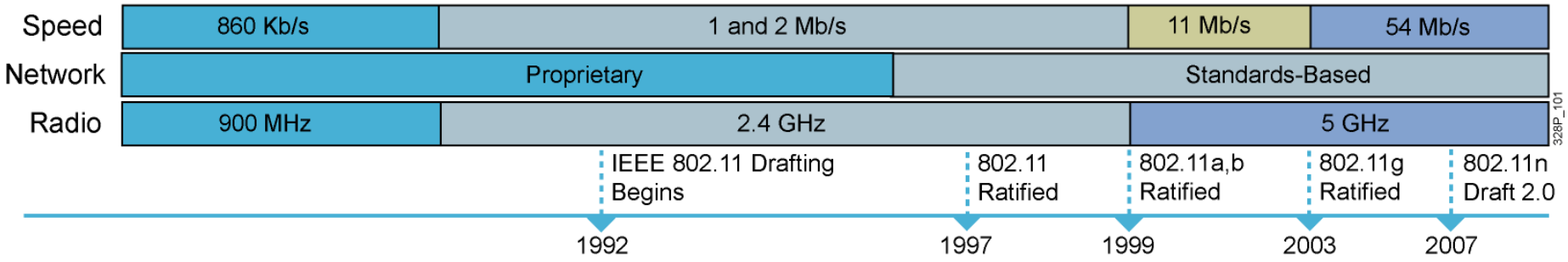
RAČUNARSKE MREŽE

13 – Bežične mreže

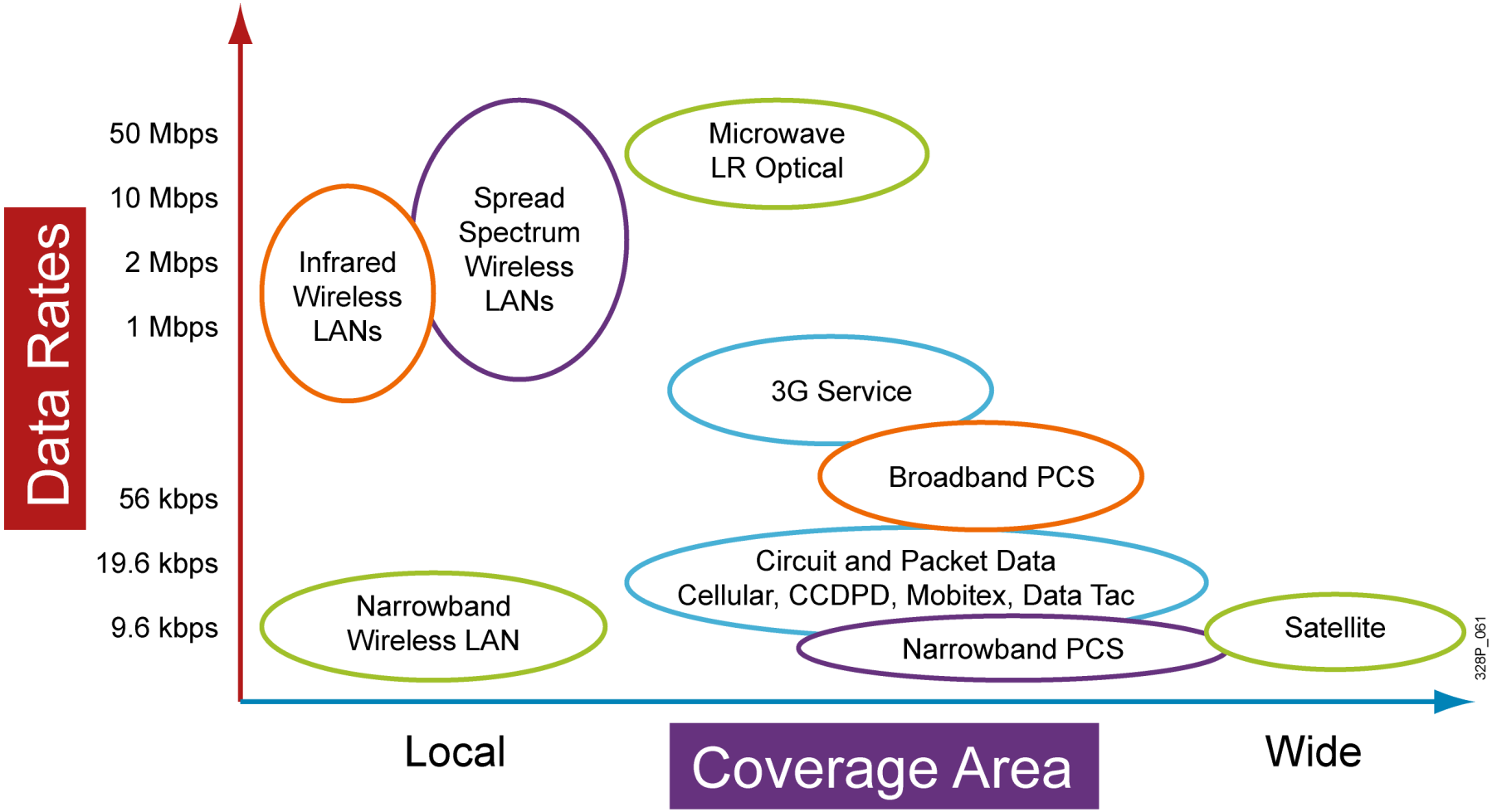
Osnove bežičnih mreža

Osnovni pojmovi

- Prvi bežični prenos: 1870 g.
- Upotreba 900-MHz opsega od 1980 g.
- Upotreba ISM opsega počinje 1990 g.
- Realizacija: u različitim ambijentalnim uslovima

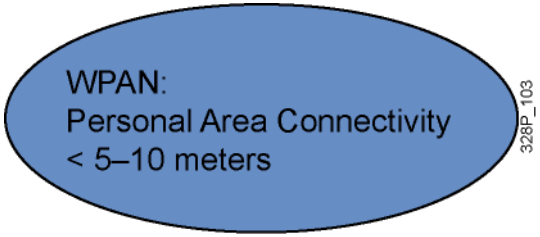


Upotreba bežičnih mreža



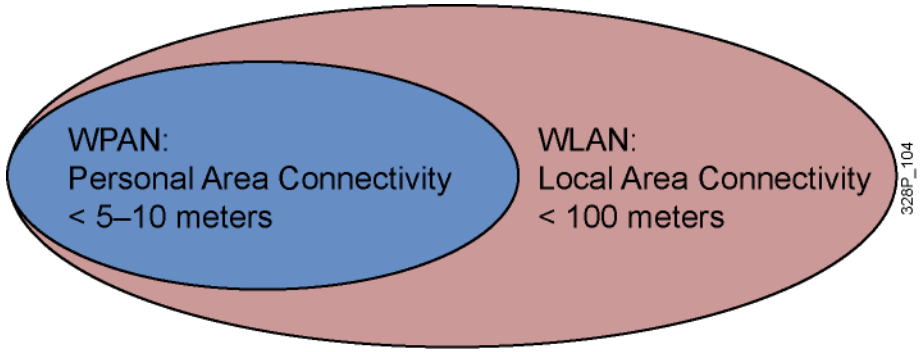
WPAN (Wireless Personal Area Network)

- WPAN mreže realizuju konekciju na malom prostoru .
- Linkovi su obično peer to peer ili male mreže.
- WPAN: jednostavne, jeftine, mobilne.
- Bluetooth je tipičan primjer.



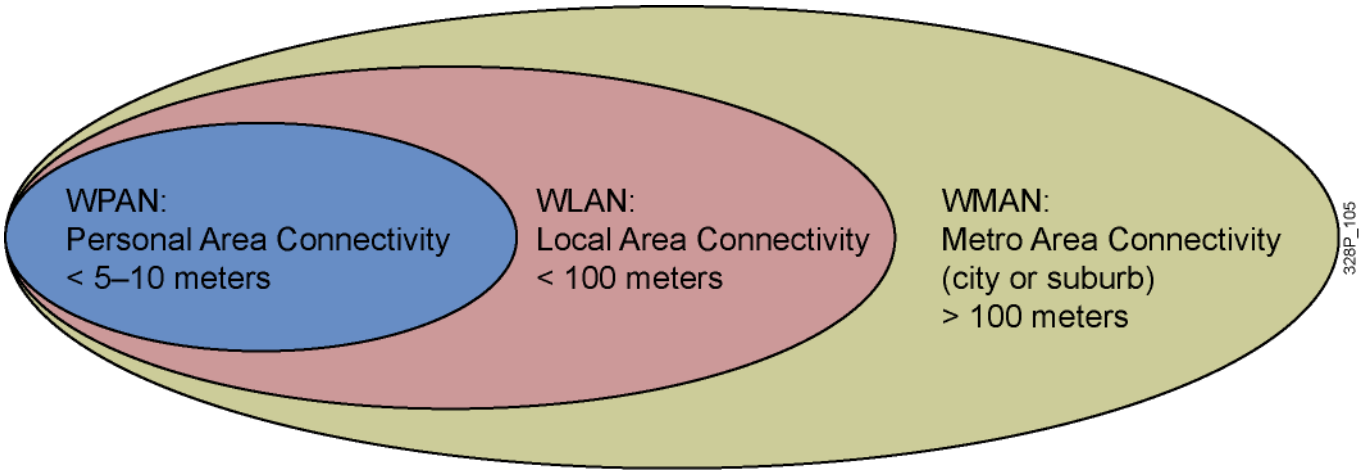
WLAN (Wireless LAN)

- Udaljenosti veće nego PAN, spektar 2.4 GHz i 5 GHz
- Potrebno više energije
- Očekuje se veći broj korisnika u mreži
- Potrebno da je dizajn fleksibilan i skalabilan



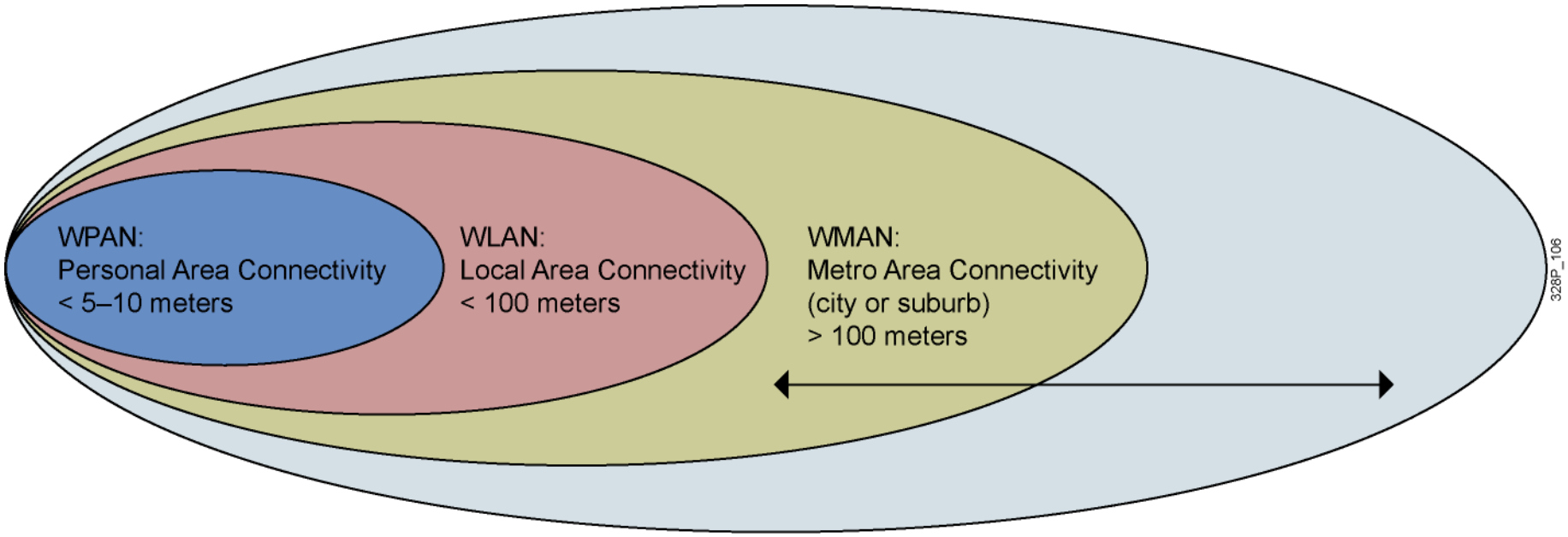
WMAN (Wireless Metro Area Network)

- Uloga: backbone ili da pokriju veće oblasti
- Obično u licenciranom spektru



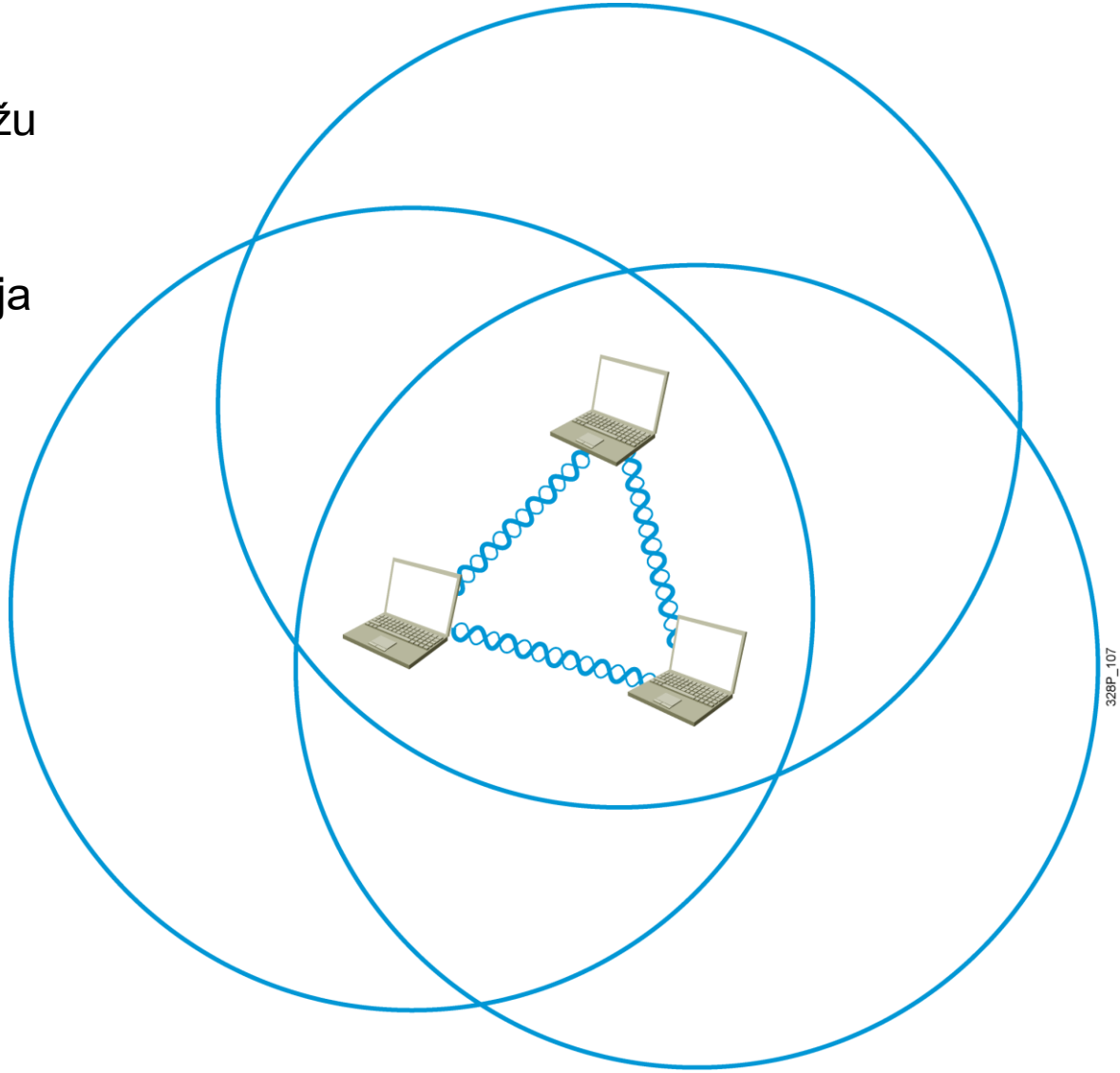
Wireless WAN

- Pokrivaju veće površine



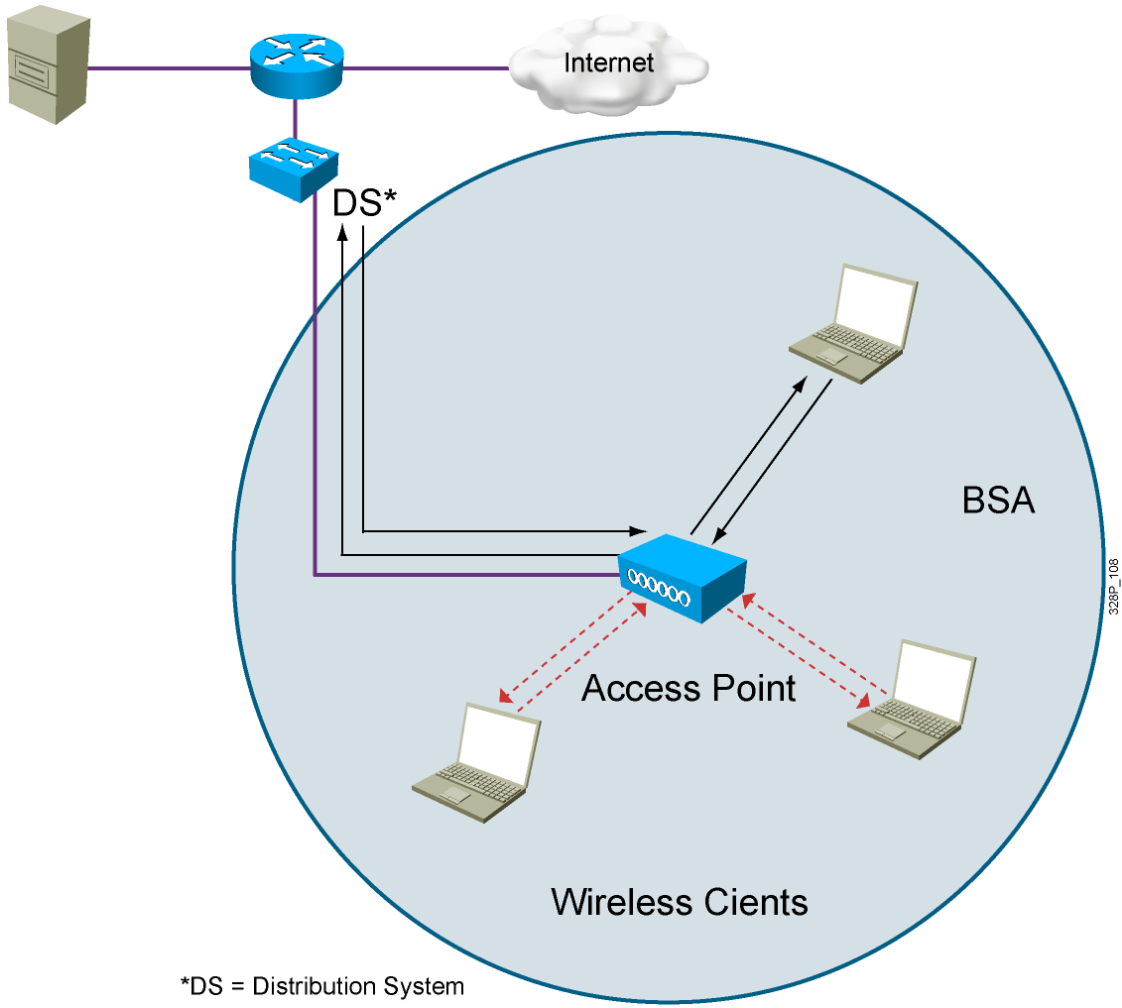
Ad Hoc mreže

- Postoji kada se povežu minimalno dva korisnika
- Ograničen broj uređaja zbog kolizije i organizacionih problema

