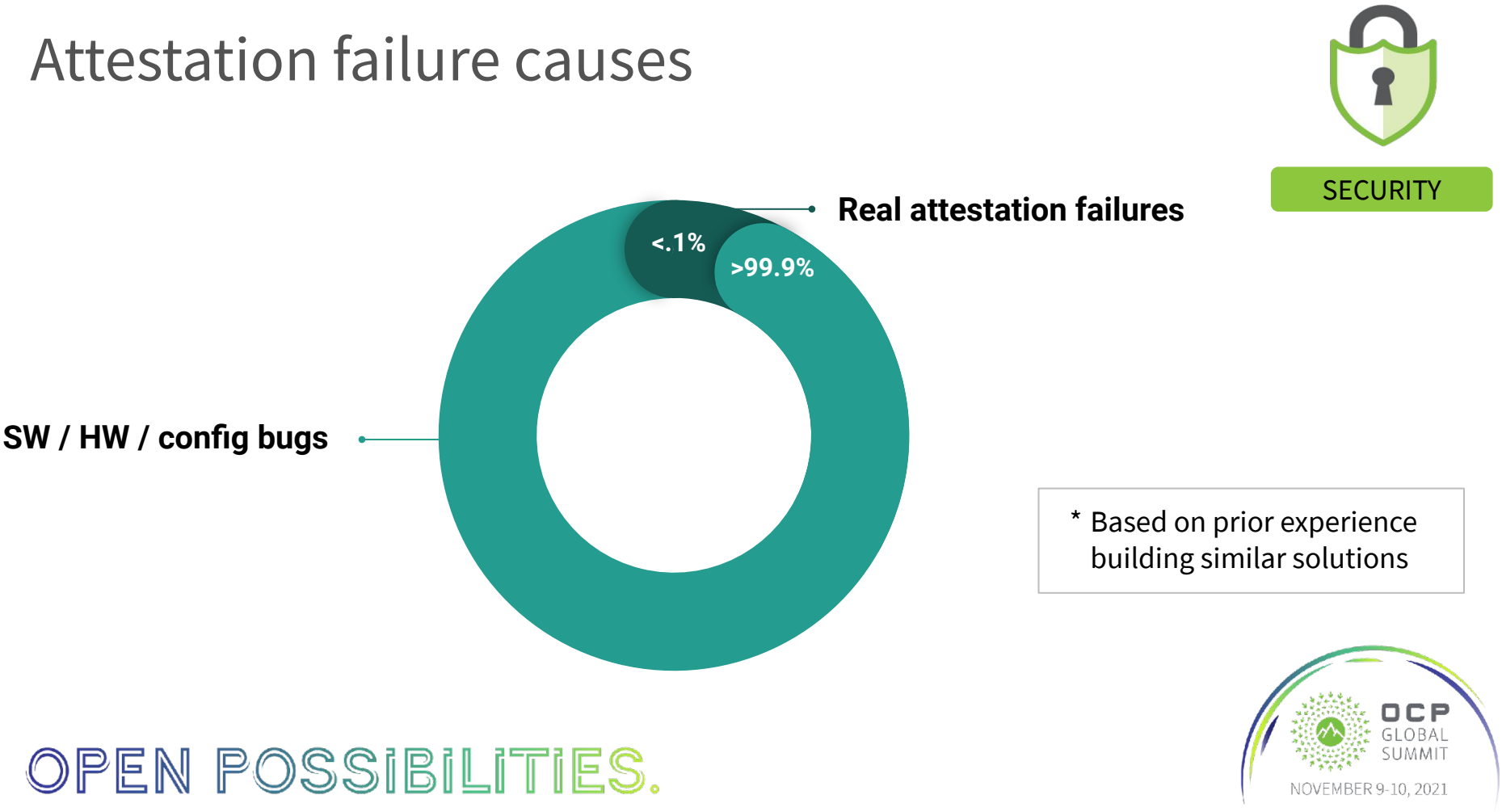
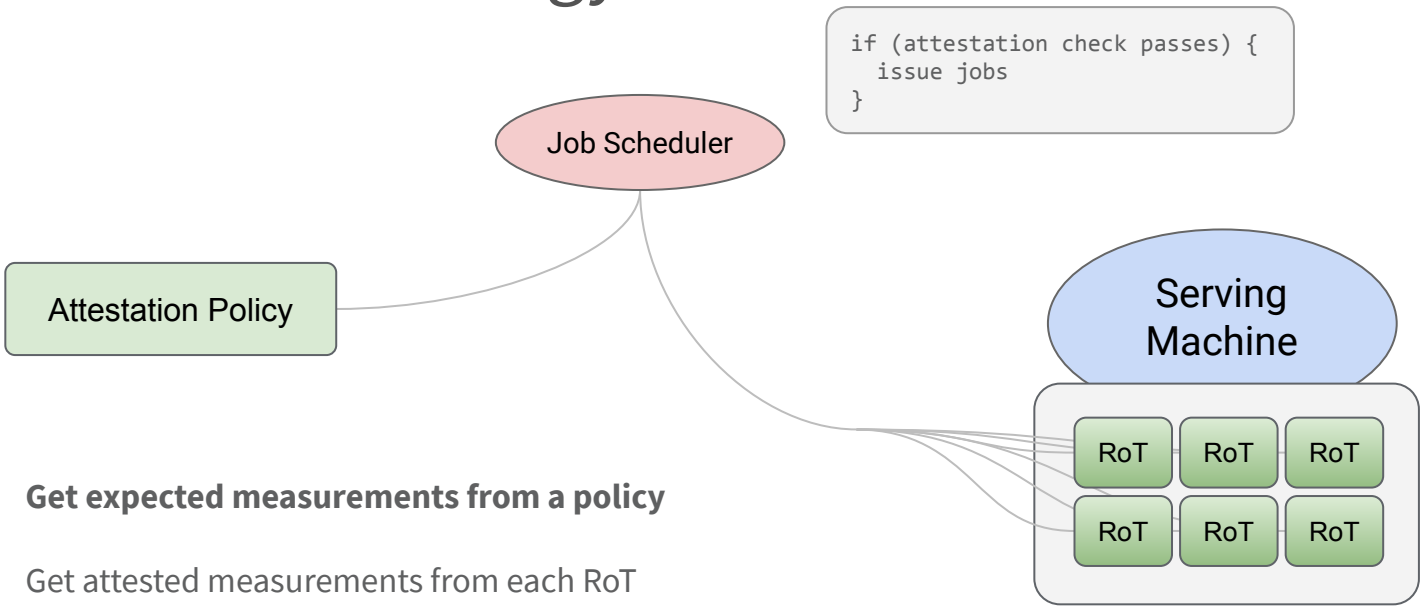
- Decrease machine complexity and increase reliability
  - **Very** hard to do reliable boot-time attestation on disaggregated machines
- **Centralized enforcement** allows flexible reaction
  - Control plane has wider visibility over the production fleet
- Some amount of local policy enforcement may be warranted
  - Not targeted for now, need more data on reliability at scale

