Spectrum Analyzer, Routing Tables

Maria Plakia plakia@csd.uoc.gr
Michalis Katsarakis katsarakis@csd.uoc.gr

Tutorial: 335a http://www.csd.uoc.gr/~hy335a/
23 October 2012

Outline

- Radio Frequency Wave Propagation
- Spectrum Analyzer Demonstration
- Routing Tables

RADIO FREQUENCY WAVE PROPAGATION

Fundamental aspects of wireless communications

***Fading*:** the *time variation* of the channel strengths due to:
- *Small-scale effect* of multipath fading

- *Larger-scale effects*, such as
  - Path loss via ***distance attenuation*** and
  - Shadowing via ***obstacles***

Interference:
Unlike the wired world where transmitter-receiver pair can often be though of as an isolated point-to-point link, wireless users communicate over the air & there is significant interference between them

Types of fading

- **Large-scale fading**

due to path loss of signal as a function of distance and shadowing by large objects (hills, buildings)

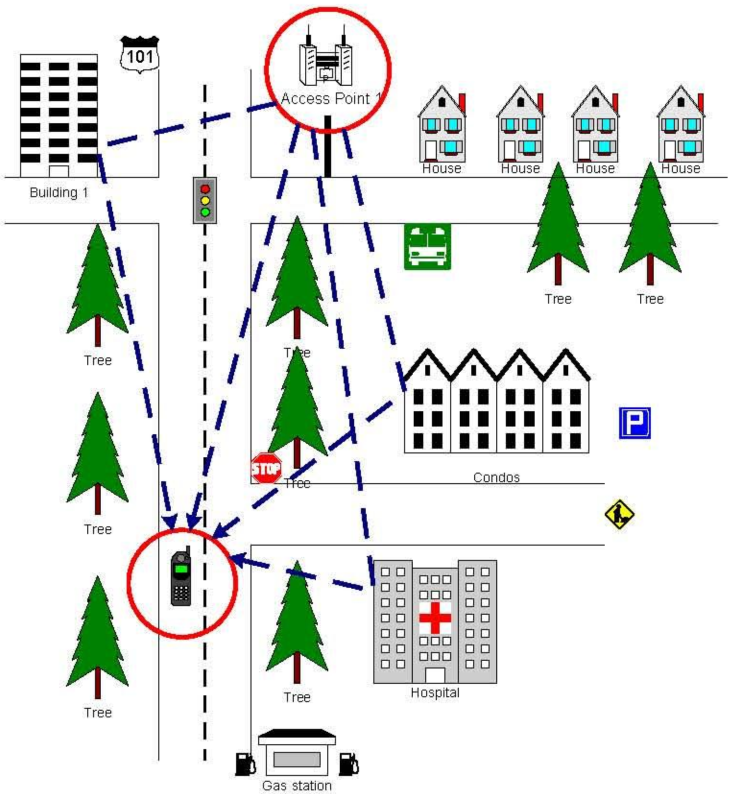
☞ This occurs as the mobile moves through a **distance of the order of the cell size** and is typically **frequency independent**

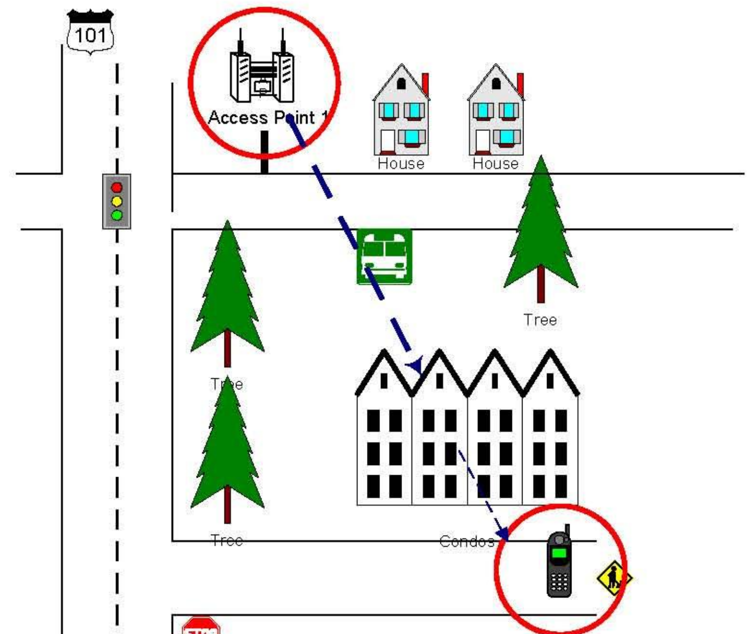
- **Small-scale fading**

due to constructive & destructive interference of ***multiple signal paths*** between the transmitter and receiver

☞ This occurs at the **spatial scale of the order of the carrier wavelength** and is **frequency dependent**

Radio Frequency Wave Propagation





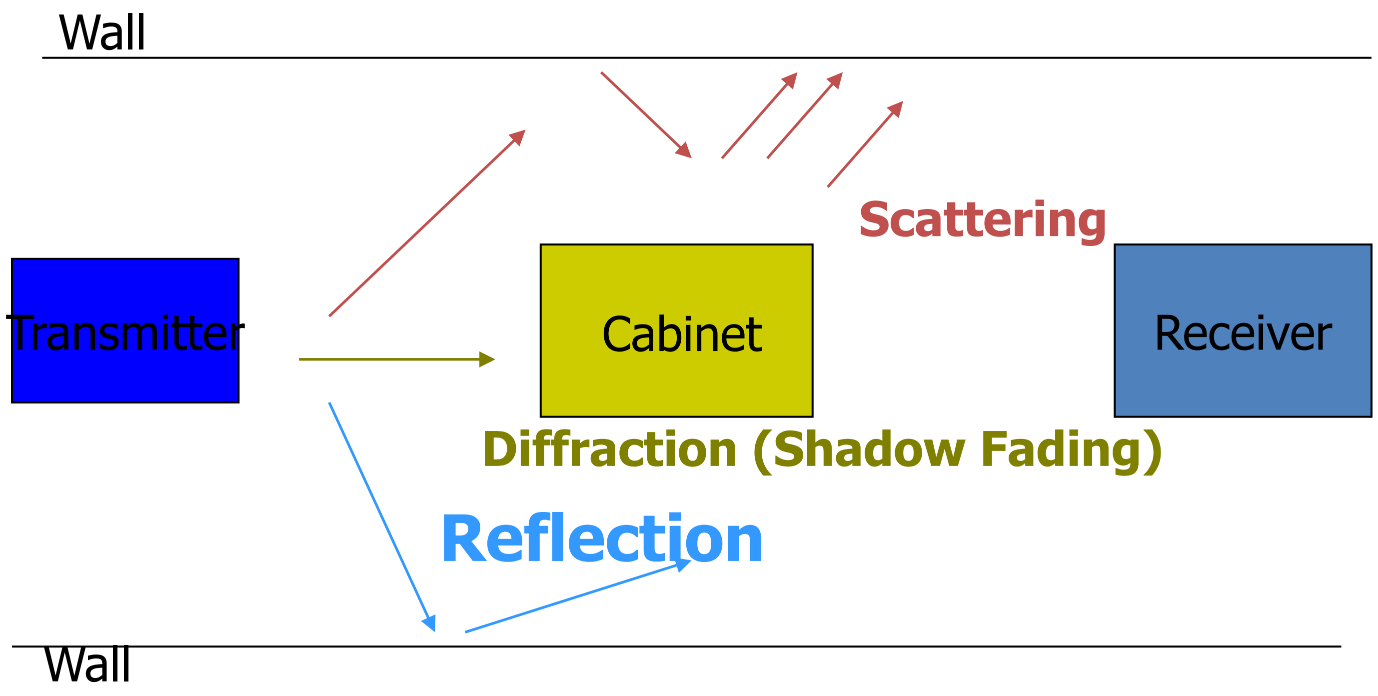
Multipath Fading

- caused by multiple reflections

Shadowing

- caused by physical obstructions

Different types of fading



Example of multi-path effect

@ 1: **free space loss** likely to give an accurate estimate of path loss
@ 2: strong line-of-sight but ground reflections can significantly influence path loss
@3: significant **diffraction** losses caused by trees cutting into the direct line of sight
@ 4: simple **diffraction** model for path loss
@ 5: multiple diffraction, loss prediction fairly difficult & unreliable

Multipath Fading

What causes multipath fading?

