ArmoredSoftware: Trust in the cloud

Annual Demonstration

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Outline

- Introduction and Project Goals
  - Big Picture
  - Implementation
- Prototype demonstration and discussion
  - Refine big picture to current demo
  - Protocol Execution
  - Attestation Protocol Execution
  - Appraisal
  - Measurement
  - Communication
- Short term goals and milestones
- Questions and guidance

Program Goal

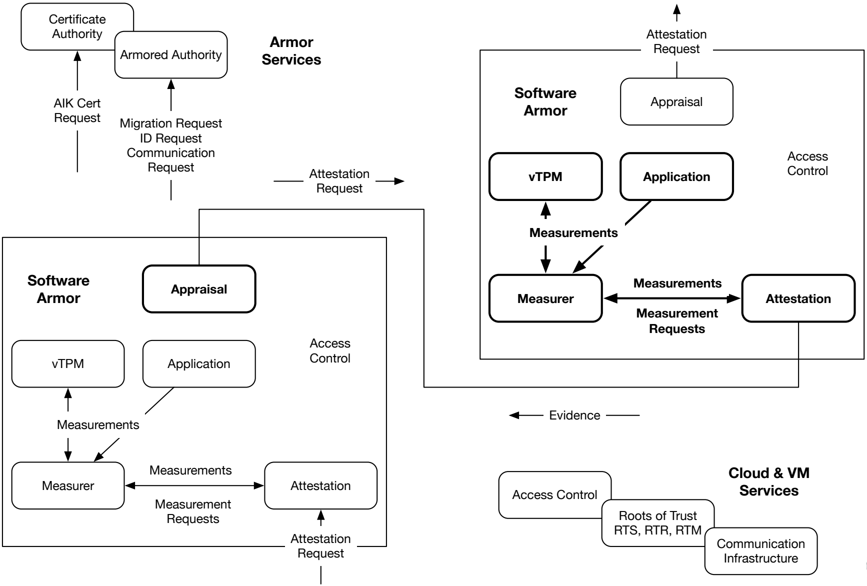
Trust in the Cloud

Provide new capabilities that help establish and maintain trustworthy cloud-based application deployment

New Capabilities

- Establish trust among cloud components
  - trust among cohorts of processes
  - trust among processes and environment
- Promote informed decision making
  - data confidentiality can be confirmed
  - execution and data integrity can be confirmed
- Autonomous run-time response and reconfiguration
  - responds to attack, failure, reconfiguration, and repair
  - response varies based on measurement
- Lightweight integration with existing cloud
  - targeting TXT, Xen, Linux, and OpenStack infrastructure
  - user-space measurement and attestation

High-Level Architecture



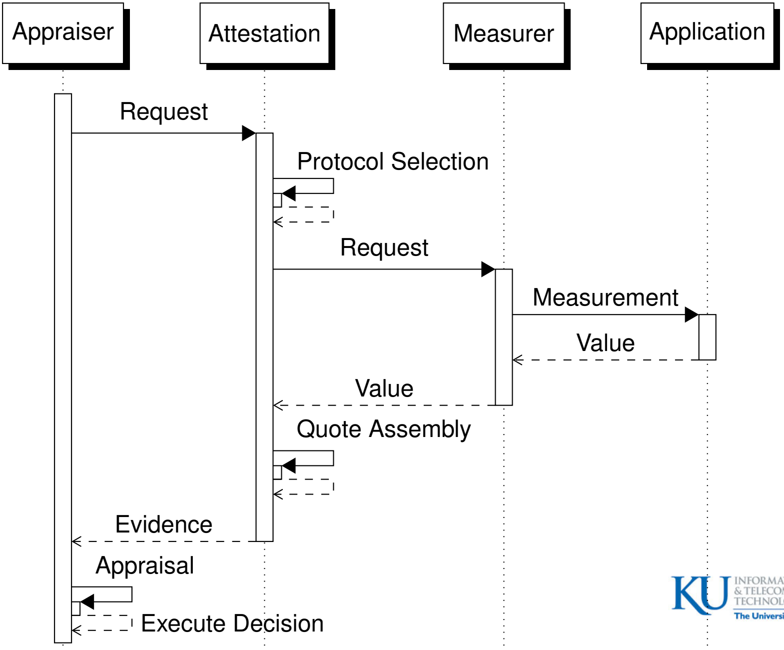
Implementation Decisions

- Standard delivery platform
  - Xen+XSM VM infrastructure
  - OpenStack cloud infrastructure
  - Fedora, HotSpot JVM, GHC
- Standard communication mechanisms
  - JSON structures for all exchanged data
  - *vchan* for on-platform communication
  - TCP/IP for off-platform communication
- Trusted Computing Group standards compliant
  - Trusted Platform Module (TPM) 1.2
  - TCG vTPM in principle
- Executable protocol representation
  - protocol fragments as first-class structures
  - strand space formal semantics

