DCNDS

Distributed Systems Security

Authentication Practice - 1

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Lecture Objectives

- Identify authentication needs for client-server systems
- Using variants of principles develop suitable protocols
- Examine Kerberos protocol

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Scenario

- Let us consider a computing environment where each user accesses services via a workstation on their desk
- A number of servers provide services such as filing, computation, printing and mail
- Servers need to protect their resources against unauthorised use, so users need to be authenticated

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Approaches

- We can use one of three broad approaches:
  - Let client workstation authenticate user and server trusts this as basis for access control and resource management
  - As above, but require the client machine to authenticate itself with the server
  - Require the user to prove their identity to each service used - might also expect server to prove its identity to clients
- Particularly as scale of system grows, the third approach, including partitioning of user space, will be needed

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Kerberos

- The need for such authentication arose in Project Athena at MIT in the 1980s, and Kerberos was developed
- Principal requirements were:
  - ***Secure:*** Kerberos should not provide an easy entry to the system for network eavesdroppers
  - ***Reliable:*** Kerberos mediates all server access so robust system is needed allowing cover when a Kerberos server fails
  - ***Transparent:*** Other than initial password entry, users should not be aware of the authentication exchanges
  - ***Scalable:*** System must be capable of supporting large numbers of clients and servers

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Notation

- We need to revise our notation to be more specific
- In particular we need to distinguish between the client machine (workstation) that the user is logged into, the user (principal) and their names and addresses
- Thus:

C	is the client's machine to/from which messages are transferred
ADc	is the network address of C
IDc	is the name of the principal using C (charles@xyz.com)

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Notation - 2

To avoid confusion we will use the notation in Stallings p326

C	Client machine (workstation)
AS	Authentication server
V	Application server (eg. file server)
Idc	Name of user on C
Pc	User's password
ADc	Network address of machine C
IDv	Name of service
Kv	Personal encryption key (SKC) of V, only known to AS and V

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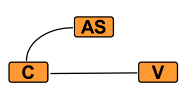
Kerberos Simple Authentication



- AS checks Principal's credentials after step 1
- If satisfied, a ticket for V is generated
- Ticket is only valid for specific user and server and from a specific client machine
- Ticket is encrypted to prevent forgery and IDc is used in step 3 so V can verify correct decryption

<u>Authentication</u>

1.	C->AS:	IDc, Pc, IDv
2.	AS->C:	Ticket = {IDc, ADc, IDv}Kv
3.	C->V:	IDc, Ticket

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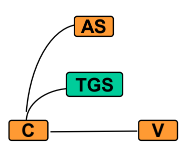
Kerberos
Simple Authentication Issues

- Password needs to be re-entered each time a different server is accessed and AS has to be contacted to issue a ticket
- May be assumed that ticket is for “one use only”, but nothing in ticket to enforce that
- Nothing to prevent ticket being used for years!
- Password is transmitted in clear text over the network

- Introduce new *Ticket Granting Service* (TGS)

Kerberos
Better Authentication



- TICKETtgs is held by client machine and used to get service tickets from TGS when needed
- Tickets include issue timestamp and validity period
- Kc is derived from C’s password, hence password not transmitted

Per login

1. C->AS: IDc, IDtgs
2. AS->C: {TICKETtgs}Kc

Per Service

3. C->TGS: IDc, IDv, TICKETtgs
4. TGS->C: TICKETv

Per Service Session

5. C->V: IDc, TICKETv

$TICKET_{tgs}$={ID_c, AD_c, Id_{tgs}, TS_1, $Life_1$}K_{tgs}

$TICKET_v$ = {Id_c, AD_c, ID_v, TS_2, $Life_2$}K_v

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Kerberos
Better Authentication - 2

- User asked for password to unwrap TICKETtgs which is held in client machine
- ∴ If C ends session before expiry of ticket captured message 2 poses no threat
- Also C cannot extend validity of ticket because encrypted with TGS's key
- TGS needs to hold private keys of servers
- Neither V nor TGS will do business if ticket is out of date or client network address is wrong

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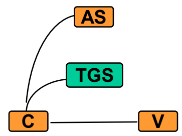
Kerberos
Better Authentication - 3

- BUT, weakness in that if E captures message 3 and fakes ADc once C ends session, new service tickets could be generated by TGS
- OR, E could capture a service ticket at step 4 and use it in similar way
- Also, we may need to authenticate servers (show they are not Trojan Horses)

Kerberos Version 4 Protocol



- All tickets are of same form, but server ID and ticket validity differ
- AUTH are *authenticators* which authenticate C to server

