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NIST PKI'06:
Integrating PKI and Kerberos (updated April 2007)

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The Slow Convergence of PKI and Kerberos

- At Connectathon 1995 Dan Nessett of Sun Microsystems was quoted saying “Kerberos will gradually move toward public-key” in reference to the publication of Internet Draft
  - **draft-ietf-cat-kerberos-pk-init-00**
- IETF CAT Working Group (Apr 1995) discussed not only pk-init-00 but also Netscape’s proposal for something called SSL.
- Eleven years and 34 drafts later PK-INIT was approved as an IETF Proposed Standard (RFC 4556)

How much more gradually can we move? ☺

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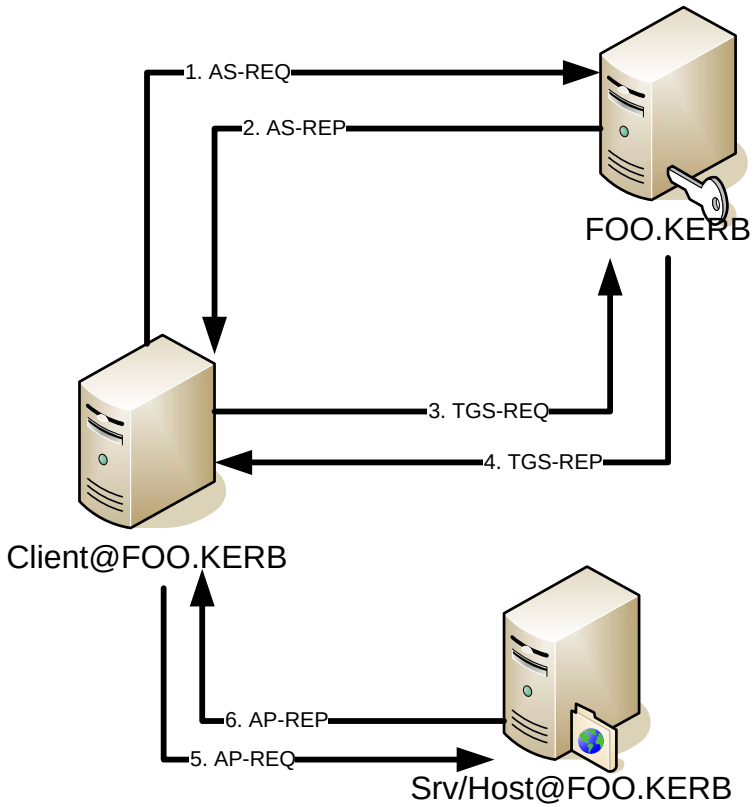
A Three Slide Overview of Kerberos V5 Before PKI: Single Realm

- The Authentication Service (AS) Exchange
  - The client obtains an "initial" ticket from the Kerberos authentication server (AS), typically a Ticket Granting Ticket (TGT).
  - The AS-REQ may optionally contain pre-authentication data to prove the client's identity.
  - The AS-REP, containing an authenticator (aka ticket), is encrypted in the client's long term key.
- The Ticket Granting Service (TGS) Exchange
  - The client subsequently uses the TGT to authenticate and request a service ticket for a particular service, from the Kerberos ticket-granting server (TGS).
- The Client/Server Authentication Protocol (AP) Exchange
  - The client then makes a request with an AP-REQ message, consisting of a service ticket and an authenticator that certifies the client's possession of the ticket session key. The server may optionally reply with an AP-REP message. AP exchanges typically negotiate session specific symmetric keys.