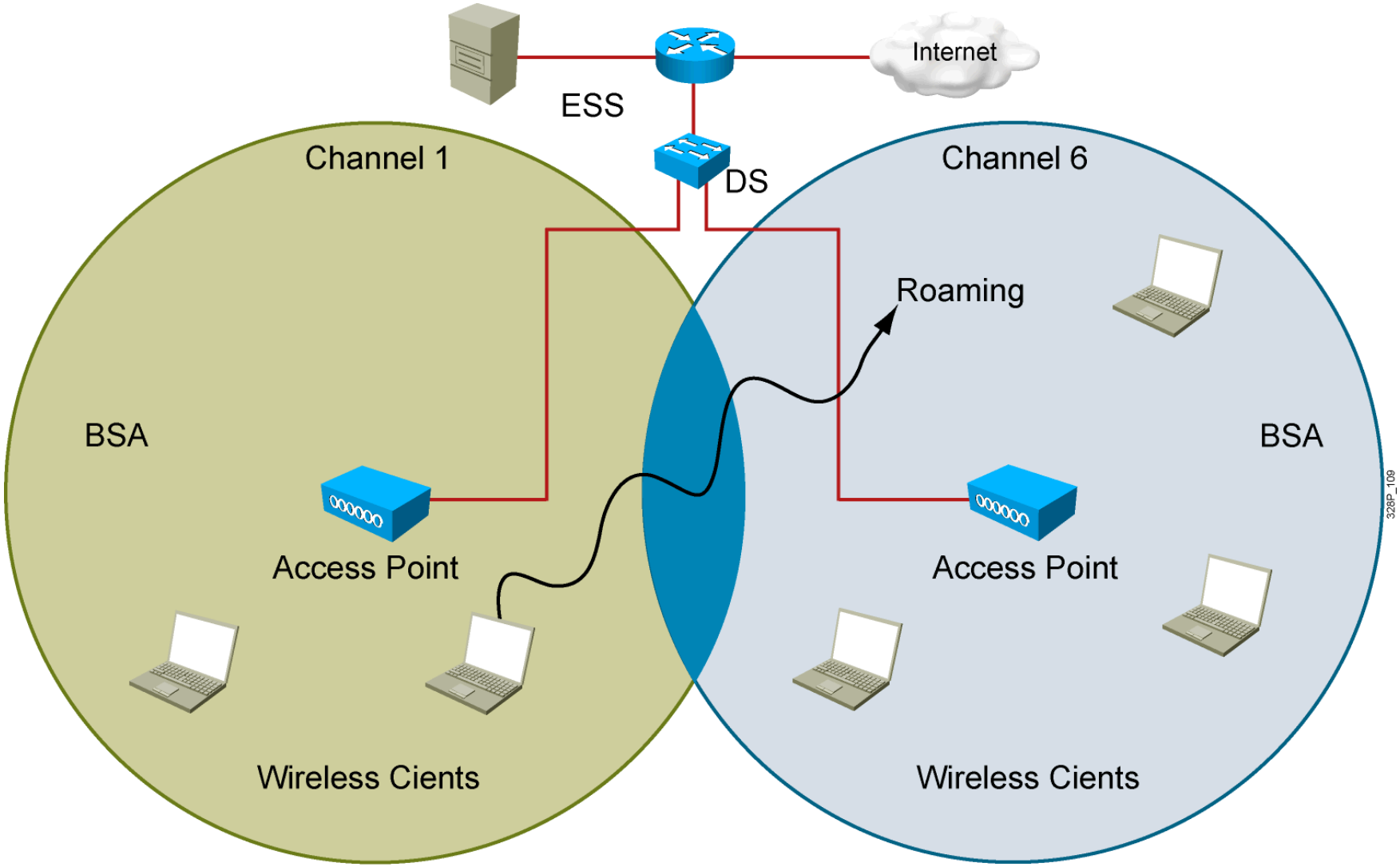


Infrastructure Mode

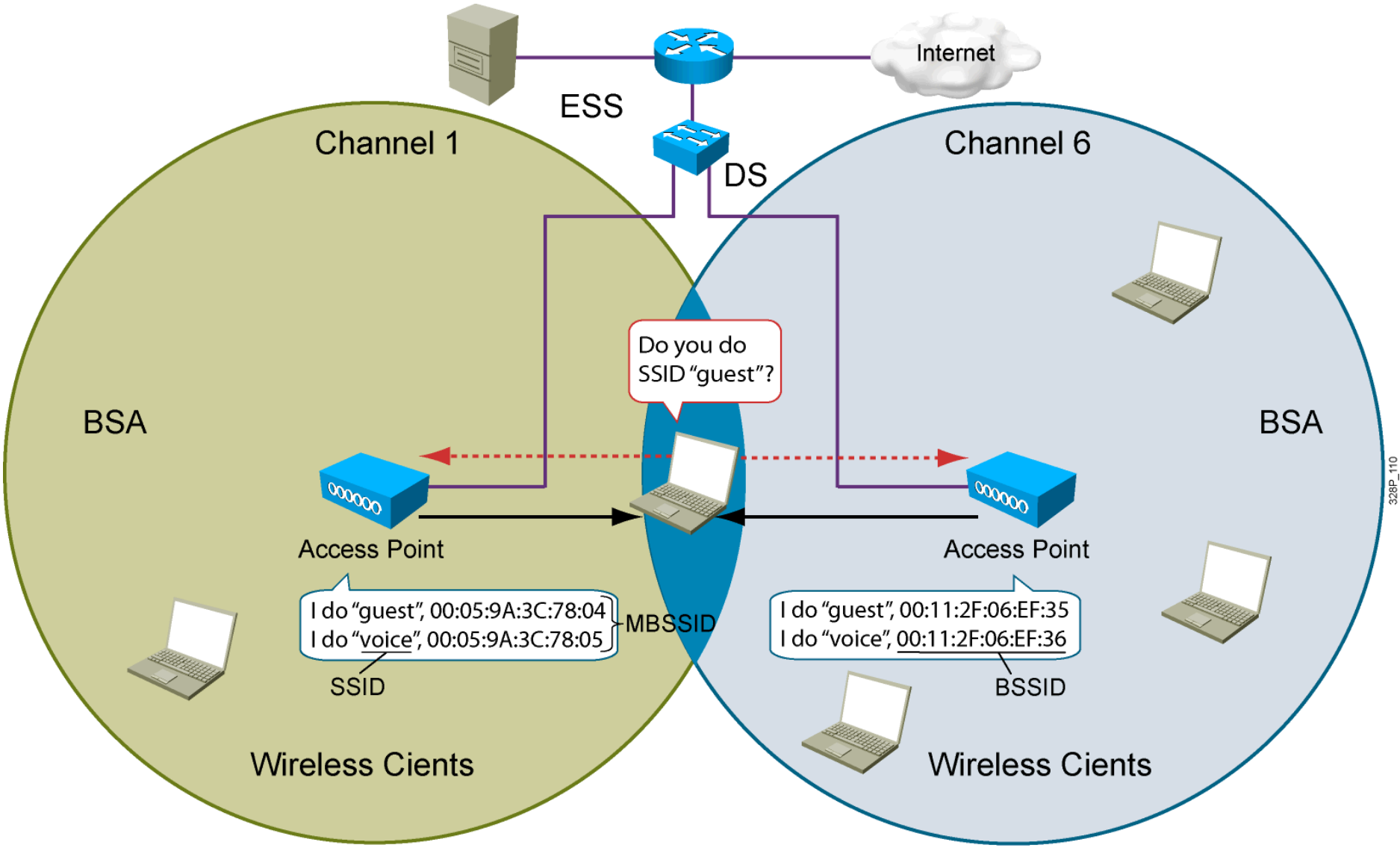
- AP rade kao “translational bridge” između 802.3 žičnih medija i 802.11 bežičnih medija.
- BSA = wireless ćelija.
- BSS =servis obezbijeđen od strane AP.



Infrastructure Mode (Cont.)

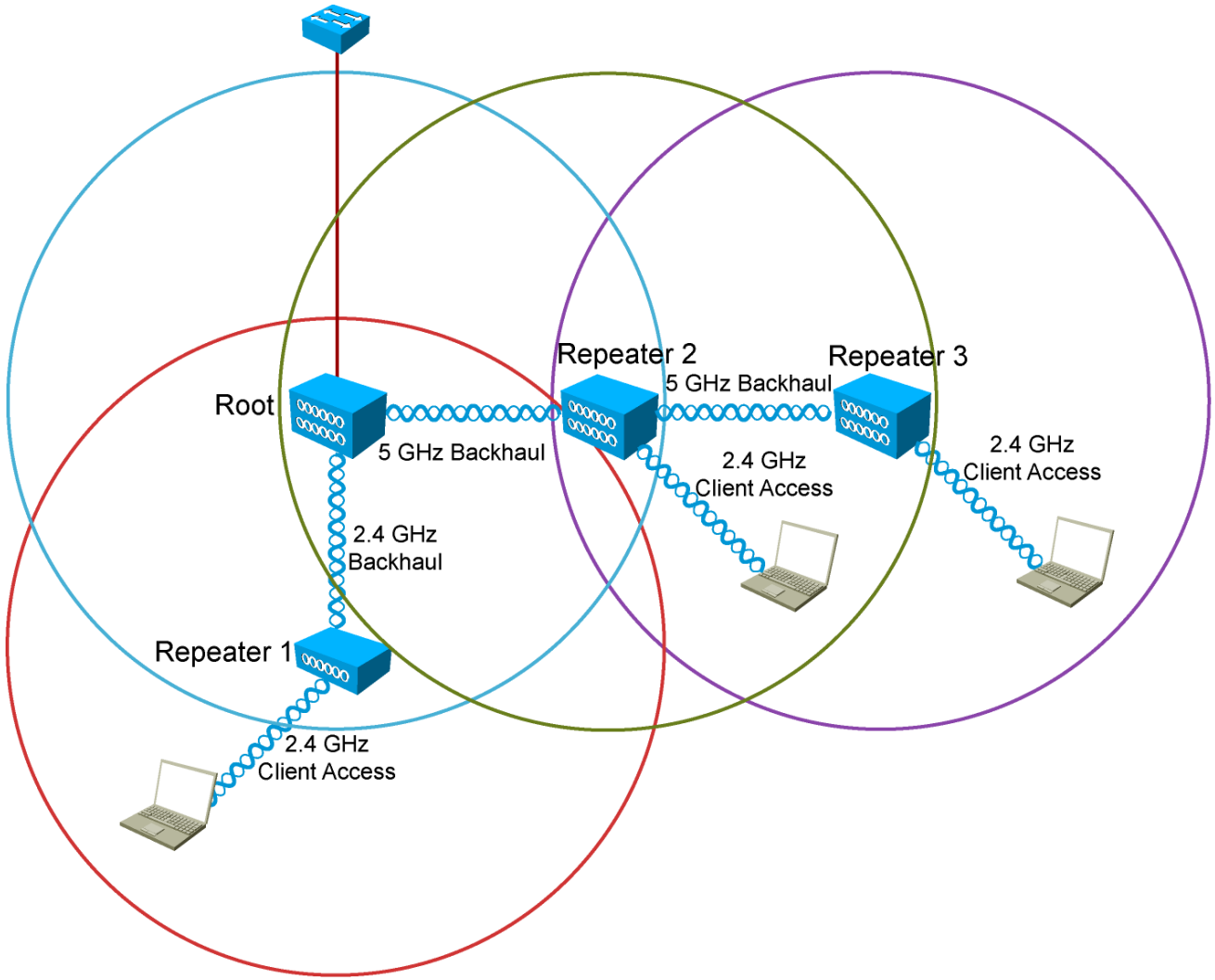


SSID (Service Set Identifier)



Repeater

- Proširuje oblast pokrivenosti AP
- Dual radio- može kreirati dual half-duplex
- Neophodno je prekrivanje ćelija od min 50%



Regulaciona tijela, standardi i sertifikacija u bežičnim komunikacijama

IEEE

- IEEE razvija komunikacione standarde
- Postoji više od 1300 protokola.
- 802.11 komitet analizira aplikacije i okruženje za primjenu bežičnih mreža
- 802.11 familija ima više od 26 subprotokola.

Wi-Fi Allijansa

- Wi-Fi Allijansa sertifikuje interoperabilnost između interoperability WLAN proizvoda.
- Uključuje 802.11a, 802.11b, 802.11g, 802.11n, dual-band proizvode i sigurnosna testiranja.
- Certifikovani proizvodi na stranici : http://www.wi-fi.com.

Regulaciona tijela

Svaka zemlja definiše pravila o upotrebi RF prostora uključujući pravila:

- Koje frekvencije su dozvoljene
- Dozvoljena transmitovana snaga zračenja („transmitters and antennae gain“, EIRP)
- Tehnike modulacije i kodovanje

Primjer FCC: 2.4-GHz EIRP Output Rules

Point-to-multipoint

- *Maximum of 36 dBm EIRP*
- *30-dBm maximum transmitter power with 6-dBi maximum gain of antenna and cable combination*
- *A 1:1 ratio between the maximum power and maximum gain*
- *Reduce transmit power below maximum of 30 dBm by 1 dBm and increase maximum antenna and cable system gain by 1dBi*

Point-to-point

- *Maximum of 36 dBm EIRP*
- *30-dBm maximum transmitter power with 6-dBi in gain of antenna and cable combination*
- *FCC allows exceeding the 36 dBm EIRP in point-to-point installations using the 3:1 ratio rule*
- *Reduce transmit power below maximum of 30 dBm by 1 dBm and increase maximum antenna and cable system gain by 3 dBi*

2.4-GHz EIRP Output Rules—FCC Example (Cont.)

Point-to-Multipoint

	Transmitter Power - dBm	Maximum Gain	EIRP
FCC Maximum	30 dBm	6 dBm	36 dBm
Cisco Maximum	20 dBm	16 dBm	36 dBm

The above values reflect the 1:1 rule.

Point-to-Point

	Transmitter Power - dBm	Maximum Gain	EIRP
FCC Maximum	30 dBm	6 dBm	36 dBm
Cisco Maximum	20 dBm	36 dBm	56 dBm

The above values reflect the 3:1 rule.

Wireless Spektar

- 2.4-GHz: ISM opseg je od 2.4 do 2.4835 GHz (2.4970 GHz Japan). Dozvoljeno je 11 kanala u USA, 13 u Evropi, i 14 Japanu.
- 5-GHz: ISM opseg je od 5.725 do 5.875 GHz.
- 5-GHz: ISM opseg se preklapa sa Unlicensed National Information Infrastructure (UNII) opsezima:
  - UNII-1 opseg od 5.15 do 5.25 GHz (4 kanala).
  - UNII-2 opseg od 5.25 do 5.35 GHz (4 kanala).
  - UNII-2 opseg proširuje opseg od 5.470 do 5.725 GHz (do 11 kanala).
  - UNII-3 opseg od 5.725 GHz do 5.825 GHz (4 kanala).

IEEE 802.11 aktivnosti standardizacije

802.11a — 5GHz, 54 Mb/s; ratified in 1999

802.11b — 2.4 GHz, 11 Mb/s; ratified in 1999

802.11d — World Mode; ratified in 2001

802.11e — QoS; ratified in 2005

802.11g — 2.4GHz, 54 Mb/s; ratified in 2003

802.11h — DFS and TPC mechanisms; ratified in 2004

802.11i — Authentication and security; ratified in 2004

802.11k — Radio resource measurement enhancements (under development)

802.11n — Higher throughput improvements using MIMO antennas (under development)

802.11t — WPP; test methods and metrics recommendation (under development)

802.11w — Protected management frames (under development)

802.11 Standardi za spektre i brzine

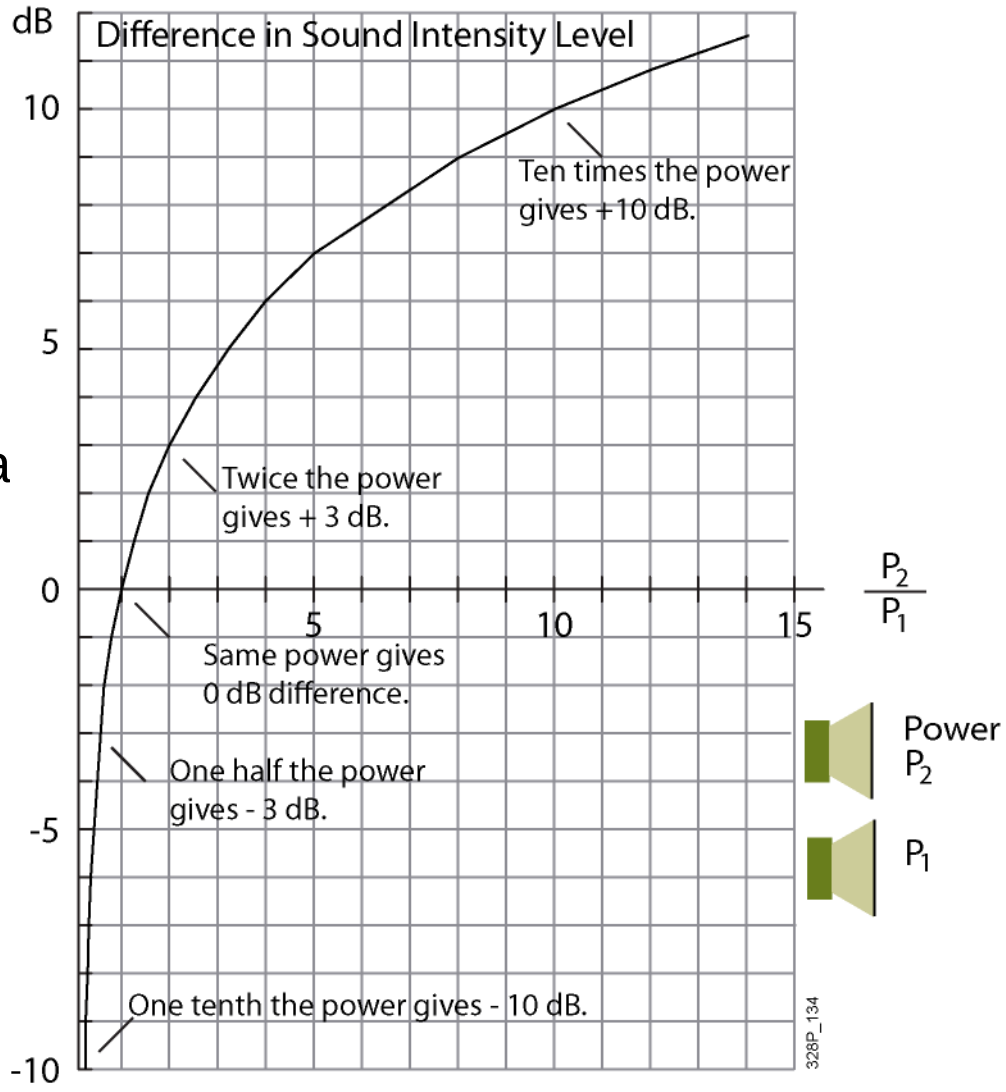
	802.11	802.11b	802.11a	802.11g		802.11n
Ratified	1997	1999	1999	2003		Not Ratified
Frequency Band	2.4 GHz	2.4 GHz	5 GHz	2.4 GHz		2.4 GHz, 5 GHz
No of Channels	3	3	Up to 23	3		varies
Transmission	IR, FHSS, DSSS	DSSS	OFDM	DSSS	OFDM	DSSS, CCK, OFDM
Data Rates (Mb/s)	1, 2	1, 2, 5.5, 11	6, 9, 12, 18, 24, 36, 48, 54	1, 2, 5.5, 11	6, 9, 12, 18, 24, 36, 48, 54	100+