Attestation failure causes



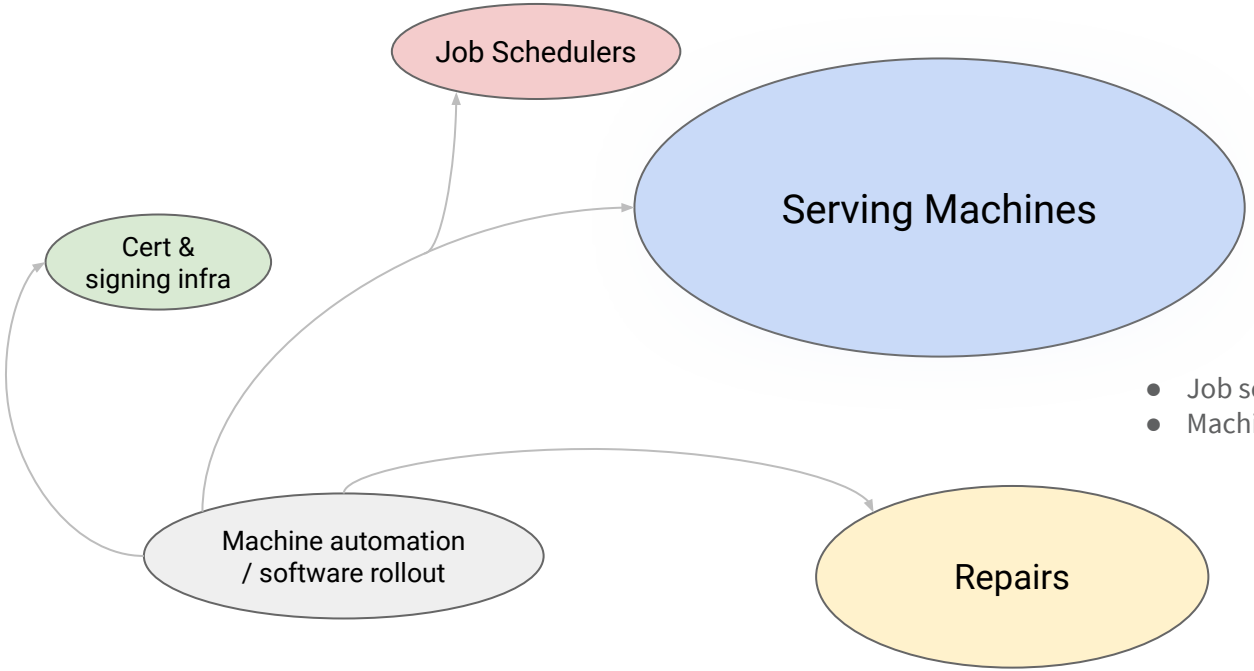
Attestation strategy



1. **Get expected measurements from a policy**
2. Get attested measurements from each RoT
3. Compare attestations to expectations

