# CWSP Guide to Wireless Security

*Chapter 8*

*Secure Wireless Authentication*

# Objectives

- Define wireless authentication
- List and describe the different types of authentication servers
- Explain the differences between various extended authentication protocols
- Describe IEEE 802.11i authentication and key management

# Defining Authentication

- It is important to understand exactly what authentication is
  - And the types of credentials that are used to authenticate users

# What is Wireless Authentication?

- Authentication
  - Users must give proof that they are authentic
  - Wired network devices are assumed to be authentic
- Wireless authentication
  - Requires device to be authenticated before being connected to the WLAN
- Types of wireless device authentication
  - Open system authentication
  - Shared key authentication

# Authentication, Authorization, and Accounting (AAA)

- Triple “A” elements
  - Authentication determines who the user is
  - Authorization determines what the user can do
  - Accounting determines what the user did
- Authentication controls access by requiring valid user credentials
- Authorization is the process that determines whether the user has the authority to carry out certain tasks
- Accounting **measures** the resources a user consumes during each network session

# Authentication, Authorization, and Accounting (AAA) (continued)

- Information can be used:
  - To find evidence of problems
  - For billing
  - For planning
- AAA servers
  - Servers dedicated to performing the AAA functions
  - Can provide significant advantages in a wireless LAN

# Authentication Credentials

- Categories of credentials
  - Something the user knows
  - Something the user is
  - Something the user has
- Passwords
  - Fall into the category of something the user knows
  - Secret combinations of letters and numbers
- Biometrics
  - Uses unique human characteristics for authentication

# Authentication Credentials (continued)

- Biometrics (continued)
  - Human characteristics commonly used
    - Fingerprints and unique characteristics of the face, hand, or voice
- Digital certificates
  - Asymmetric encryption or public key cryptography
    - Private key is used to encrypt messages
    - Public key is used to decrypt messages
  - Electronic files used to uniquely identify users and resources over networks
  - Issued by a trusted third party (certification authority (CA))

# Authentication Credentials (continued)



**Figure 8-1** Fingerprint scanner

# Authentication Credentials (continued)

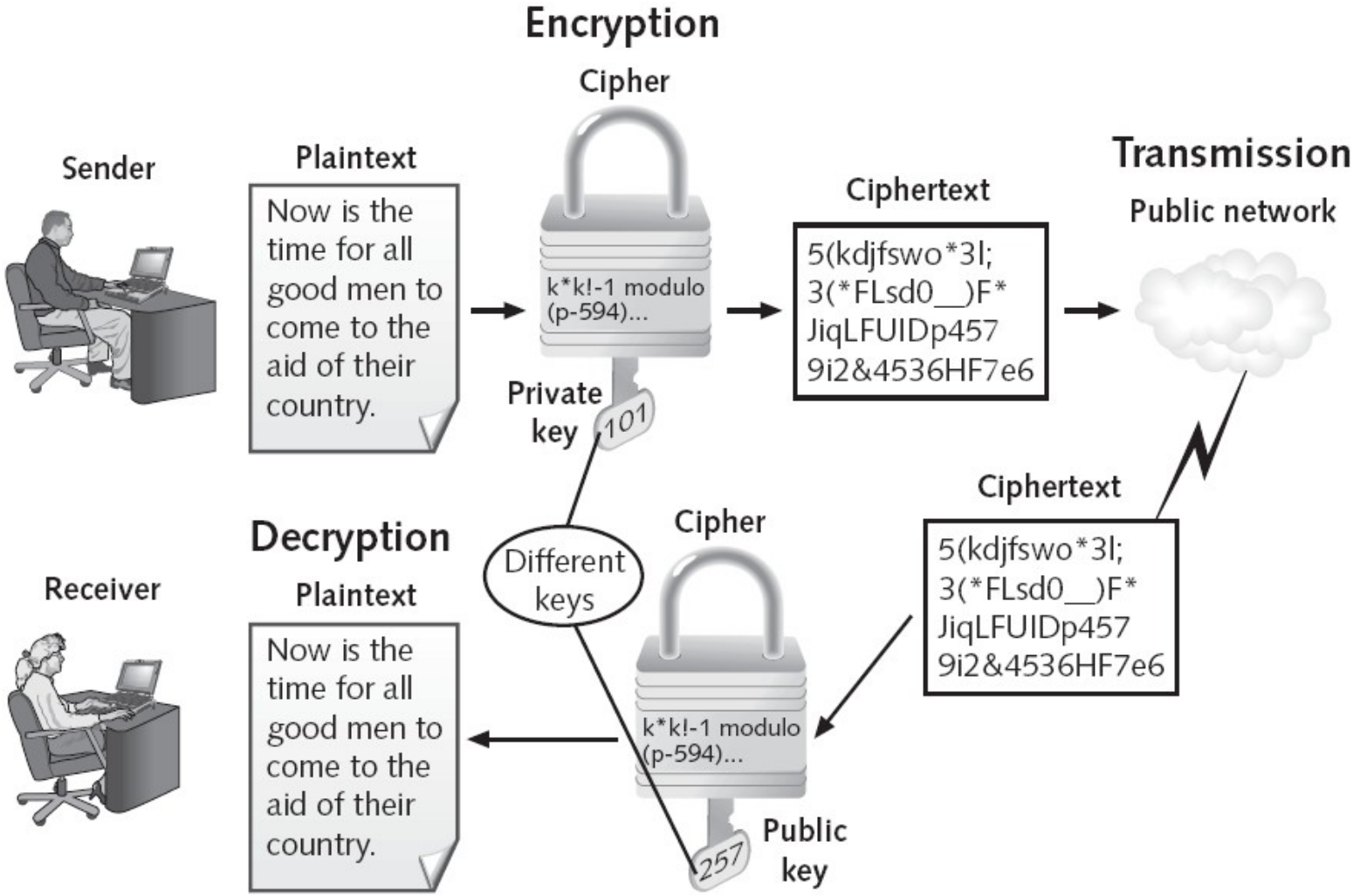



**Figure 8-2** Asymmetric encryption

# Authentication Credentials (continued)

- Digital certificates (continued)
  - Registration authority (RA)
    - Handles some CA tasks, such as processing certificate requests and authenticating users
  - Information in a certificate
    - A serial number
    - The holder's public key
    - The name of the certification authority
    - The name of the holder and other identification info
    - The start and stop date in which the certificate is valid

# Authentication Credentials (continued)

- Digital certificates (continued)
  - Can be used for authentication in a wireless LAN
  - Can also be used to provide encryption between the wireless device and the AP
  - Public Key Infrastructure (PKI)
    - System of using digital certificates, CAs, and other registration authorities
      - That verify and authenticate the validity of each party involved in a transaction over a public network
    - There currently is no single standard for using a PKI