- Transmitter radiates power in many directions
- Receiver collects power from many directions
- Signals are reflected by various objects
- Many different paths exists between transmitter & receiver

Results in

- Delay spreads
  - Signals along different paths arrive at different times
  - One “symbol” bit may overlap with another
- Time varying signal amplitudes at receiver

Types of Fading

- Fading can be fast or slow (rapid fluctuation of signal)
- Fading can be flat or frequency-selective
- All four combinations possible

Shadow Fading

- Obstacles and their absorption behavior

- Shadowing differs from multi-path fading:

☞ **Duration** of shadow fade lasts for **multiple seconds** or **minutes**, and hence occurs at a much slower time-scale compared to multi-path fading

Reflection

- Wave impinges upon a large object when compared to the wavelength of the propagating wave

- Reflections occur from the surface of
  - The earth
  - Buildings
  - Walls

Scattering

- Another **type of reflection**
- Can occur in the atmosphere or in reflections from **very rough** objects
- **Very large number of individual paths**

☞ Received waveform is better modeled as an **integral over paths** with infinitesimally small differences in their lengths rather than as a sum

RF Communications

Radio Frequency (RF) waves are effected by

- Distance between the transmitter and receiver
  - Inverse power law
- Reflection (e.g. ground reflection)
- Diffraction (e.g. from building)
- Scattering (e.g. from trees)
- Links may not be bi-directional
  - **A** can hear **B**, but **B** can't hear **A** (e.g. because of receiver sensitivity)
- Radio waves may be blocked (absorbed) by objects
  - e.g by buildings, humans, rain, walls, glass windows

Path Loss: Distance between the transmitter and receiver

Multipath Fading: Reflection, Diffraction, Scattering

Shadowing: Radio waves may be blocked (absorbed) by objects

Degree of attenuation generally depends on frequency

Free-space propagation model

- Assumes a **single direct path** between the base station and the mobile
- Predicts received signal strength when the transmitter and receiver have a **clear, unobstructed line-of-sight path between them**
- Typically used in an **open wide environment**

Examples: satellite, microwave line-of-sight radio links

Free space model

$P_r(d)=P_tG_tG_r\lambda^2/[(4\pi)^2d^2L]$

P_t,P_r: transmitter/receiver power

G_t, G_r: transmitter/receiver antenna gain

$G = 4\pi A_e/\lambda^2$

L: system loss factor (L=1 no loss)

A_e: related to the physical size of the antenna

λ: wavelength in meters, f carrier frequency, c :speed of light

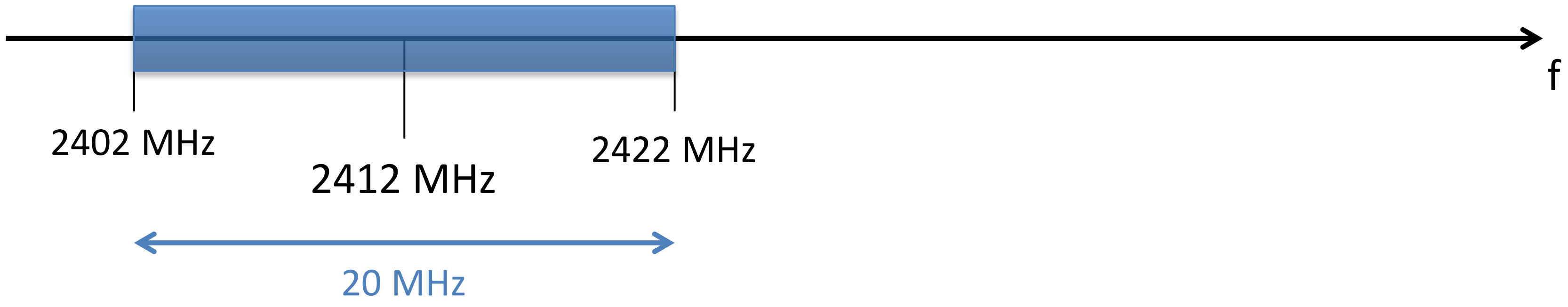
$\lambda = c/f$

SPECTRUM ANALYZER DEMONSTRATION

802.11 Channels

- Channel Bandwidth
  - 22 MHz (802.11b - DSSA)
  - 20 MHz (802.11g - OFDM)
- 13 Channels (14 in Japan)
  - 5MHz apart

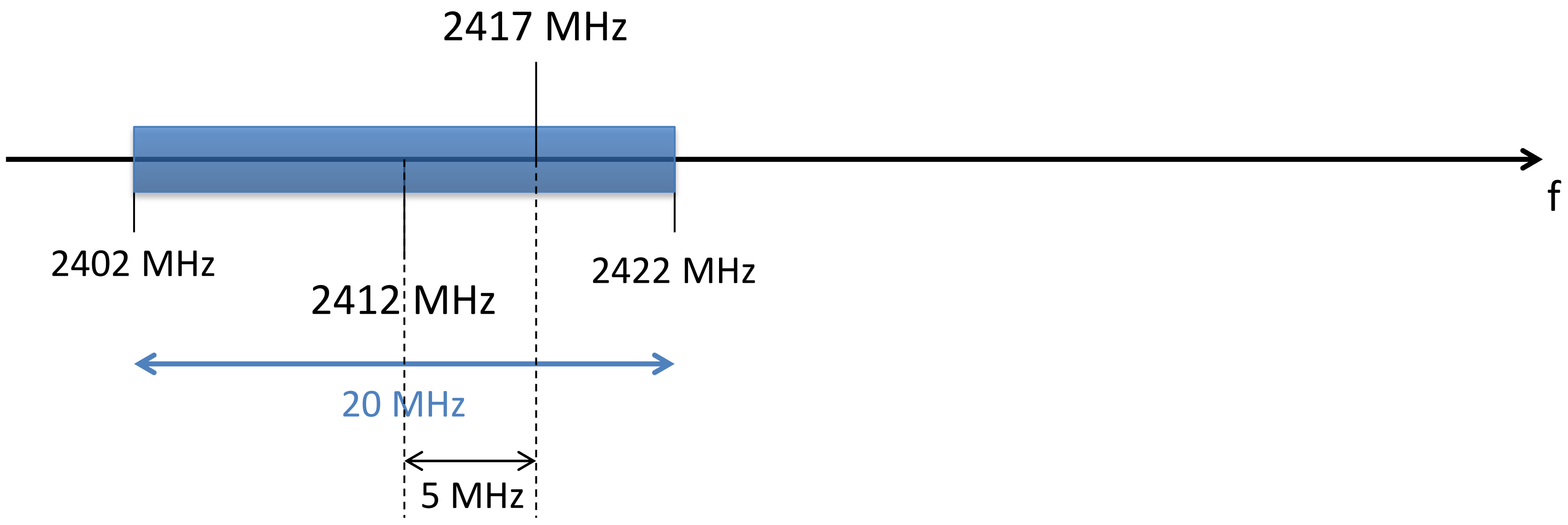
Ch. 01: 2412 MHz
Ch. 02: 2417 MHz
Ch. 03: 2422 MHz
…
Ch. 13: 2472 MHz



802.11 Channels

- Channel Bandwidth
  - 22 MHz (802.11b - DSSA)
  - 20 MHz (802.11g - OFDM)
- 13 Channels (14 in Japan)
  - 5MHz apart