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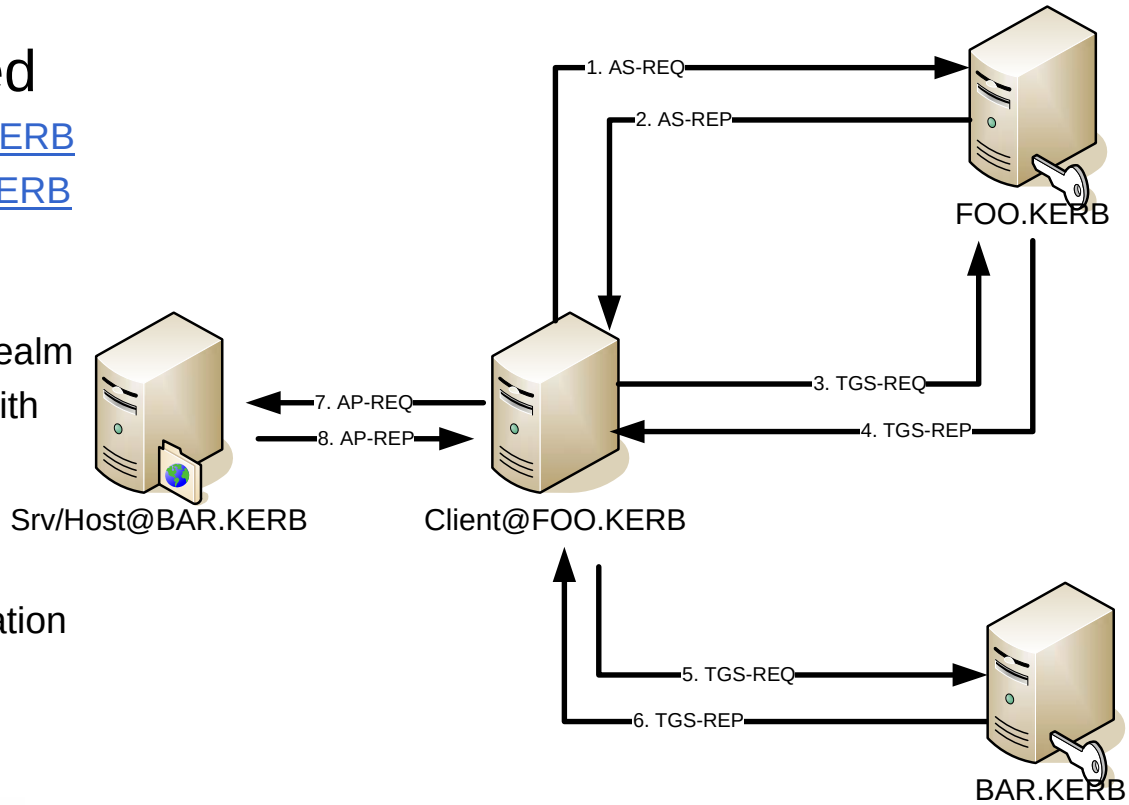
Slide 2: Kerberos 5 Cross Realm

Tickets Obtained

krbtgt/FOO.KERB@FOO.KERB
krbtgt/BAR.KERB@FOO.KERB
Srv/Host@BAR.KERB

Cross Realm works when realm FOO.KERB shares a key with realm BAR.KERB.

In all cases, the KDC must share a key with the application Service.