What We Are Demonstrating

- Execution of a CA-based Attestation Protocol
  - Attestation request
  - Protocol execution
  - Evidence appraisal
- Major architectural subsystems
  - Appraiser
  - Attestation Manager
  - Measurer
  - Instrumented JVM
  - vTPM and Certificate Authority
- Anomaly Detection
  - Bad signatures and PCRs
  - Bad CA certificates
  - Bad quotes and AIKs
  - Bad measurements

Abstract CA-Based Attestation Protocol



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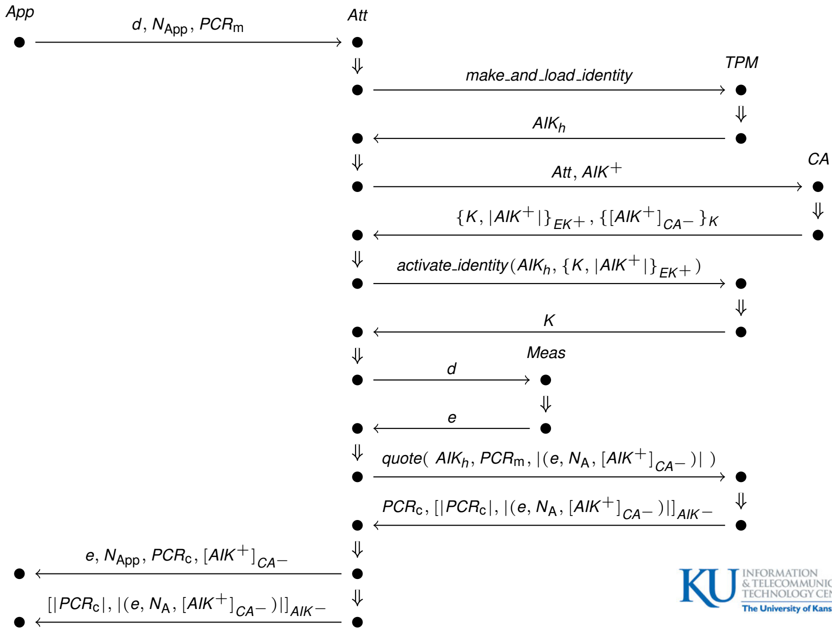
Message List Representation

$$App \rightarrow Att : d, N_{\mathrm{App}}, PCR_{\mathrm{m}} \text{ on } C_{AppAtt}$$
$$Att \rightarrow TPM : make\_and\_load\_identity \text{ on } C_{AttTPM}$$
$$TPM \rightarrow Att : Att, AIK_h \text{ on } C_{TPMAtt}$$
$$Att \rightarrow CA : Att, AIK^+ \text{ on } C_{AttCA}$$
$$CA \rightarrow Att : \{K, |AIK|\}_{EK^+}, \{[AIK^+]_{CA^-}\}_{K^+} \text{ on } C_{CAAtt}$$
$$Att \rightarrow TPM : activate\_identity(AIK_h, |AIK|) \text{ on } C_{AttTPM}$$
$$TPM \rightarrow Att : K \text{ on } C_{TPMAtt}$$
$$Att \rightarrow Meas : d \text{ on } C_{AttMeas}$$
$$Meas \rightarrow Att : e \text{ on } C_{MeasAtt}$$
$$Att \rightarrow TPM : quote(\ AIK_{\mathrm{h}}, PCR_{\mathrm{m}}, |(e, N_{\mathrm{A}}, [AIK^+]_{CA^-})|\ ) \text{ on } C_{AttTPM}$$
$$TPM \rightarrow Att : PCR_{\mathrm{c}}, [|PCR_{\mathrm{c}}|, |(e, N_{\mathrm{A}}, [AIK^+]_{CA^-})|]_{AIK^-} \text{ on } C_{TPMAtt}$$
$$Att \rightarrow App : e, N_{\mathrm{App}}, PCR_{\mathrm{c}}, [AIK^+]_{CA^-} \text{ on } C_{AttApp}$$
$$Att \rightarrow App : [|PCR_{\mathrm{c}}|, |(e, N_{\mathrm{A}}, [AIK^+]_{CA^-})|]_{AIK^-} \text{ on } C_{AttApp}$$