# Authentication Servers

- Most common types
  - RADIUS
  - Kerberos
  - TACACS+
  - Lightweight Directory Access Protocol (LDAP)

# RADIUS

- RADIUS: Remote Authentication Dial-In User Service
  - Developed in 1992
- For “high volume service control applications”
  - Such as dial-in access to a corporate network
- RADIUS client
  - Dial-up server or wireless access point
  - Responsible for sending user credentials and connection parameters to a RADIUS server
- RADIUS server
  - Authenticates and authorizes RADIUS client request

# RADIUS (continued)

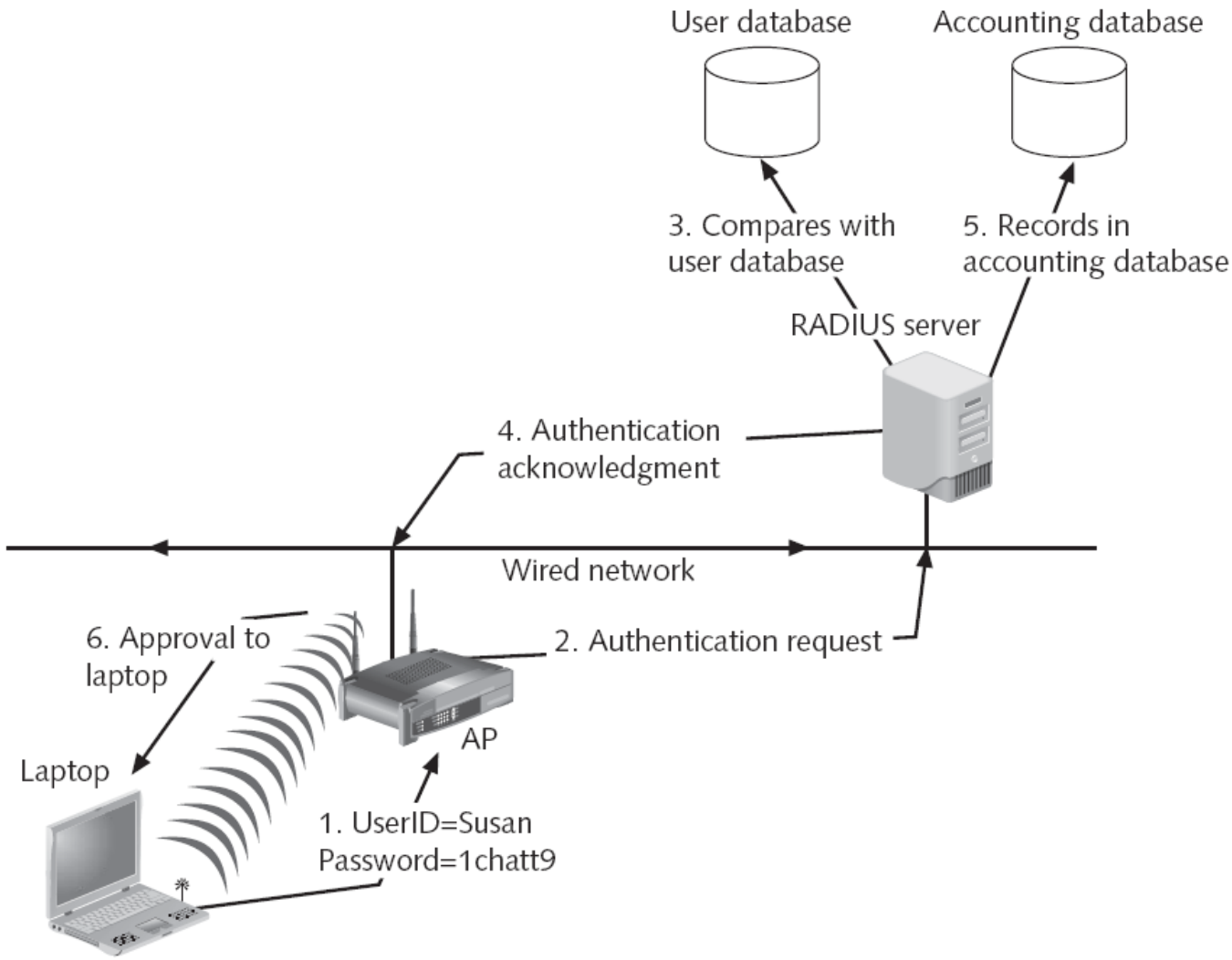



**Figure 8-3** RADIUS authentication

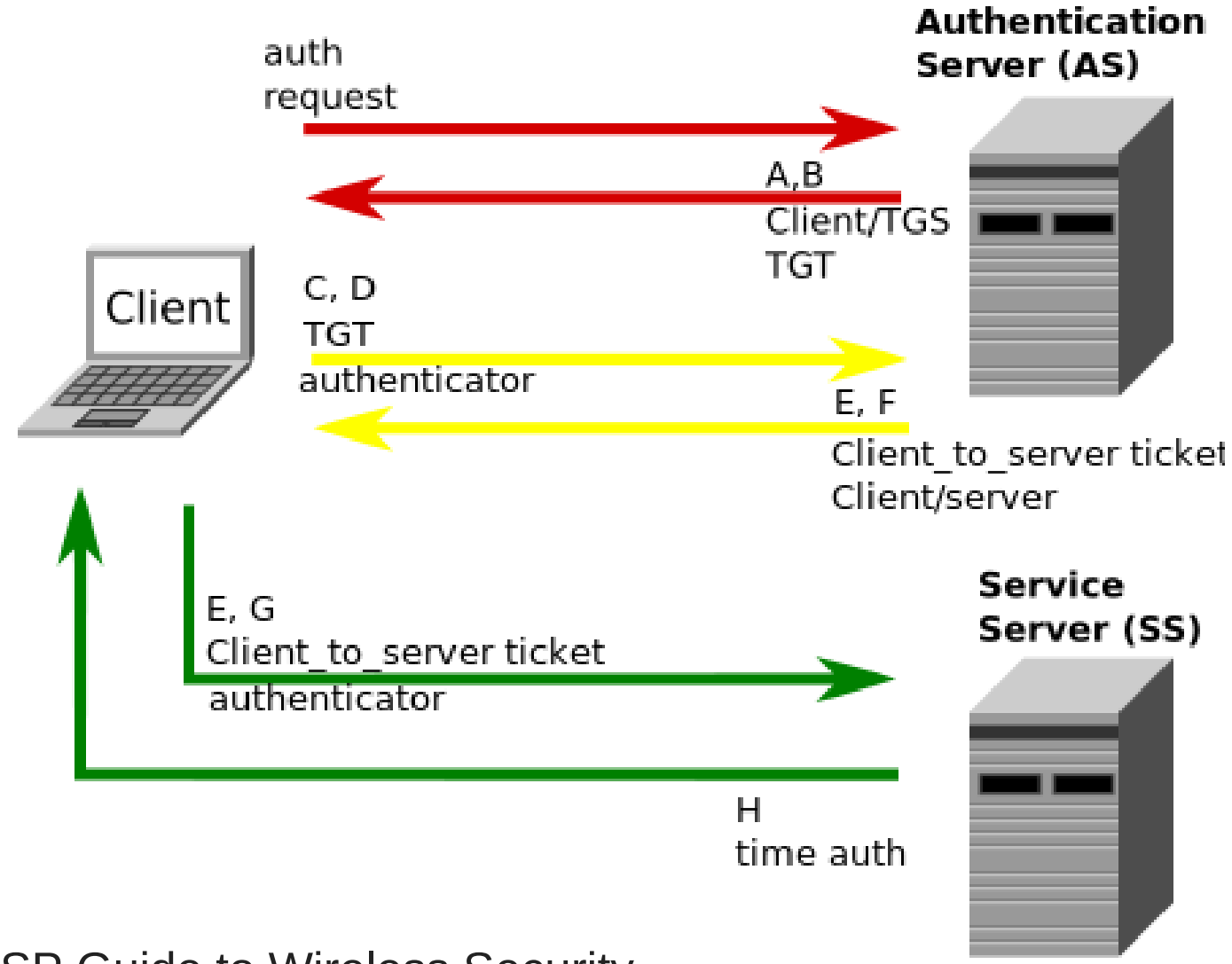
# RADIUS (continued)