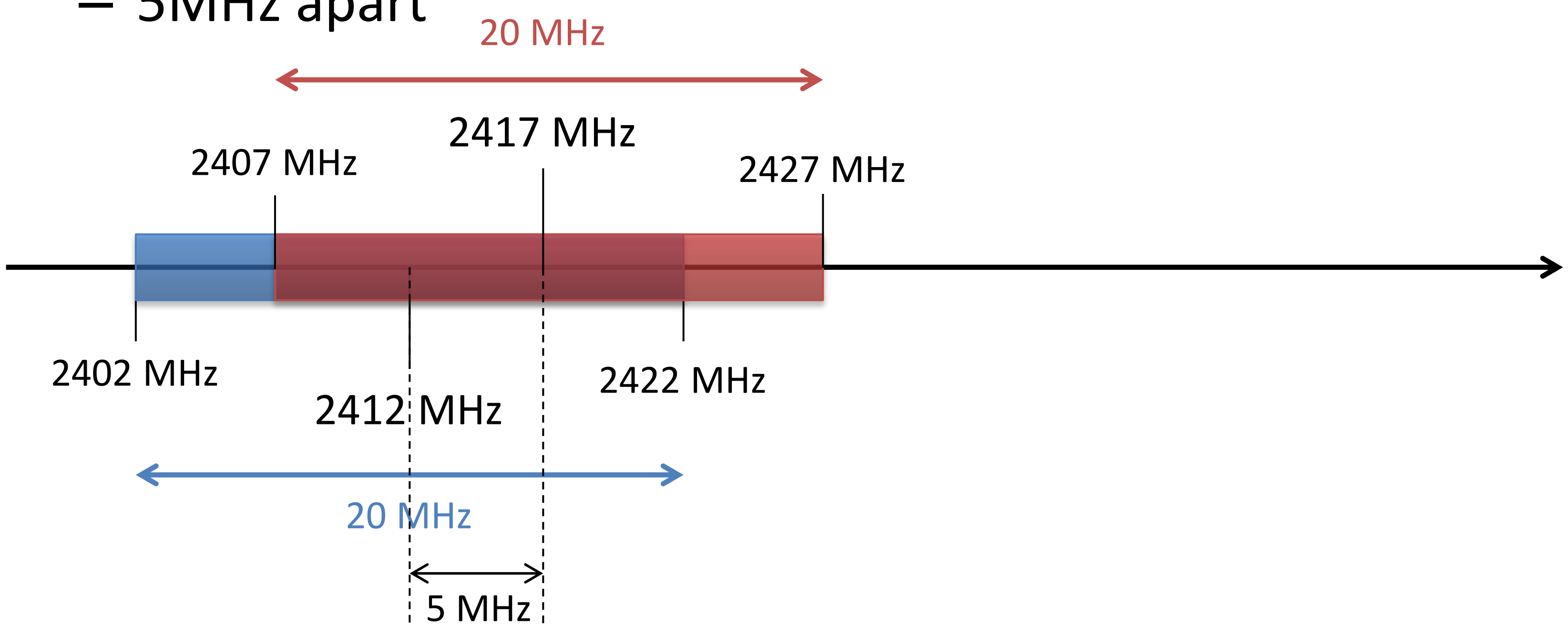
Ch. 01: 2412 MHz
Ch. 02: 2417 MHz
Ch. 03: 2422 MHz
…
Ch. 13: 2472 MHz



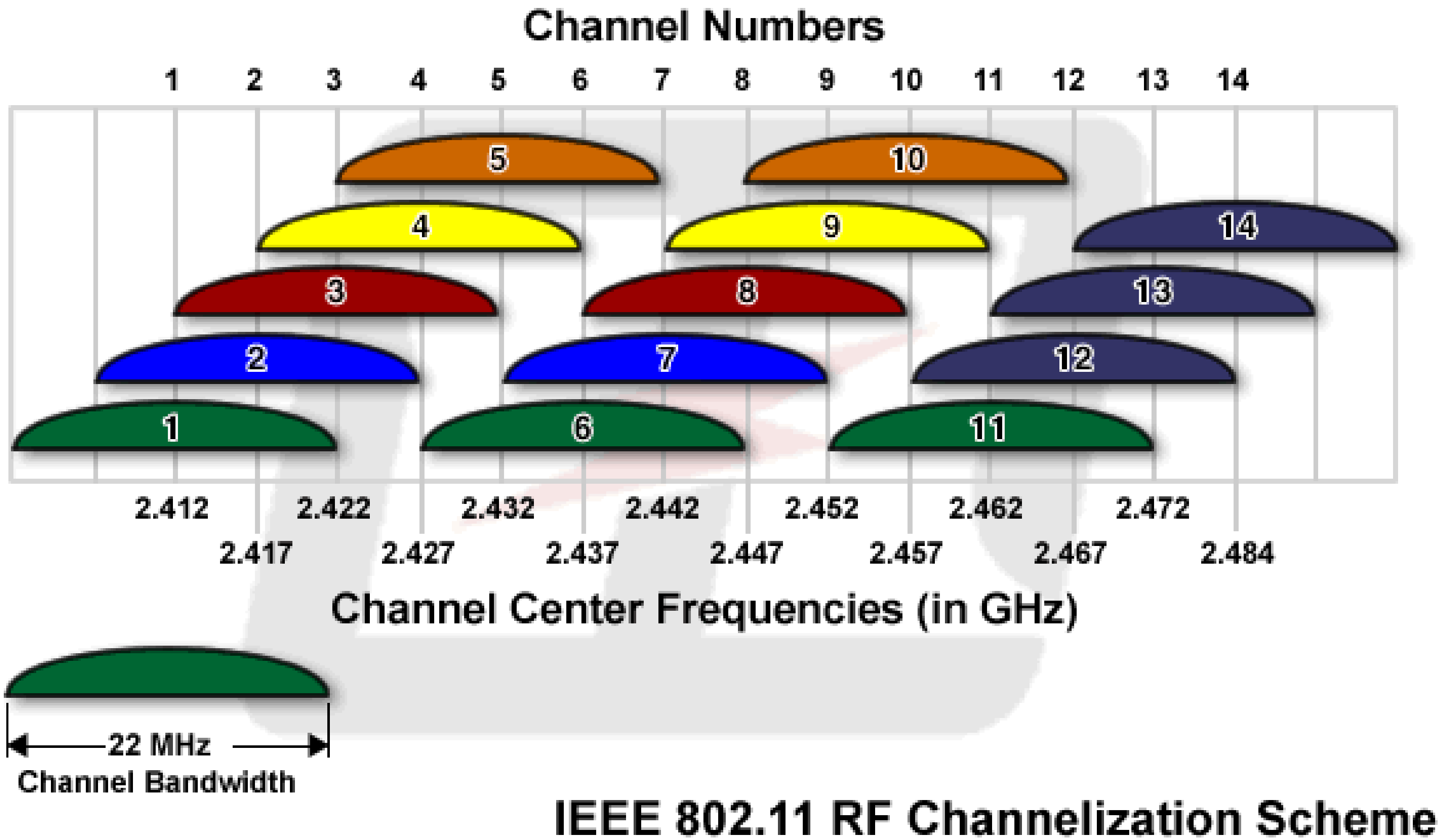
802.11 Channels

- Channel Bandwidth
  - 22 MHz (802.11b - DSSA)
  - 20 MHz (802.11g - OFDM)
- 13 Channels (14 in Japan)
  - 5MHz apart

