

# ArmoredSoftware: Trust in the cloud

Annual Demonstration

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## 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

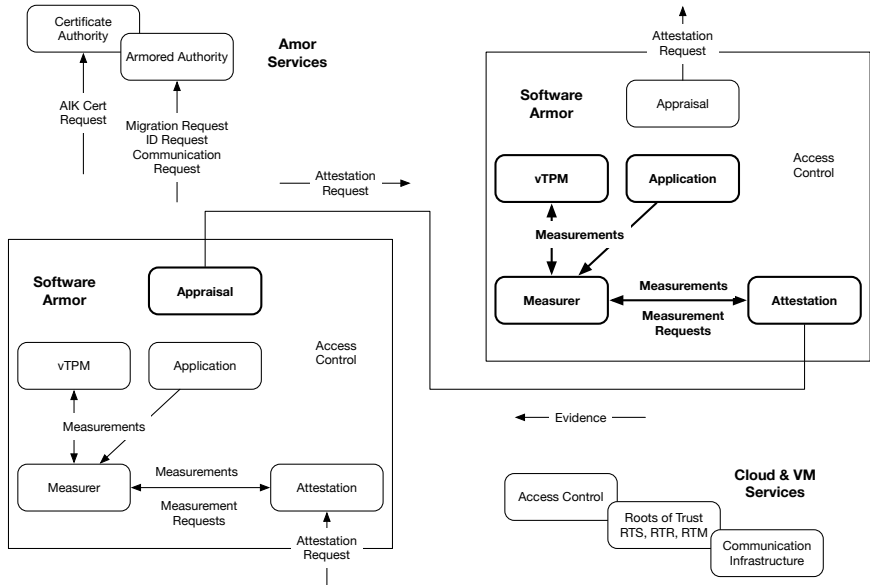
## Questions and guidance

## Trust in the Cloud

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

- ▶ 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

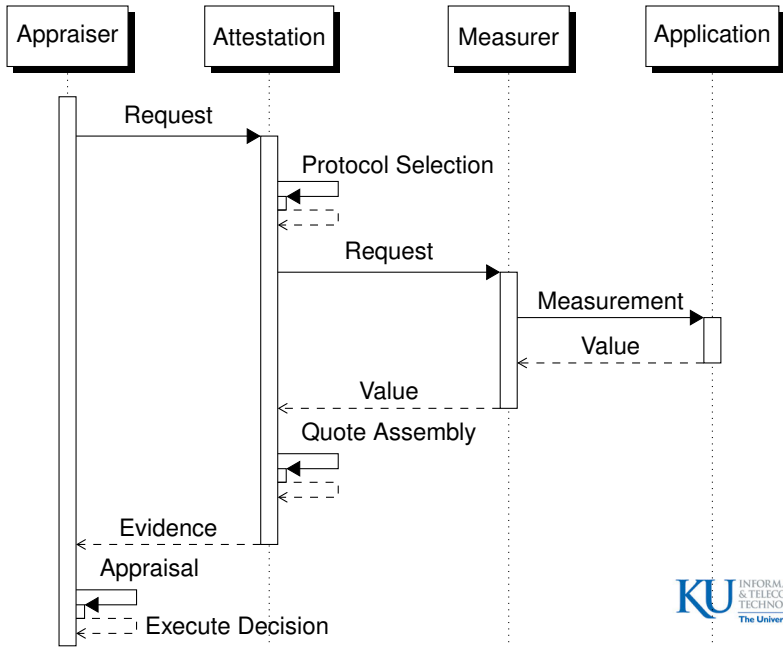


- ▶ Standard delivery platform
  - ▶ Xen+XSM VM infrastructure
  - ▶ OpenStack cloud infrastructure
  - ▶ Fedora, HotSpot JVM, GHC
- ▶ Standard communication mechanisms
  - ▶ JSON structures for all exchanged data
  - ▶ *vchan* for on-platform communication
  - ▶ TCP/IP for off-platform communication
- ▶ 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