SECURITY

On the subject of availability



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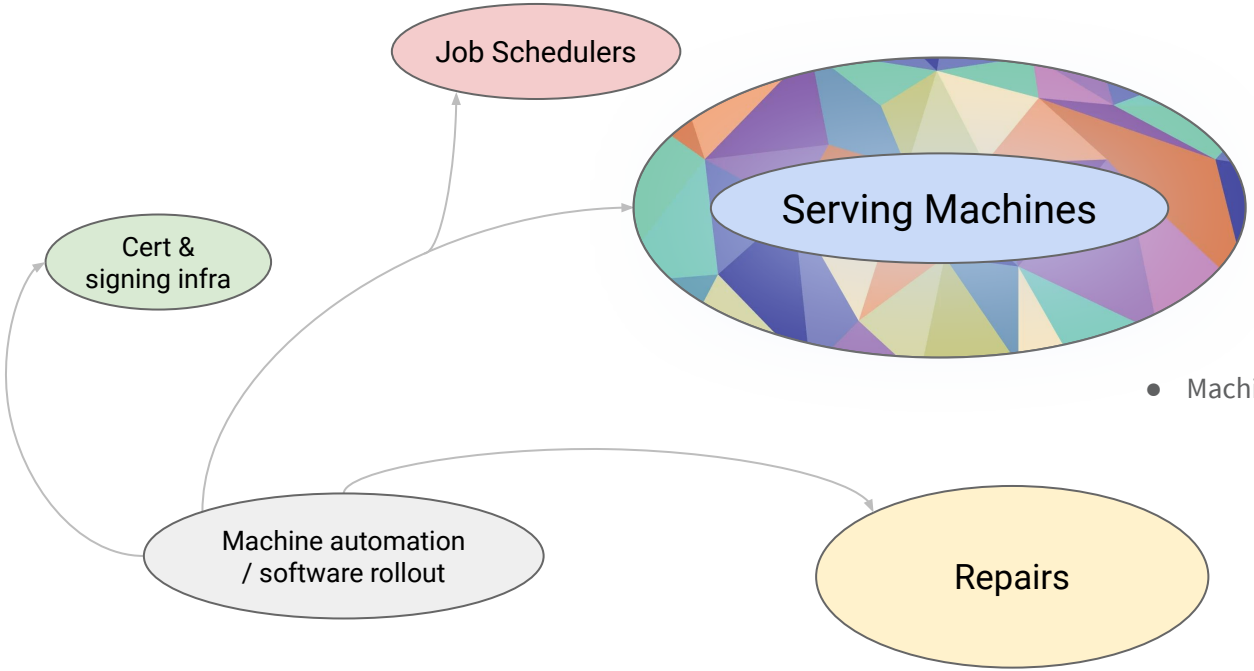
- Job schedulers **must** be highly available
- Machine automation can be less available

On the subject of availability



SECURITY

- Machines are not homogeneous

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Graphic from Vecteezy.com

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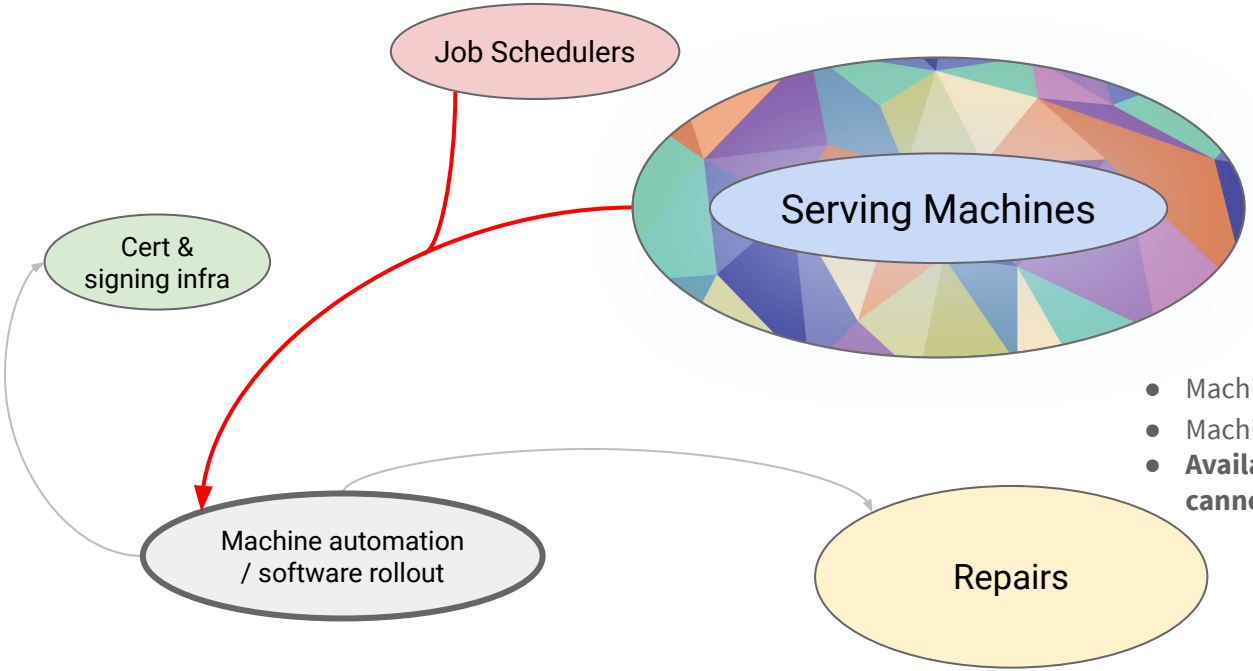
On the subject of availability