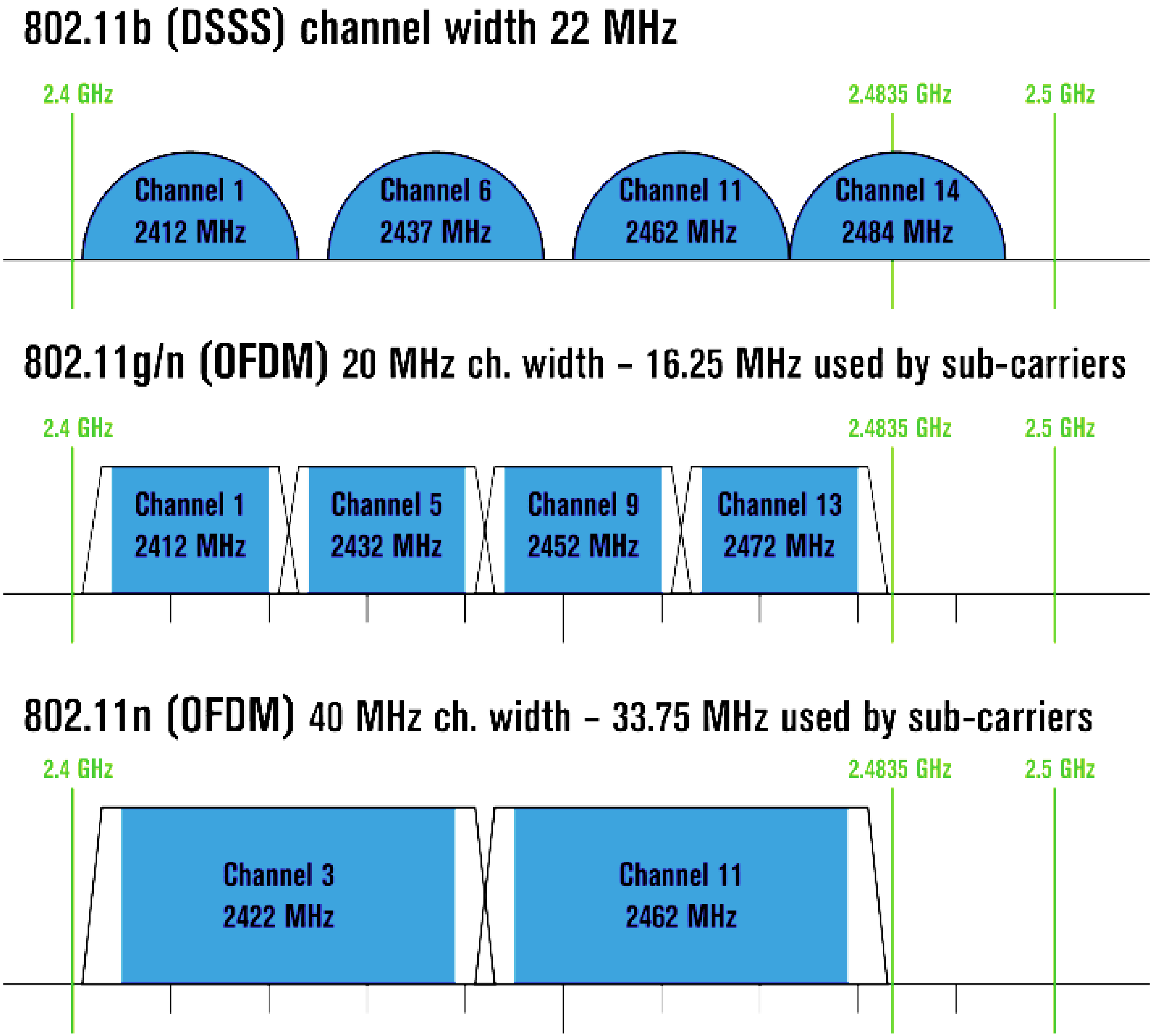
Ch. 01: 2412 MHz
Ch. 02: 2417 MHz
Ch. 03: 2422 MHz
…
Ch. 13: 2472 MHz



