Cross-Realm Kerberos Authentication

A study into implementations and compatibility

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Introduction

- Around since ancient times ('80s)
  - Version 5 from 1993, revised in 2005
- Offers authentication in networks between clients and services
- Single Sign On
  - "Yesteryear's OAuth"
- Many implementations exist
  - Active Directory
  - Heimdal
  - MIT Kerberos
  - Shishi

Previous research

- Implementation of cross-realm referral handling in MIT Kerberos client
- Research by Cervesato et al. illustrated the possibility to impersonate users by rogue KDCs
- Much debate about cross-realm options
  - But very little in the way of implementations
- Specifying Kerberos 5 cross-realm authentication

Goals

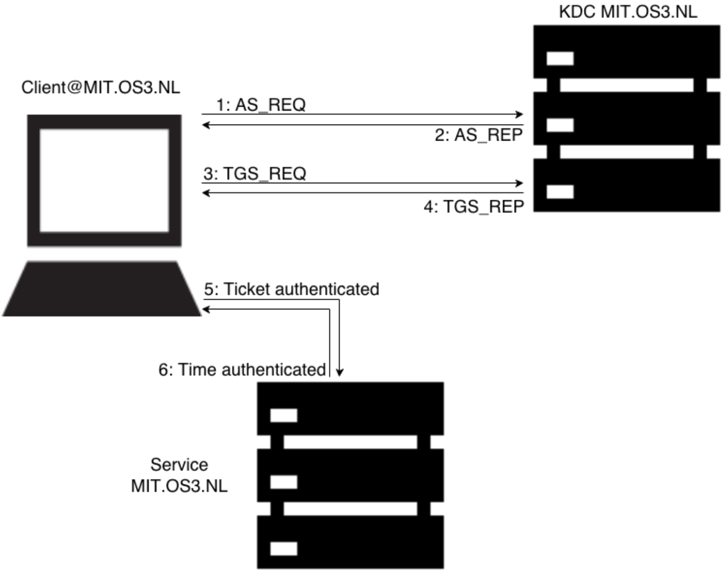
The goal is to check the current status of Kerberos implementations and identifying possibilities for dynamic configuration to enable cross-realm authentication. E.g. using an @OS3.NL account to authenticate a user for their Facebook profile.

- Analyse the interoperability between implementations
- Research default behaviour for edge cases
- Research options for Cross Realm trust configurations
- Analyse cryptographic behaviour

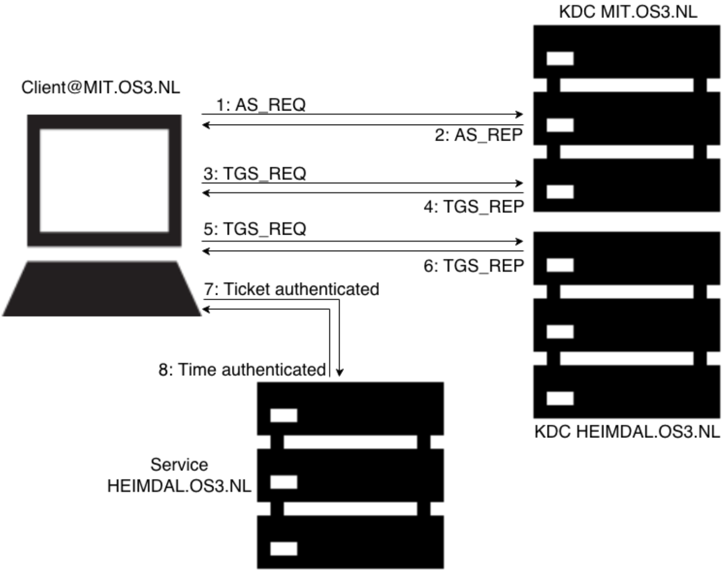
Kerberos recap

- Authentication provider relying on trusted third party
- Based on shared secrets
- Tickets are encrypted so only the intended recipient can decrypt it
- Designed to provide authentication on untrusted networks
- Password is not send over the network
- Supports public key cryptography

Kerberos Illustrated



Kerberos Cross-Realm Illustrated



Testing basic functionality

- Testing combinations of all implementations, focused on receiving a valid ticket
- Clients authenticated using password
- Services using keytab via GSS-API

Requirements

- Machines taking role of either client, service, or KDC.
- Configured DNS
- Patience

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- Machines taking role of either client, service, or KDC.
- Configured DNS
- Patience
  - A lot of it