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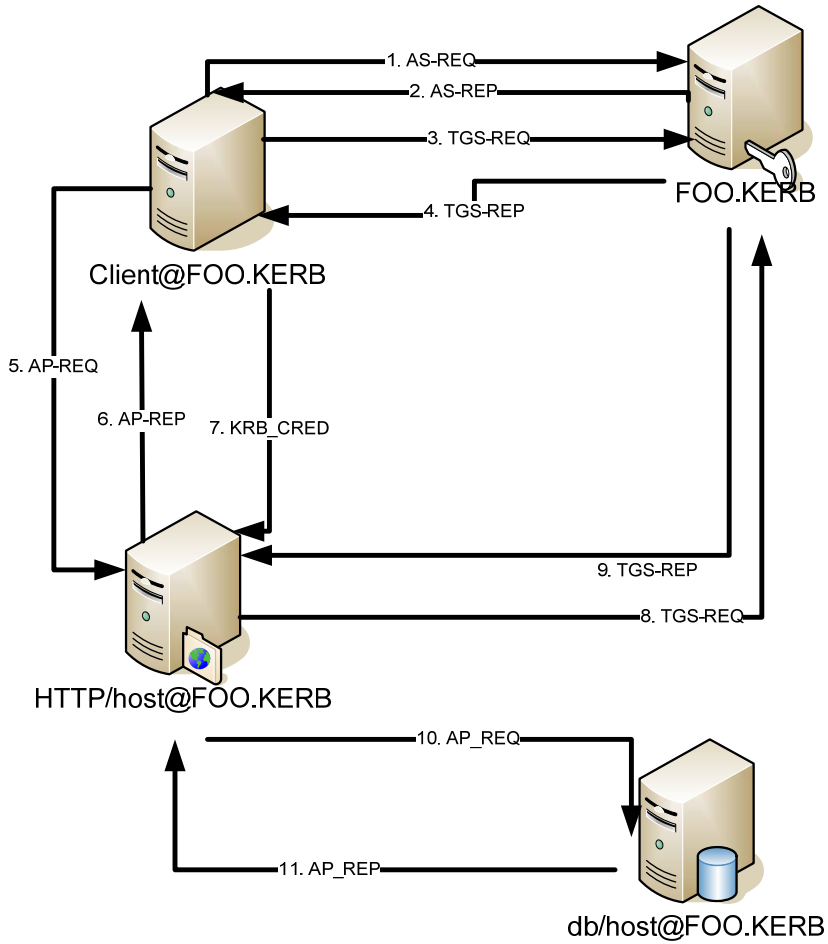
Slide 3: Kerberos 5 Delegation

- Delegation utilizes the ability to FORWARD tickets from a client machine to a service.
- The service can then assume the identity of the client in order to authenticate to a subsequent service.
- Constraints can be applied to the forwarded tickets using authorization data.



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PKI and Kerberos have each excelled in separate but overlapping spheres

PKI and the Web

- Smartcards for logon
- Web Service authentication
- TLS authenticated services
  - FTP, SMTP, IMAP, many more …
- Signatures and Privacy (S/MIME)
  - E-mail
  - Instant Messages