802.11 Channels

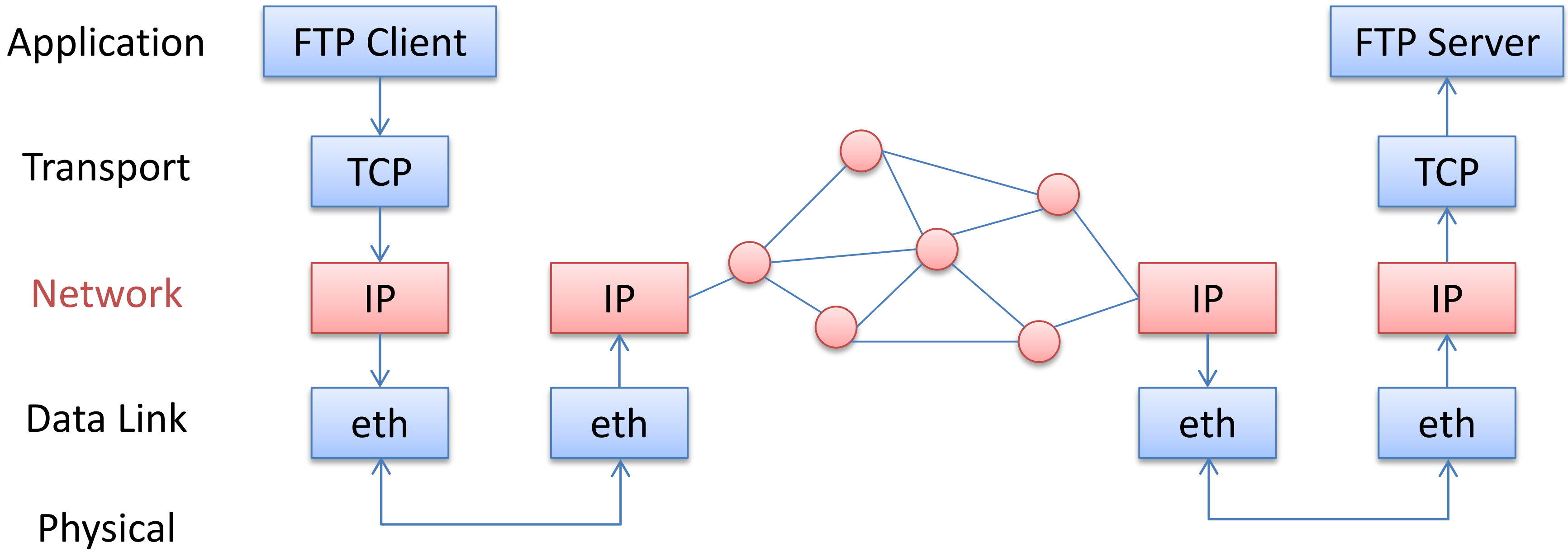


Non-Overlapping Channels for 2.4 GHz WLAN

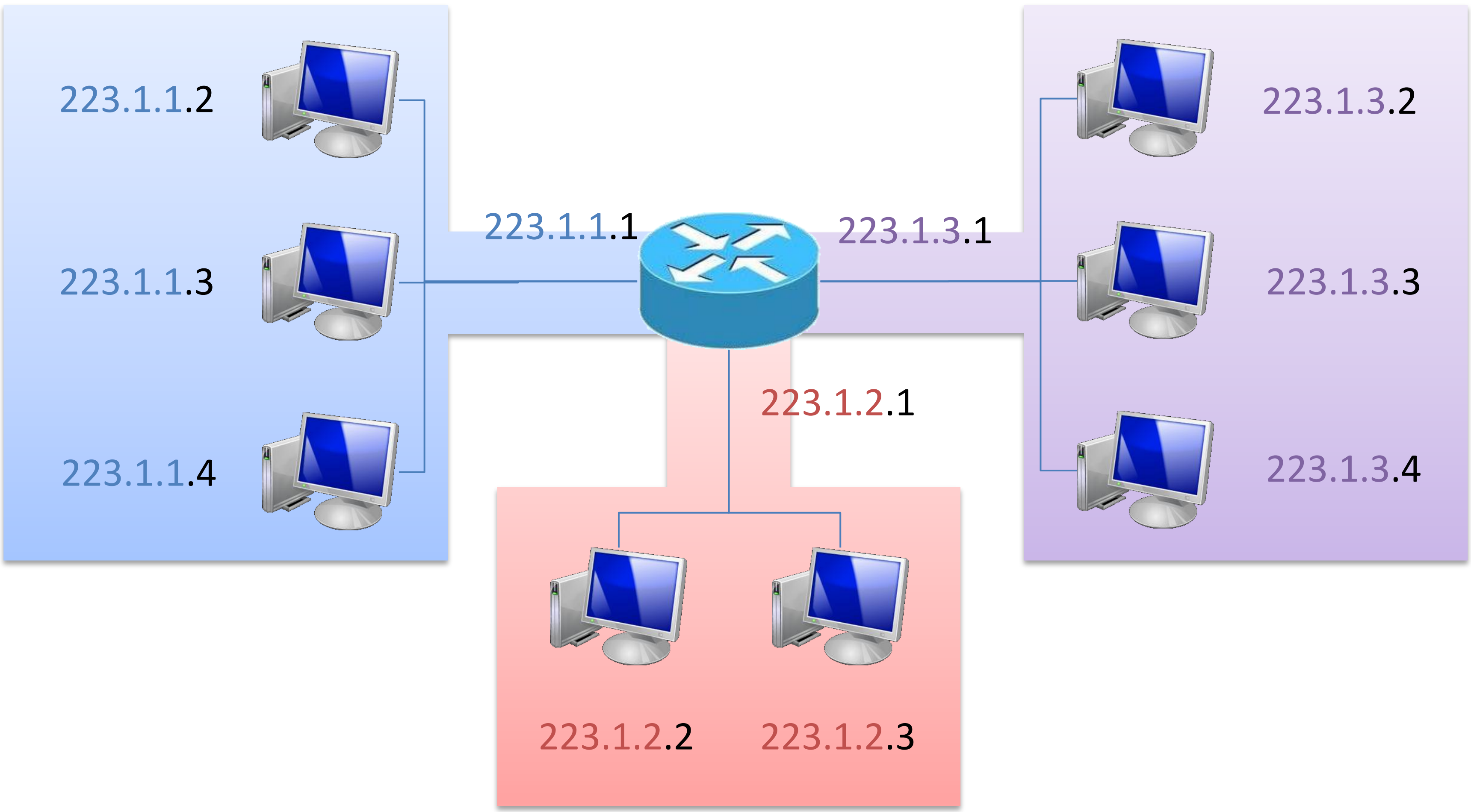


ROUTING TABLES

The Network Layer

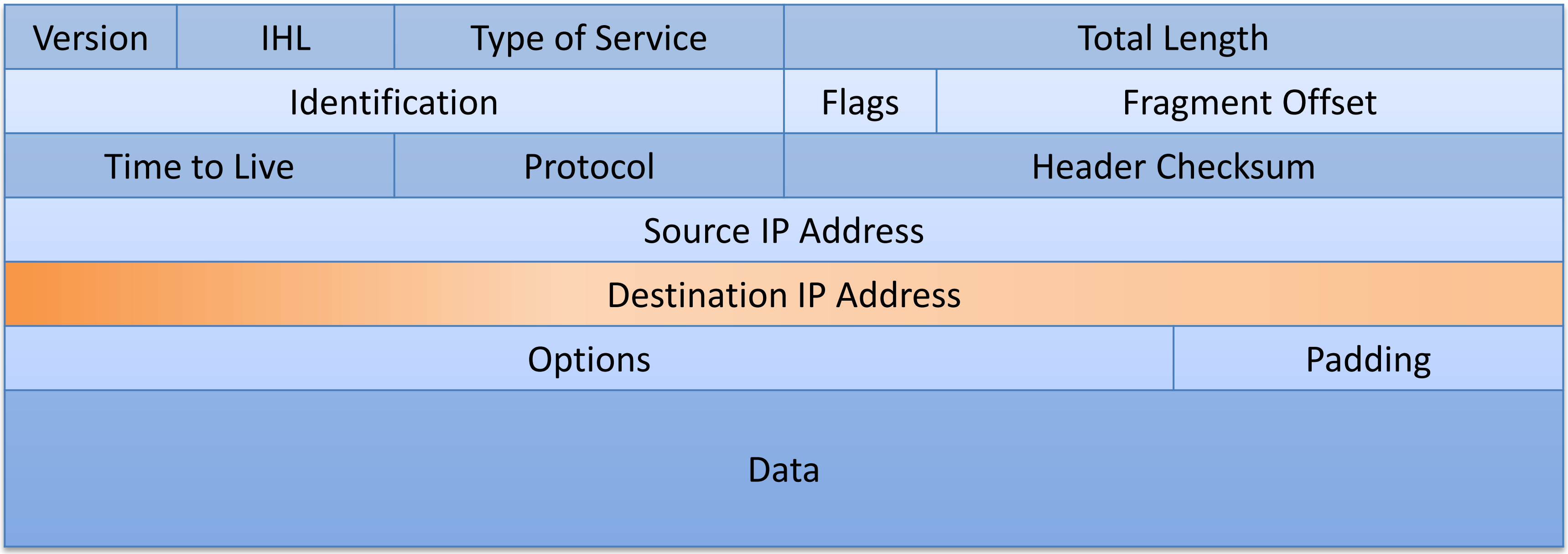


IP address



223.1.1.2
223.1.1.3
223.1.1.4
223.1.1.1
223.1.3.1
223.1.3.2
223.1.3.3
223.1.3.4
223.1.2.1
223.1.2.2
223.1.2.3

IP datagram

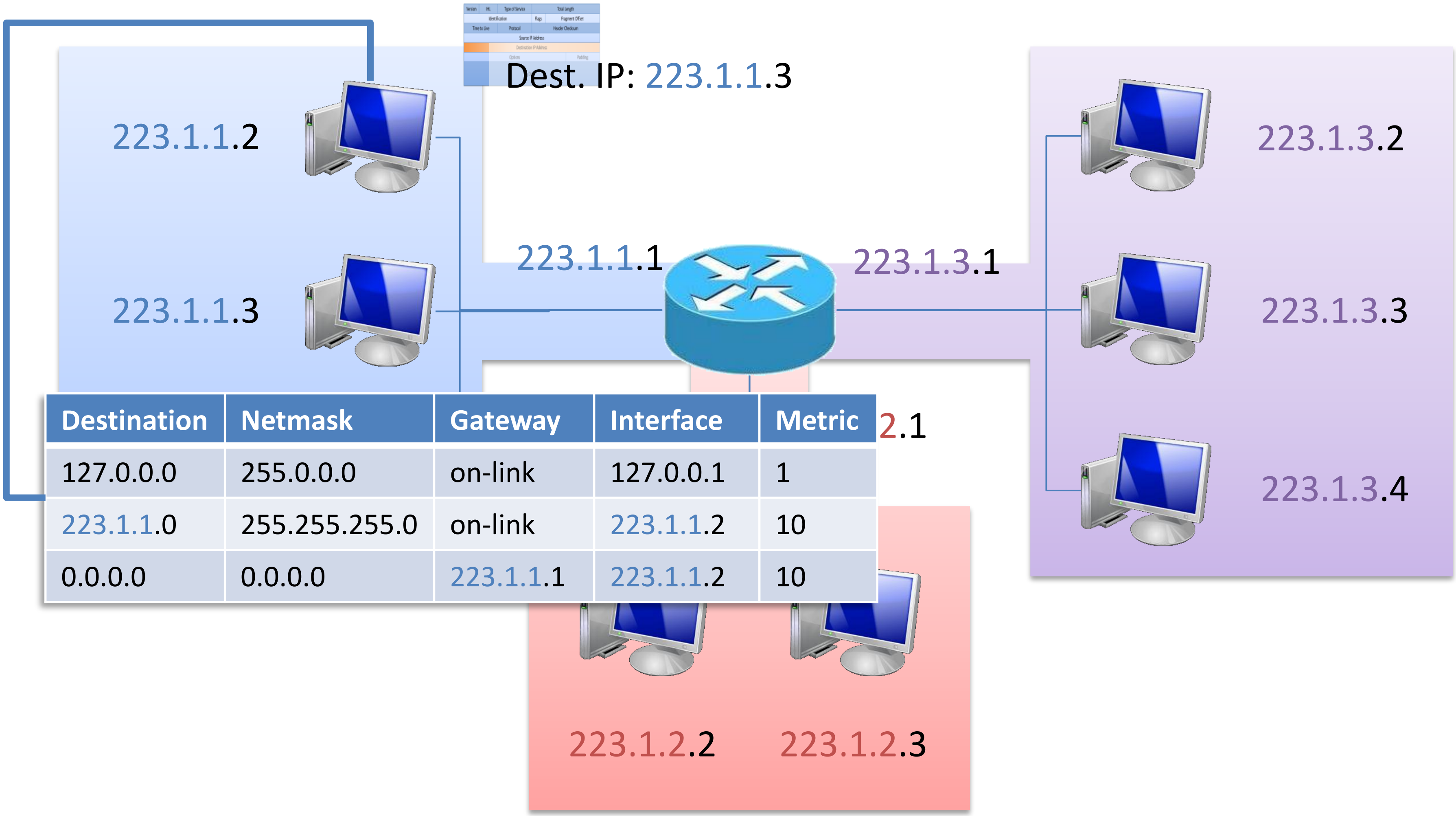


Version
IHL
Type of Service
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source IP Address
Destination IP Address
Options
Padding
Data