Testing basic functionality

	KDC			
Client	Active Directory	Heimdal	MIT	Shishi
Active Directory	✓	✗[1]	✗[1]	✗[1]
Heimdal	✓	✓	✓	✓
MIT	✓	✓	✓	✓
Shishi	✓	✓	✓	✓
Service	Active Directory	Heimdal	MIT	Shishi
Active Directory	✓	✗[1]	✗[1]	✗[1]
Heimdal	✓	✓	✓	✓
MIT	✓	✓	✓	✓
Shishi	✗[2]	✗[2]	✗[2]	✗[2]

Table: Compatibility between implementations

[1] No service available for testing

[2] Shishi GSSAPI not implemented yet, but service ticket can be requested

Crypto compatibility

	Active Directory	Heimdal	MIT	Shishi
AES128/256-SHA1	✓	✓	✓	✓
CAMELLIA128/256-CTS-CMAC			✓	
DES3-CBC-SHA1		✓	✓	✓
DES-CBC-CRC[3]	✓		✓	✓
DES-CBC-MD5[3]	✓		✓	✓
DES-CBC-MD4[3]			✓	✓
RC4-HMAC-EXP[3]			✓	✓
RC4-HMAC	✓	✓	✓	✓

Table: Ciphers implemented

[3] Considered weak[2]

Testing PKINIT compliance

- Use of public key cryptography for authentication and encryption
- Chain of trust maintained as standard X.509 certificates
- Any certificate authority
- Extended Key Usage (EKU)
    - X.509 Subject Alternative Name (SAN) extension
- Or if you're Microsoft:
    - dNSName containing a SAN of the hostname of the KDC

PKINIT Results

- Shishi no support.
- Windows has it's own format
- MIT EKU tested/confirmed
- Heimdal support for both formats, EKU tested/confirmed
  - Connecting to MIT KDC weak encryption, DH parameters

DNS

Kerberos uses DNS to find the KDC servers of a realm. This is accomplished by using SRV records and will make the realm configuration in the configuration

- _kerberos._tcp.ad.os3.nl. IN SRV 01 00 88 ad.os3.nl.
- _kerberos._udp.ad.os3.nl. IN SRV 01 00 88 ad.os3.nl.

- Behaviour was analysed under several configurations
- MIT Kerberos 5, Heimdal and Shishi clients all use DNS if realm is unknown[4]

[4] provided a user specifies a realm when attempting to perform initial authentication

Cross-Realm setup

- All manually configured, no automatic options available
- Requires shared secret between KDCs
- All cross-realm trusts are one-way
    - Add a principal in the right direction
- Two-way trust is possible
    - Add principals for both directions

Cross-Realm requirements

	Active Directory	Heimdal	MIT	Shishi
Active Directory	✓	✓	✓	✗[5]
Heimdal	✓	✓	✓	✗[5]
MIT	✓	✓	✓	✗[5]
Shishi	✗[5]	✗[5]	✗[5]	✗[5]

Table: Cross compatibility

[5] Shishi does not support cross realm configuration

Conclusion

- The implementations adhere to the protocol
    - Most conflicts occur from other variables
- Much remains to be done to enable auto-configuration
    - Public key cryptography for communication between KDCs
- Heimdal and MIT Kerberos 5 are most compatible

Note:
Many documents are outdated when it concerns Kerberos

Future Work

- Finish Shishi
- Better debugging options in the implementations
- Improve interoperability between implementations
- Dynamic configurable trust
- Foreign trust policies
- Asynchronous Cryptography for Cross-Realm trust
    - PKCROSS started as draft but remains unfinished
        - As of this week some activity again on the mailing list

Questions?

Takeaways in Kerberos

- Check your time
- KERBEROS LOVES CAPS (and so do config files)
- When in doubt, DNS!

Special thanks to Michiel Leenaars and Rick van Rein for their input and feedback during this project.

- I. Cervesato et al. "Specifying Kerberos 5 Cross-realm Authentication". In: *Proceedings of the 2005 Workshop on Issues in the Theory of Security*. WITS '05. Long Beach, California, 2005, pp. 12–26. ISBN: 1-58113-980-2.
- L. Hornquist Astrand and T. Yu. *Deprecate DES, RC4-HMAC-EXP, and Other Weak Cryptographic Algorithms in Kerberos*. RFC 6649 (Best Current Practice). Internet Engineering Task Force, July 2012.