Osnove RF matematike

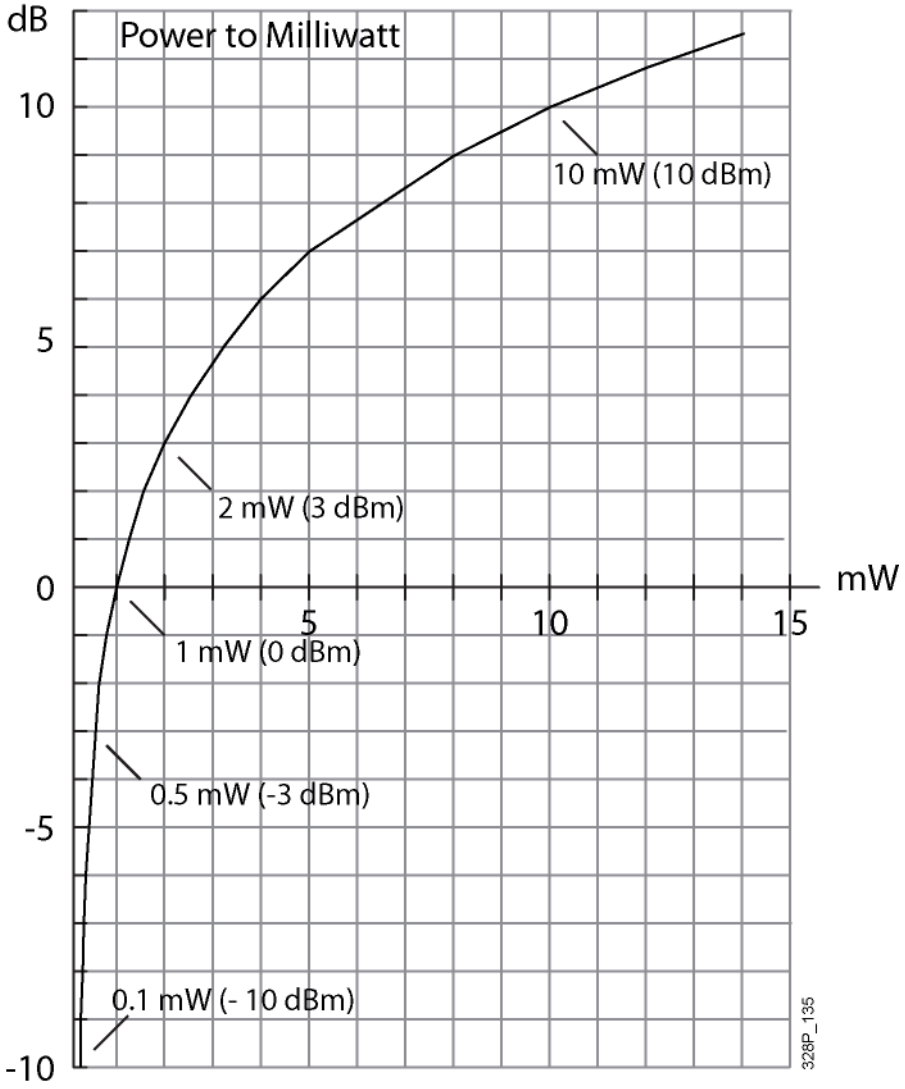
Decibel

Poređenje snaga zračenja:

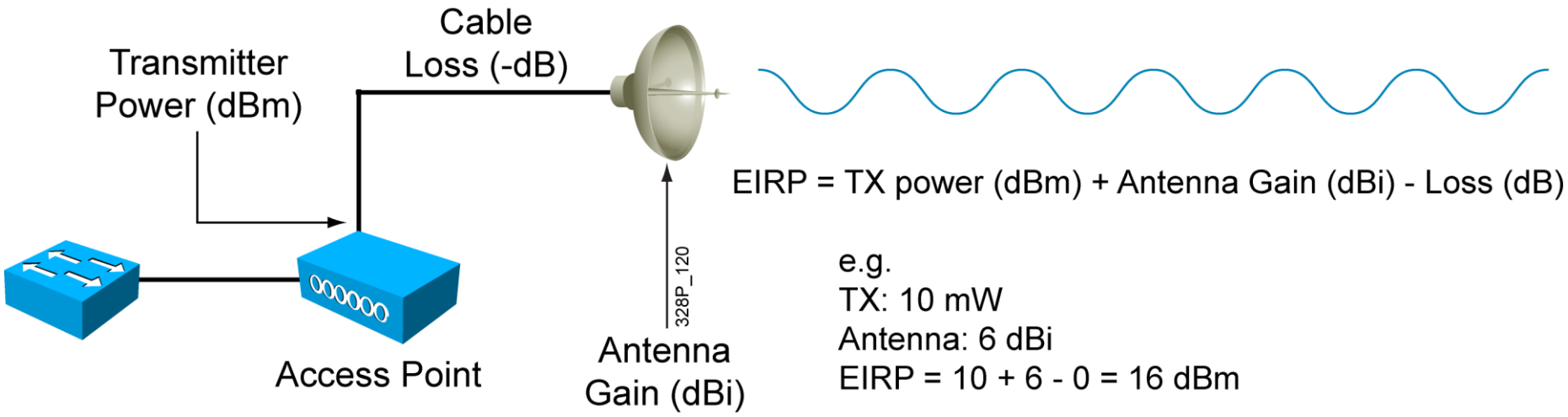
- 0 dB = ista snaga
- 3 dB = dvostruka snaga
- -3 dB = polovina snage
- 10 dB = 10 puta veća snaga
- -10 dB = 1/10 snage



dBm


dB
Power to Milliwatt
10
5
0
-5
-10
10 mW (10 dBm)
2 mW (3 dBm)
1 mW (0 dBm)
0.5 mW (-3 dBm)
0.1 mW (- 10 dBm)
mW
5
10
15
328P_135

Efektivna izračena snaga



EIRP: Effective Isotropic Radiated Power

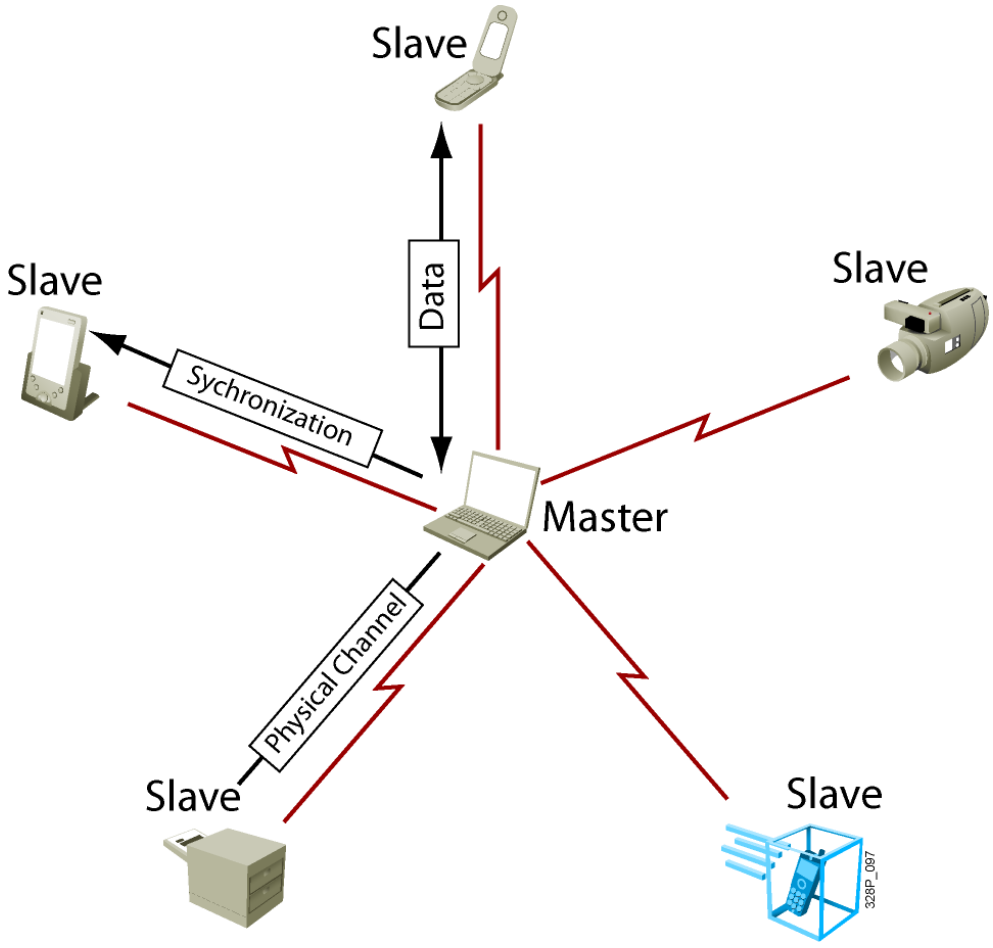
Osnovne Non-802.11 Wireless tehnologije i njihov uticaj na WLAN

Bluetooth

- Radio sistem (radio frequencijski standard) koji definiše koncept-wireless personal area network (WPAN).
- Nominalna veličina linka do 10m/ 0 dBm (~100m sa 20 dBm)
- Transmituje od 2.402 GHz do 2.480 GHz (79 kanala)
- Brzine do 720 kb/s
- Klase proizvoda: 100 mW, 2.5 mW and 1 mW
- Nema line-of-sight restrikcija
- Visoka sigurnost

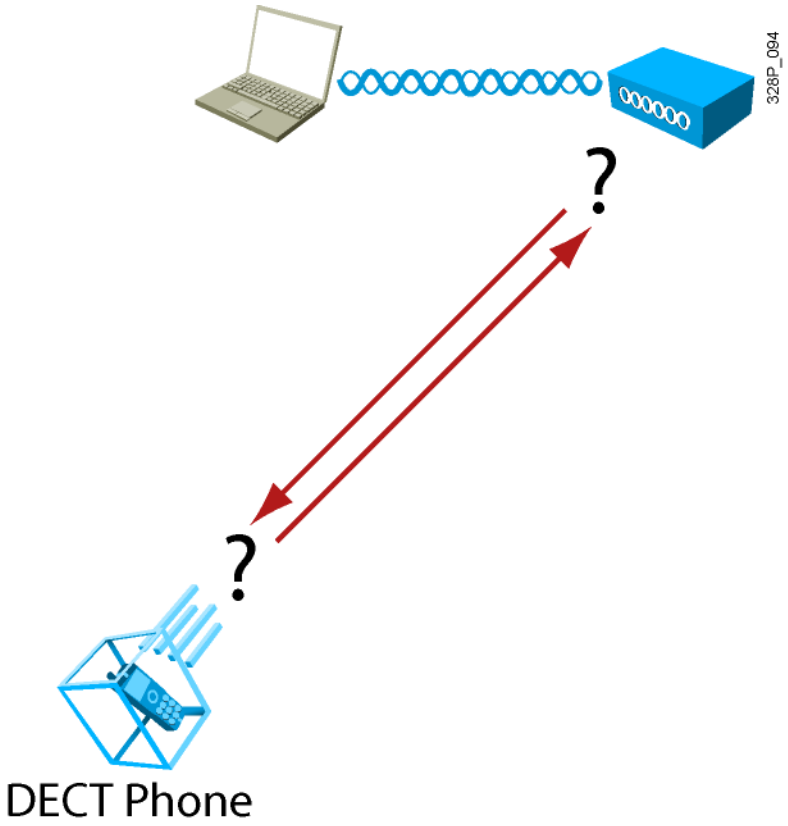
Bluetooth (Cont.)

- Bluetooth mreža: do 7 slave uređaja i jedan master.
- Ćelija se zove“piconet.”
- Bluetooth omogućuje jednostavnu realizaciju ad-hoc mreže.



Bežični telefon

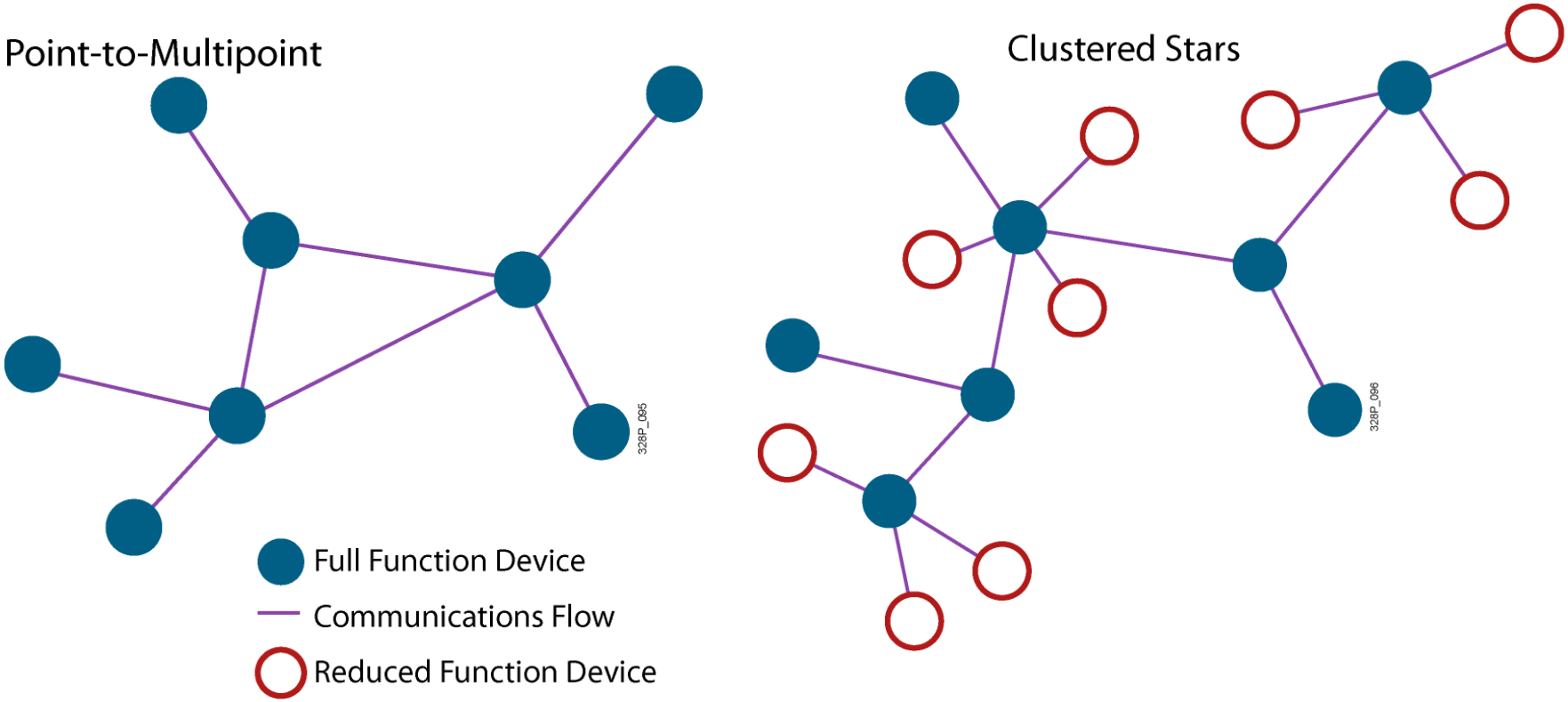
- Telefon je klijent na baznoj stanici.
- Koristi se TDMA (Time Division Multiple Access) i FDMA (Frequency Division Multiple Access).
- Protokoli dobijeni od ISDN.
- Nisu kompatibilni sa Wi-Fi, ali zbog istog frekvencijskog opsega je moguća interferencija.



ZigBee

- Novi standard za “short range mesh“ umrežavanje
  - Baziran naIEEE 802.15.4 standard
  - Pouzdanost
- Dizajniran za „low-power“ aplikacije
  - Dug vijek baterije
- „Low data rate“
  - 20 do 250 kb/s (zavisi od opsega)
- Sigurnost
  - AES-128 enkripcija
- Samostalna kofiguracija
  - Dozvoljava ad-hoc mreže
  - Jednostavnost instalacije i konfiguracije
- Primjene: daljinsko upravljanje, klimatizacija, automatizacija, i slično.
- Jefinija implementacija od Wi-Fi ili Bluetooth

