Security protocols: Authentication

Luca Veltri

(mail.to: luca.veltri@unipr.it)

Corso di Sicurezza nelle reti, a.a. 2009/2010

http://www.tlc.unipr.it/veltri

Authentication Authorization Accounting

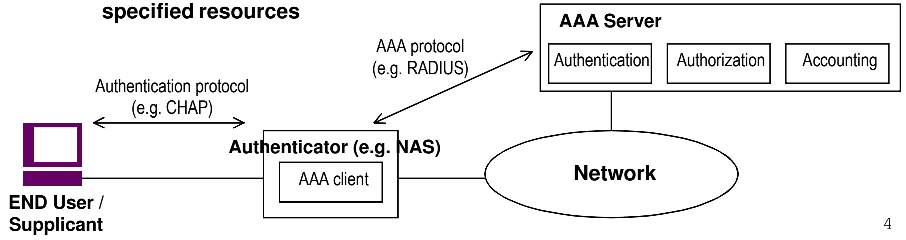
- Authentication
  - **involves validating the end users' identity prior to permitting them the access to a network service**
  - **the end-user needs to posses an unique piece of information that serves as unambiguous identification credentials**
    - a username/password combination,
    - a secret key, or
    - biometric data (fingerprints, for example))
  - **the result of the authentication depends on the matching of the user supplied data with the stored data**
- Authorization
  - **defines what rights and services the end user is allowed once access is granted**
  - **Authentication and authorization are usually performed together**

Authentication Authorization Accounting

- Accounting
  - **the third "A," provides the methodology for collecting information about the end user's resource consumption**
  - **which can then be processed for billing, auditing, and capacity-planning purposes**

AAA general model

- AAA processing can be summarized in the following steps:
  - **End user connects to the point-of-entry device (authenticator) and requests access to the system/service**
    - it contains an AAA client function
    - in case of network access this device is called NAS (Network Access Server)
  - **authenticator collects and forwards the end user's credentials to the AAA server**
  - **AAA server processes the data and returns an accept or reject response and other relevant data to the AAA client**
  - **authenticator notifies the end user that access is granted or denied for the specified resources**



AAA servers

- the AAA server can be housed on a general-purpose computing system
- A single AAA server can act as a centralized administrative control point for multiple AAA clients contained within different vendor-sourced NAS and network components

AAA protocols

- Examples of authentication protocols:
  - **PAP (Password Authentication Protocol)**
  - **CHAP (Challenge Handshake Authentication Protocol)**
  - **EAP (Extensible Authentication Protocol)**
  - **HTTP Digest Authentication**
- Example of AAA protocols:
  - **RADIUS (Remote Authentication Dial In User Service)**
  - **Diameter**
- Example of access control scheme (e.g. in WLAN):
  - **IEEE 802.1X**

PAP

- Password Authentication Protocol (PAP)
  - **Costituisce il protocollo di autenticazione più semplice, impiegato nelle comunicazioni che utilizzano il Point to Point Protocol (PPP)**
  - **Prevede lo scambio di username e password in chiaro tra le entità che intendono autenticarsi (possibilità di autenticazione monodirezionale, bidirezionale)**
    - la sicurezza è demandata agli eventuali protocolli di trato inferiore

PAP

- PAP uses a 2-way handshake
  - **Authenticate-Request packet is repeated until a valid reply packet is received, or an optional retry counter expires**
- In PPP this is done upon initial link establishment
  - **after the Link Establishment phase is complete, an Id/Password pair is repeatedly sent by the peer to the authenticator until authentication is acknowledged or the connection is terminated**
- PAP is not a strong authentication method
  - **passwds are sent in clear, and there is no protection from playback or repeated trial and error attacks**
    - any implementations which include a stronger authentication method (such as CHAP, described below) should offer to negotiate that method prior to PAP
  - **it is most appropriately used where a plaintext password must be available to simulate a login at a remote host**

PAP

- PAP Packet format

1B	1B	2B	
Code	Identifier	Length	Data

  - ➢ **Code: the type of PAP packet**
    - 1 = Authenticate-Request
    - 2 = Authenticate-Ack
    - 3 =Authenticate-Nak
  - ➢ **Identifier: one octet that aids in matching requests and replies**
  - ➢ **Length: length including the Code, Identifier, Length and Data fields**
  - ➢ **Data: the format is determined by the Code field**