SECURITY

- Machines are not homogeneous
- Machine automation knows intended state
- **Availability inversion! Job schedulers cannot depend on machine automation**

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Graphic from Vecteezy.com

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Store signed policies on-machine

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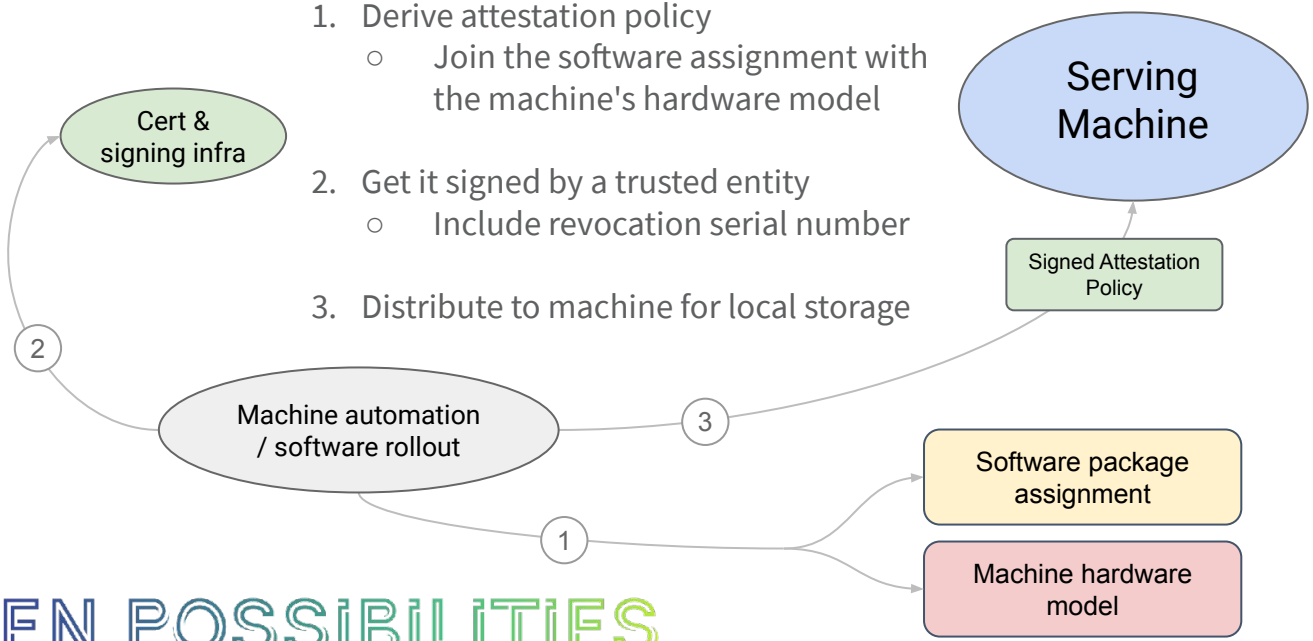
1. Derive attestation policy
   - Join the software assignment with the machine's hardware model
2. Get it signed by a trusted entity
   - Include revocation serial number
3. Distribute to machine for local storage



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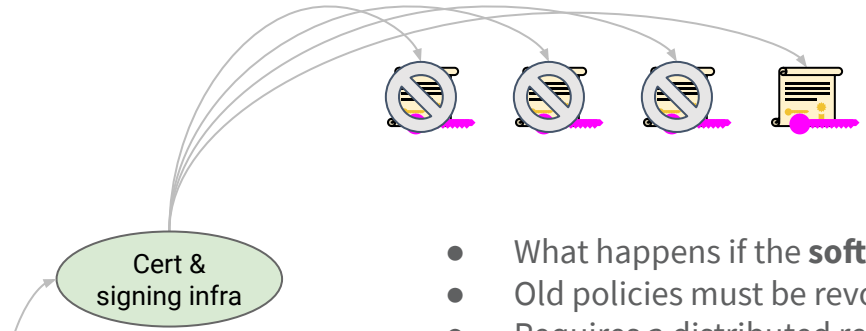
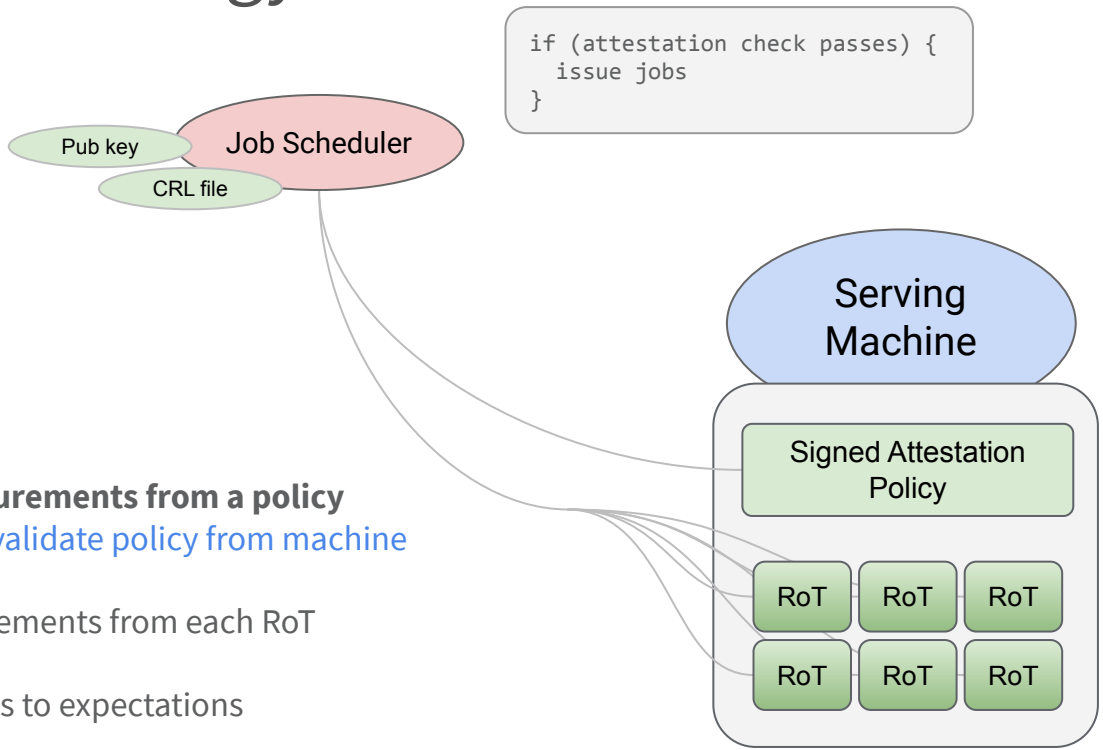
Revoking signed policies