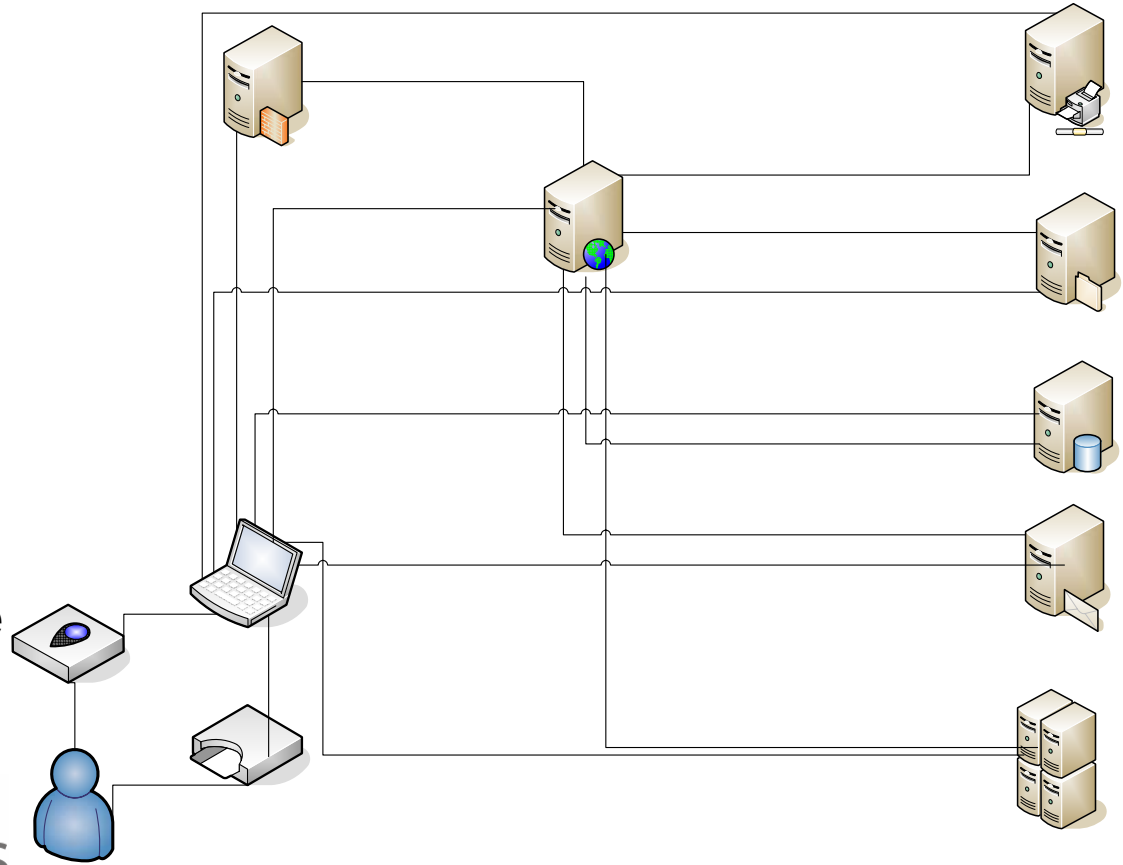
Kerberos and Enterprise Services

- Console Logon
- Remote Console Logon
- File System Access
  - AFS, NFS, CIFS, FTP
- E-mail Service Access
- Print Services
- Real-time authenticated messaging
  - Zephyr

But combining PKI and Kerberos is necessary for true Single Sign-On

- Multifactor Initial Authentication
- Mutual Client Server authentication
- With Delegation
- Through Proxies
- Supporting all protocols

It's a big task but we can do it!!!



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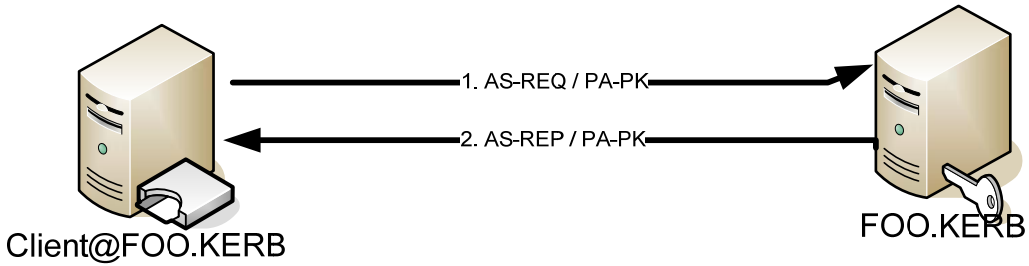
How the PKI and Kerberos worlds can be joined

- Imagine a world in which each Kerberos Key Distribution Center is also a Certificate Authority.
  - Its not hard to do, think Microsoft Active Directory.
- PK-INIT*
  - Kerberos Initial Ticket Acquisition using Public Key
    - Certificates or Raw Key Pairs
- PK-CROSS
  - Establishment of Kerberos Cross Realm relationships using Public Key
    - Mutual Authentication of KDCs
    - Secure Generation of Static Keys
- PK-APP (aka kx509/kca)*
  - Acquisition of Public Key certificates via Kerberized Certificate Authorities

*implementations are currently available

PK-INIT: How does it work?



- PK-INIT is implemented as a Kerberos Pre-authentication mechanism
- If the client's request adheres to KDC policy and can be validated by its trusted CAs, then the reply is encrypted either with
  - A key generated by a DH key exchange and signed using the KDC's signature key, or
  - A symmetric encryption key, signed using the KDC's signature key, and then encrypted with the client's public key.
- Any required keying material is returned to the client as part of the AS-REP's PA-PK data.
- If the client can validate the KDC's signature, obtain the encryption key, and decrypt the reply, then it has successfully obtained an Initial Ticket Granting Ticket.