# Message List Representation

$App \rightarrow Att : d, N_{App}, PCR_m \text{ on } C_{AppAtt}$

$Att \rightarrow TPM : make\_and\_load\_identity \text{ on } C_{AttTPM}$

$TPM \rightarrow Att : AIK^+, AIK_h \text{ on } C_{TPMAtt}$

$Att \rightarrow CA : Att, AIK^+ \text{ on } C_{AttCA}$

$CA \rightarrow Att : \{K, |AIK|\}_{EK^+}, \{[AIK^+]_{CA^-}\}_{K^+} \text{ on } C_{CAAtt}$

$Att \rightarrow TPM : activate\_identity(AIK_h, |AIK|) \text{ on } C_{AttTPM}$

$TPM \rightarrow Att : K \text{ on } C_{TPMAtt}$

$Att \rightarrow Meas : d \text{ on } C_{AttMeas}$

$Meas \rightarrow Att : e \text{ on } C_{MeasAtt}$

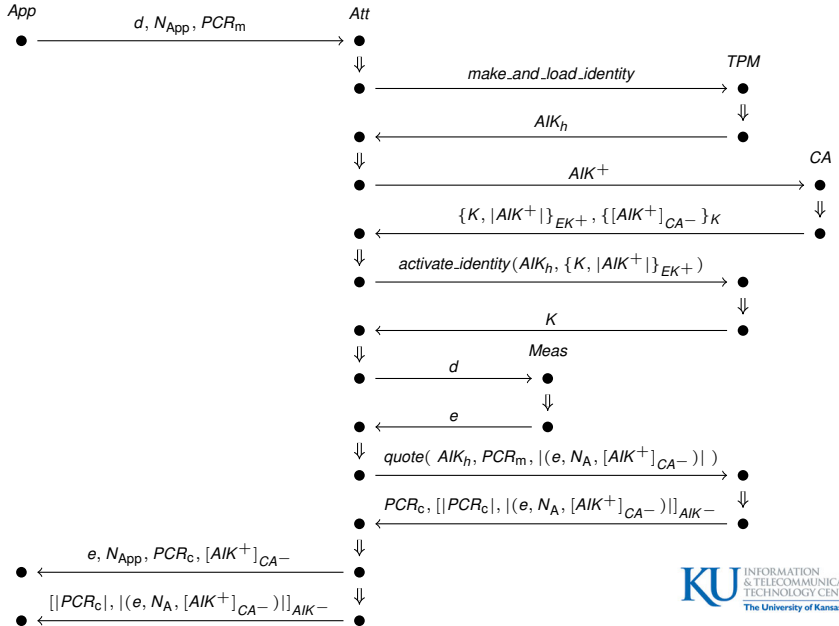
$Att \rightarrow TPM : quote( AIK_h, PCR_m, |(e, N_A, [AIK^+]_{CA^-})| ) \text{ on } C_{AttTPM}$

$TPM \rightarrow Att : PCR_c, [|PCR_c|, |(e, N_A, [AIK^+]_{CA^-})|]_{AIK^-} \text{ on } C_{TPMAtt}$

$Att \rightarrow App : e, N_{App}, PCR_c, [AIK^+]_{CA^-} \text{ on } C_{AttApp}$

$Att \rightarrow App : [|PCR_c|, |(e, N_A, [AIK^+]_{CA^-})|]_{AIK^-} \text{ on } C_{AttApp}$

# Strand Space Diagram Representation



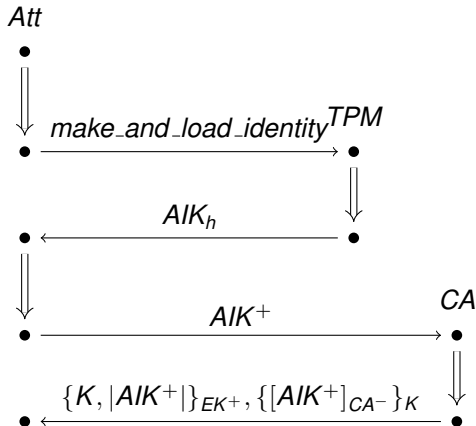
# Attestation Request



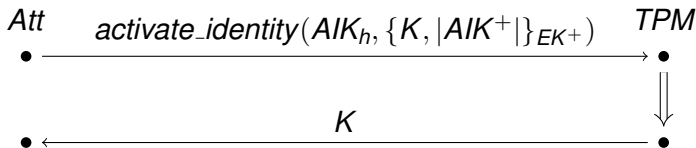
- ▶ Initiate with an attestation request
  - ▶  $d$  abstractly defines desired evidence
  - ▶  $N_{App}$  is the appraiser's nonce
  - ▶  $PCR_m$  selects PCRs
- ▶ Attestation agent selects and executes protocol based on request

