Trust Management:
An Overview

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"Classic" Trust Management

- For answering questions of the form: "Should I perform this (dangerous) action?"
- Systematic approach to managing
  - security policies
  - credentials
  - trust relationships
- Term coined in 1996
  - Blaze, Feigenbaum, Lacy. "Decentralized Trust Management." IEEE S&P (Oakland), 1996.

Trust Management: Compliance Checking

- Provides advice to applications on whether "dangerous" actions should be permitted
- Compliance checker uses local policy & signed credentials in making these decisions
  - guarantees that only actions that conform to policy will be approved
- As long as all dangerous actions are checked with the compliance checker, we know the security policy is being followed

Distributed/Decentralized Policy

- In a “perfect world”, the policy is in one place, specified by one person or entity
- But in the real world, different parts of the policy often come from different places
  - delegation of authorization
  - different administrators for different services
  - multiple requirements for access
- You may not even be able to look at the whole policy in one place
- Scale here means complexity & distribution

Policies and credentials do similar things

- A *policy* tells *who* is trusted to do *what*
  - *who* might be a public key
  - *what* is some potentially “dangerous” action
    - spend money, claim to be “matt blaze”, access a document
- A *credential* delegates trust to *someone else*
  - *someone else* might also be a public key (e.g., a CA)
- Distributed systems blur the line between policies and credentials
  - a credential is a policy signed by someone trusted

Public Key Infrastructure

- Why don't certificates and PKIs solve everything?
  - applications want an answer to this question:
    - "is this the correct public key for this purpose?"
    - current applications need ad hoc mechanism
  - PKI systems quietly restate this by answering another question instead:
    - "who owns this public key?"
    - X.509 certificates are good at doing this
- The two questions aren't quite the same…

Why is PKI not the solution?

- Focuses authorization on identity
  - turns a hard problem into a harder one
- Encourages outsourcing of exactly what you shouldn’t outsource
  - identity management
- Creates additional points of failure
- Encourages completely artificial intermediaries who seek to fill lucrative (and unneeded) vacuum
  - certificate authorities
  - OS & browser vendors