- RADIUS servers (continued)
  - Can be used in conjunction with VLAN tagging for additional security
- RADIUS allows a company to maintain user profiles in a central database
  - That all remote servers can share

# Kerberos

- Authentication system
  - Developed by the Massachusetts Institute of Technology (MIT)
- Used to verify the identity of networked users
- Kerberos authentication server
  - Provides a ticket to the user
  - Ticket contains information linking it to the user
- User presents this ticket to the network for a service
- Service examines ticket to verify user identity

# Kerberos


Authentication Server (AS)
auth request
A,B
Client/TGS TGT
Client
C, D
TGT
authenticator
E, F
Client_to_server ticket
Client/server
E, G
Client_to_server ticket
authenticator
Service Server (SS)
H
time auth

# Terminal Access Control Access Control System (TACACS+)

- TACACS+
  - Industry standard protocol specification
  - Forwards username and password information to a centralized server
  - Designed to support thousands of remote connections
  - Supports authentication, authorization, and auditing

# Lightweight Directory Access Protocol (LDAP)

- Directory service
  - Database stored on the network
  - Contains information about users and network devices
- X.500
  - International Organization for Standardization (ISO) standard for directory services
  - White-page service
    - Looks up information by name
  - Yellow-pages service
    - Searches for information by category

# Lightweight Directory Access Protocol (LDAP) (continued)

- Information is in a directory information base (DIB)
- Entries in the DIB are arranged in a tree structure called the directory information tree (DIT)
  - Each entry is a named object and a set of attributes
- X.500 standard does not define any representation for the data stored
- Directory Access Protocol (DAP)
  - Protocol for a client application to access an X.500 directory

# Lightweight Directory Access Protocol (LDAP) (continued)

- Lightweight Directory Access Protocol (LDAP)
  - Sometimes called X.500 Lite
  - Simpler subset of X.500
- Primary differences
  - LDAP was designed to run over TCP/IP
  - LDAP has simpler functions
  - LDAP encodes its protocol elements in a less complex way than X.500
- LDAP makes it possible for almost any application in any platform to obtain directory information

# Lightweight Directory Access Protocol (LDAP) (continued)

- LDAP is often used in a WLAN in two different ways
  - Authentication server can use LDAP for retrieving user information
  - Many RADIUS servers support interfacing with an LDAP database

An entry can look like this when represented in LDAP Data Interchange Format (LDIF) (LDAP itself is a binary protocol):

```
dn: cn=John Doe,dc=example,dc=com
cn: John Doe
givenName: John
sn: Doe
telephoneNumber: +1 888 555 6789
telephoneNumber: +1 888 555 1232
mail: john@example.com
manager: cn=Barbara Doe,dc=example,dc=com
objectClass: inetOrgPerson
objectClass: organizationalPerson
objectClass: person
objectClass: top
```

# Authentication Design Models

- Single site deployment
  - Simplest type of authentication model
  - Consists of one or more RADIUS servers accessing a centralized authentication database
  - Used when all WLAN users are located at a single site
  - Advantages
    - Only one authentication database to support
    - Fairly easy to increase the capacity of the single site
  - Disadvantages
    - Can be more difficult to scale as more users are added