PAP

- PAP Authenticate-Request packet format

1B	1B	2B	1B		1B	
Code	Identifier	Length	Peer-ID Len	Peer-ID	Passwd Len	Passwd

- Authenticate-Ack (Nak) packet format

1B	1B	2B	1B	
Code	Identifier	Length	Msg Len	Message

CHAP

- Challenge Handshake Authentication Protocol (CHAP)
  - ➢ **Sviluppato per eliminare i limiti del PAP**
  - ➢ **Prevede che l'entità che deve autenticare sfidi l'entità che intende autenticarsi (meccanismo Challenge-response): la sfida consiste nella verifica che l'entità che intende autenticarsi sia in possesso di una shared secret condivisa con l'entità autenticante**
  - ➢ **l'entità che si vuole autenticare a partire dal challenge calcola il valore di response tramite una "one-way hash" function del challenge + un segreto (una chiave o passwd)**
  - ➢ **L'entità che deve autenticare controlla la risposta calcolando localmente il valore hash atteso**
  - ➢ **Ad intervalli regolari l'autenticatore può inviare nuove sfide (challenges)**
  - ➢ **Esistono varie implementazioni**
    - Shiva Propietary-Password Authentication Protocol (SPAP)
    - Appletalk Remote Access Protocol (ARAP)
    - Microsoft CHAP (MSCHAP)
  - ➢ **IETF RFC 1994, "PPP Challenge Handshake Authentication Protocol (CHAP)", August 1996**

CHAP packet format

- Code field [1B]
  - ➢ **identifies the type of CHAP packet**

1	Challenge
2	Response
3	Success
4	Failure

- Identifier field [1B]
  - ➢ **aids in matching challenges, responses and replies**
- Length field [2B]
  - ➢ **indicates the length of the CHAP packet**
- Data field
  - ➢ **is zero or more octets; the format is determined by the Code field**

1B	1B	2B	
Code	Identifier	Length	Data

CHAP Request/Response format

- Value-Size [1B]
  - **indicates the length of the Value field**
- Value
  - **variable stream of octets; it MUST be changed each time a Challenge is sent**
  - **the length depends upon the method used to generate the octets, and is independent of the hash algorithm used**
  - **The Response Value is the one-way hash calculated over a stream of octets consisting of the Identifier, concatenated with the "secret", concatenated with the Challenge Value;**
    the length depends upon the hash algorithm (16 octets for MD5)
- Name field
  - **identification of the system transmitting the packet**

1B	1B	2B	1B		
Code	Identifier	Length	Value-size	Value	Name

CHAP bidirectional authentication

- The authentication can be full duplex
  - **the same protocol can be used in both directions**
- The secret SHOULD NOT be the same in both directions
  - **This would allow an attacker to replay the peer's challenge, accept the computed response, and use that response to authenticate**

One-Time Password (OTP)

- One-time password systems are designed to counter "replay attack”
- It uses a sequence of one-time (single use) passwords; that are not sent through the network during authentication
- Two entities
  - **generator**
    - produces the appropriate one-time password from the user's secret pass-phrase and from information provided in the challenge from the server
  - **server**
    - send a challenge that includes the appropriate generation parameters to the generator
    - verify the one-time password received
    - store the last valid one-time passwd received, and the seq number

OTP (cont.)

- Initial step
  - **the pass phrase is concatenated with a seed that is transmitted from the server in clear text**
- Computation
  - **a sequence of one-time passwords is produced by applying the secure hash function a number times (N) to the output of the initial step (called S)**
  - **the next one-time password to be used is generated by passing S though the secure hash function N-1 times**
- The sequence number and seed together constitute a larger unit of data called the challenge
  - **The syntax of the challenge is:**
  - **otp-<algorithm identifier> <sequence integer> <seed>**
- An example of an OTP challenge is:
  - **otp-md5 487 dog2**

EAP (Extensible Authentication Protocol)

- RFC 3748 (June 2004)
- Protocollo generale di autenticazione che può supportare diversi metodi tra cui OTP,TLS,CHAP…
  - **particolarmente utilizzato nelle WLAN in IEEE802.1x, WPA e IEEE802.11i**
- Esistono 4 tipi di pacchetti: EAP-request, EAP-response, EAP-success, EAP-failure
- Ad ogni request deve corrispondere sempre una response. Le richieste e le relative risposte possono essere di più tipi tra cui:
  - **identity,**
  - **EAP-OTP,**
  - **EAP-TLS,**
  - **EAP-MS-CHAP-v2…**
- Il tipo di richiesta è specificato in un preciso campo (EAP-type) dell'EAP-request, stesso vale per le risposte
- I pacchetti EAP-success ed EAP-failure non contengono dati

EAP (cont.)