Routing Table

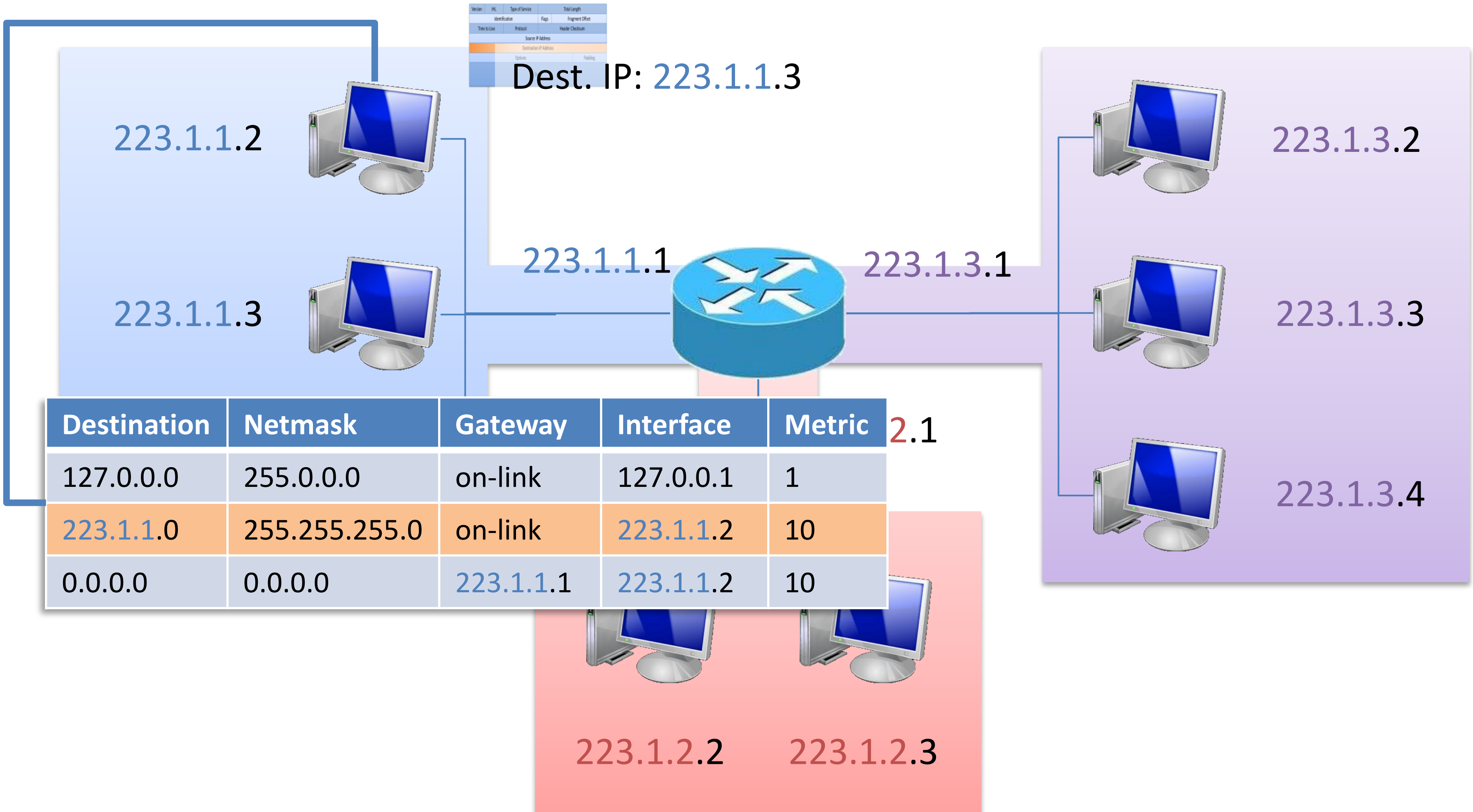
Destination	Netmask	Gateway	Interface	Metric
127.0.0.0	255.0.0.0	on-link	127.0.0.1	1
223.1.1.0	255.255.255.0	on-link	223.1.1.2	10
0.0.0.0	0.0.0.0	223.1.1.1	223.1.1.2	10

Routing



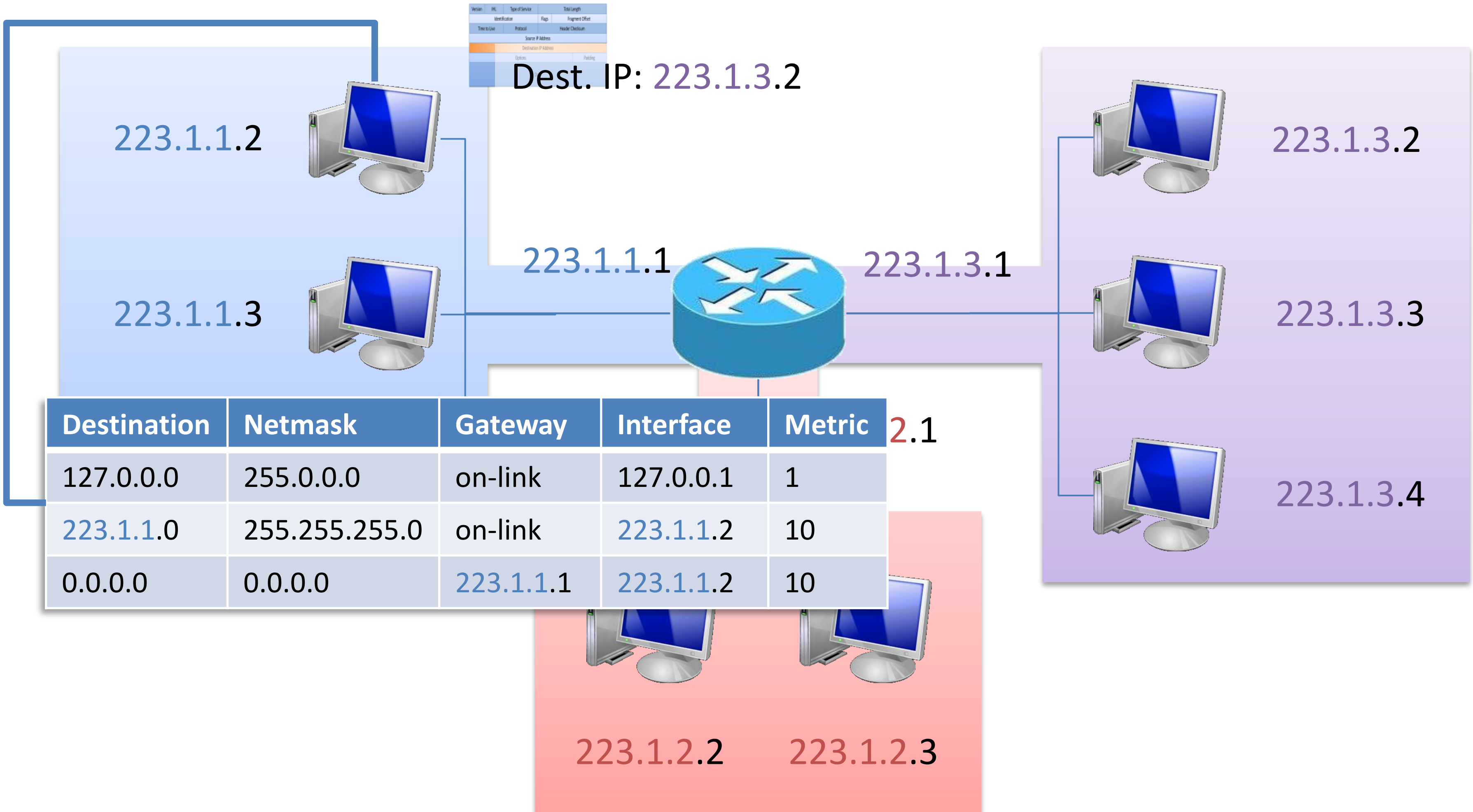
Destination	Netmask	Gateway	Interface	Metric
127.0.0.0	255.0.0.0	on-link	127.0.0.1	1
223.1.1.0	255.255.255.0	on-link	223.1.1.2	10
0.0.0.0	0.0.0.0	223.1.1.1	223.1.1.2	10