# Authentication Design Models (continued)

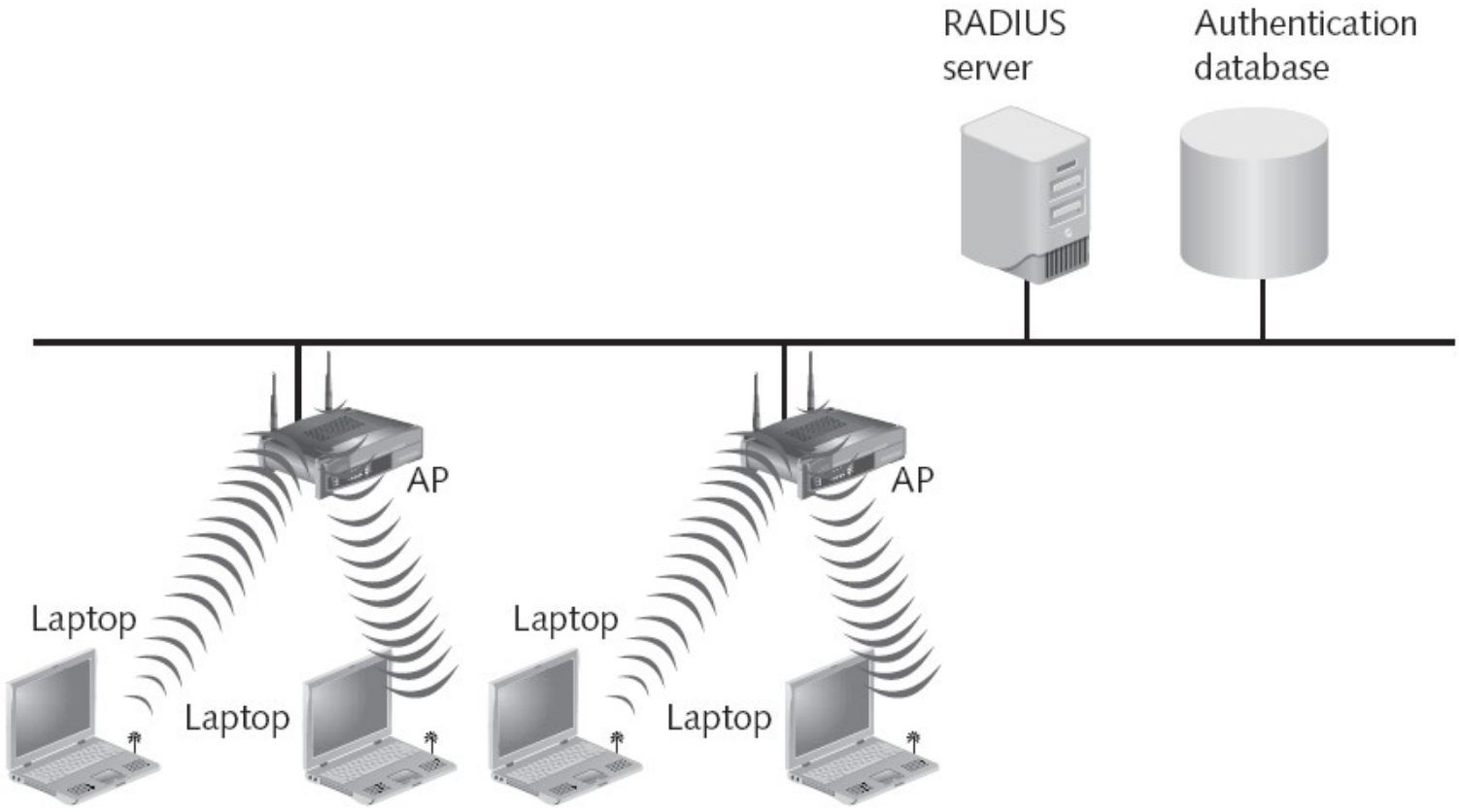



**Figure 8-4** Single site deployment

# Authentication Design Models (continued)

- Distributed autonomous site deployment
  - Uses local authentication with one or more RADIUS servers at each site
  - Authentication **database is replicated** from one central site to each local site
  - RADIUS servers actually perform the authentication and any accounting activity
  - Advantages
    - Does not rely on a remote network connection
    - Additional RADIUS servers can be added to remote site

# Authentication Design Models (continued)

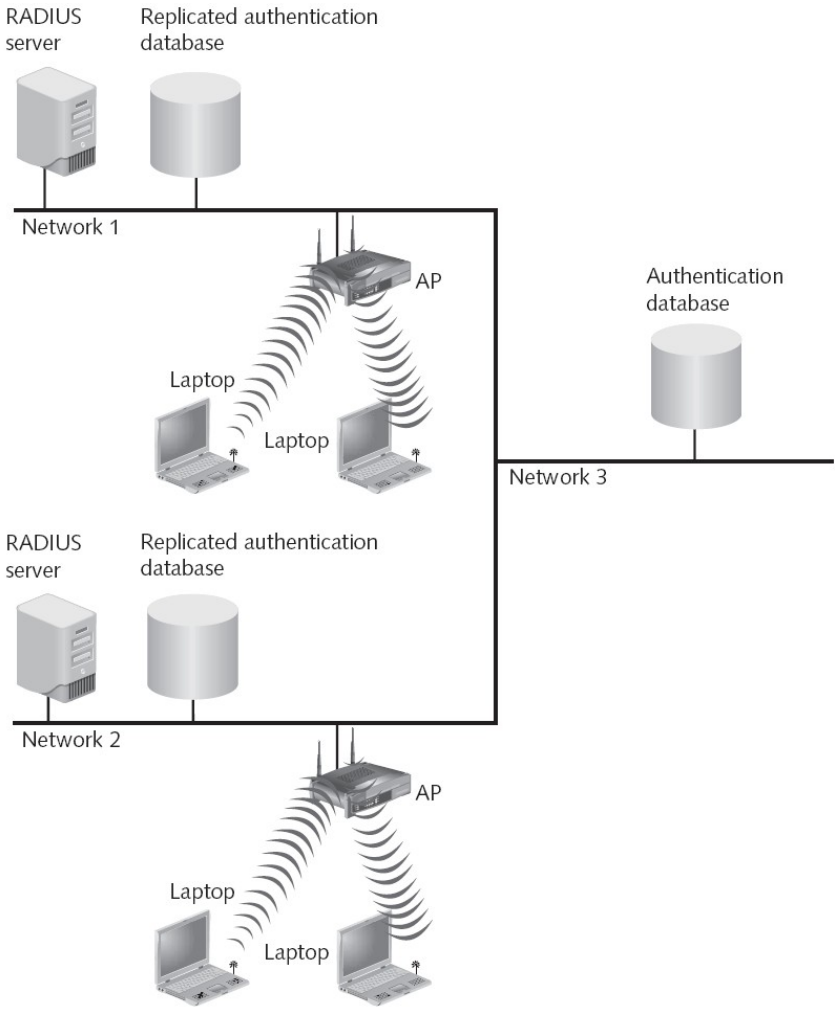



**Figure 8-5** Distributed autonomous site deployment

# Authentication Design Models (continued)

- Distributed sites with centralized authentication and security deployment
  - Rely on remote RADIUS servers for authentication
  - Management advantage
    - RADIUS servers and authentication database are all centrally located
  - Disadvantages
    - Depends on the reliability of the network connection
    - Bottleneck can occur if a large number of wireless users are supported