SECURITY

- What happens if the **software intent** or **hardware model** change?
- Old policies must be revoked
- Requires a distributed revocation mechanism
  - Such as a CRL (certificate revocation list)

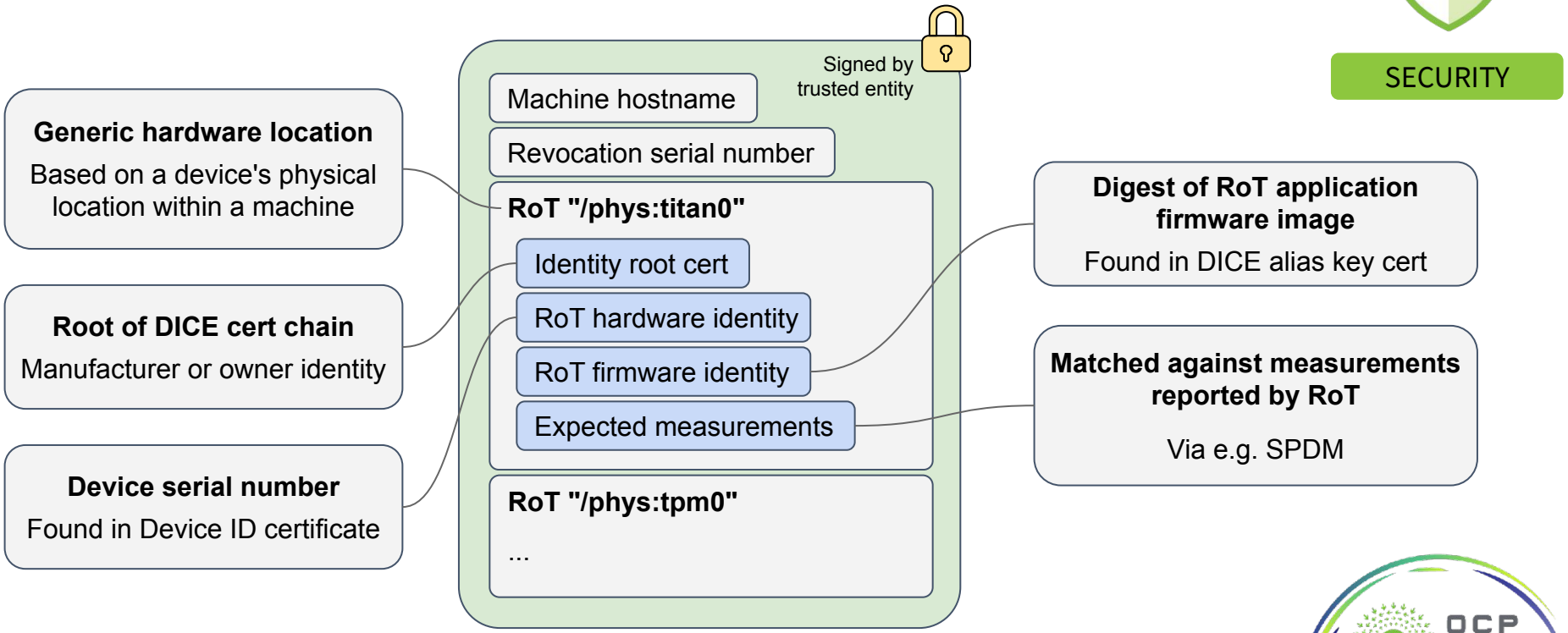
Attestation strategy



SECURITY

1. **Get expected measurements from a policy**
   - Retrieve and validate policy from machine
2. Get attested measurements from each RoT
3. Compare attestations to expectations

What's in the attestation policy?