Strand Space Diagram Representation



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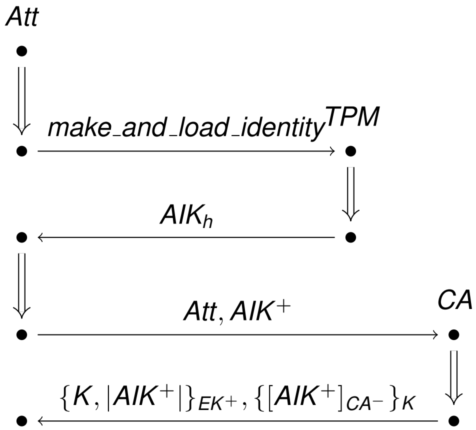
Attestation Request

$$\mathit{App} \xrightarrow{d,\, N_{\text{App}},\, \mathit{PCR}_{\text{m}}} \mathit{Att}$$

- Initiate with an attestation request
  - d abstractly defines desired evidence
  - N_{App} is the appraiser's nonce
  - PCR_{m} selects PCRs
- Attestation agent selects and executes protocol based on request

Generating and Certifying an AIK

- Request a new AIK from TPM (optional)
- Receive AIK handle
- Request AIK^+ signed by CA (AIK cert)
- Receive AIK cert encrypted with session key K
- Receive K encrypted with public EK



Activating the AIK

$$\begin{array}{ccc} \mathit{Att} & & \mathit{TPM} \\ \bullet & \xrightarrow{\mathit{activate\_identity}(AIK_h, \{K, |AIK^+|\}_{EK^+})} & \bullet \\ & & \Downarrow \\ \bullet & \xleftarrow{K} & \bullet \end{array}$$

- Request TPM decryption of the *AIK* cert
- Receive *K* used to decrypt signed public *AIK*
- Only TPM can gain access to *K*
- Only TPM can obtain signed, public *AIK*
- Oddly, No manipulation of the *AIK* in this “activation” process

Measurement

$$
\begin{tikzcd}
\overset{Att}{\bullet} \arrow[rrr, "d"] & & & \overset{Meas}{\bullet} \arrow[d, Rightarrow] \\
\bullet & & & \bullet \arrow[lll, "e"']
\end{tikzcd}
$$

- Request information from measurer
- Receive evidence *e* from measurer
- *d* is abstract allowing protocol reuse
- Most protocols make many requests of the measurer

Generating a Quote

$$\begin{array}{ccc} \textit{Att} & & \textit{Meas} \\ \bullet & \xrightarrow{\textit{quote}(\ \textit{AIK}, \textit{PCR}_{\mathrm{m}}, |(e, N_{\mathrm{A}}, [\textit{AIK}^{+}]_{CA^{-}})|\ )} & \bullet \\ & & \Downarrow \\ \bullet & \xleftarrow{\textit{PCR}_{\mathrm{c}}, [|\textit{PCR}_{\mathrm{c}}|, |(e, N_{\mathrm{A}}, [\textit{AIK}^{+}]_{CA^{-}})|]_{\textit{AIK}^{-}}} & \bullet \end{array}$$

- Request a quote from the TPM
  - $\textit{AIK}$ identifies the signing $\textit{AIK}$
  - $\textit{PCR}_m$ identifies desired PCRs
  - $|(e, N_{\mathrm{A}}, [\textit{AIK}^{+}]_{CA^{-}})|$ guarantees integrity of returned evidence
- Receive quote from TPM
  - $\textit{PCR}_{\mathrm{c}}$ is PCR composite built from requested PCRs
  - $[|\textit{PCR}_{\mathrm{c}}|, |(e, N_{\mathrm{A}}, [\textit{AIK}^{+}]_{CA^{-}})|]_{\textit{AIK}^{-}}$ is the signed quote

Appraisal

$$\begin{tikzcd}[column sep=huge]
\mathit{Att} & \mathit{Meas} \\
\bullet & \bullet \arrow[l, "{e, N_{\mathrm{App}}, PCR_{\mathrm{c}}, [AIK^{+}]_{CA^{-}}}"'] \arrow[d, Rightarrow] \\
\bullet & \bullet \arrow[l, "{[|PCR_{\mathrm{c}}|, |(e, N_{\mathrm{A}}, [AIK^{+}]_{CA^{-}})|]_{AIK^{-}}}"']
\end{tikzcd}$$

- Receive quote from the attestation manager
- Receive evidence from the attestation manager
- Evaluate evidence and quote

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3-4 Slides on Attestation Protocol Execution

1-2 Slides on Appraisal

3-4 Slides on Measurement

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2-3 Slides on Communication Mechanisms

Goals and Milestones for 2015

- Push to the cloud
- Establish roots of trust and trust argument
- Executable protocol representation and protocol semantics
- Operational, integrated vTPM prototype
- Name Server / Certificate Authority prototype
- More capable measurement
- Downloadable demonstration

Questions and Guidance

- What problems are interesting?
- What problem would be a nice attention grabber?
- What should we be watching and integrating with?

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