# Authentication Design Models (continued)

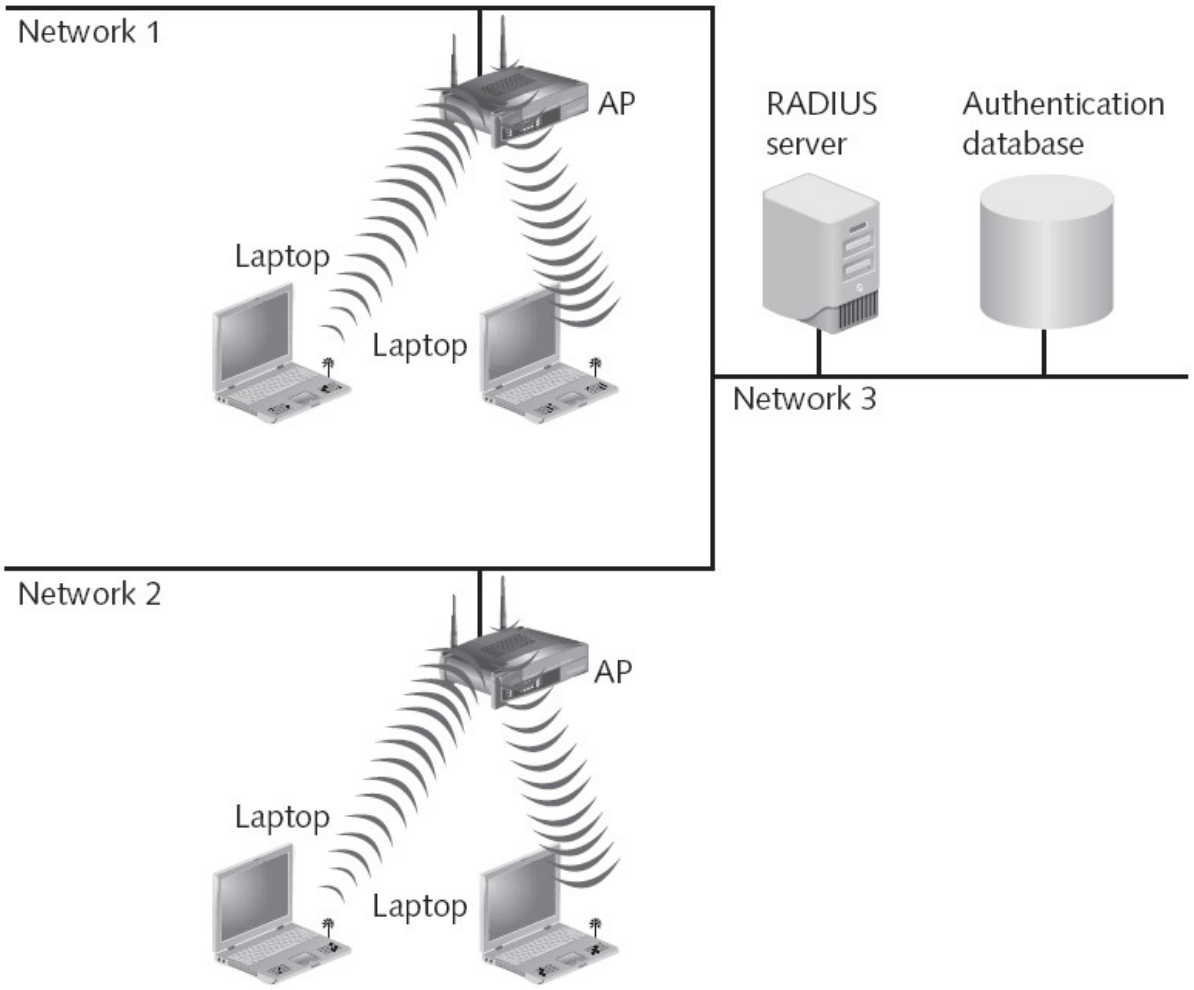



**Figure 8-6** Distributed sites with centralized authentication and security deployment

# Authentication Design Models (continued)

- Distributed sites and security with centralized authentication deployment
  - RADIUS servers are located at each site to perform authentication
  - Authentication database is centrally located
  - Advantage
    - Mitigates the bottleneck problem
  - Disadvantage
    - Depends on the reliability of the network connection

# Authentication Design Models (continued)

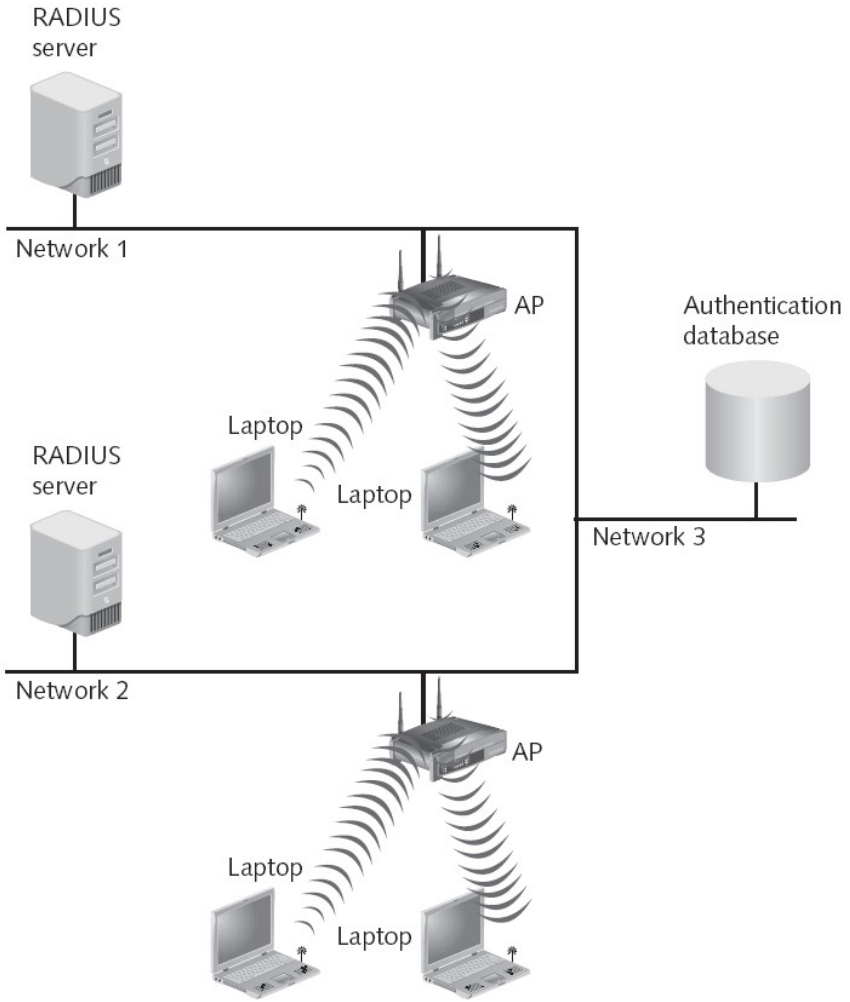



**Figure 8-7** Distributed sites and security with centralized authentication deployment

# Authentication Design Models (continued)

**Table 8-1** Authentication design deployment models

| Model | Location of RADIUS servers | Location of authentication database | Advantages | Disadvantages |
|---|---|---|---|---|
| Single site | Local | Local | Only one authentication database to support | May be difficult to scale if large number of users added |
| Distributed autonomous sites | Local | Remote | Does not rely on remote network connection | Not all authentication databases can be easily replicated |
| Distributed sites with centralized authentication and security | Remote | Remote | Authentication database more secure because not replicated | Dependent on reliable network link |
| Distributed sites and security with centralized authentication | Local | Remote | Reduces "bottleneck" processing | Dependent on reliable network link |

# Extended Authentication Protocols (EAP)

- Extensible Authentication Protocol (EAP)
  - Management protocol of IEEE 802.1x
  - Governs the interaction between the wireless device, access point, and RADIUS server
- EAP was designed with flexibility in mind
  - Different protocols can be used to support different authentication methods
    - And associated network security policies