Routing



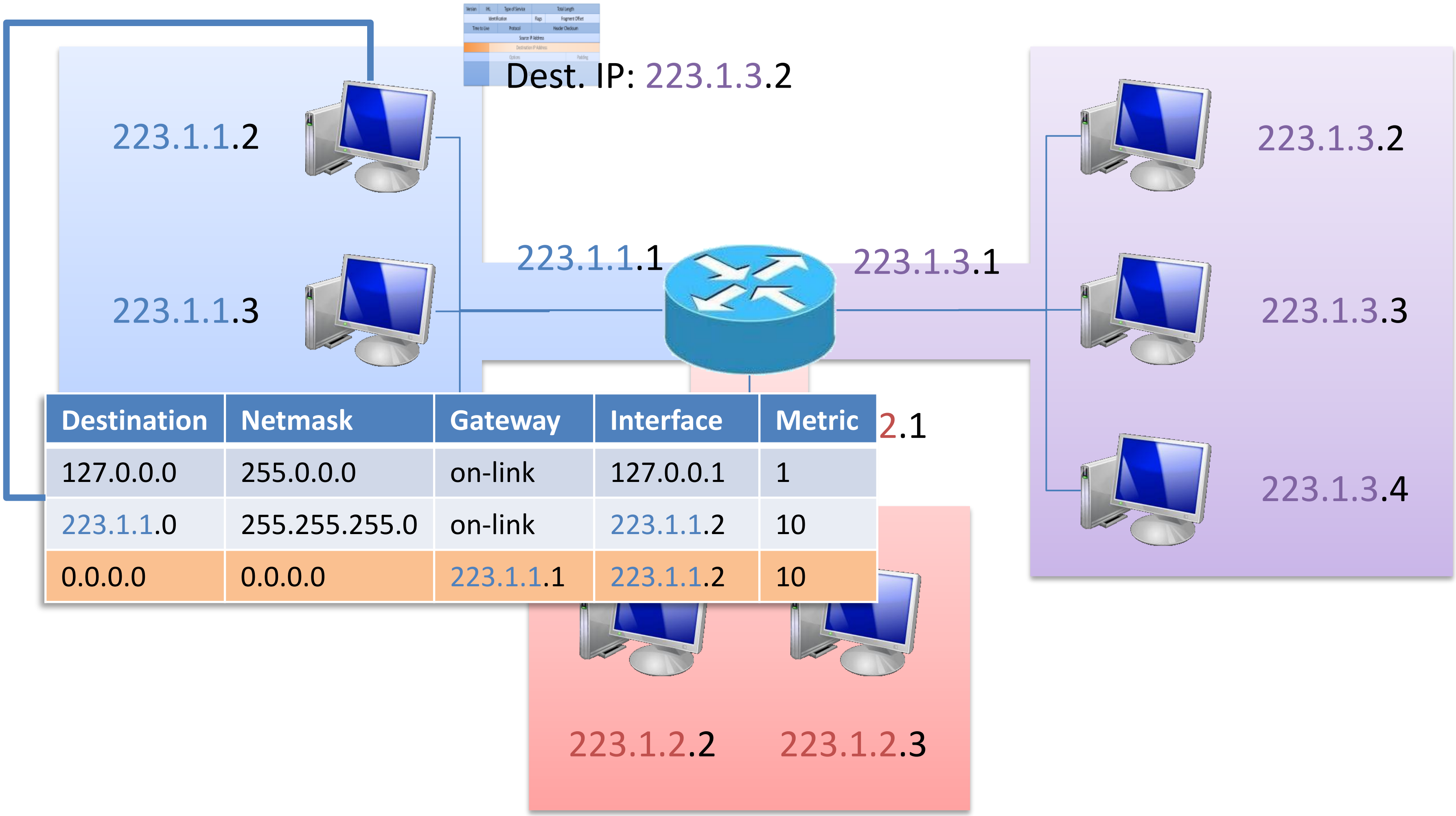
Destination	Netmask	Gateway	Interface	Metric
127.0.0.0	255.0.0.0	on-link	127.0.0.1	1
223.1.1.0	255.255.255.0	on-link	223.1.1.2	10
0.0.0.0	0.0.0.0	223.1.1.1	223.1.1.2	10

Routing



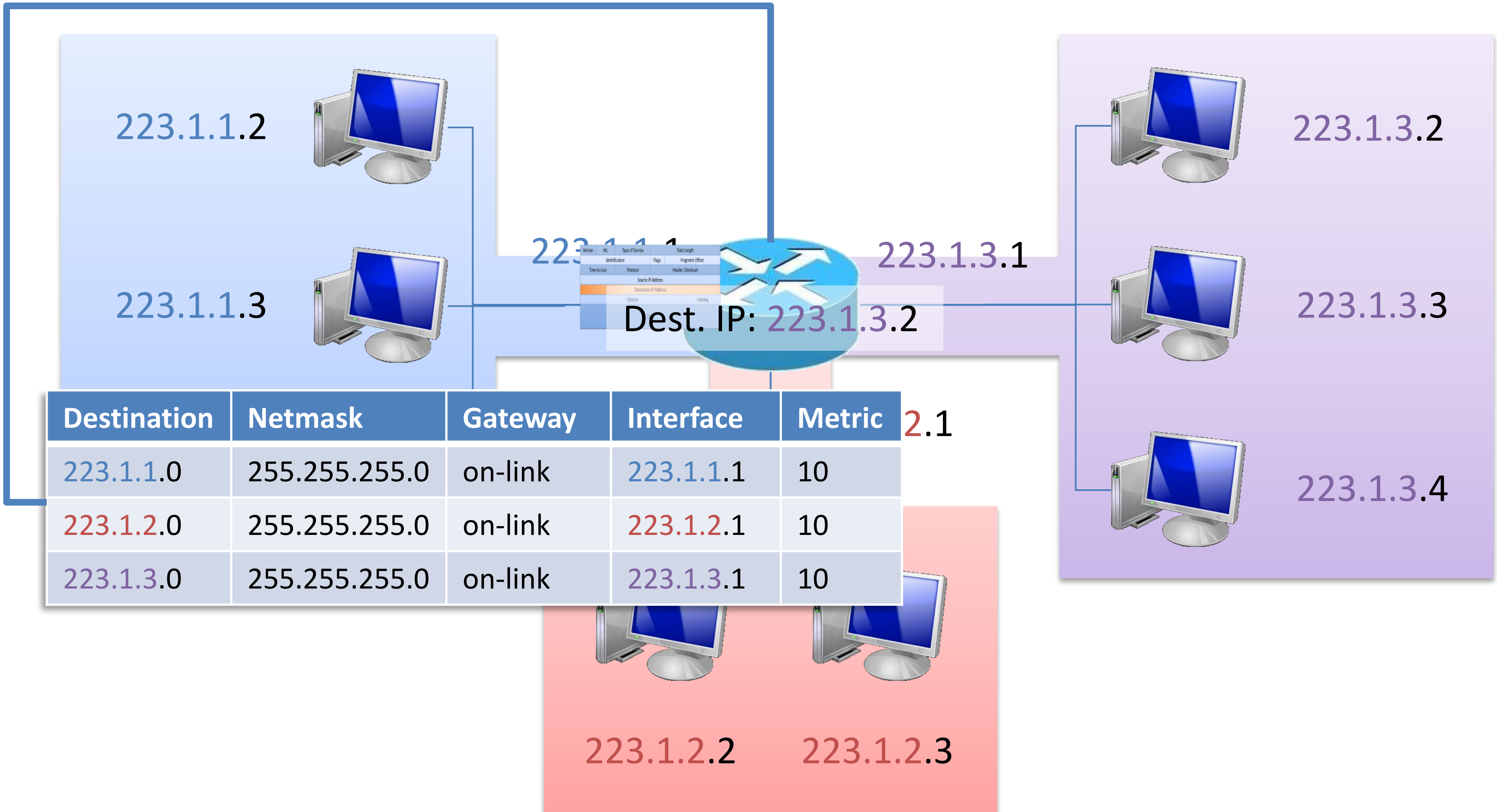
Destination	Netmask	Gateway	Interface	Metric
127.0.0.0	255.0.0.0	on-link	127.0.0.1	1
223.1.1.0	255.255.255.0	on-link	223.1.1.2	10
0.0.0.0	0.0.0.0	223.1.1.1	223.1.1.2	10