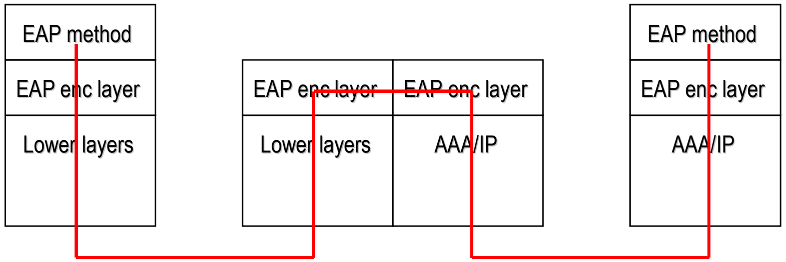
- EAP provides its own support for duplicate elimination and retransmission, but is reliant on lower layer ordering guarantees
- Typically runs directly over data link layers such as PPP or IEEE 802, without requiring IP
  - **may be used on dedicated links as well as switched circuits, and wired as well as wireless links**
    - encapsulated in PPP
    - over IEEE 802: EAPOL (EAP over LAN)
- It is used to select a specific authentication mechanism
  - **can support multiple authentication mechanisms without having to pre-negotiate a particular one**
  - **typically after the authenticator requests more information in order to determine the specific authentication method to be used**
- Examples of authentication methods:
  - **OTP, CHAP, TLS**

EAP (cont.)

- It permits the use of a backend authentication server which may implement some or all authentication methods
  - **the authenticator (e.g. a NAS, like a switch or an WLAN AP) acts as a pass-through for a backend authentication server**
    - do not have to understand each authentication method
  - **separation of the authenticator from the backend authentication server simplifies credentials management and policy decision making**
- EAP entities:
  - **Peer**
    - The end of the EAP Link that responds to the authenticator (the Supplicant in IEEE-802.1X)
  - **Authenticator**
    - The end of the EAP link initiating EAP authentication (as in IEEE-802.1X)
  - **Backend authentication server**
    - an entity that provides an authentication service to an authenticator (as in IEEE-802.1X)
    - when used, this server typically executes EAP methods for the authenticator

Pass-through Authenticator

- Where an authenticator operates as a pass-through, it forwards packets between the peer and a backend authentication server, based on the EAP layer header fields (Code, Identifier, Length)



EAP authentication exchange

- The authenticator sends a Request to authenticate the peer
  - **The type field indicates the type of authentication method**
  - **Typically, the authenticator may send also an initial Identity Request; the identity may not be required where it is determined by the port to which the peer has connected or where the identity is obtained in another fashion (via calling station identity or MAC address, etc.)**
- The peer sends a Response packet in reply to a valid Request
  - **Response packet contains a Type field, which corresponds to the Type field of the Request**
- The authenticator sends an additional Request packet, and the peer replies with a Response
  - **the sequence of Requests and Responses continues as long as needed**
- The authenticator transmits an EAP Failure (Code 4) or an EAP Success (Code 3)

EAP packet format

- Code field [1B]
  - **identifies the type of EAP packet**

1	Request
2	Response
3	Success
4	Failure

- Identifier field [1B]
  - **aids in matching Responses with Requests**
- Length field [2B]
  - **indicates the length of the EAP packet**
- Data field
  - **is zero or more octets; the format is determined by the Code field**