ZigBee mreža



- Nije kompatibilan sa Wi-Fi
- Koristi ISM band i moguća interferencija

Drugi Non-802.11 uređaji –moguća interferencija

Microwave Ovens

Wireless Video Cameras

Radar

Motion Detectors

Wireless Headphones

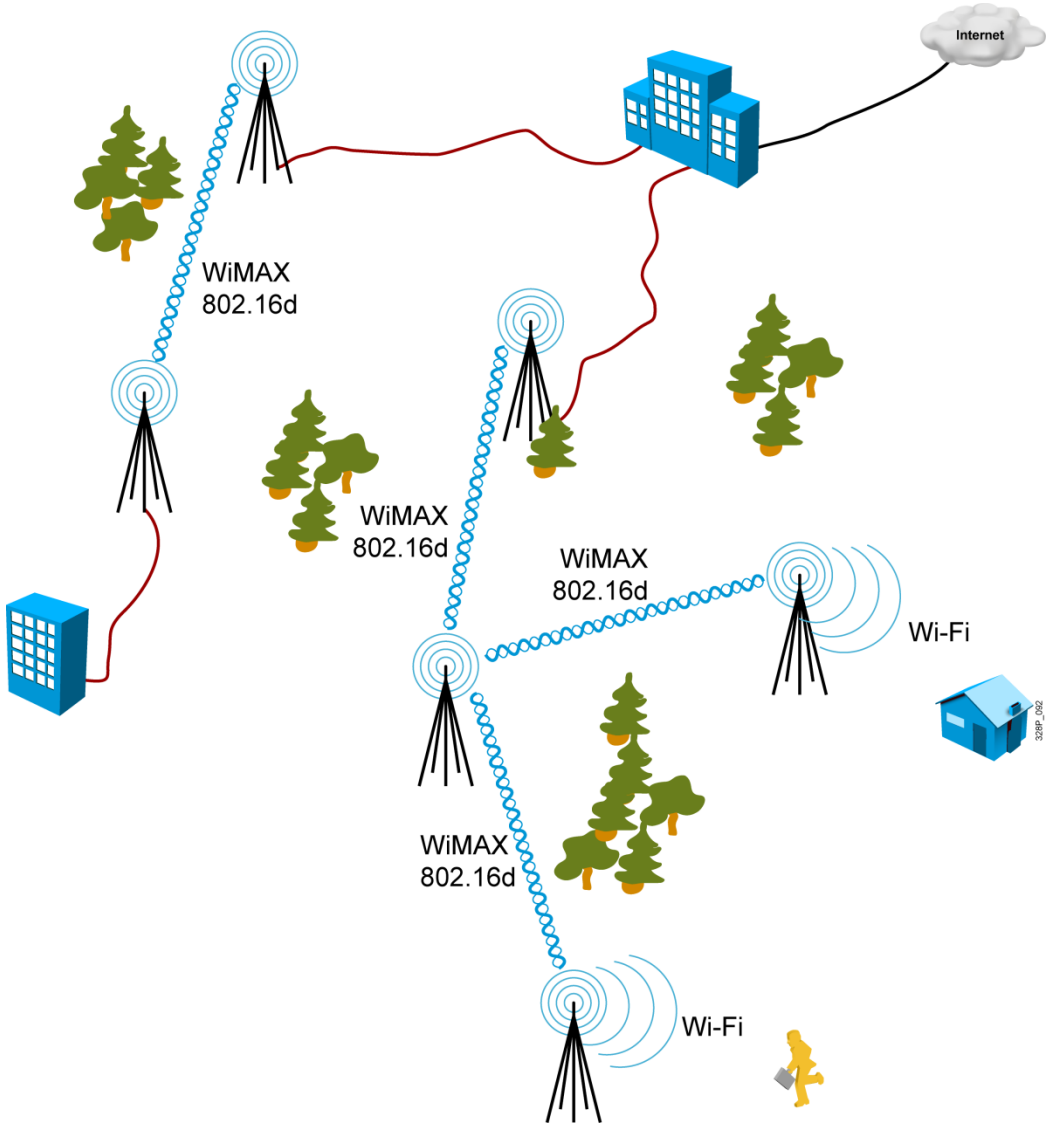
Outdoor Microwave Links

Fluorescent Lights

Wireless Game Controller

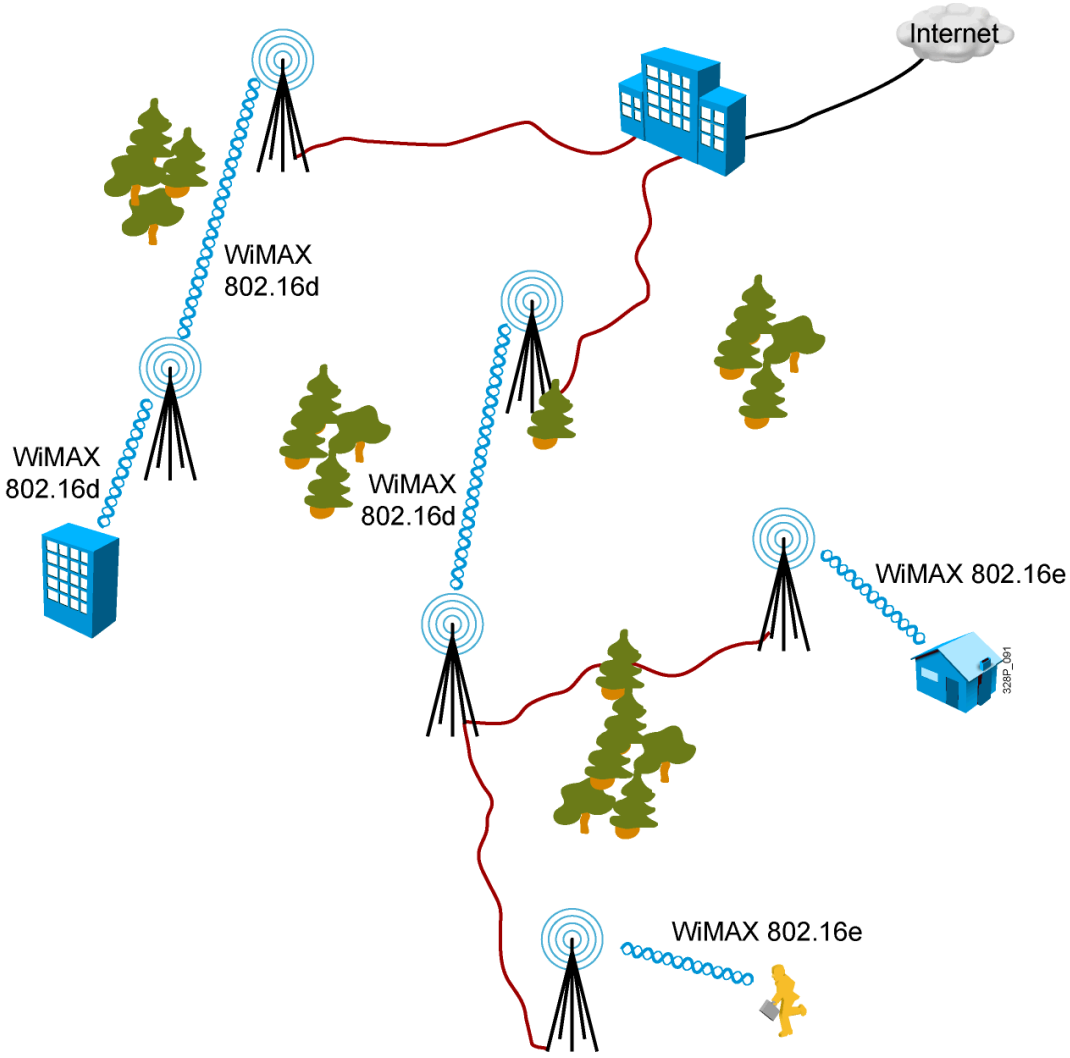
WiMAX tehnologija

- WiMAX -Worldwide Interoperability for Microwave Access.
- IEEE 802.16 podržan od WiMAX Forum.
- Fiksni WiMAX, baziran na 802.16d
- Upotreba kao backbone, T1/E1 linije
- Realizacija „last mile“ konektivnosti pomoću WiFi ili žičanim medijem
- Velike udaljenosti sa velikim brzinama



WiMAX tehnologija

- „Last mile“ konektivnost bazirana na 802.16e
- Mobilni korisnici
- „Line-of-sight“ ograničenja
- Udaljenosti 4 do 6 milja, brzine do 40 Mb/s, ali zavisi od udaljenosti i linije vidljivosti



Wireless LAN

Poređenje WLAN i LAN

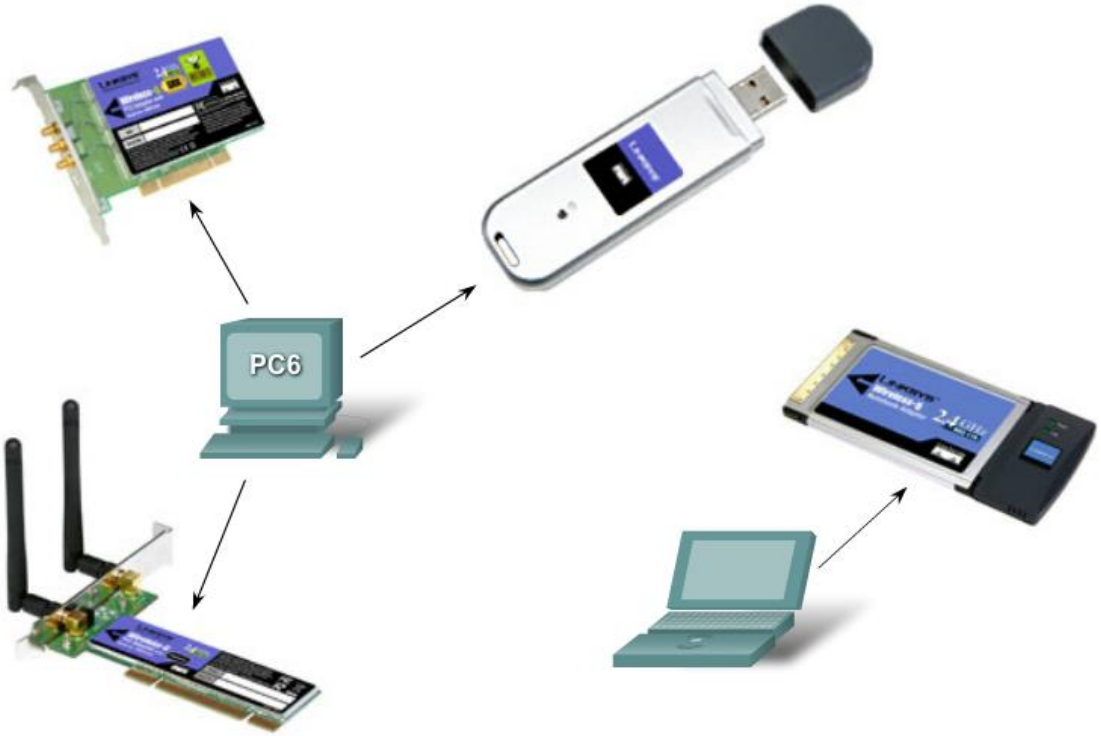
- Pregled osnovnih karakteristika WLAN i LAN mreža

Characteristic	802.11 Wireless LAN	802.3 Ethernet LANs
Physical Layer	Radio Frequency (RF)	Cable
Media Access	Collision Avoidance	Collision Detection
Availability	Anyone with a radio NIC in range of an access point	Cable connection required
Signal Interference	Yes	Inconsequential
Regulation	Additional regulation by local authorities	IEEE standard dictates

Osnovne WLAN komponente

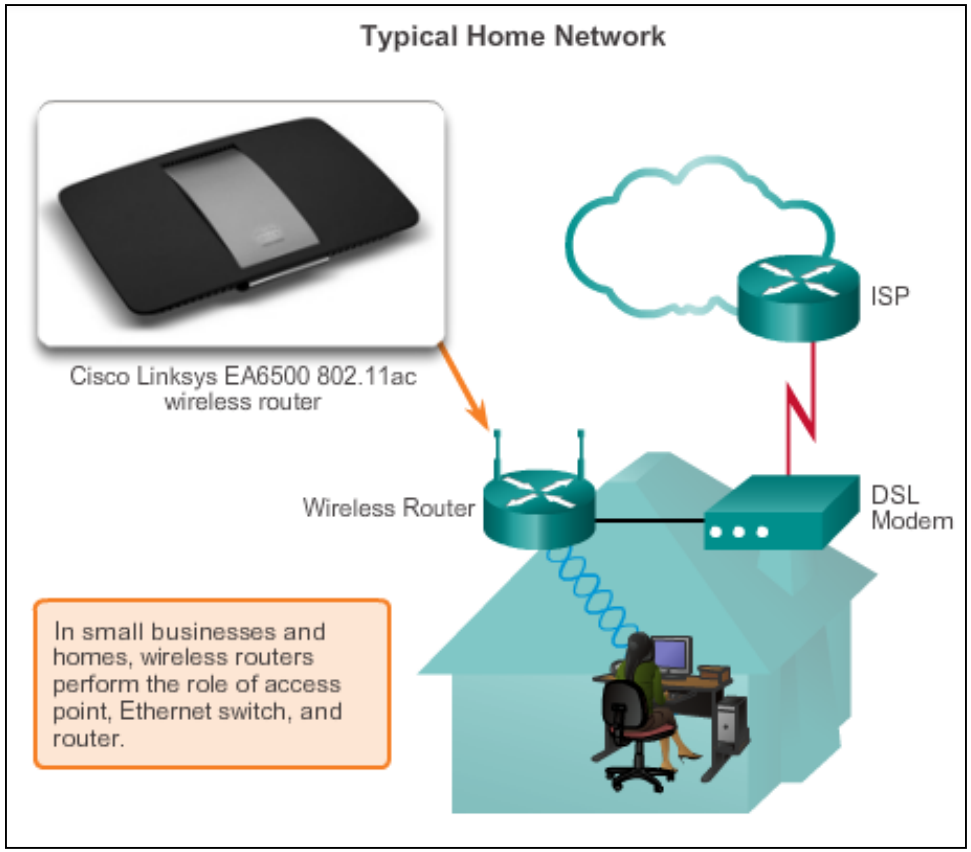
- Neophodna upotreba bežičnih mrežnih adaptera i uređaja kao što su wireless router ili wireless AP

- Wireles NIC



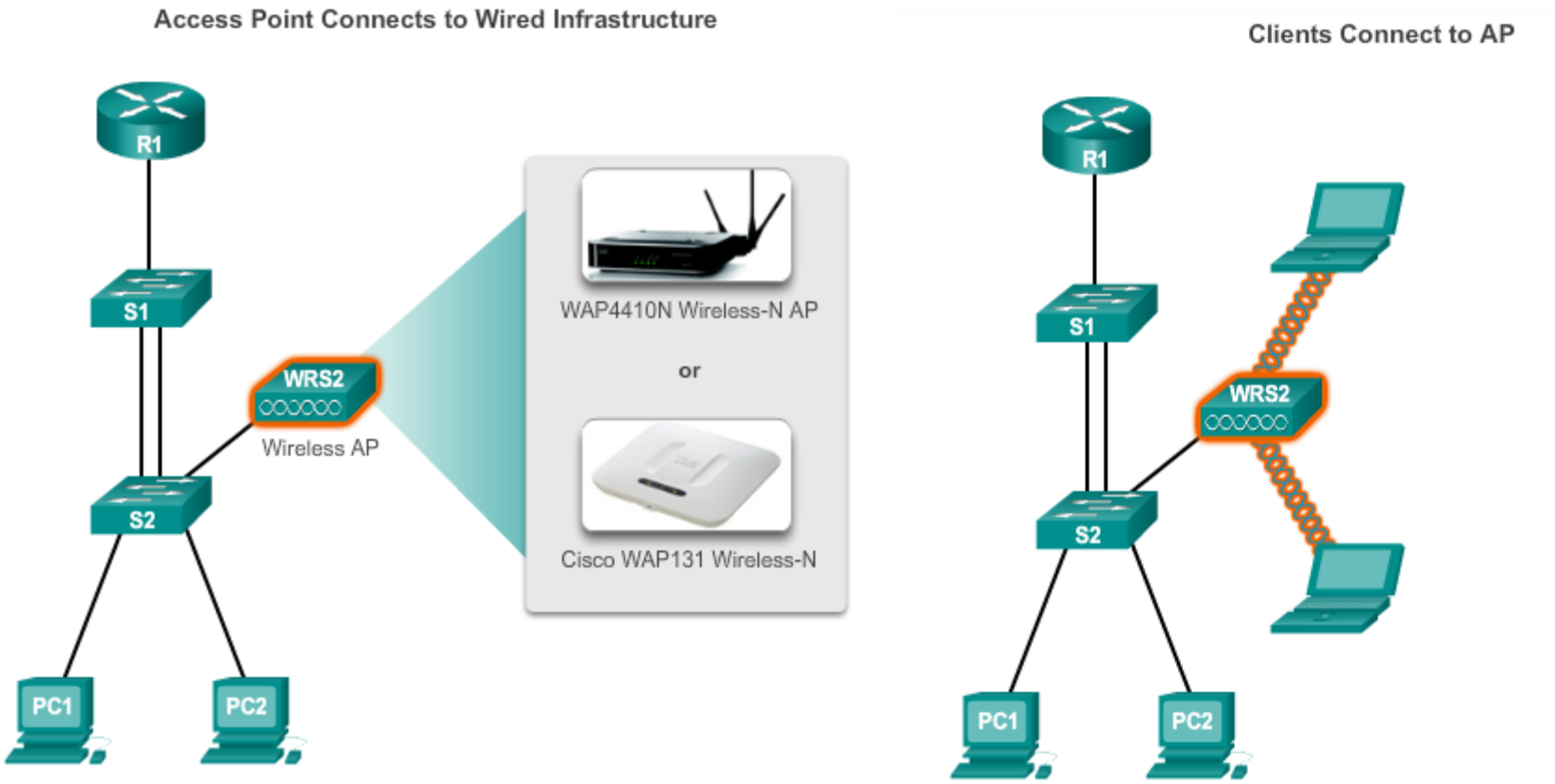
Osnovne WLAN komponente

- Wireles home router
- U manjim kućnim i poslovnim aplikacijama wireless router ima višestruku ulogu i to kao: AP, switch i router.



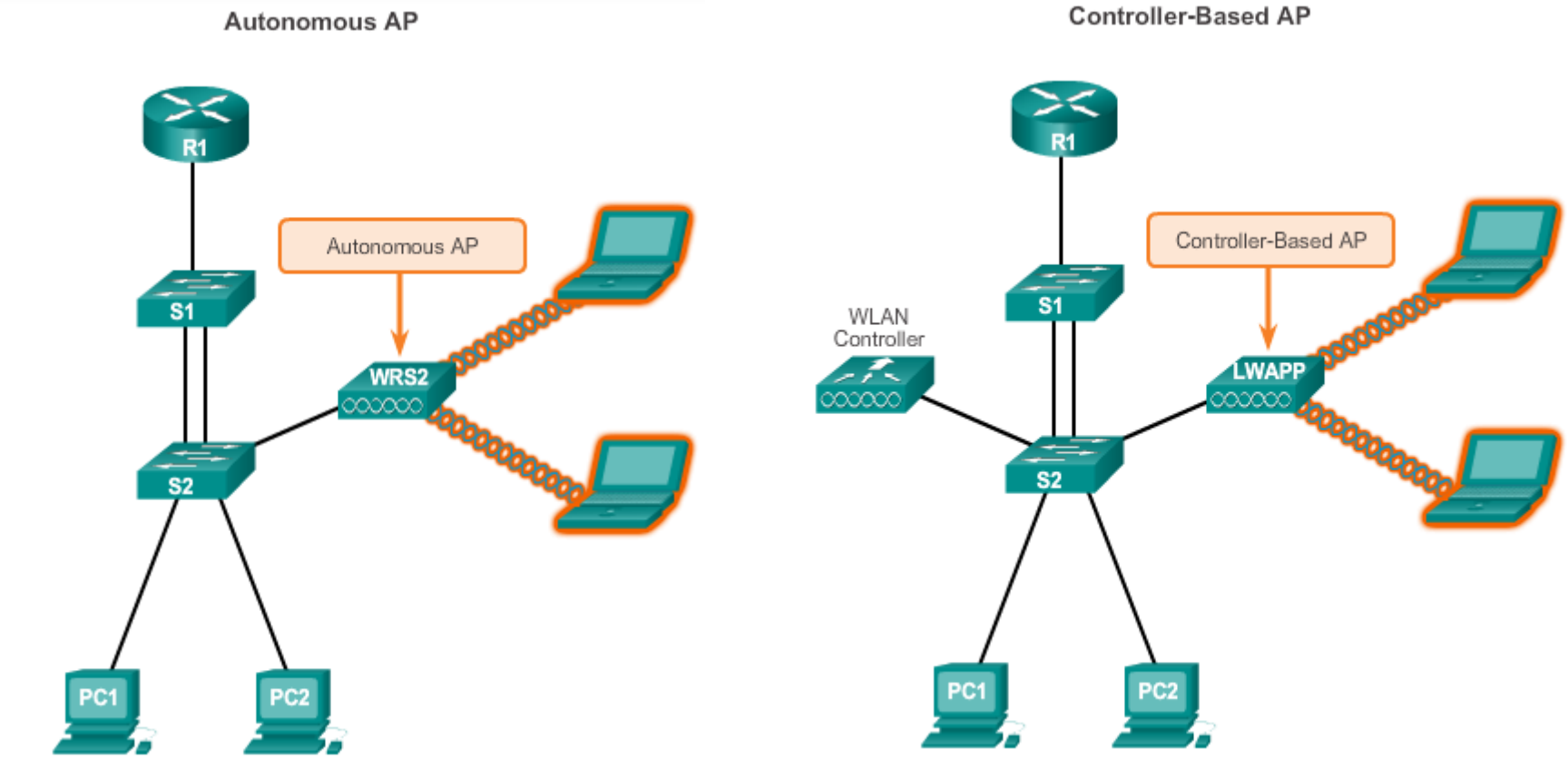
„Business Wireless Solutions“

- Primjer proširenje postojeće 802.3 Ethernet LAN infrastrukture upotrebom WLAN-a

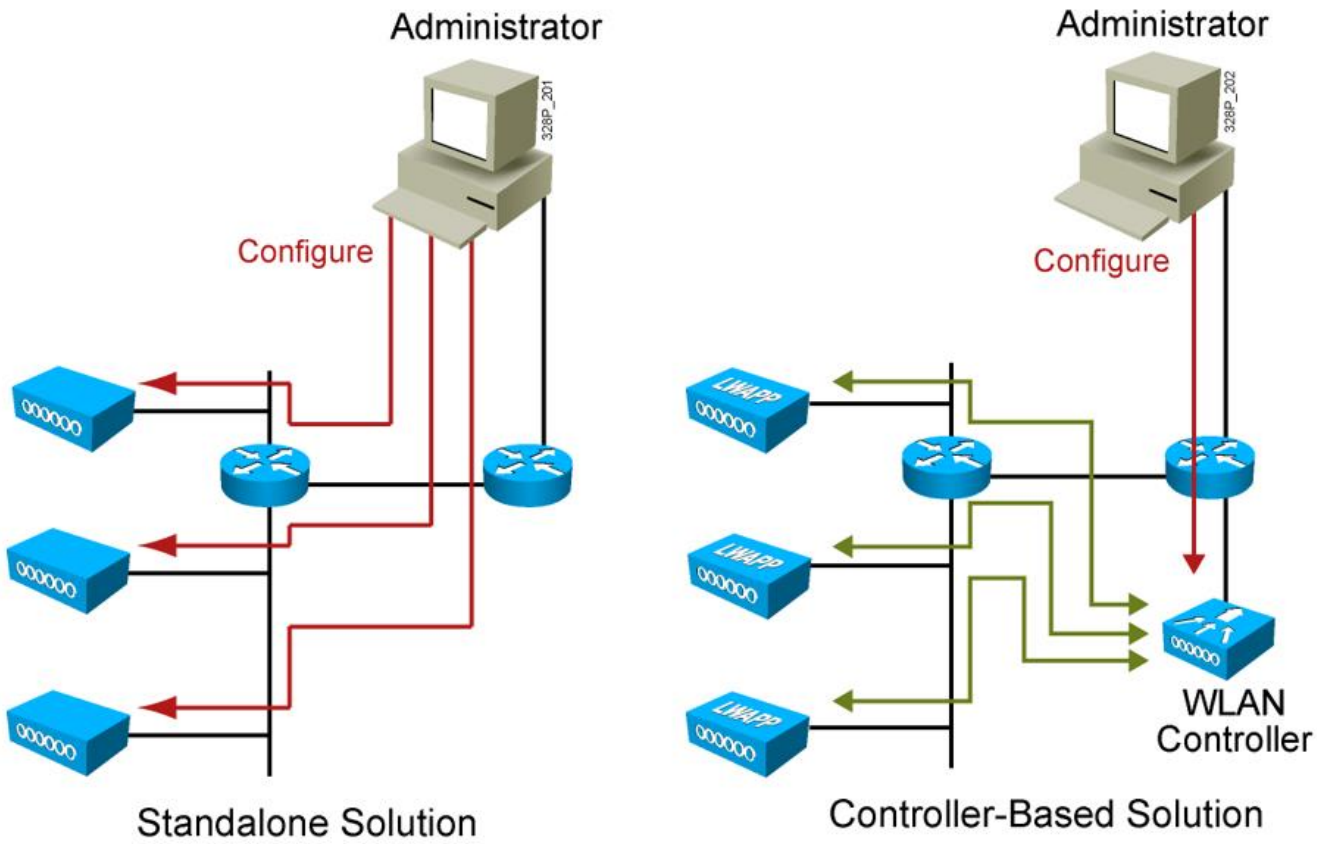


„Business Wireless Solutions“

- Mogućnost konfiguracije i administracije svakog AP („standalone“ AP) pojedinačno ili upotreba kontrolera i „lightweight“ AP uređaja .