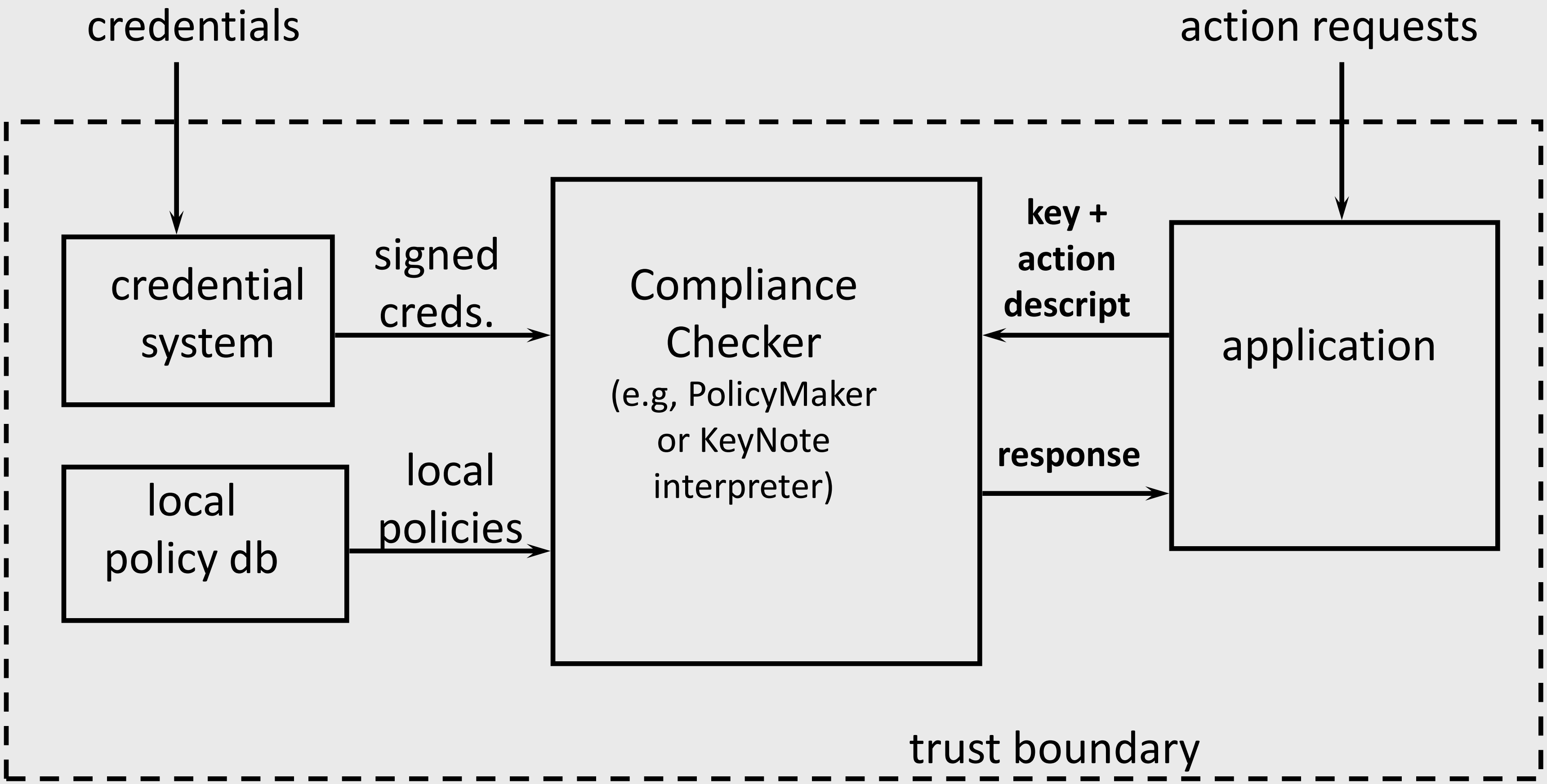
Classic Trust Management Principles

- Separate mechanism from policy
  - application-specific data, general mechanisms
  - certificate-based systems get this backwards!
- Use a general language for writing application-specific policies and credentials
- Interpreter for this language can serve as a compliance checker that applications call to test whether an action is allowed based on policy & credentials

Classic Trust Management Elements

- A language for *Actions*
  - operations with security consequences for applications
- A naming scheme for *Principals*
  - entities that can be authorized to request actions
- A language for *Policies*
  - govern the actions that principals are authorized for
- A language for *Credentials*
  - allow principals to delegate authorization
- A *Compliance Checker* and interface
  - service that determines whether a requested action should be allowed, based on policy and a set of credentials

Classic
Trust Management Architecture



Early Trust Management Languages

- PolicyMaker
  - Blaze, Feigenbaum, Lacy, 1996
  - Compliance cheking semantics formalized in Blaze, Feigenbaum, Strauss, 1998
  - very general, designed more for study than use
- KeyNote
  - Blaze, Feigenbaum, Ioannidis, Keromytis 1997
  - defined in RFC 2704
  - designed to be used, especially in Internet apps
- Both share same basic semantic structure

The *KeyNote* Trust Management System

- *Actions* are represented as name/value pairs
  - Semantics of attributes are defined by application
- *Principals* can be arbitrary names or public keys
- Common language for policies and credentials
  - "Assertions" authorize a principal to perform actions that pass a predicate testing the action attributes
  - Built in delegation scheme: credentials just signed policies
  - Monotonic: adding an assertion can never cause something that was authorized to not be authorized
- KeyNote evaluates action against policies & credentials and returns advice to application

KeyNote History

- Designed in 1997-1999
  - "standardized" in RFC-2704 in 1999
- Successor to PolicyMaker (1996)
  - PolicyMaker was intended as a system to study trust management concepts and theory
  - KeyNote was intended for actual use
- Successful in that:
  - it was useful for everything we intended it for
  - it was also useful for some applications we didn't envision
- But not exactly the language we would design today

KeyNote Example (policy and authorization cert)

```
Authorizer: "POLICY"
Licencees: "DSA:1f203faa2babd11ffe"
Conditions: application=="spend_money"
   && value < 50000;
```

```
Authorizer: "DSA:1f203faa2babd11ffe"
Licencees: "DSA:23dd11ff12efcafeff"
Conditions: application == "spend_money"
   && value < 10000;
Signature: "093a3134ffa38172200333110a2bc"
```

KeyNote applications

- KeyNote was designed for small- and medium-scale internet applications
- Integrated into policy layer for
  - Apache web server
  - IPSec VPN management
- Used inside AT&T

Trust Management and Large-Scale Systems

- In the 1990's, conventional wisdom was that hierarchical certificates (e.g., X509) were as the "magic bullet" solution to trust
  - but unfortunately, PKI is hierarchical, inflexible
  - even military organizations aren't as hierarchical as X509 certificate infrastructures assume!
- We developed the original trust management model partially as a response to X.509 model
  - the real world is much less hierarchical
  - needs flexibility and decentralized control.
- Large scale government systems that require flexible controls (e.g., GIG)

Limitations of the "Classic" Trust Management Model

- Trust management layer is a powerful architectural model, but does not address:
  - enterprise infrastructure and revocation
  - policies for changing external conditions
    - e.g., behave differently when offline
  - complex quantitative decision making
  - interaction with devices/systems/entities outside the policy enforcement layer
- These are all requirements in large-scale systems

Example: Dynamic Network Policy

- Often makes sense to have a very restrictive, hierarchical policy in normal operation
- But under crisis conditions (in the military, a war; in the civil world, a DDoS attack), it may make sense to relax the policy in specific ways
  - e.g., allow logins based on expired credentials
- Traditional security policy approaches don't do this well or securely
  - how to quantify and detect that this has happened
  - how to be sure the attacker can't artificially create the conditions that force you to relax policy

A Dynamic Trust Management Framework

- Inputs beyond policy and credentials
  - human input
  - risk-based data (e.g., output from network sensors to reliably detect changing conditions)
- More expressive languages that account for variety of input and more complex policy calculations
- Infrastructure to support policy distribution and revocation
- But all still encapsulated in a single trust management layer

Some future directions

- Trust management at the cyber-physical interface
  - physical security systems
    - increasingly characterized by tight coupling between electronic systems and human interface – *people* are part of the system, and so are computers
    - existing systems integrate the human-computer policy engine poorly
  - Electronic voting
    - what are the trust requirements?
    - how can we quantify & manage risk?
    - what to do when irregularities are detected?