1B	1B	2B	
Code	Identifier	Length	Data

EAP Request/Response format

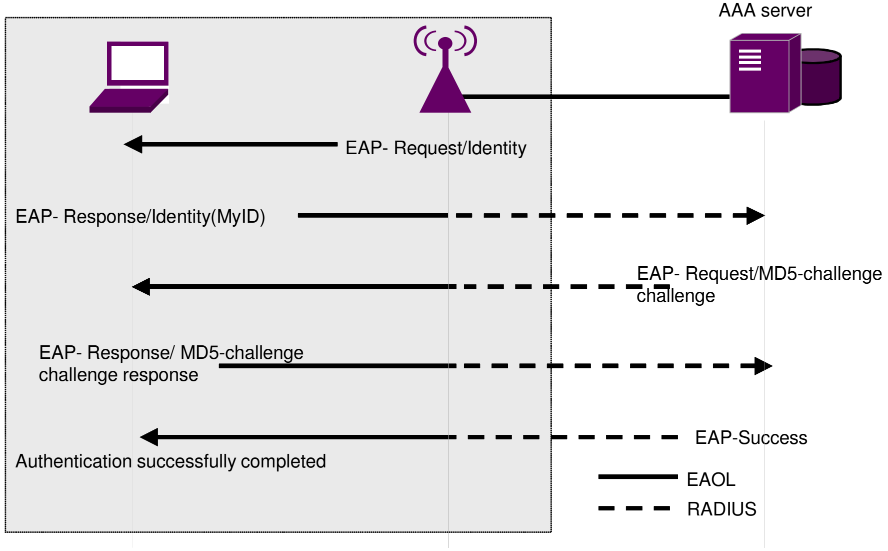
- Type field [1B]
  - **indicates the Type of Request or Response**
  - **some types**

1	**Identity (used to query peer identity)**
2	**Notification (used to convey displayable messages)**
3	**Nak (Response only, utilized for the purposes of method negotiation)**
4	**MD5-Challenge**
5	**One Time Password (OTP)**
6	**Generic Token Card (GTC)**
13	**EAP TLS**

  - **normally, the Type field of the Response will be the same as the Type of the Request**
- The Type-Data field
  - **varies with the Type of Request and the associated Response**

1B	1B	2B	1B	
Code	Identifier	Length	Type	Type-Data

Example: EAP/CHAP


AAA server
EAP- Request/Identity
EAP- Response/Identity(MyID)
EAP- Request/MD5-challenge
challenge
EAP- Response/ MD5-challenge
challenge response
EAP-Success
Authentication successfully completed
EAOL
RADIUS

RADIUS

RADIUS

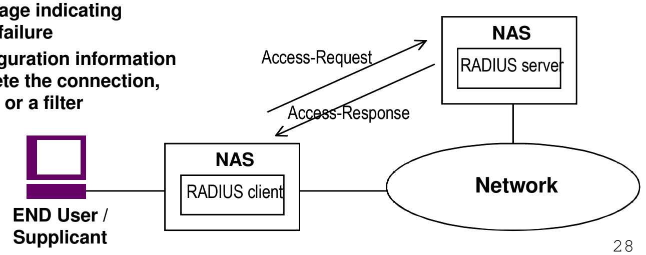
- Remote Access Dial-In User Service (RADIUS) - RFC 2138
- The best-known and most widely deployed AAA protocol
- developed in the mid-1990s by Livingston Enterprises (since acquired by Lucent) for providing authentication and accounting services to their NAS devices
- The IETF formalized that effort in 1996 with the RADIUS WG

RADIUS functional attributes

- Client-server-based operations
  - **A RADIUS client resides on the NAS and communicates over the network with a RADIUS server running on a host computer**
  - **Additionally, a RADIUS server may serve as a proxy client for another RADIUS or authentication server**
- Network security
  - **All communications between a RADIUS client and server are authenticated by virtue of a shared secret key that is never sent over the network**
  - **In addition, user passwords contained in RADIUS messages are encrypted to prevent hackers from reading them by snooping the network**
- Flexible authentication
  - **RADIUS can support multiple authentication mechanisms, including PAP and CHAP**

Typical RADIUS configuration

- An end-user dials into a NAS
- Using a prompt, or perhaps PPP frames, the NAS collects the username and password from the end user
- It then forward an encrypted Access-Request message over the network to the RADIUS server
  - **The message may also contain attributes such as the NAS port ID and IP address**
- The RADIUS server then checks the User-Name attribute and returns an Access-Reject or an Access-Accept message to the NAS
  - **optional text message indicating the reason for the failure**
  - **or additional configuration information required to complete the connection, such as an IP addr or a filter**



RADIUS functional attributes (cont.)