# Extended Authentication Protocols (EAP) (continued)

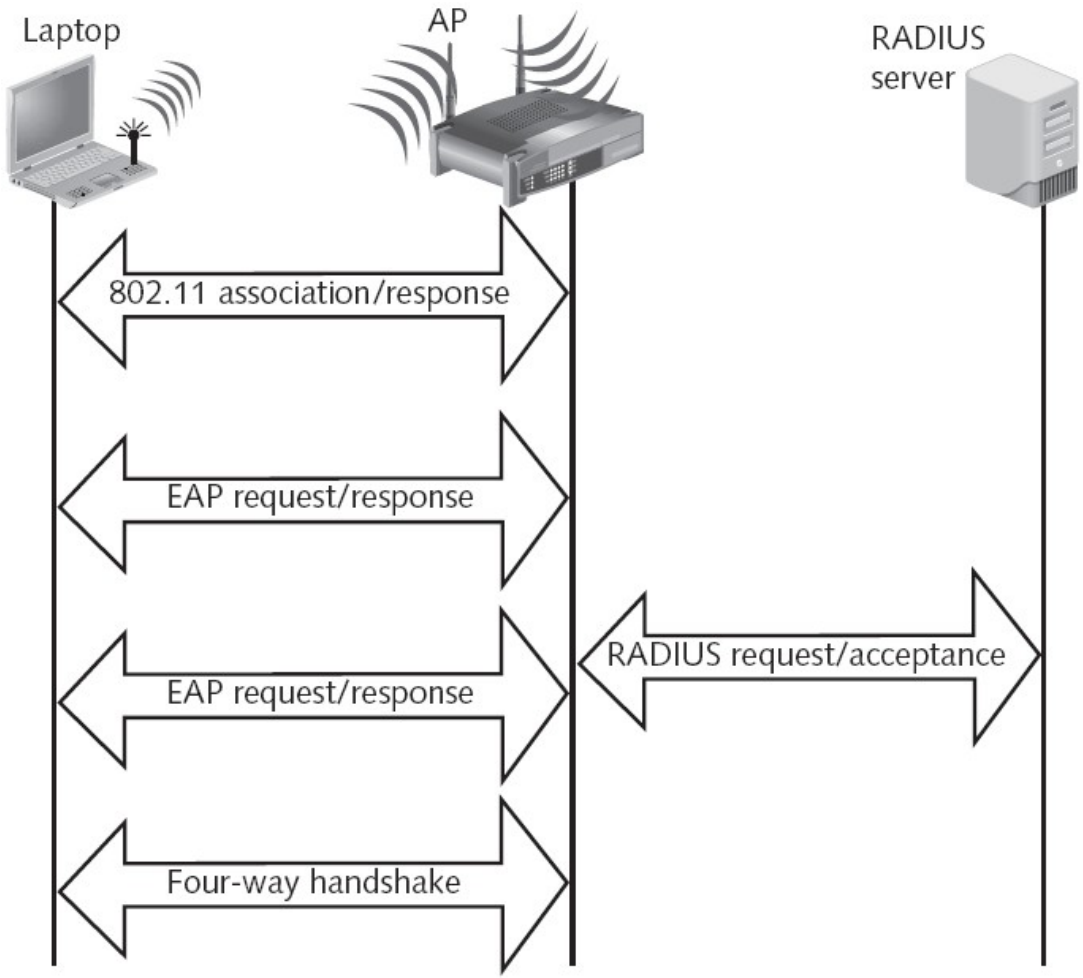



**Figure 8-8** EAP in IEEE 802.1x

# EAP Weak Protocols

- Still used but have security vulnerabilities with wireless networks
- Protocols include:
  - Extended Authentication Protocol–MD 5 (EAP-MD5)
    - Allows a RADIUS server to authenticate wireless devices stations
  - Cisco's Lightweight EAP (LEAP)
    - Considered a step above EAPMD5

# IEEE 802.11 Authentication and Key Management

- Once a user's device is authenticated, the next step is to enable encryption
- Encryption is based on a series of interrelated keys