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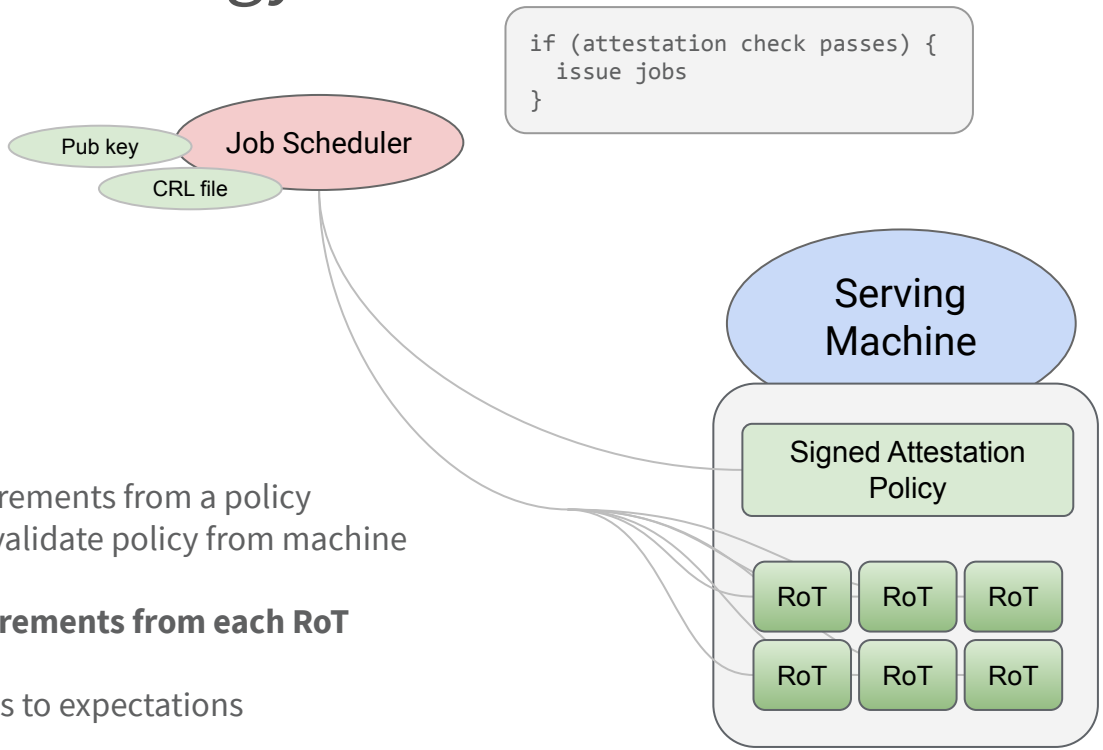
Attestation strategy



