Robust and Scalable Security Monitoring and Compliance Management for Dynamic Energy Delivery Systems

Key Distribution for the Internet of Energy

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GOALS

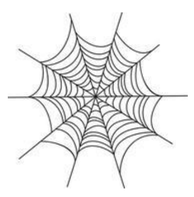
- Develop a secure and resilient **key distribution** architecture that supports **millions** of devices.
- Centrally managed.
  - Group policy enforcement and auditing.
  - Must be able to revoke keys.
- Must be disruption-tolerant.
  - Must continue to operate for a given time, even if network communications are cut off.
- Automated key management for low-power devices (computation/memory).
  - Resolve entropy problem.
- Allow authorized third-party access.

CURRENT APPROACHES

- Public key infrastructure

  - Central certificate authorities.
  - Authorize with a chain of trust.
    - Third-party authorization is complicated.
  - Revocation of certificates:
    - CRL (static lists) will get large quickly; impractical on low-power devices.
    - OCSP (online check): What happens in case of lost connectivity?
      - Accept everything or reject everything?
        - » Neither is acceptable.

- Pretty Good Privacy (PGP):



  - Web of trust.
    - (I trust you, you trust him → I trust him).
  - Completely distributed.
  - No central control or enforcement.
  - Key revocation requests need to be sent to the whole network.
    - Impractical.
  - Third-party authorization not accounted for.

OUR APPROACH

- **Combine** ideas from enterprise key management, identification, and authorization protocols.

- **Kerberos**
  - *Cached* central authorizations.
  - Central policy enforcement.
  - Disruption-tolerant.
  - Keys expire with a short lifetime (no need to revoke).

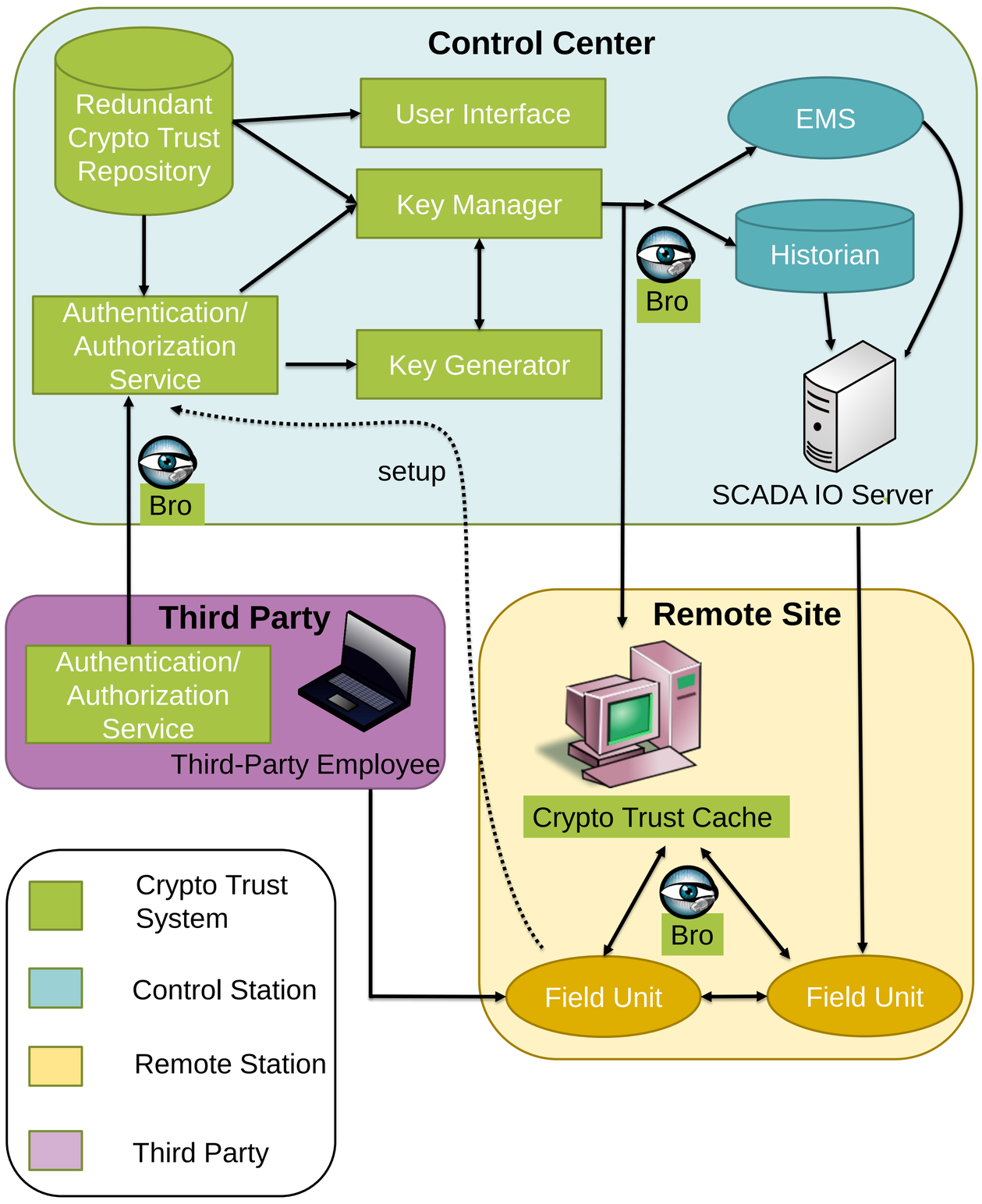
- **802.1ar**
  - Device identity and authentication.

- **802.1x**
  - Tunneled authorization of not yet authenticated devices.

- **KMIP** (Key Management Interoperability Protocol)
  - Automated key registration/update.
  - Group keying.
  - Support for legacy devices.

- **Bro**
  - Monitor the network.
  - Key management and authentication systems are high-value targets.
  - Add cheap remote sensors, like BeagleBoard or Raspberry Pi, in remote site to monitor correct key management behavior.

OUR APPROACH



WHAT HAPPENS…

- … if communication to the remote site breaks?
  - Crypto Cache provides field devices with key material until its timer runs out. (This provides enough time to fix the fault.)
- … if a field device is compromised?
  - The field device will no longer receive key updates. Because of the short lifetime of keys, other devices will no longer trust the compromised device.
- … internally when a new field device is added?
  - The device is provided with a secure tunnel to the authentication service, while being excluded from the rest of the network.
  - After authentication is complete, the device generates a public key pair, or receives one if it is not capable of key generation.
  - The key is signed by the central authority for a limited time.
  - The field device can now communicate with other devices.
- … if the signature of the authority times out?
  - The device can receive an extension from the trust cache or a new signature from the central service.
- … if I want to add a legacy device?
  - KMIP allows integration of field devices that do not support the proposed architecture.

PROJECT OUTCOMES

- Prototype key management system.
- Bro-based defense architecture.
- Test scenarios and models.
- Performance validation.
- Comparison with other key management systems (IEC052351, NISTIR 7628).
- Research platform with test applications for future security research.

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