# IEEE 802.11 Authentication and Key Management

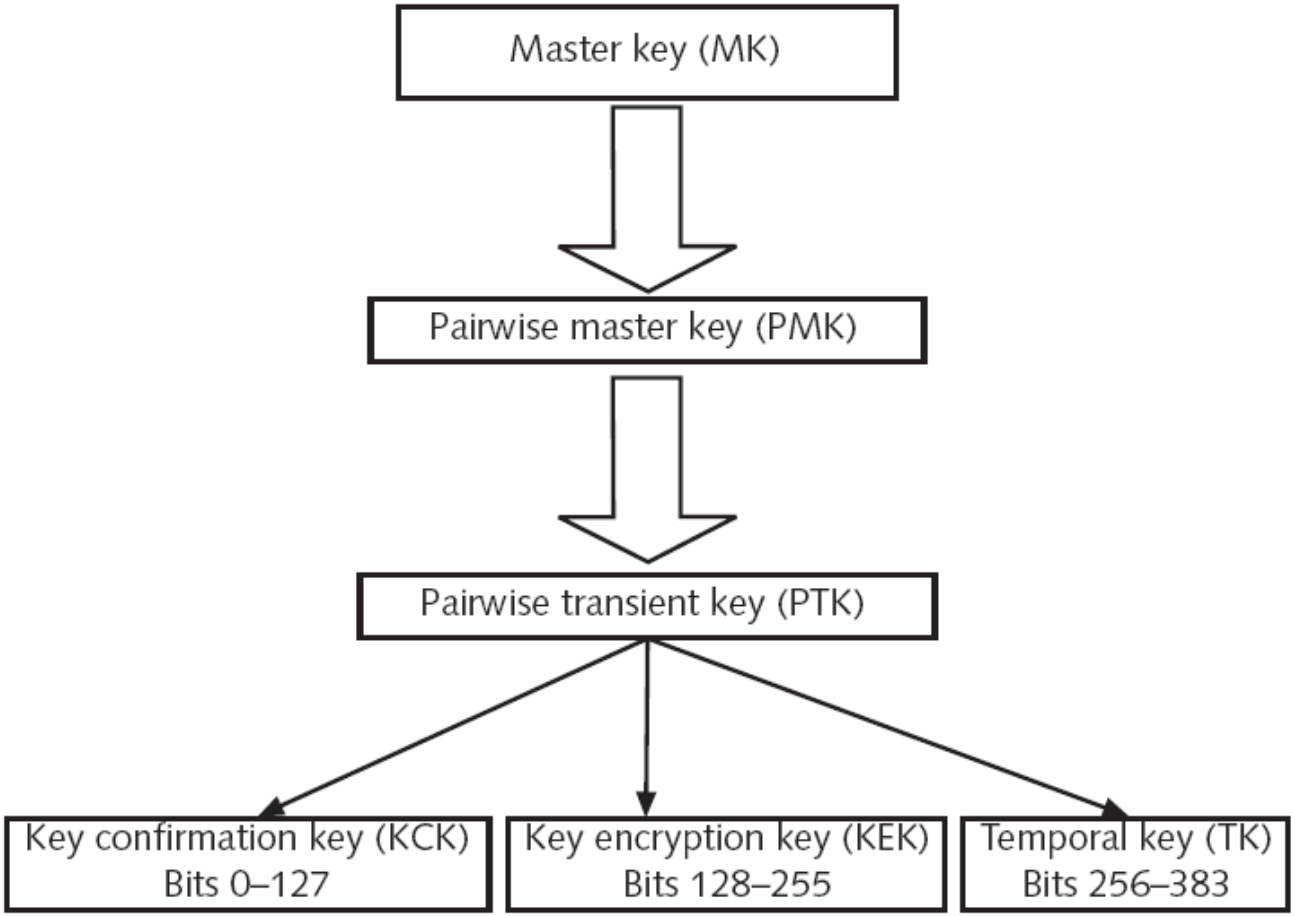



**Figure 8-9** Key hierarchy

# Master Key (MK)

- All other keys are formed from the master key
- When using IEEE 802.1x:
  - MK is sent from the authentication server (usually a RADIUS server) to the authenticator (access point)
    - As part of an acceptance packet
  - MK is encrypted within an EAP packet
  - AP forwards this packet directly to the wireless device
    - Without seeing its contents

# Pairwise Master Key (PMK)

- Two ways for retrieving a PMK
  - In WPA or WPA2 Personal security model
    - Preshared key (PSK) is entered by a user into both the access point and the wireless device
    - PSK is used in conjunction with the SSID to form the mathematical basis of the PMK
  - In WPA or WPA2 Enterprise security model
    - PMK is generated by the RADIUS server and sent to the access point
    - Wireless device generates its own PMK

# Pairwise Transient Key (PTK)

- PTK is generated by combining the PMK with four pieces of data
  - The supplicant's (wireless device) MAC address
  - The authenticator's (access point) MAC address
  - A nonce created by supplicant
  - A nonce created by the authenticator
- PTK is itself divided into three keys
  - Key confirmation key (KCK)
  - Key encryption key (KEK)
  - Temporal key