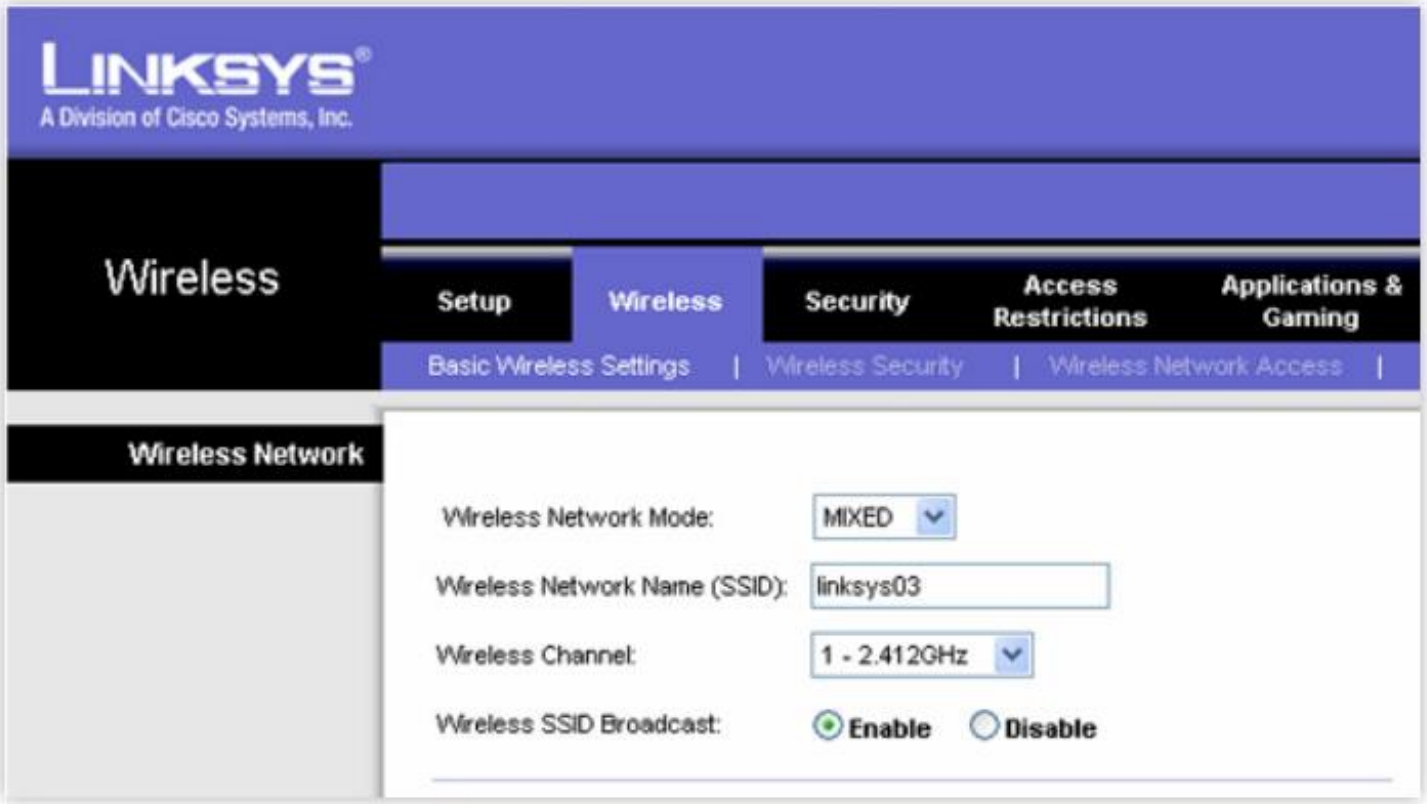
„Standalone“ i „Lightweight“ AP



Osnovni konfiguracioni parametri

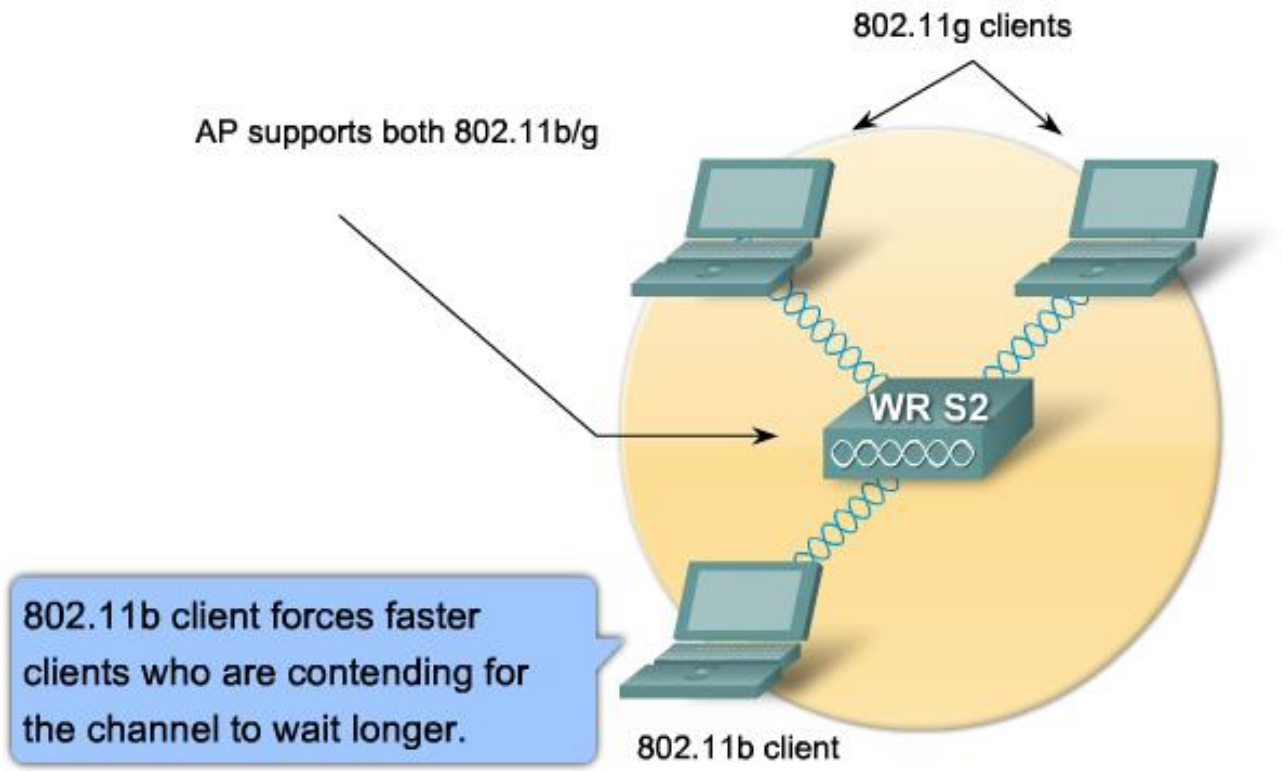
- Osnovni parametri:

  SSID, Password, Network Mode,Security Mode, Channel Settings



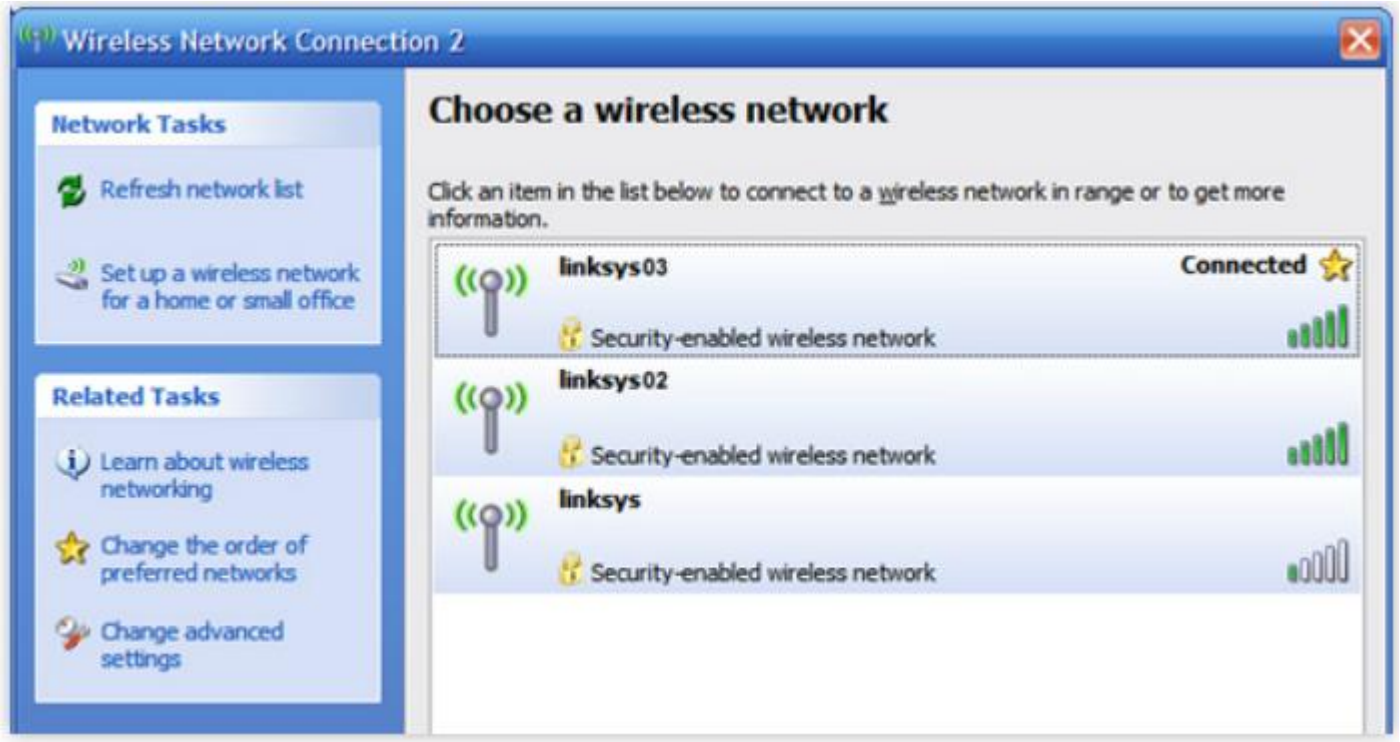
Osnovni konfiguracioni parametri

- Network mode se odnosi na korištene WLAN protokole: 802.11a, b, g, ili n.
- 802.11g je unazad kompatibilan sa 802.11b---access point podržava oba standarda.
- Mixed mode: AP konfigurisan da dozvoljava rad na oba mode



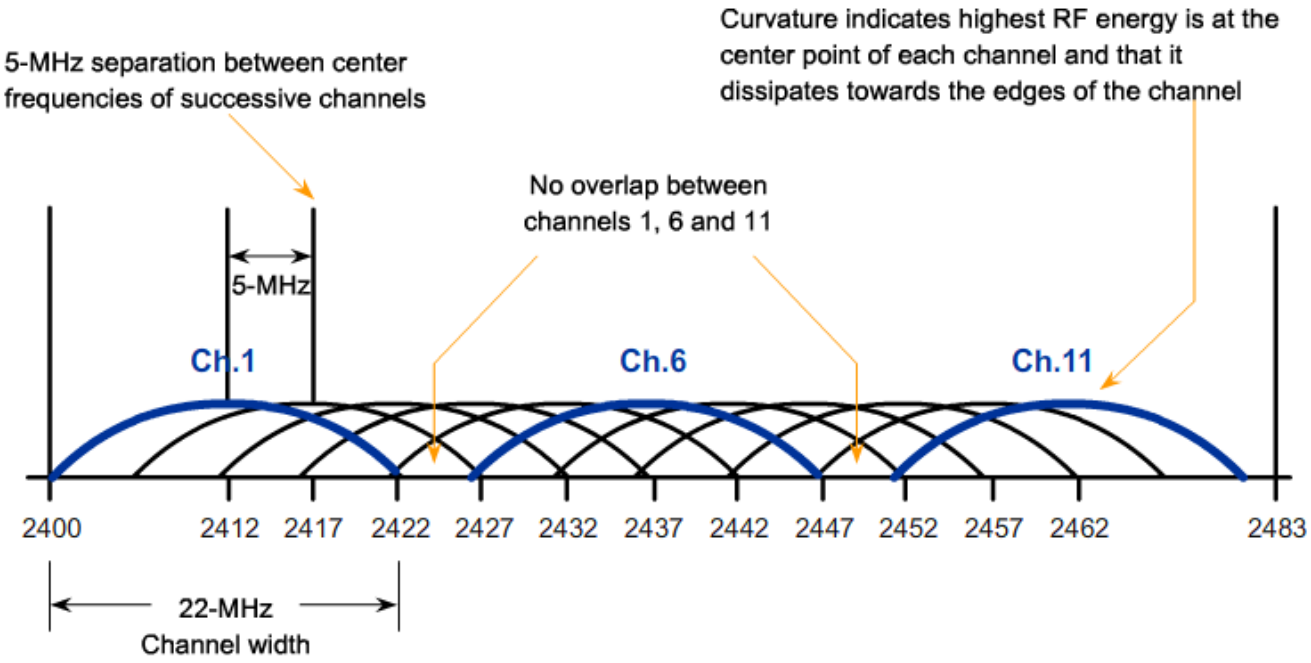
Osnovni konfiguracioni parametri

- SSID je jedinstveni identifikator koji se koristi da se razlikuju bežične mreže
- Nekoliko AP može da dijeli SSID

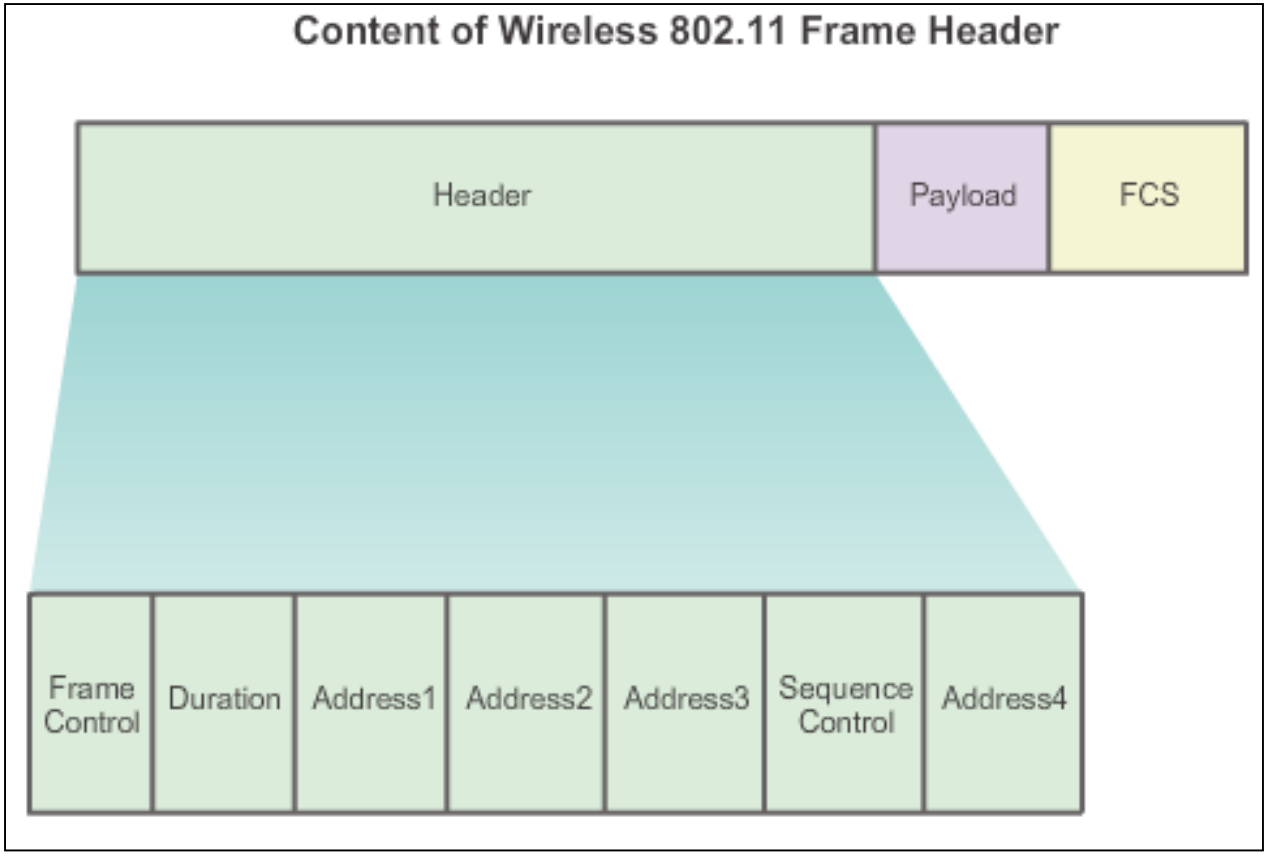


Osnovni konfiguracioni parametri

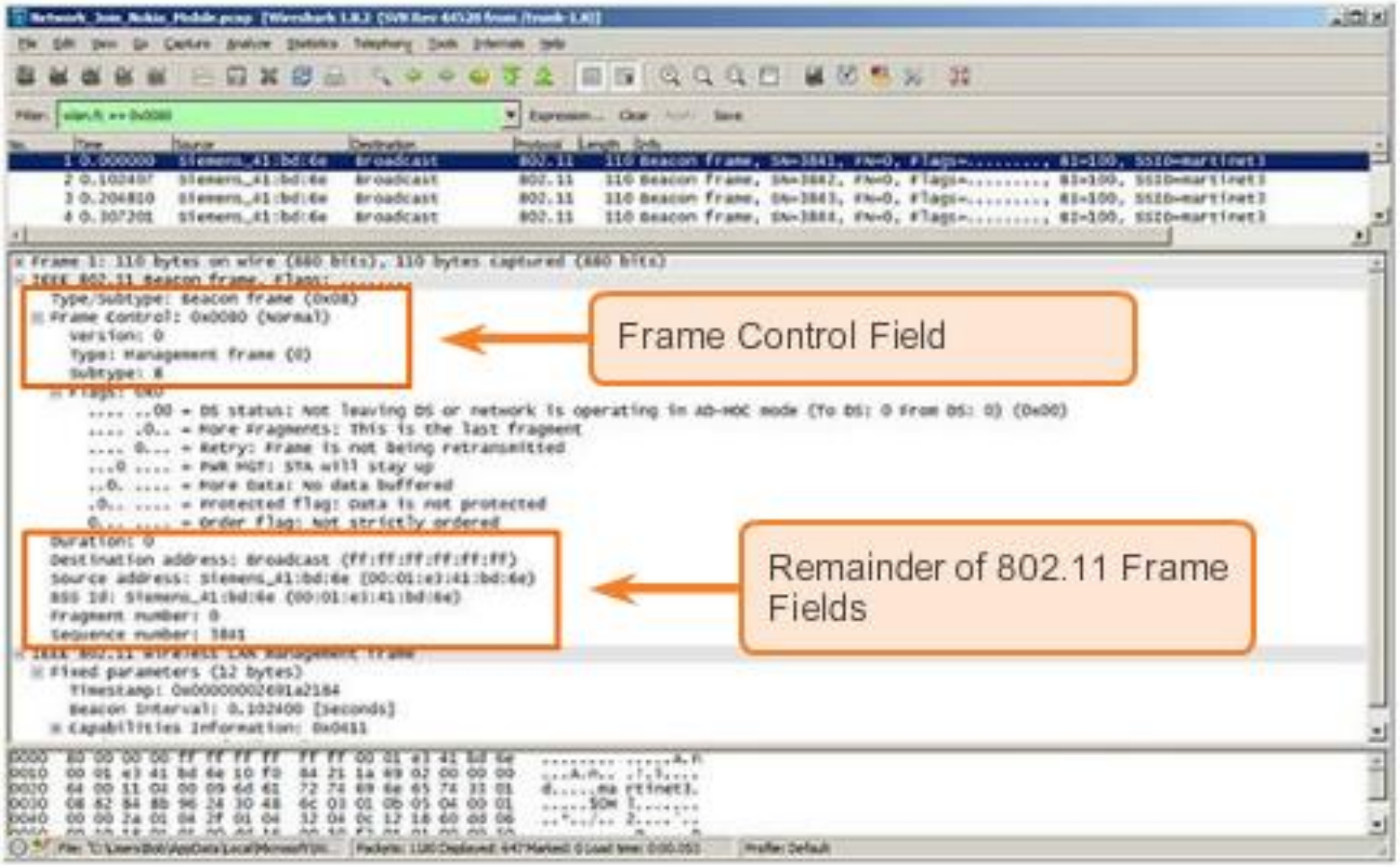
- IEEE 802.11 uspostavlja šemu kanala koji se koriste u nelicenciranom ISM RF opsegu u WLAN mrežama.
- 2,4 GHz opseg je raspodijeljen u 11 kanala u USA i 13 kanala u Evropi.
- Preporuka je da se izbjegava preklapanje kanala. Primjer: Ako se koriste tri AP mogu se koristiti kanali 1,6,11.