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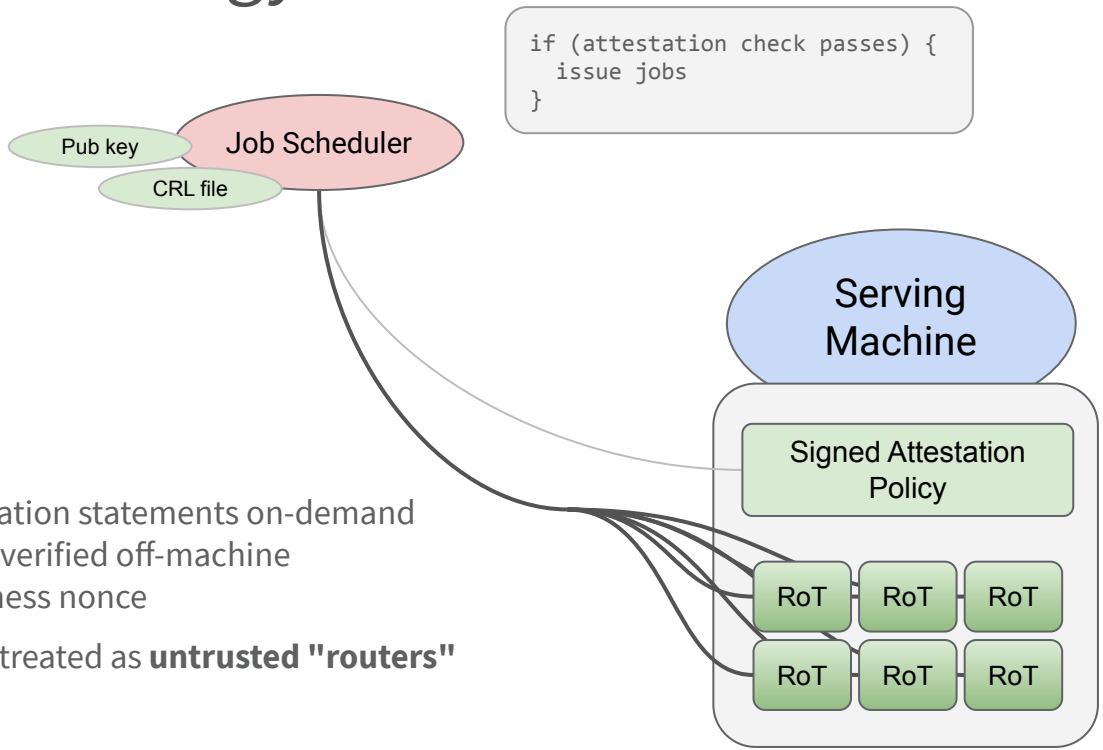
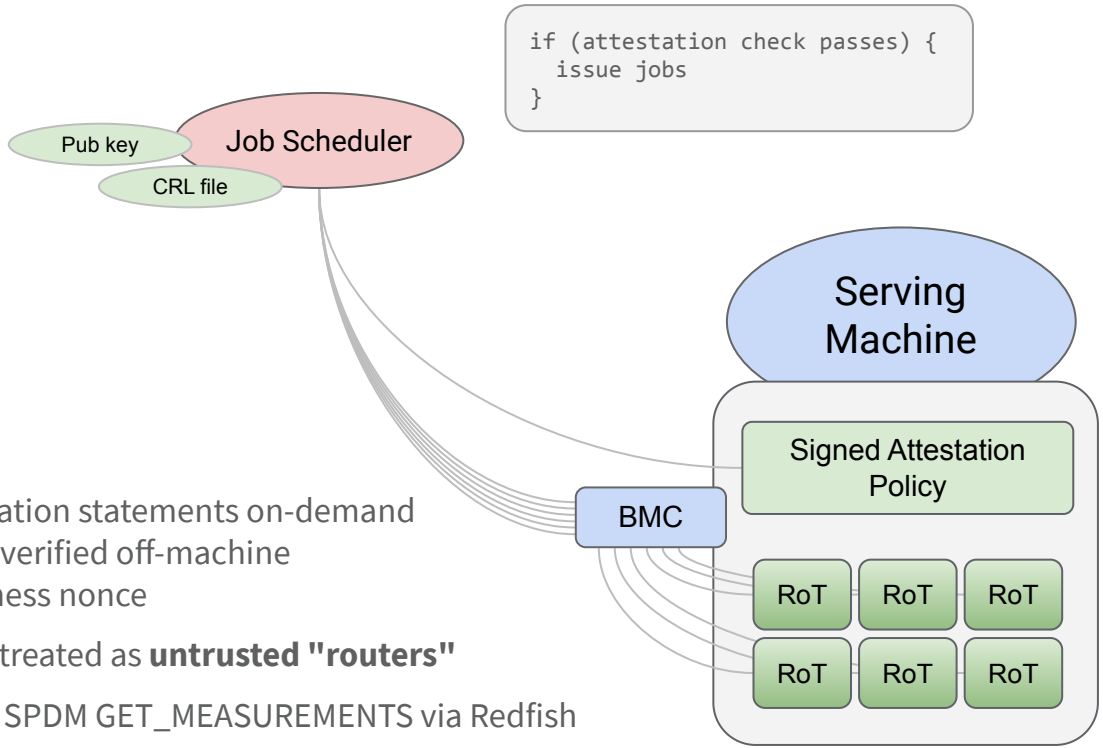
Attestation strategy



SECURITY

- Each RoT emits attestation statements on-demand
  - Signed by RoT, verified off-machine
  - Includes freshness nonce
- Intermediate entities treated as **untrusted "routers"**
  - Such as BMCs

Attestation via BMCs



SECURITY

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- One implementation: SPDM GET_MEASUREMENTS via Redfish

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BMC = Baseboard Management Controller
SPDM = Security Protocol and Data Model
Redfish = Machine management protocol