Routing



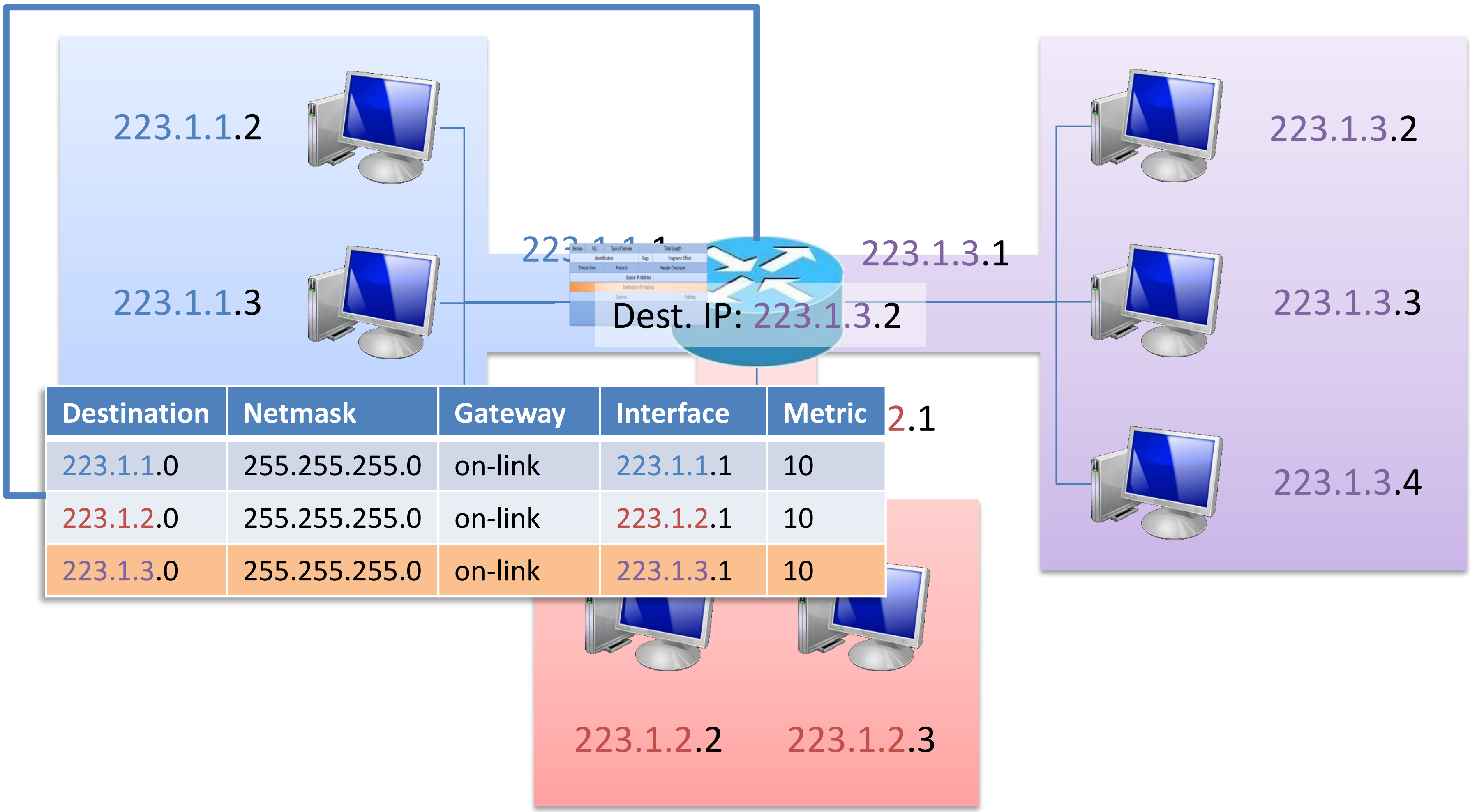
Destination	Netmask	Gateway	Interface	Metric
127.0.0.0	255.0.0.0	on-link	127.0.0.1	1
223.1.1.0	255.255.255.0	on-link	223.1.1.2	10
0.0.0.0	0.0.0.0	223.1.1.1	223.1.1.2	10

Routing



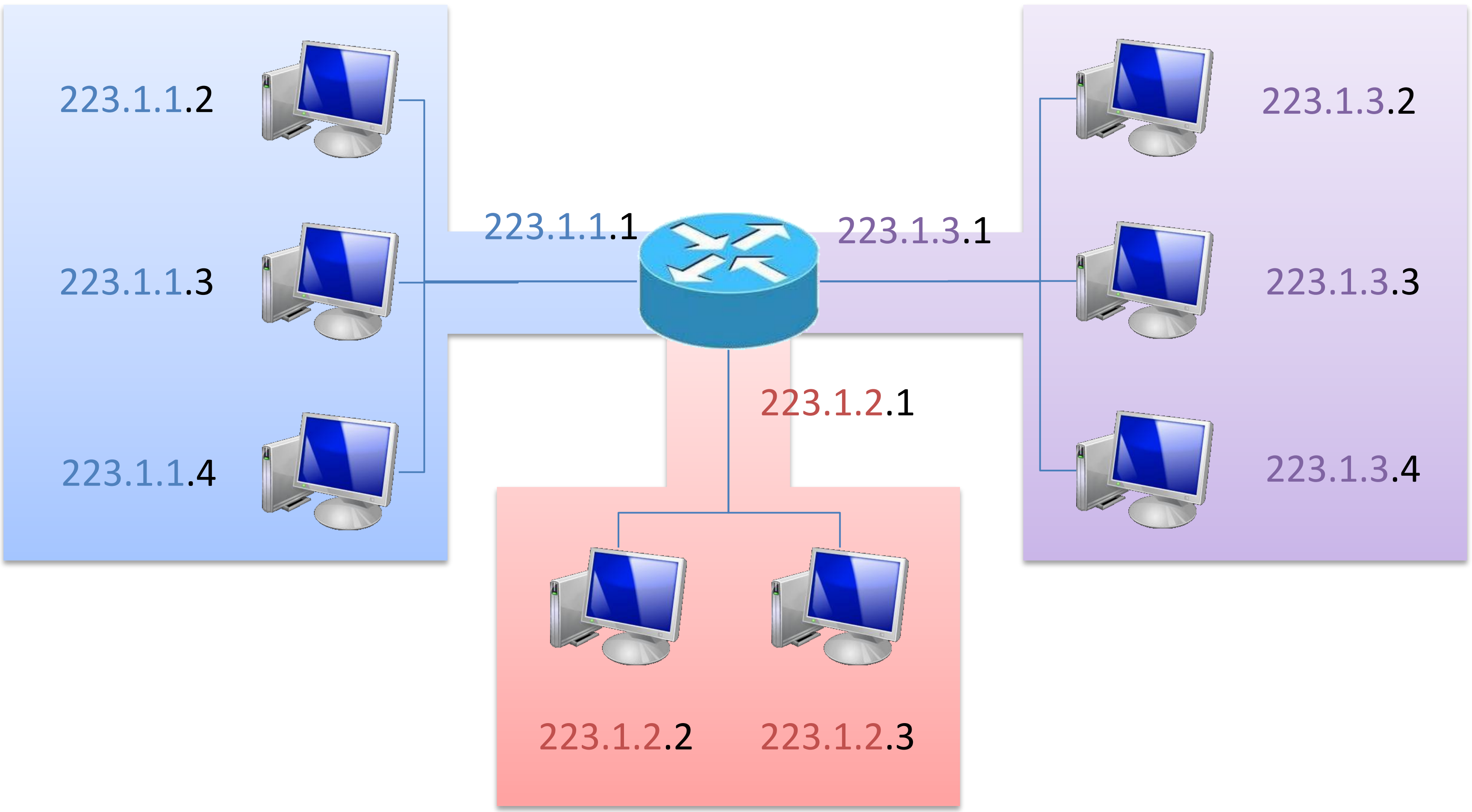
Destination	Netmask	Gateway	Interface	Metric
223.1.1.0	255.255.255.0	on-link	223.1.1.1	10
223.1.2.0	255.255.255.0	on-link	223.1.2.1	10
223.1.3.0	255.255.255.0	on-link	223.1.3.1	10

Routing



Destination	Netmask	Gateway	Interface	Metric
223.1.1.0	255.255.255.0	on-link	223.1.1.1	10
223.1.2.0	255.255.255.0	on-link	223.1.2.1	10
223.1.3.0	255.255.255.0	on-link	223.1.3.1	10

Routing



223.1.1.2
223.1.1.3
223.1.1.4
223.1.1.1
223.1.3.1
223.1.2.1
223.1.3.2
223.1.3.3
223.1.3.4
223.1.2.2
223.1.2.3