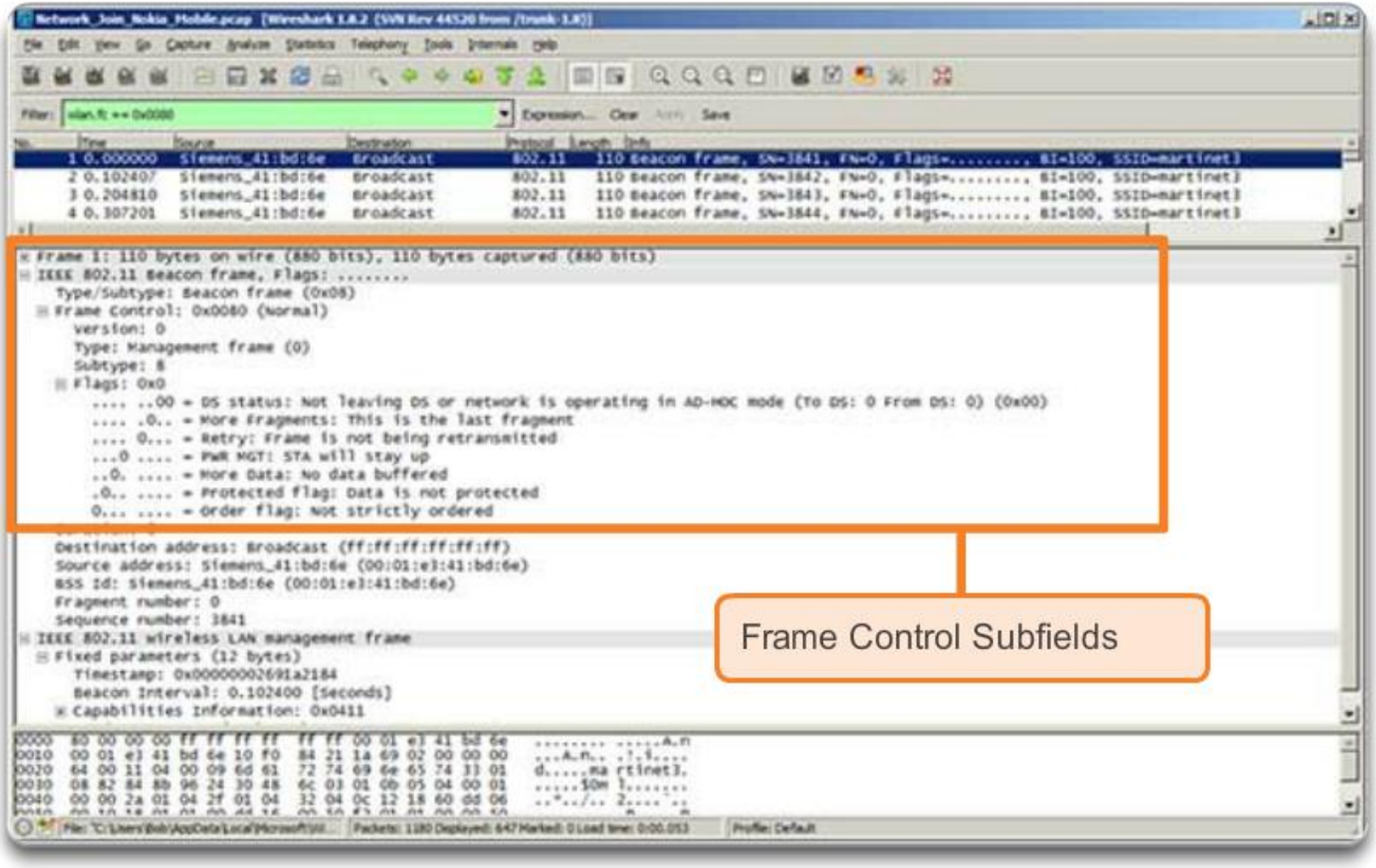
Wireless 802.11 Frame



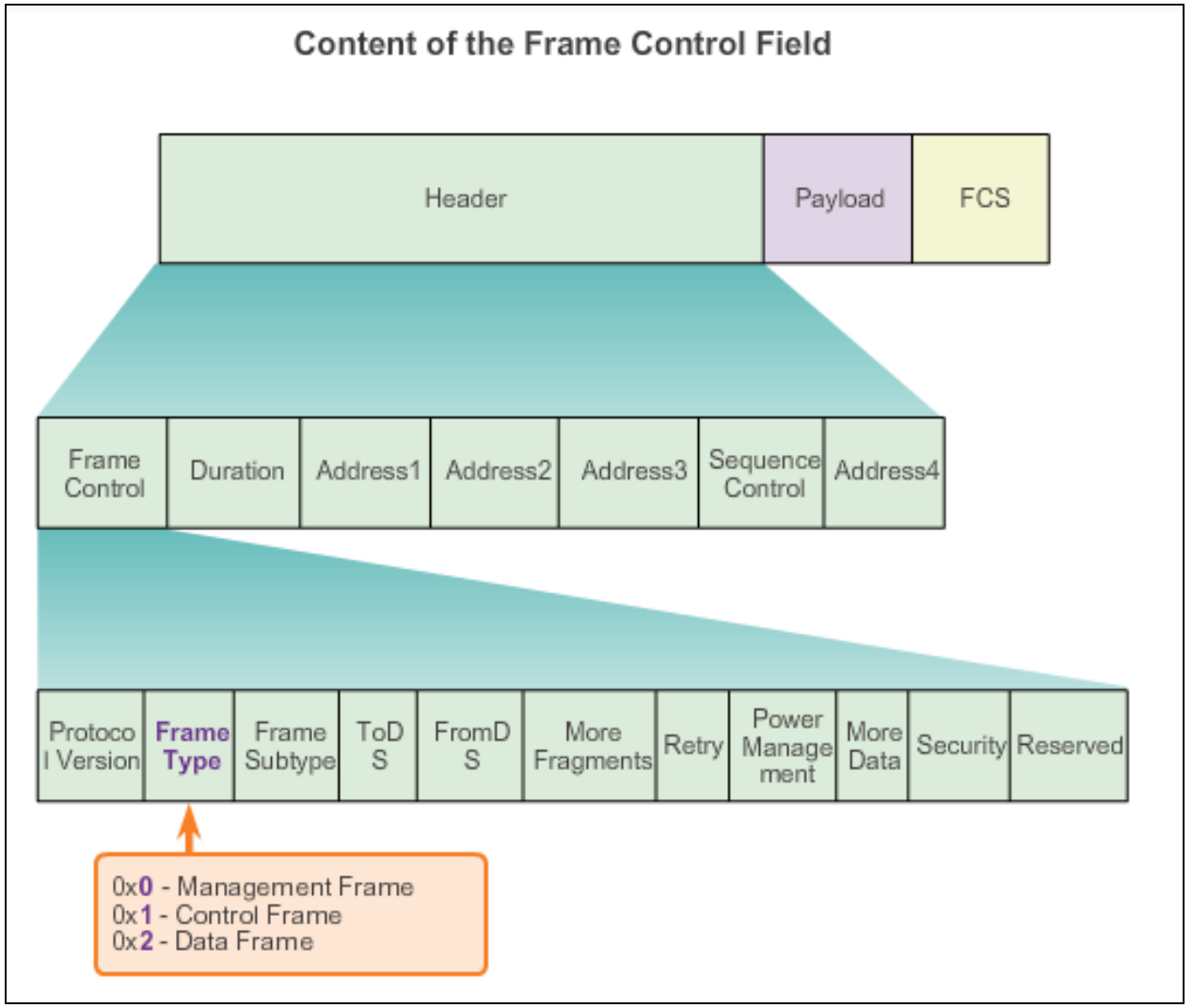
Wireless 802.11 Frame



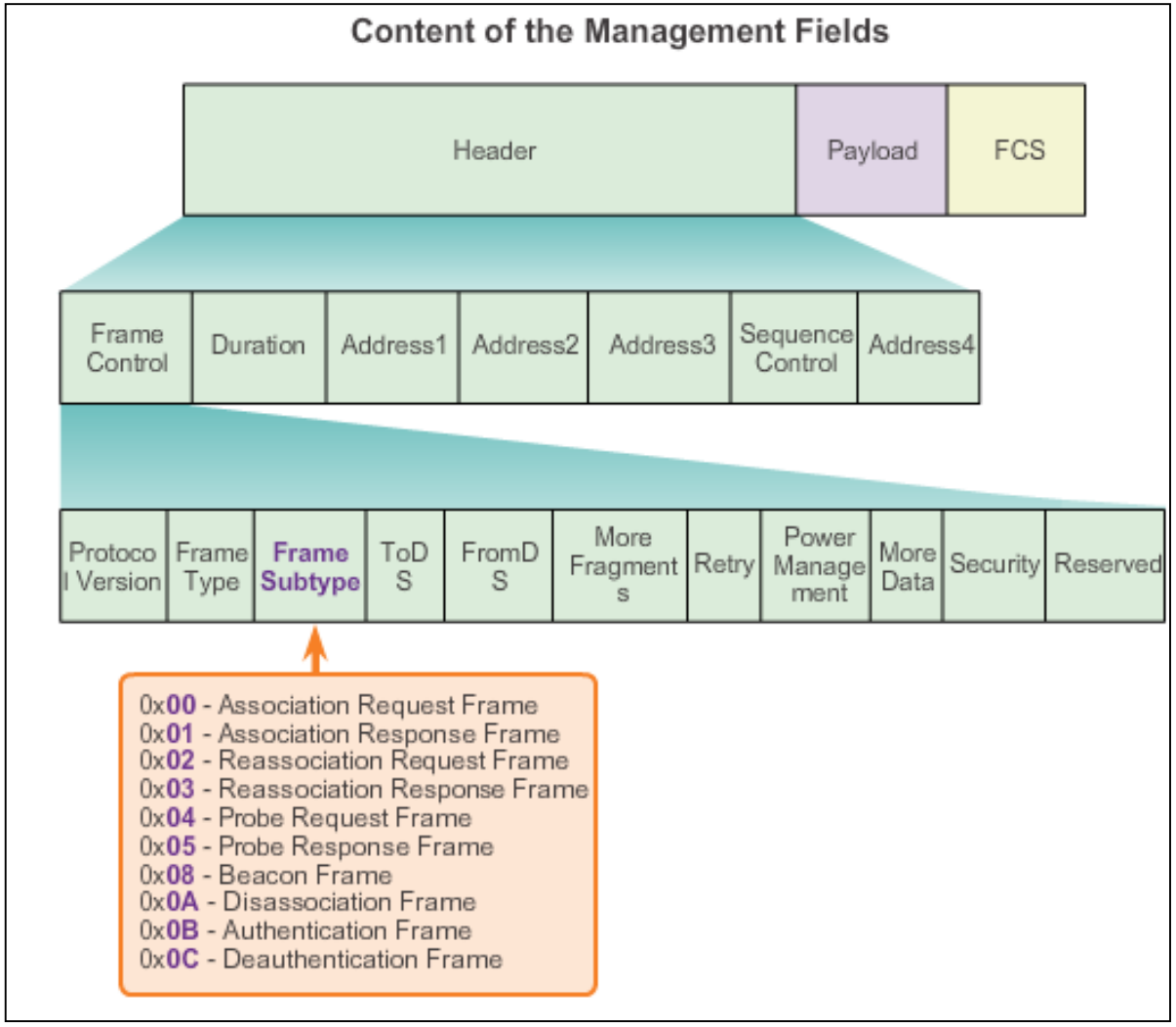
Wireless 802.11 Frame



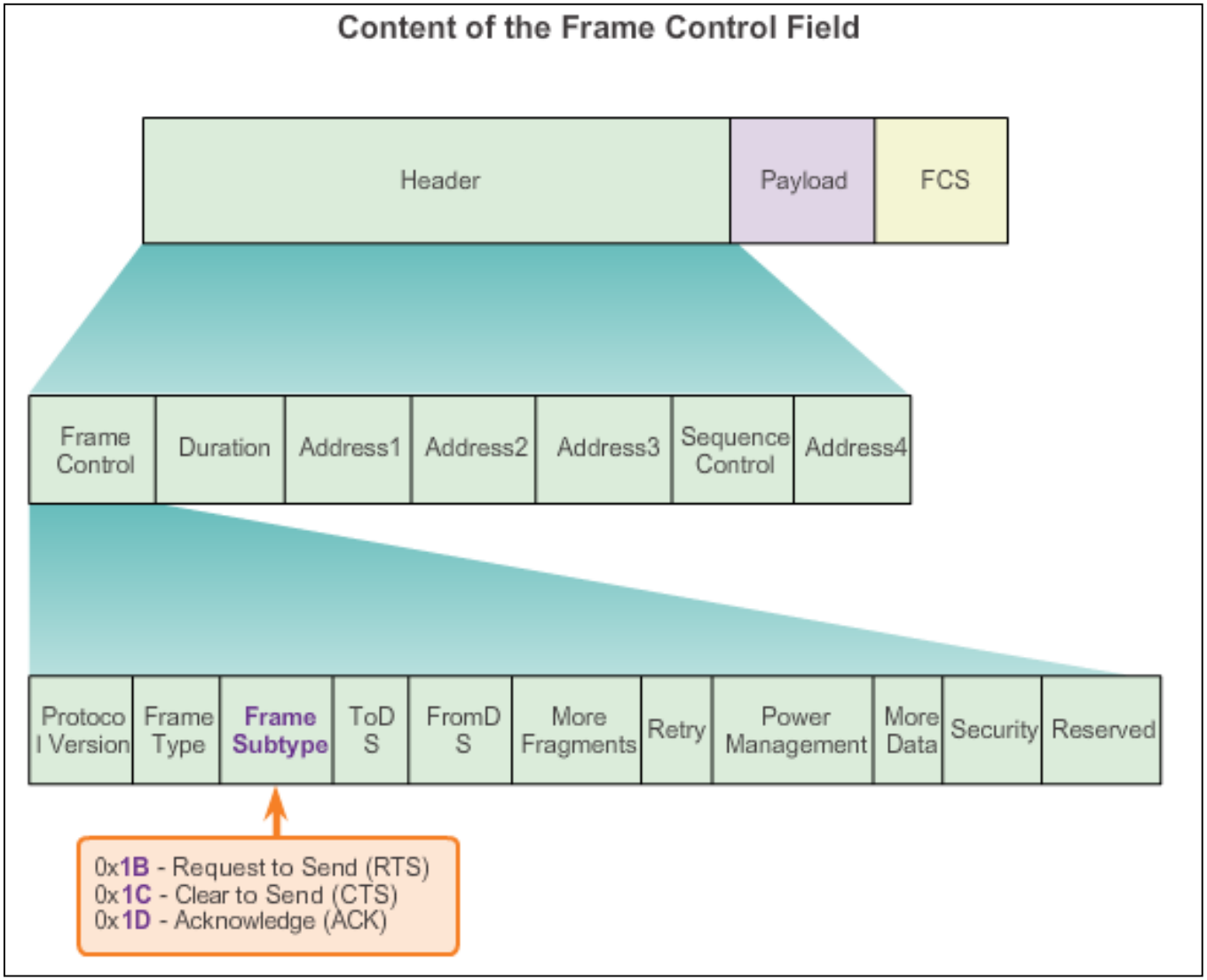
Wireless Frame Type



Management Frames



Control Frames

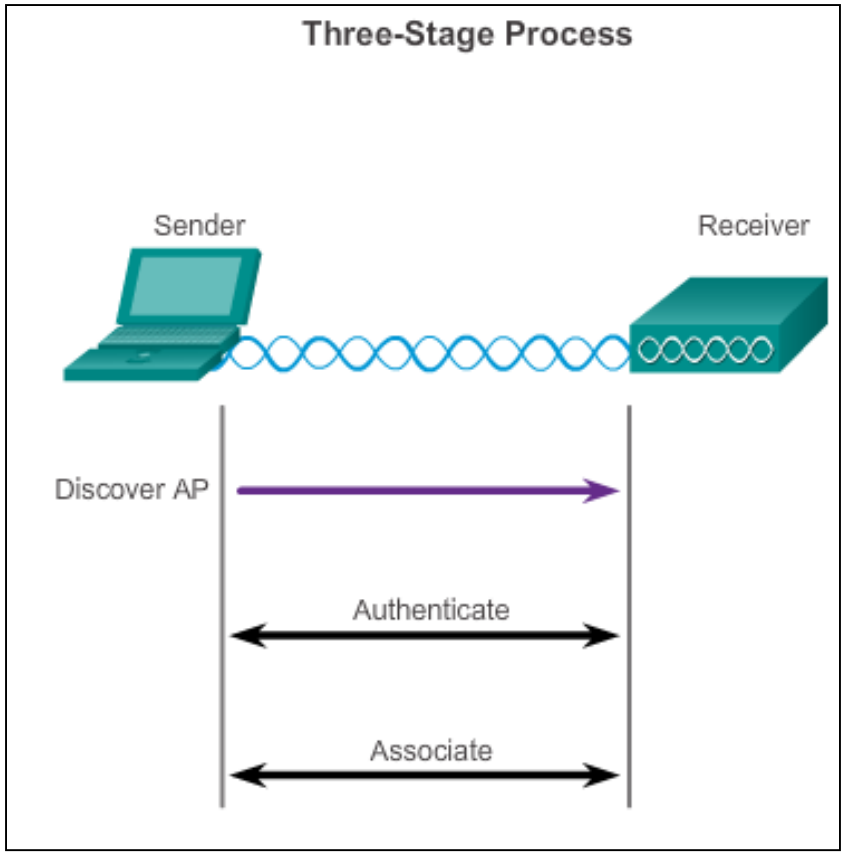


Asocijacija klijenata na AP –tri faze

- Otkrivanje AP

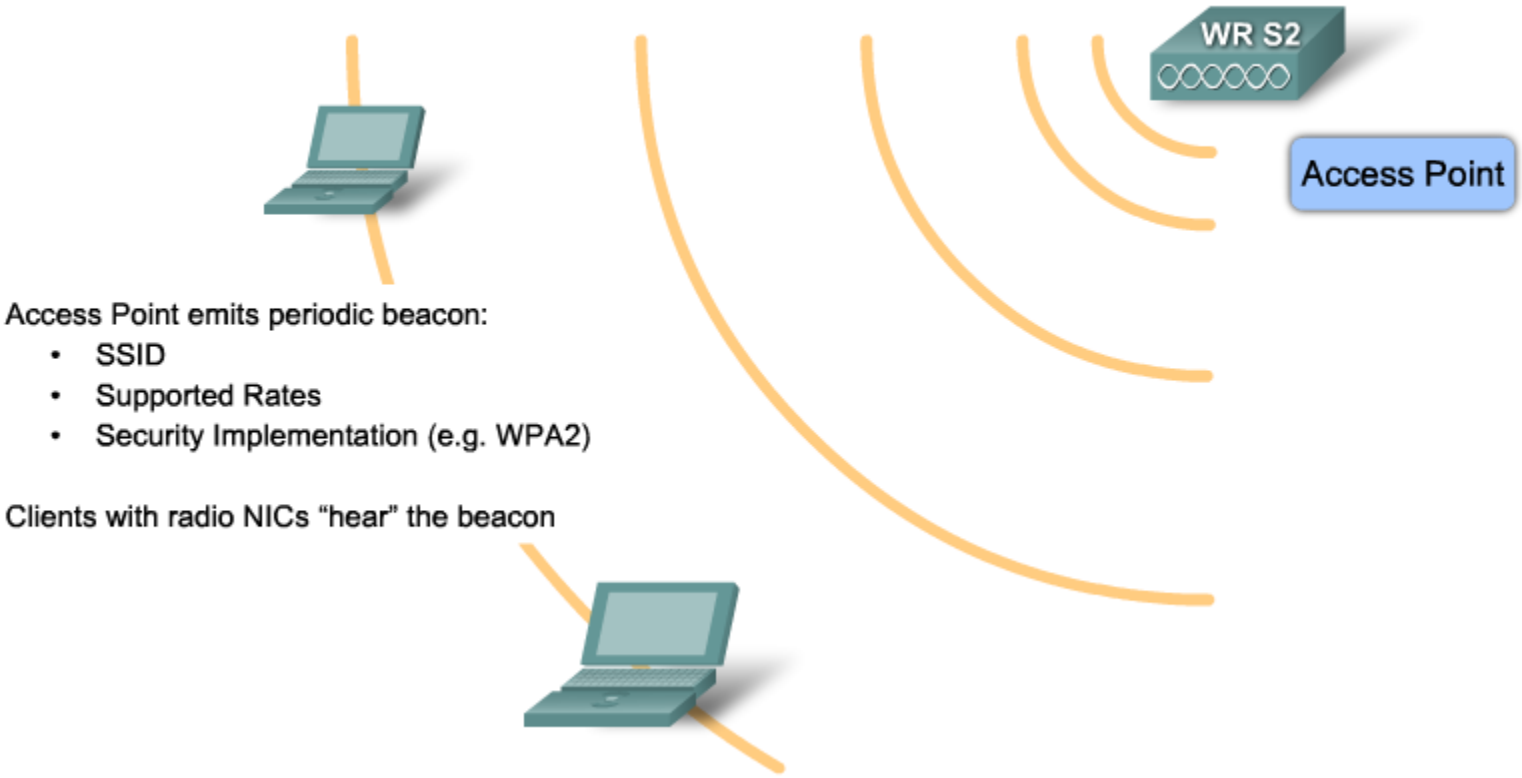
Passive Mode: Ne mora se poznavati SSID

Active Mode: Klijent mora da poznaje SSID



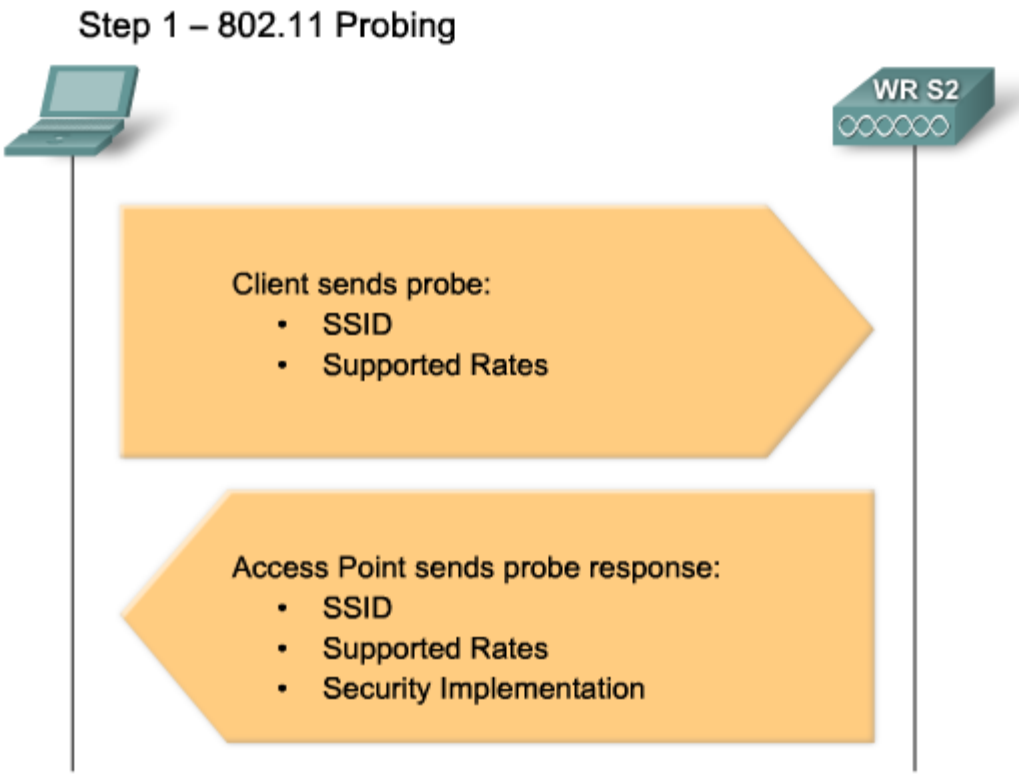
Asocijacija klijenata na AP -Beacon

- Beacon je frejm koji se u WLAN mrežama koristi da se oglasi prisustvo.
- Uloga je da WLAN klijenti uče koje mreže i AP su raspoložive u datoj oblasti.



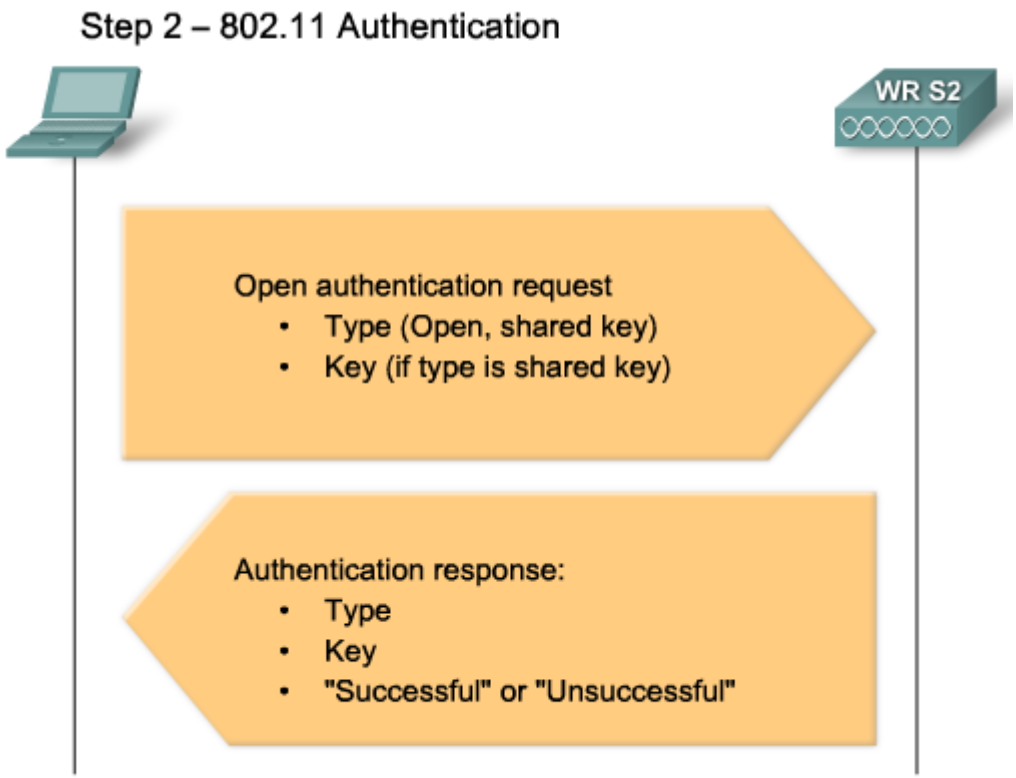
Asocijacija klijenata na AP -Probing

- Klijenti traže mrežu šaljući „probe“ zahtjev na više kanala
- Probe request specificira SSID i bit rate.