# Pairwise Transient Key (PTK) (continued)

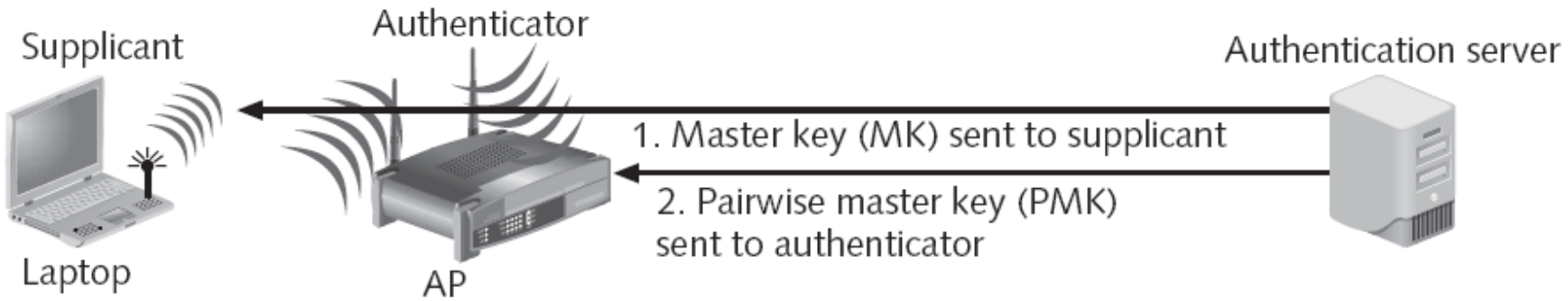



**Figure 8-10** Key creation in WPA or WPA2 Enterprise security model

# Pairwise Transient Key (PTK) (continued)

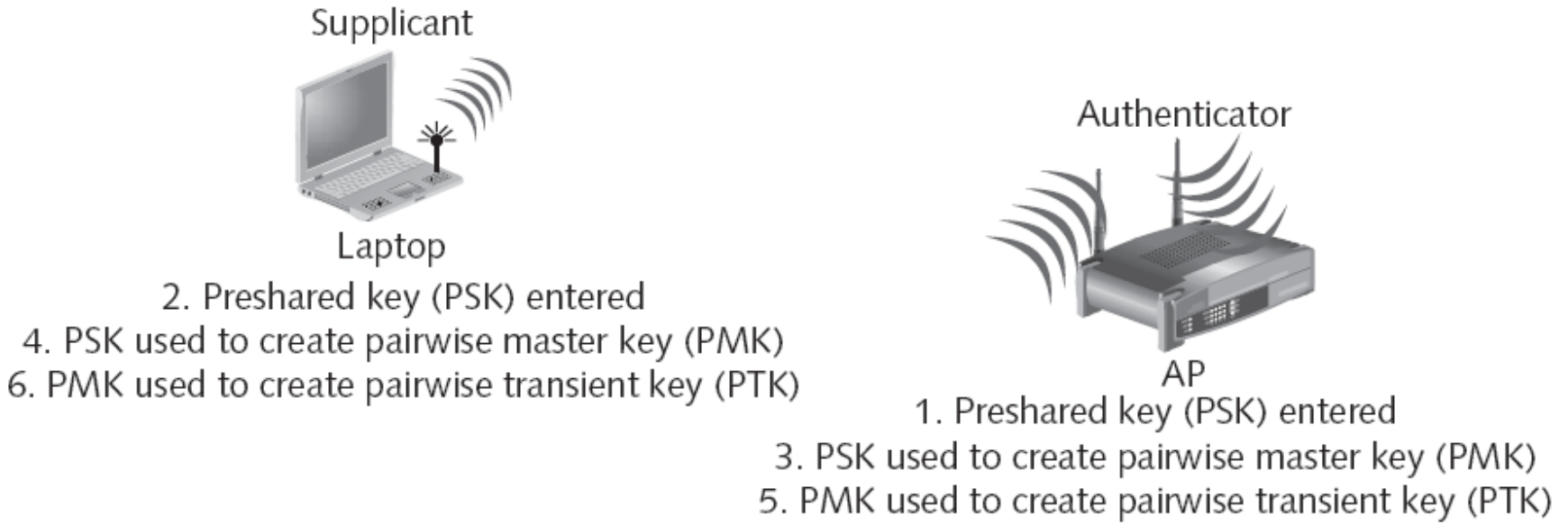



**Figure 8-11** Key creation in WPA or WPA2 Personal security model

# Group Keys (continued)

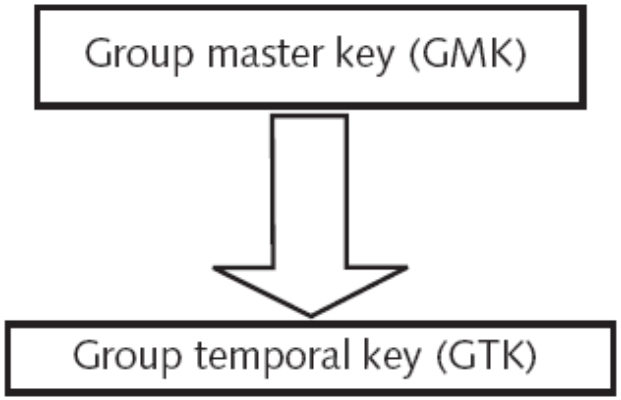



**Figure 8-12** Group key hierarchy

# Group Keys

- MKs are used for unicast transmissions
- Group keys (GK)
  - Used for broadcast transmissions
- Group master key (GMK)
  - Starting point of the group key hierarchy
  - Simply a random number
- Group temporal key (GTK)
  - Created using the GMK, authenticator's MAC address, and a nonce from the authenticator
  - Used to decrypt broadcast messages from APs

# Handshakes (continued)

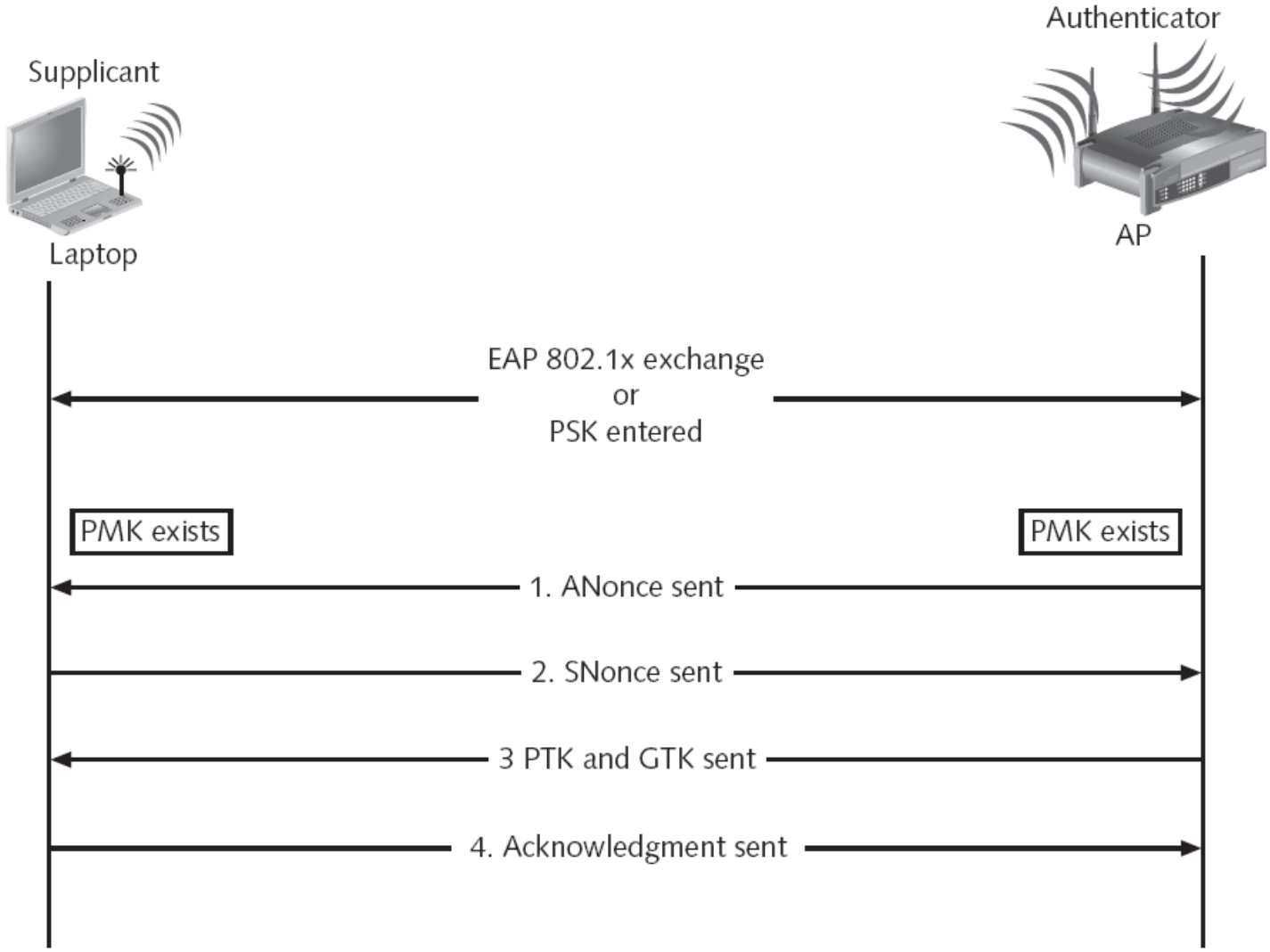



**Figure 8-13** Four-way handshake

# Handshakes

- Handshake
  - Exchange of info between APs and wireless devices
- Four-way handshake
  - Exchange of information for the MK
  - Accomplishes the following tasks:
    - Authenticates the security parameters that were negotiated
    - Confirms PMK between supplicant and authenticator
    - Establishes the temporal keys to be used by the data-confidentiality protocol

# Handshakes (continued)

- Four-way handshake (continued)
  - Accomplishes the following tasks (continued):
    - Performs the first group key handshake
    - Provides keying material to implement the group key handshake
- Group-key handshake
  - Authenticates the GTK
  - Preceded by the four-way handshake

# Wireless Authentication and Encryption Summary

- Based on the IEEE 802.11i security protocol
  - WPA Enterprise and WPA2 Enterprise security models utilize IEEE 802.1x port-based authentication
  - Credentials used can be passwords, biometrics, and digital certificates
  - EAP manages port-based authentication
  - EAP-TLS, PEAP, and others are used for encryption
- IEEE 802.1x
  - Provides the wireless device a unique encryption key called the MK
    - Used to create other encryption keys

# Summary

- Wireless authentication is the process of a device proving that it is “genuine” and not an imposter
- Authentication servers are used to authenticate users in a WLAN
  - Most common type is a RADIUS server
- EAP
  - Management protocol of IEEE 802.1x that governs the interaction between the wireless device, access point, and RADIUS server

# Summary (continued)

- IEEE 802.11 authentication and key management is based on a key hierarchy
- When an AP sends a broadcast packet to all wireless devices, GKs are used
  - Starting point of the group key hierarchy is the GMK