# Generating and Certifying an AIK

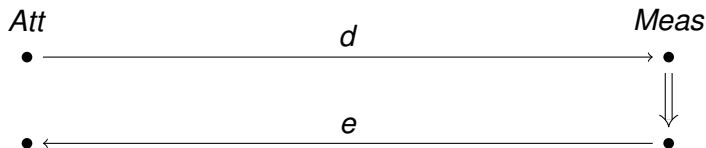
- ▶ Request a new *AIK* from TPM (optional)
- ▶ Receive *AIK* handle
- ▶ Request  $AIK^+$  signed by CA (*AIK* cert)
- ▶ Receive *AIK* cert encrypted with session key  $K$
- ▶ Receive  $K$  encrypted with private  $EK$



# Activating the AIK

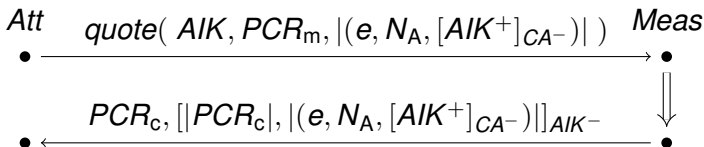


- ▶ Request TPM decryption of the *AIK* cert
- ▶ Receive *K* used to decrypt signed public *AIK*
- ▶ Only TPM can gain access to *K*
- ▶ Only TPM can obtain signed, public *AIK*
- ▶ Oddly, No manipulation of the *AIK* in this “activation” process

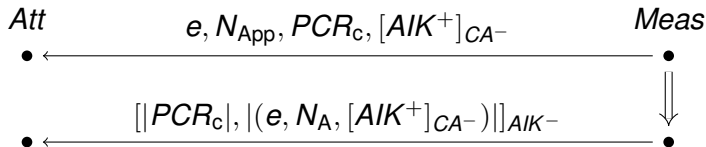


- ▶ Request information from measurer
- ▶ Receive evidence  $e$  from measurer
- ▶  $d$  is abstract allowing protocol reuse
- ▶ Most protocols make many requests of the measurer

# Generating a Quote



- ▶ Request a quote from the TPM
  - ▶  $AIK$  identifies the signing  $AIK$
  - ▶  $PCR_m$  identifies desired PCRs
  - ▶  $|(e, N_A, [AIK^+]_{CA-})|$  guarantees integrity of returned evidence
- ▶ Receive quote from TPM
  - ▶  $PCR_c$  is PCR composite built from requested PCRs
  - ▶  $[|PCR_c|, |(e, N_A, [AIK^+]_{CA-})|]_{AIK-}$  is the signed quote



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



## 3-4 Slides on Attestation Protocol Execution

# 1-2 Slides on Appraisal

## 3-4 Slides on Measurement




## 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?

-  G. Coker, J. Guttman, P. Loscocco, A. Herzog, J. Millen, B. O'Hanlon, J. Ramsdell, A. Segall, J. Sheehy, and B. Sniffen. Principles of remote attestation.  
*International Journal of Information Security*, 10(2):63–81, June 2011.
-  F. J. T. Fábrega, J. C. Herzog, and J. D. Guttman. Strand spaces: Proving security protocols correct.  
*Journal of computer security*, 7(2):191–230, 1999.
-  V. Haldar, D. Chandra, and M. Franz. Semantic remote attestation – a virtual machine directed approach to trusted computing.  
In *Proceedings of the Third Virtual Machine Research and Technology Symposium*, San Jose, CA, May 2004.