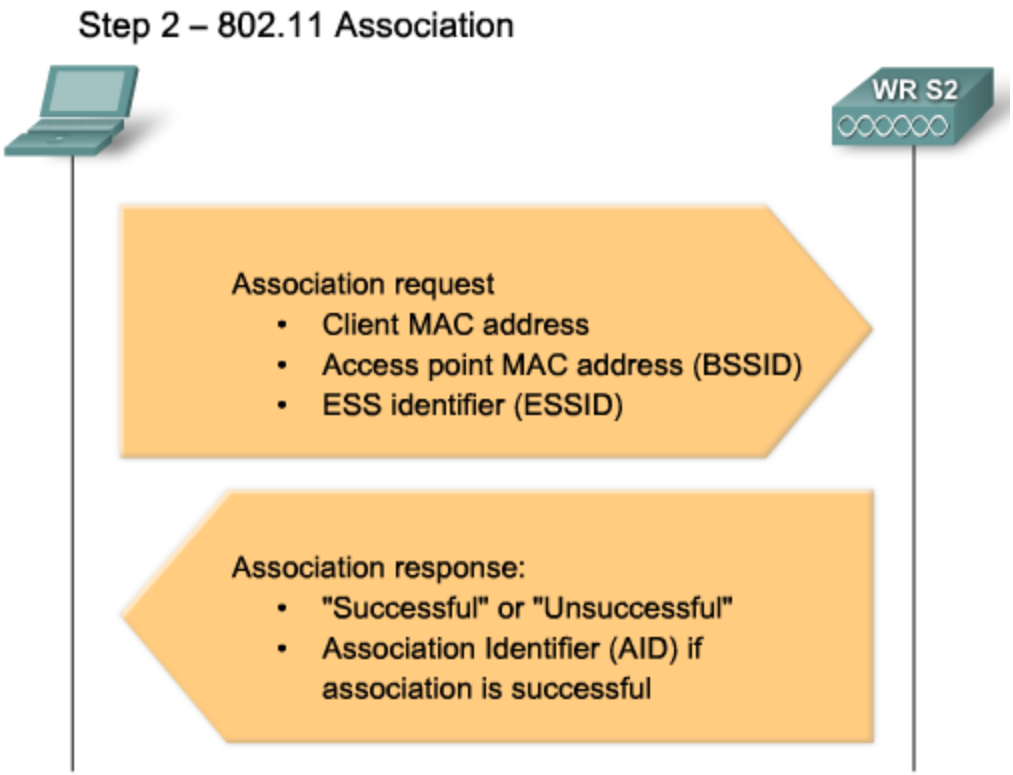
Asocijacija klijenata na AP - autentifikacija

- Dva mehanizma autentifikacije:
  -open authentication,
  -upotreba ključeva koji se dijele između AP i klijenta



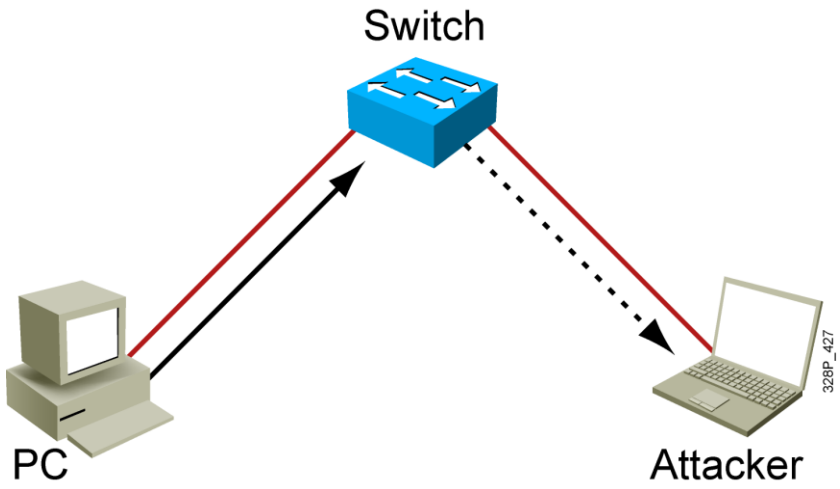
Asocijacija klijenata na AP -asocijacija

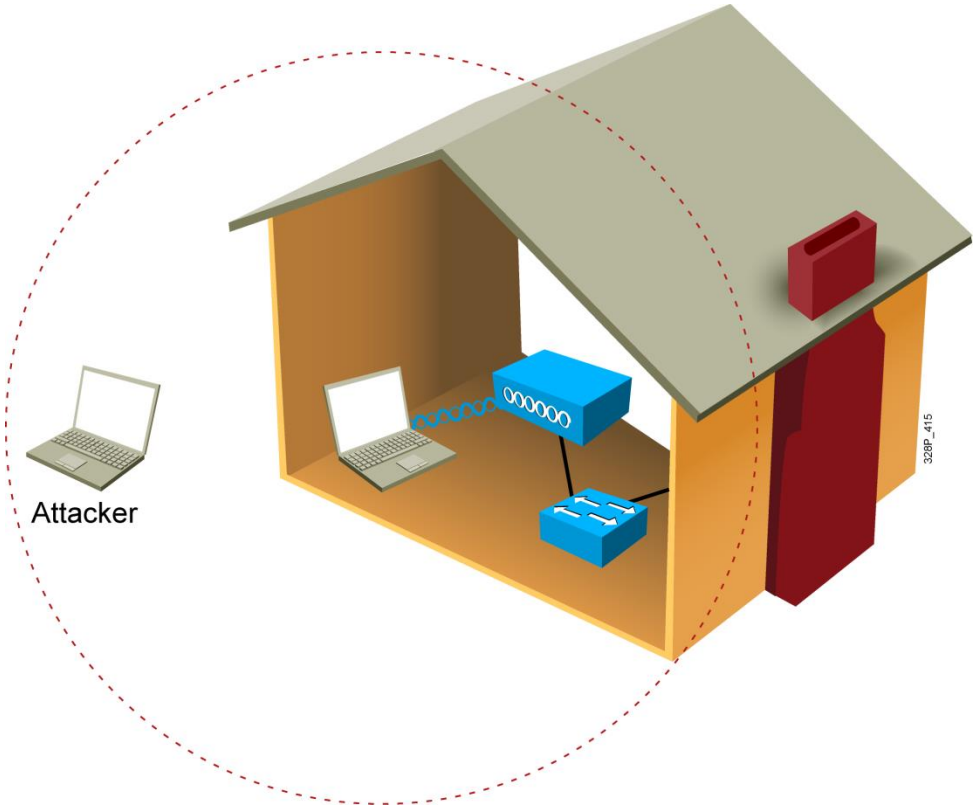
- Uspostavlja se veza između AP i klijenta
- Klijent uči BSSID, a AP mapira logički port (AID) za klijenta
- AID (association identifier) je ekvivalent portu na switch-u



Wireless LAN
-osnovni pojmovi sigurnosti

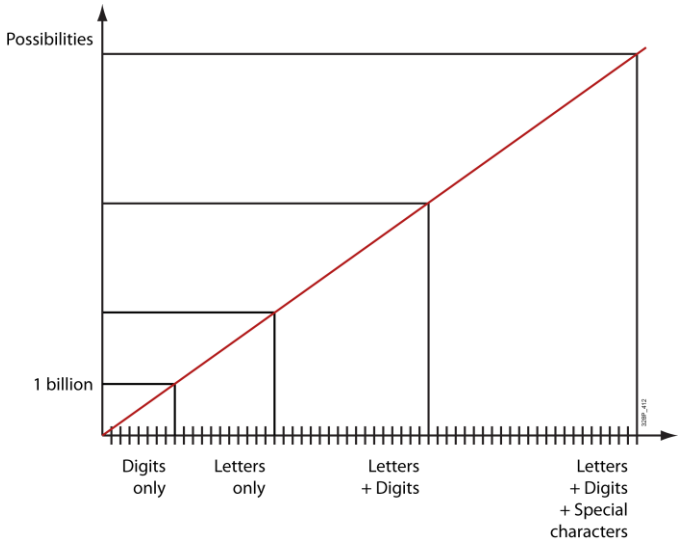
Privatnost: Wired / Wireless

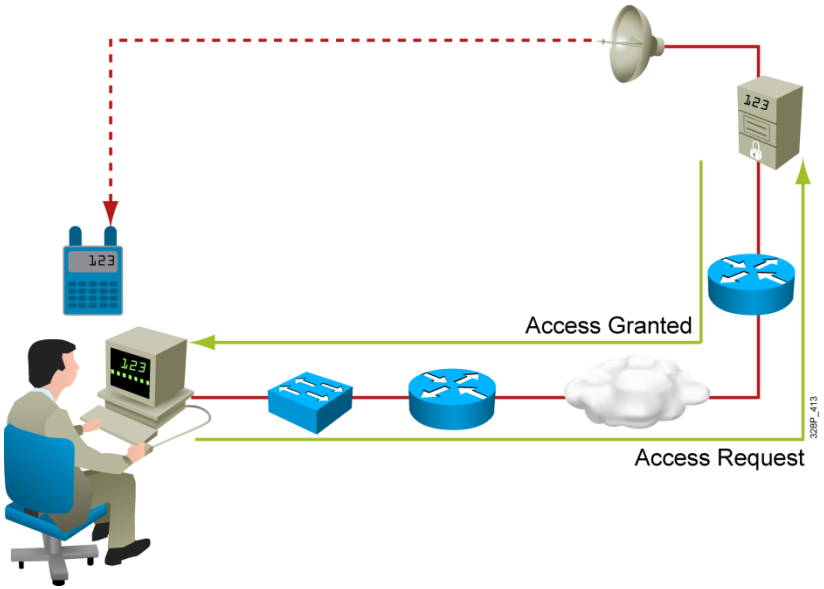




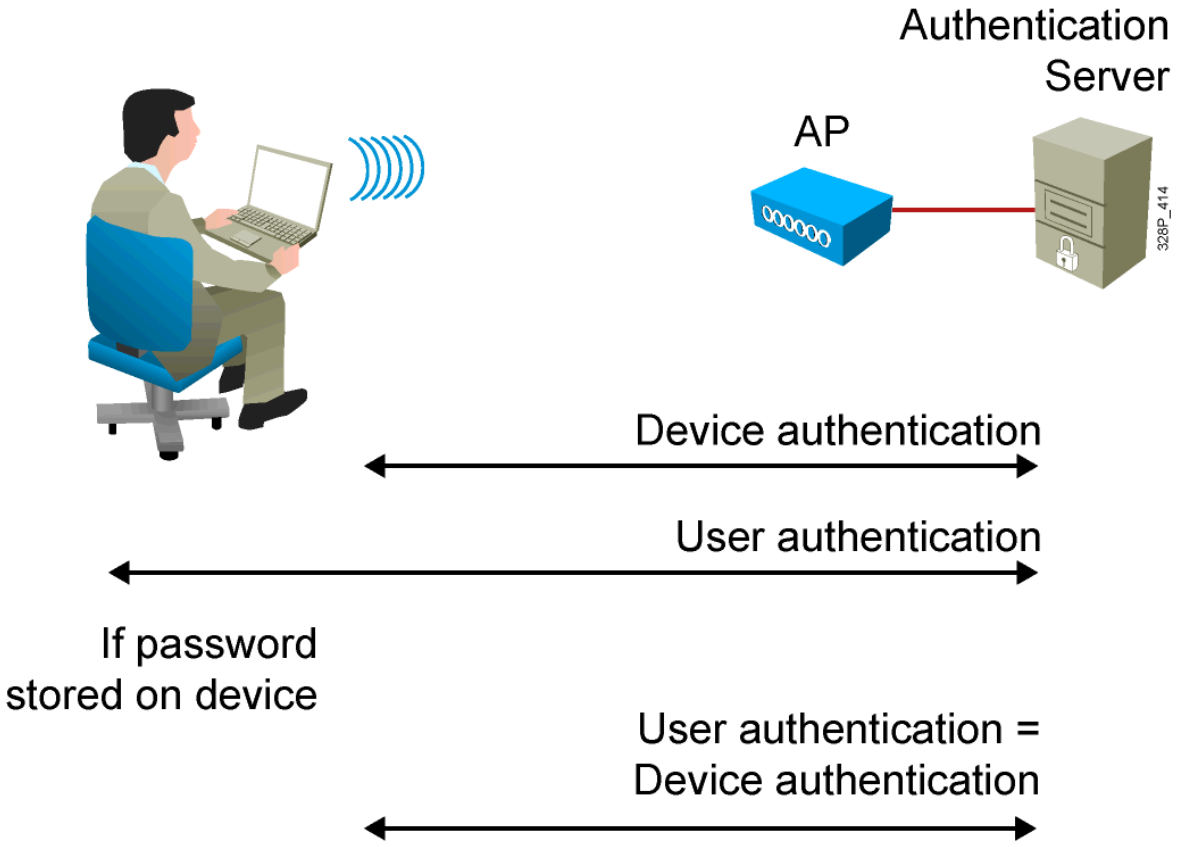
Autentifikacija-opšti koncepti

- Dokaz o identitetu se može pružiti koristeći:
  - Nešto što se poznaje!
    - Password
    - „Something you do“
  - Nešto što se posjeduje!
    - „Physical object“
    - „Value read from a device you have“
  - Nešto što jesi!
    - „Biometric reading“