Attestation via BMCs

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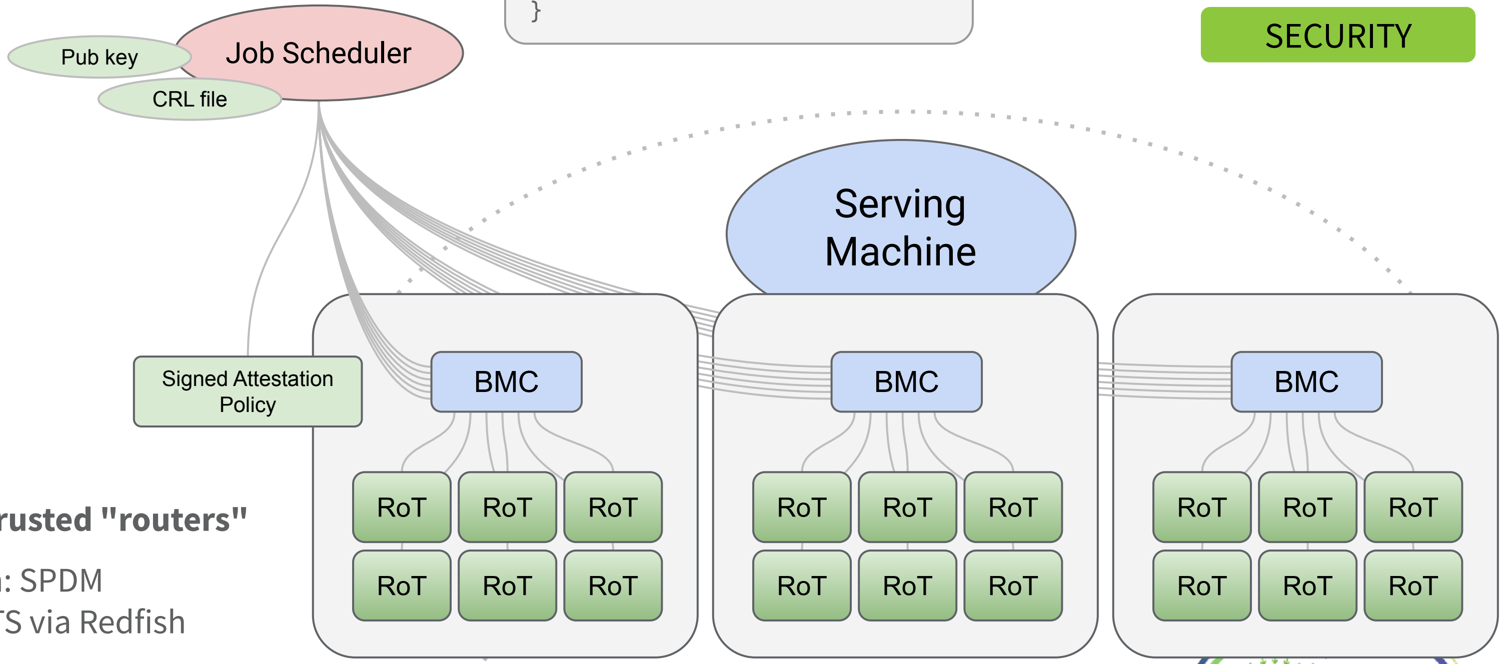
```
if (attestation check passes) {
  issue jobs
}
```



- BMCs treated as **untrusted "routers"**
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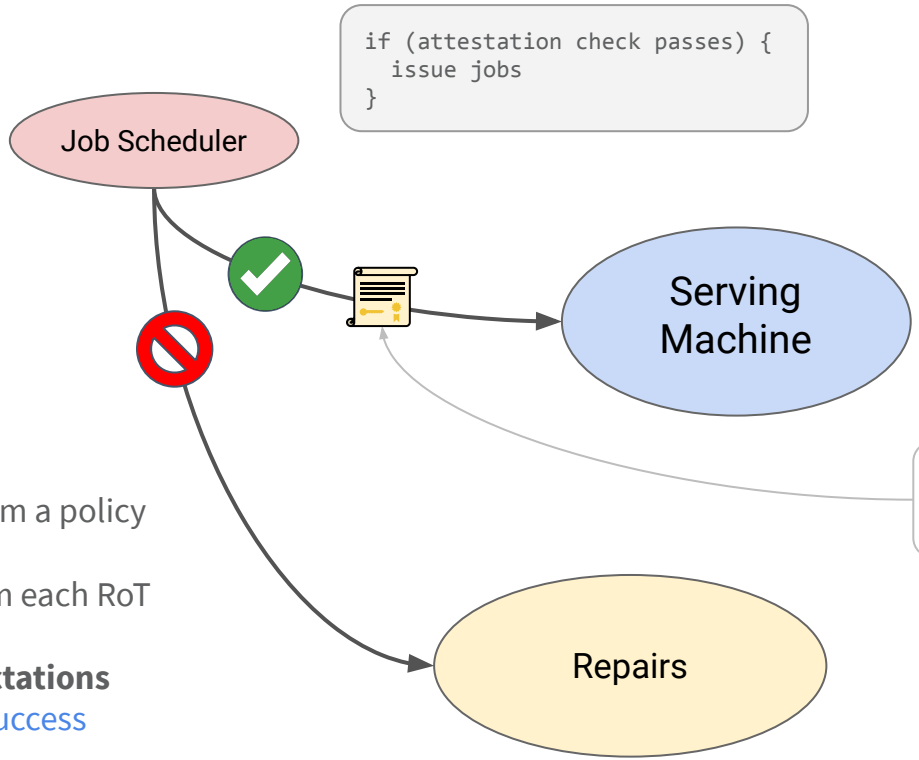
Attestation results



SECURITY

1. Get expected measurements from a policy
2. Get attested measurements from each RoT
3. **Compare attestations to expectations**
   - Issue job + task cred on success

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Graphic from Emoji One

Closed vs Open

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- Some parts of this scheme are custom (and that's okay)
  - Software packaging & rollout infra
  - Machine hardware model
  - Job scheduling infra
  - Revocation mechanisms
- Some parts can and should be open
  - Policy format
    - See CoRIM+CoMID+CoSWID
  - Exposing RoT signatures to the off-machine verifier
    - DMTF proposal: SPDM GET_MEASUREMENTS over Redfish

Call to Action

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- **Get involved**
  - Join the OCP Security Project (& TCG/DMTF)
- **Close standards gaps, for example:**
  - Need common SPDM measurement profiles
  - Would like TPM to support "first instruction integrity"
- **Share your experiences**
  - A rising tide lifts all boat

- Keep an eye on Google's Platform Integrity Github repo: google/PINT
- Contact us: {jeffandersen, jdcooke}@google.com

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Thank you!