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PK-INIT: Not Vaporware

- Draft -9 deployed by Microsoft in Windows 2000 and above
- The Proposed Standard (RFC 4556) is being deployed today:
  - Microsoft Vista
  - Heimdal Kerberos
- Future deployments:
  - MIT Kerberos 1.7 and the operating systems that distribute it

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PK-INIT: Opening the doors to alternative enrollment models

- Trusted CA issued certificate can be enrolled with multiple realms
- Raw public key pairs can be used instead of certs allowing SSH style enrollments
- A single smart card can be enrolled with multiple realms allowing the acquisition of TGTs for multiple service providers

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PK-CROSS: Easing the administrative challenges to key exchange

- Kerberos Cross Realm succeeds in Active Directory Forests because the key establishment is automated
- Kerberos Cross Realm works for the major Universities and Government labs because they have taken the time to manually establish keys
- For the rest of us, an automated key establishment protocol is required. Public key crypto could reduce the administrative burden to the configuration of policy.

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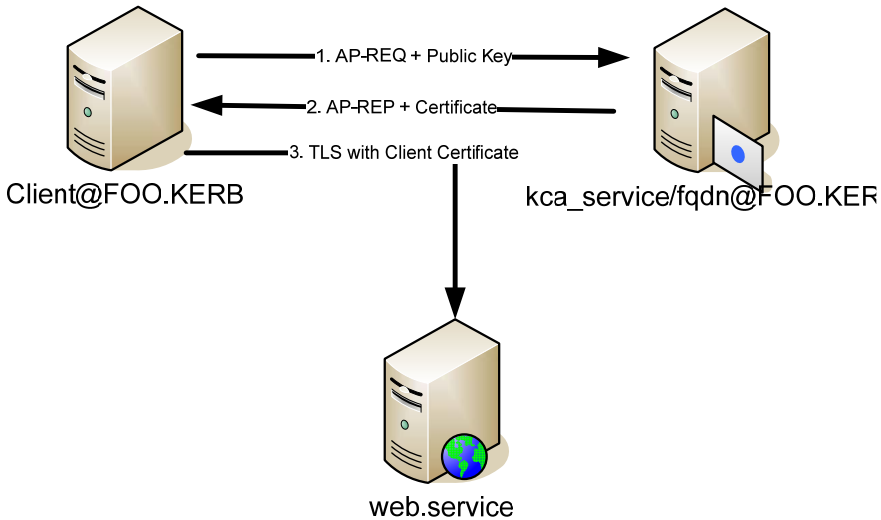
KX.509 (or How to authenticate using a Kerberos identity to a PKI service)

- KX509 utilizes a Kerberos Application Service authentication to communicate with a special certificate service that issues client certificates with the same identity and valid lifetime as the Kerberos Service ticket.
- The resulting certificate is placed in the certificate store for use by applications such as web browsers.



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What's Next for Kerberos and PKI Integration?

- Standardize PK-CROSS and PK-APP (kx509/kca)
- Strive for Zero Configuration
- Standardize the use of SAML decoration of PKI Certificates and Kerberos Tickets
- Standardize a firewall friendly method of communicating with Kerberos KDCs
  - Microsoft and Secure Endpoints are co-authoring IAKERB, a proxy mechanism that permits Kerberos TGS requests to be tunneled as part of a GSS-API service authentication
- Improve the user experience
  - Focus deployment efforts on the goal of reducing the number of credentials end users are responsible for securing

References

- KX509/Kerberized Certificate Authority
  http://www.kx509.org
- IETF Kerberos Working Group
  http://www.ietf.org/html.charters/krb-wg-charter.html
- Heimdal PKINIT
  http://people.su.se/~lha/patches/heimdal/pkinit/
- Microsoft Windows 2000 PKINIT
  http://support.microsoft.com/kb/248753/en-us

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Q & A

Requirements for Federated Single Sign-On

- Trusted initial authentication
  - Smartcards, Zero Knowledge Inference, Biometrics, One Time Pads.
  - May require different methods depending on the environment
- Mutual Authentication between each set of endpoints
- Delegation of credentials with constraints
  - Forwardable Kerberos tickets
  - Authorization Data (MS PAC, SAML) provide constraints
- Ability to present a recognizable credential to each service
  - Certificates or Tickets
- Federated acceptance of presented credentials

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