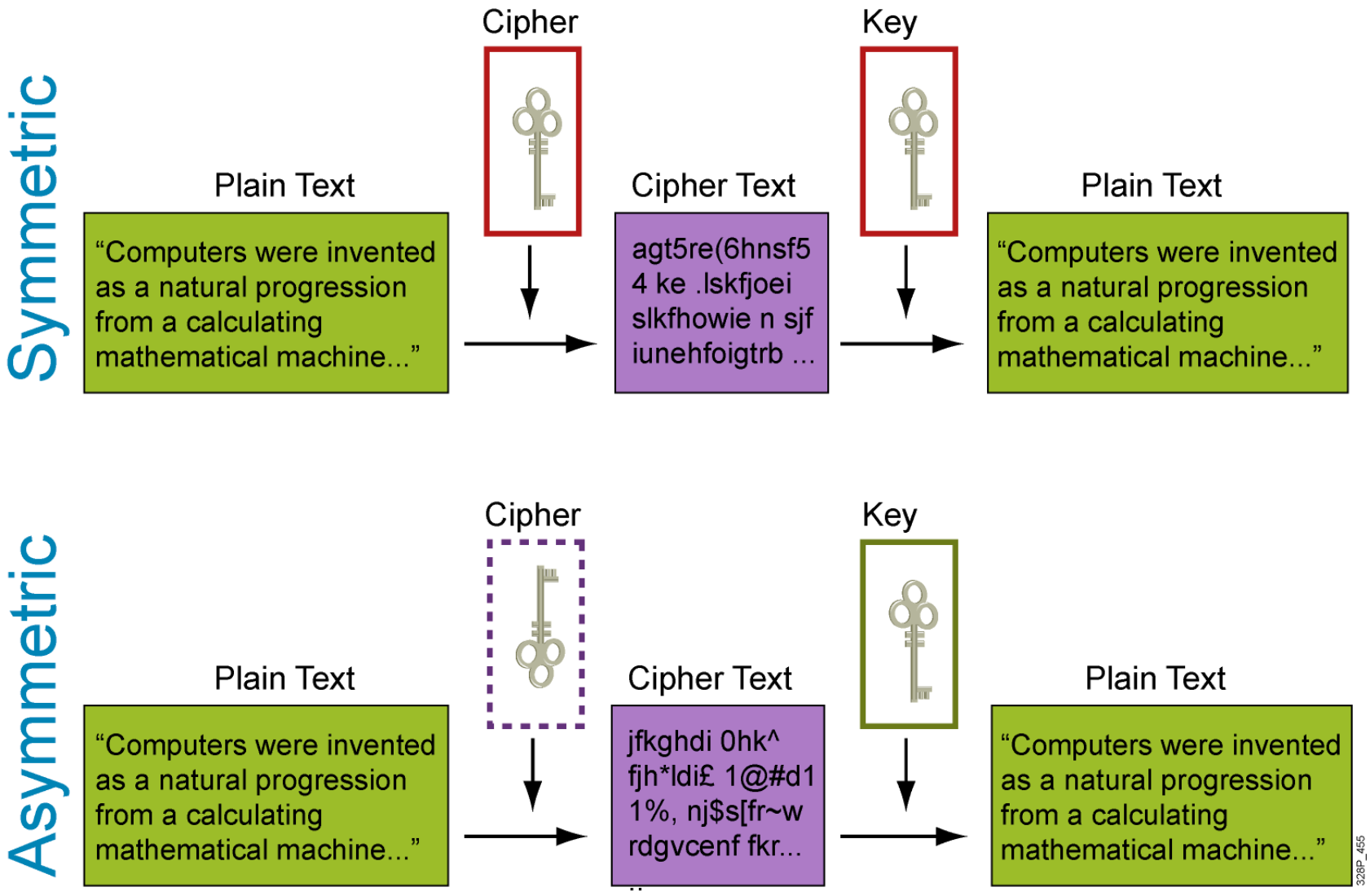




Authentifikacija uređaja/korisnika



Simetrična i asimetrična enkripcija



Open, WEP, MAC-osnovni pojmovi

- Open autentifikacija je „default“ IEEE 802.11 metod pristupa. Bazira se samo na poznavanju SSID.
- WEP se može koristiti i za autentifikaciju i enkripciju. Ne smatra se pouzdanim metodom zaštite privatnosti u bežičnim mrežama.
- Moguće je realizovati filtriranje bazirano na MAC adresama po WLAN. Autorizacija klijenata po MAC adresama se može izvesti lokalno, na kontroleru ili pomoću RADIUS servera.

Autentifikacija -open

1- Client sends probe request. [RF-Packet]

2- Access points (A/B) send probe response. Client evaluates access point response, selects best access point. [RF-Packet]

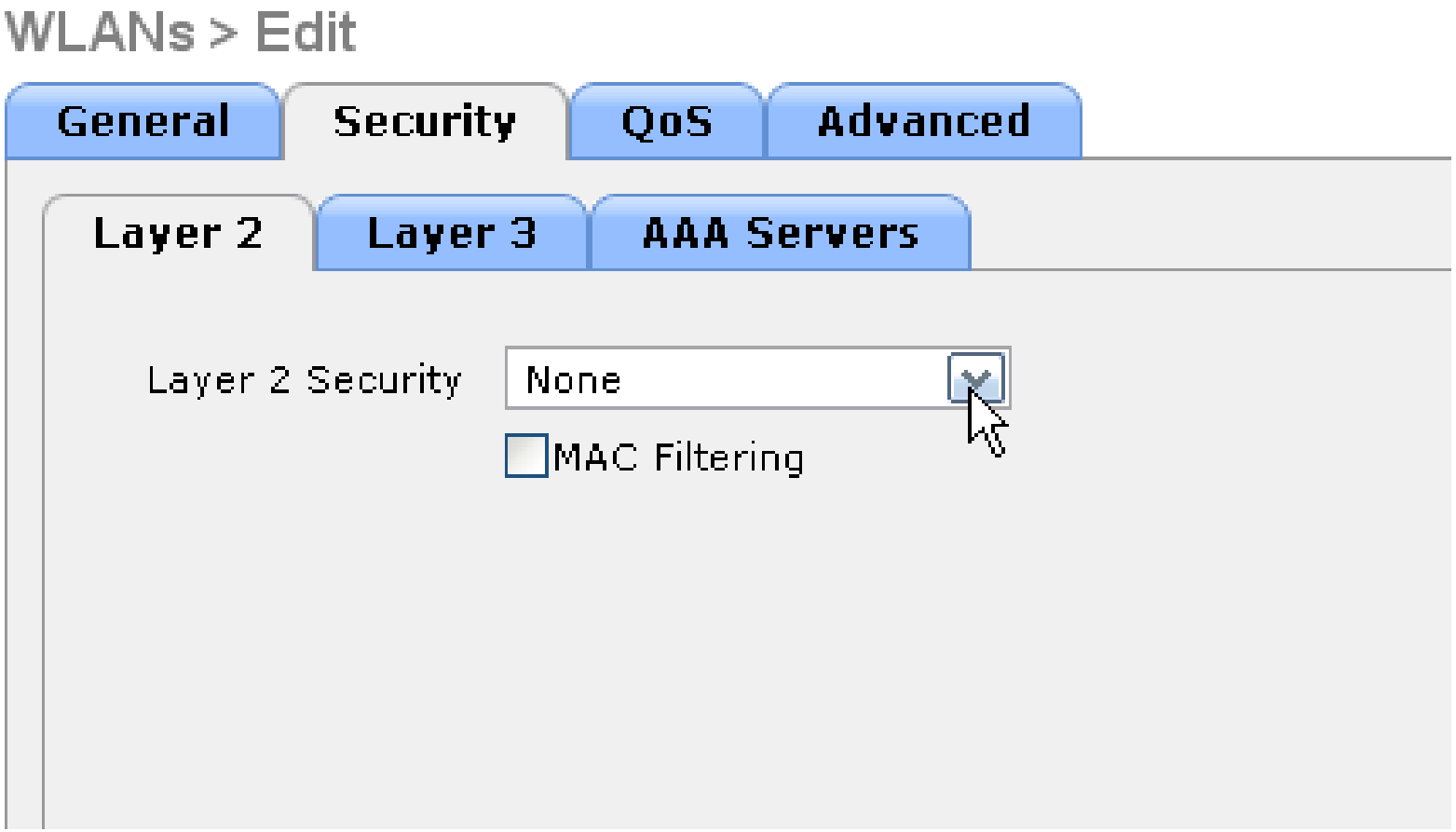
3- Client sends authentication request to selected access point (A). [RF-Packet]

4- Access point (A) confirms authentication and registers client. [RF-Packet]

5- Client sends association request to selected access point (A). [RF-Packet]

6- Access point (A) confirms association and registers client. [RF-Packet]

Primjer: WLANs > Edit > Security



Autentifikacija : PSK (WEP)

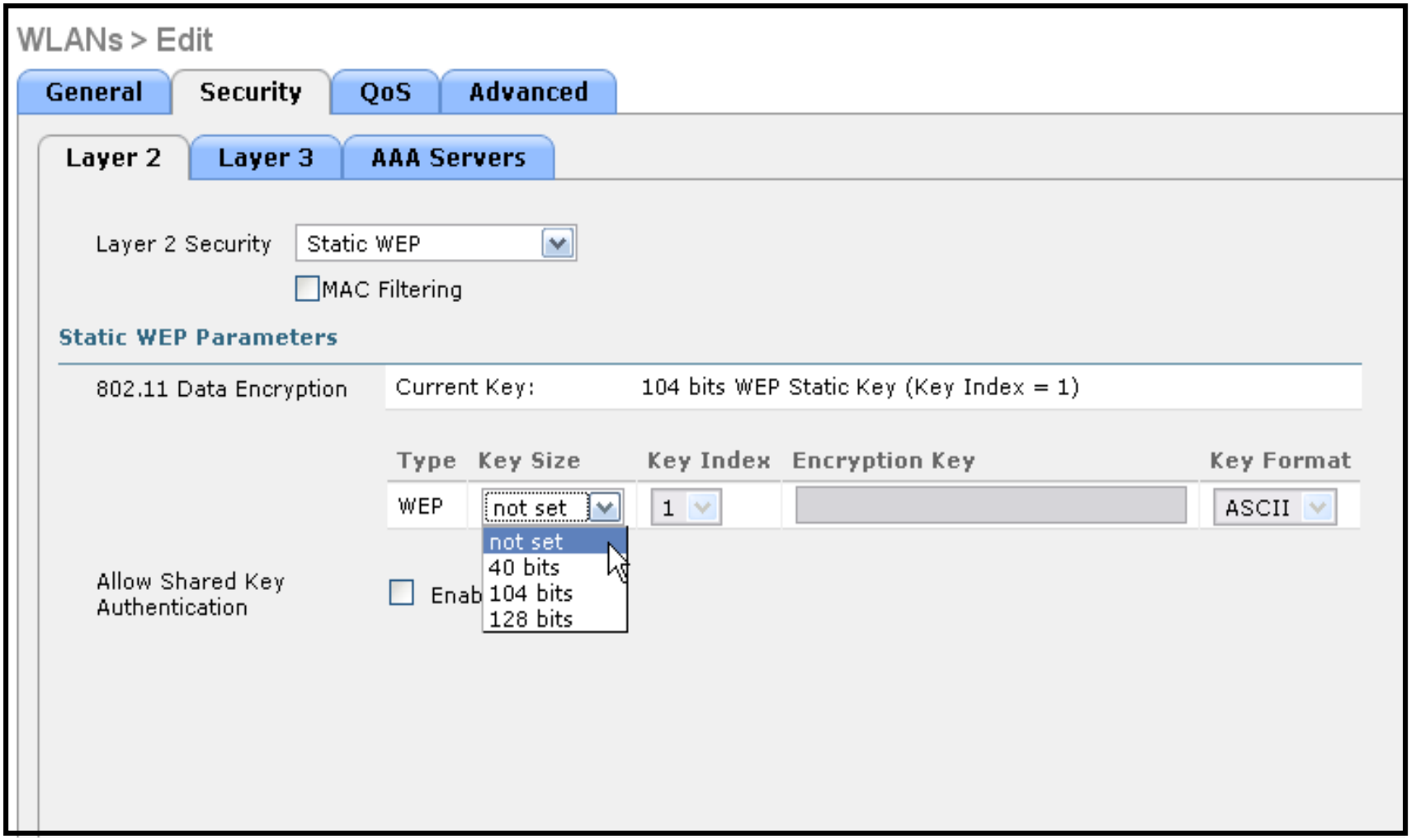
- WLAN sigurnosni protokol definisan u 802.11 specifikaciji:
  - Realizuje se na Layer 2 i ne omogućuje „end-to-end“ sigurnost

4- Access point (A) sends authentication response containing the unencrypted challenge text. [RF-Packet]

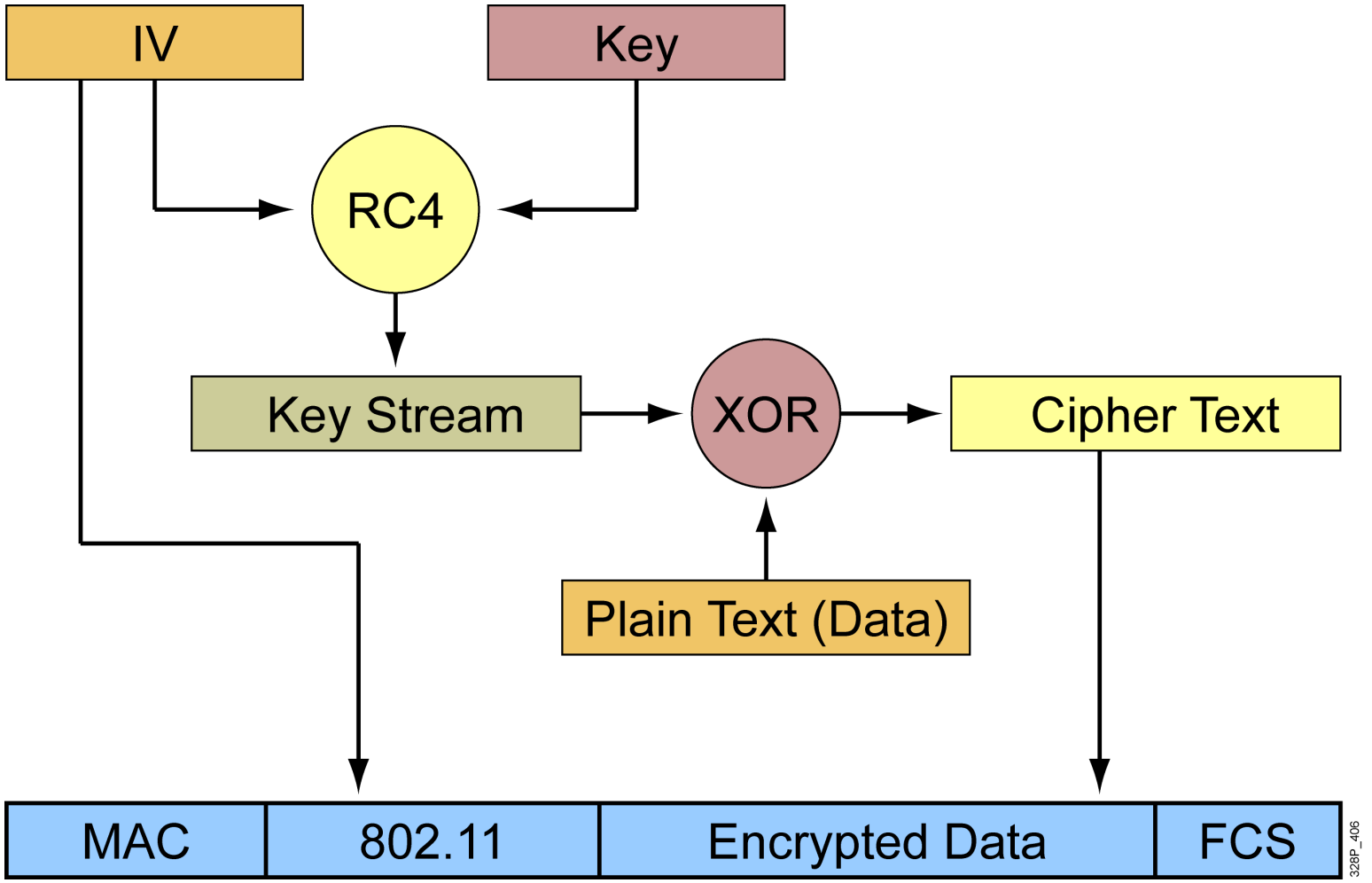
5- Client encrypts the challenge text using one of its WEP keys and sends it to access point (A). [RF-Packet]

6- Access point (A) compares the encrypted challenge text with its copy of the encrypted challenge text. If the text is the same, access point (A) will allow the client onto the WLAN. [RF-Packet]

Primjer: WEP konfiguracija



WEP Engine


IV
Key
RC4
Key Stream
XOR
Cipher Text
Plain Text (Data)
MAC
802.11
Encrypted Data
FCS
328P_406

Primjer: WLAN > Edit

Može se realizovati kombinacija sa drugim principima Layer 2 ili Layer 3 sigurnosti