Per login

1. C->AS: IDc, IDtgs, TS1
2. AS->C: {Kctgs, IDtgs, TS2, Life2, TICKET(tgs, 2)}Kc

Per Service

3. C->TGS: IDv, TICKET(tgs, 2), AUTH(tgs, 3)
4. TGS->C: {Kcv, IDv, TS4, TICKET(v, 4)} Kctgs

Per Service Session

5. C->V: TICKET(v, 4), AUTH(v, 5)
6. V->C: {TS5+1}Kcv

TICKET(s, i)={Kcs, IDc, ADc, IDs, TSi, Lifei}K_s

AUTH(s, I) = {Idc, Adc, Tsi}Kcs

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Kerberos Version 4 Protocol - 2

- Session keys Kctgs and Kcv are introduced and securely conveyed to client machine from AS or TGS
- Authenticator relies on only C being able to decrypt messages with Kc
- Replay thwarted because T3 and T5 indicate current time so replay should be noticeable
- Steps 4 and 6 provide proof that servers are legitimate ie. they possess Ktgs and Kv resp.

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Kerberos Realms

- Within a given administration, eg. department:
  - AS has UID and (hashed) password of all users and key of TGS
  - TGS must have secret keys of all servers
- This is known as a Realm
- Users may need to access servers in remote realms, so:
  - TGS shares keys for trusted TGS in other realms

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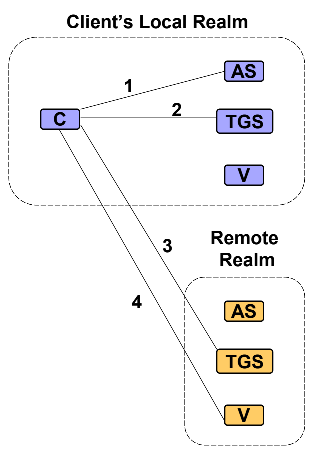
Kerberos Realms - 2



- Version 4 Protocol easily extended by local TGS issuing ticket for remote TGS (dialogue 2)
- Client then contacts remote realm for server ticket (dialogue 3)

Kerberos
Version 5 Protocol

- Improvements over version 4 to deal with:
  - Environmental shortcomings
  - Technical deficiencies

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Kerberos
Version 5 Protocol - 2

- Environmental
  - Removes dependence on DES, allowing different algorithms and key lengths to be used
  - Removes IP dependency so can be used eg. with ISO addresses
  - Byte ordering dependency removed by using ASN.1 Basic Encoding Rules
  - Ticket lifetime specified by start+end time not up to 256 x 5 minutes
  - Authentication forwarding to allow delegated access to servers eg. print server delegated to access file server
  - Inter-realm improvement so fewer than $O(N^2)$ inter-realm relationships needed, ie. scales much better

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Kerberos Version 5 Protocol - 3

- Technical
  - Removes double encryption of tickets in steps 2 and 4 of V4 protocol
  - Uses standard CBC encryption mode instead of Propagating CBC which has weaknesses
  - Client and server can negotiate a sub-session key rather than use the session key offered by TGS
  - Some measure to make password attacks more difficult (pre-authentication)
- See Stallings pp 335-340 for more details
- See RFC 1510 for full details (90pp!)

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Kerberos Version 5 Protocol

Per login

1. C->AS: Options, IDc, REALMc, IDtgs, Times, Nonce1
2. AS->C: REALMc, IDc, TICKET(tgs), {Kctgs, Times, Nonce1, REALMtgs, IDtgs}Kc

Per Service

3. C->TGS: Options, IDv, Times, Nonce2, TICKET(tgs), AUTH1
4. TGS->C: REALMc, Idc, TICKET(v), {Kcv, Times,Nonce2, REALMv, IDv} Kctgs

Per Service Session

5. C->V: Options, TICKET(v), AUTH2
6. V->C: {TS2, Subkey, Seq}Kcv

TICKET(s) = {Flags, Kcs, REALMc, IDc, ADc, Times}K_s

AUTH1 = {Idc, REALMc, TS1}Kctgs

AUTH2 = {Idc, REALMc, TS2, Subkey, Seq}Kcv

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Further Reading

- Stallings W, "Cryptography and Network Security: Principles and Practice", 2ed, Prentice Hall, 1999, 0-13-869017-0
  - **Kerberos:** pp 323-340
- Pfleeger C, "Security in Computing", 2ed, Prentice Hall, 1997, 0-13-185794-0
  - **Kerberos:** pp 412-415

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Further Reading

- Steiner J, Neuman C, Schiller J, "Kerberos: An Authentication Service for Open Networked Systems", Proc. Winter 1988 USENIX Conference, February 1988
- Bryant W "Designing an Authentication System: A Dialogue in Four Scenes", Project Athena Document, Feb 1988 (http://web.mit.edu.kerberos/www/dialogue.html)
- Kohl J, Neuman B, Ts'o T, "The Evolution of Kerberos Authentication Service", in *Brazier & Johansen, Distributed Open Systems, IEEE Computer Society Press, 1994* (http://web.mit.edu/kerberos/www/papers.html)

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