- ***Attribute/Value Pairs***
  - **RADIUS messages carry AAA information encoded in type-length-value fields, called attributes (or attribute/value pairs - AVP)**
  - **Common examples of attributes include**
    - User-Name,
    - User-Password,
    - Framed-Protocol (such as PPP),
    - Framed-IP-Address (IP address for end user),
    - and so on

Diameter

Diameter

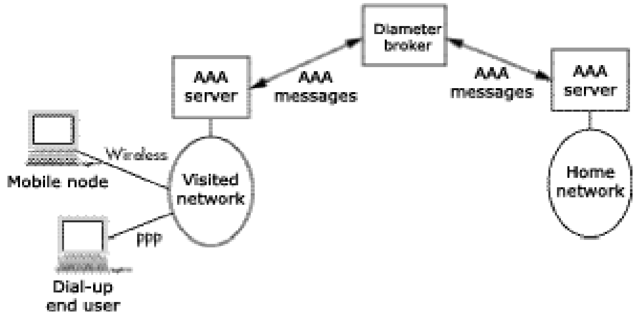
- RADIUS was originally engineered for small network devices supporting just a few end-users requiring simple server-based authentication
- Dial providers must currently provide AAA services for hundreds and thousands of concurrent end users accessing network services over a variety of technologies
- They must also support AAA services across ISP boundaries in a secure and scalable manner
- IETF has develop a next-generation AAA protocol: “Diameter”

Diameter characteristics

- Lightweight, peer-based AAA protocol
- Designed to offer a scalable foundation for introducing new policy and AAA services over existing (PPP) and emerging (roaming, mobile IP) network technologies
- It employs many of the same mechanisms as RADIUS, including UDP transport, encoded attribute/value pairs, and proxy server support
- Diameter also attempts to correct limitations inherent in the RADIUS protocol
  - **for example, a RADIUS attribute value cannot exceed 255 bytes..**
- Diameter supports TCP or SCTP (Stream Control Transmission Protocol) transports
- Diameter permits unsolicited commands from server to client
  - **useful to perform a specific accounting function**

Diameter characteristics (cont.)

- Diameter provides an end-to-end security mechanism that is not found in RADIUS
- Diameter was designed from the beginning to support roaming and mobile IP networks



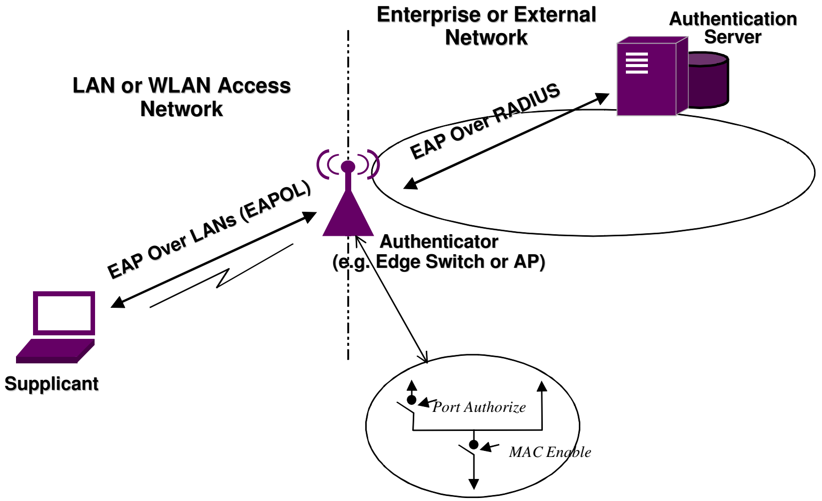
- The broker can act as a certificate authority (CA)

IEEE 802.1X
Port-Based Network Access Control

IEEE 802.1X

- Increased use of 802 LANs in public and semi-public places
- Desire to provide a mechanism to associate end-user identity with the port of access to the LAN
  - **establish authorized access**
  - **enable billing and accounting mechanisms**
  - **personalize network access environment**
- Leverage existing AAA infrastructure currently used by other forms of network access (e.g. dial-up)
- Initially intended for 802.1D (MAC Bridges), but since expanded to include other access devices (e.g. 802.11, smart repeater)
- Encapsulate the EAP in 802 Frames (EAPOL) with a few extensions to handle unique characteristics of 802 LANs

General Topology of 802.1X


Enterprise or External Network
Authentication Server
LAN or WLAN Access Network
EAP Over RADIUS
EAP Over LANs (EAPOL)
Authenticator
(e.g. Edge Switch or AP)
Supplicant
Port Authorize
MAC Enable