Access Control List

What are ACLs?

ACLs are lists of conditions that are applied to traffic traveling across a router's interface. These lists tell the router what types of packets to accept or deny. Acceptance and denial can be based on specified conditions.

ACLs can be created for all routed network protocols, such as Internet Protocol (IP) and Internetwork Packet Exchange (IPX).

ACLs can be configured at the router to control access to a network or subnet.

Some ACL decision points are source and destination addresses, protocols, and upper-layer port numbers.

ACLs must be defined on a per-protocol, per direction, or per port basis.

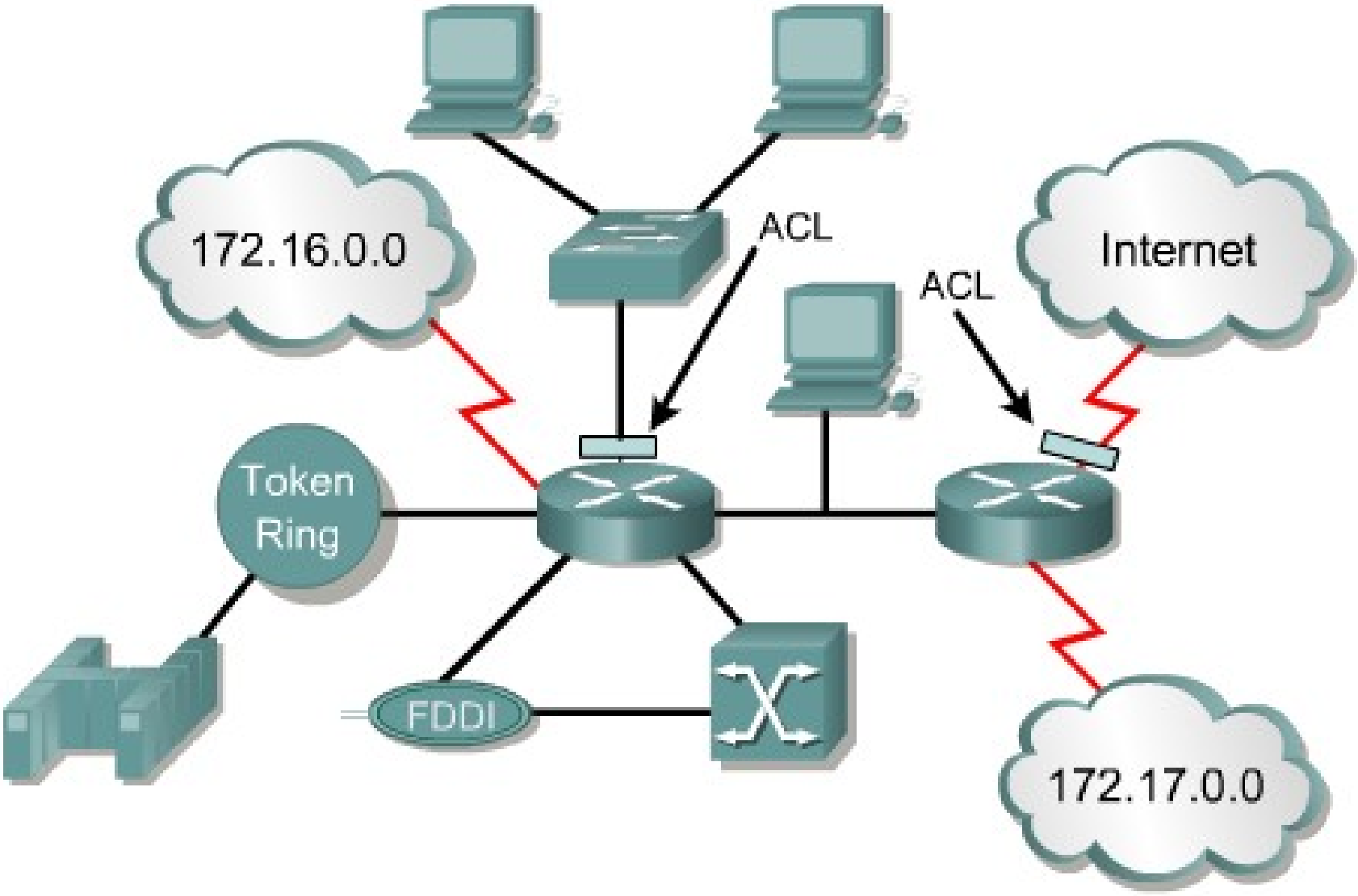
Reasons to Create ACLs

The following are some of the primary reasons to create ACLs:

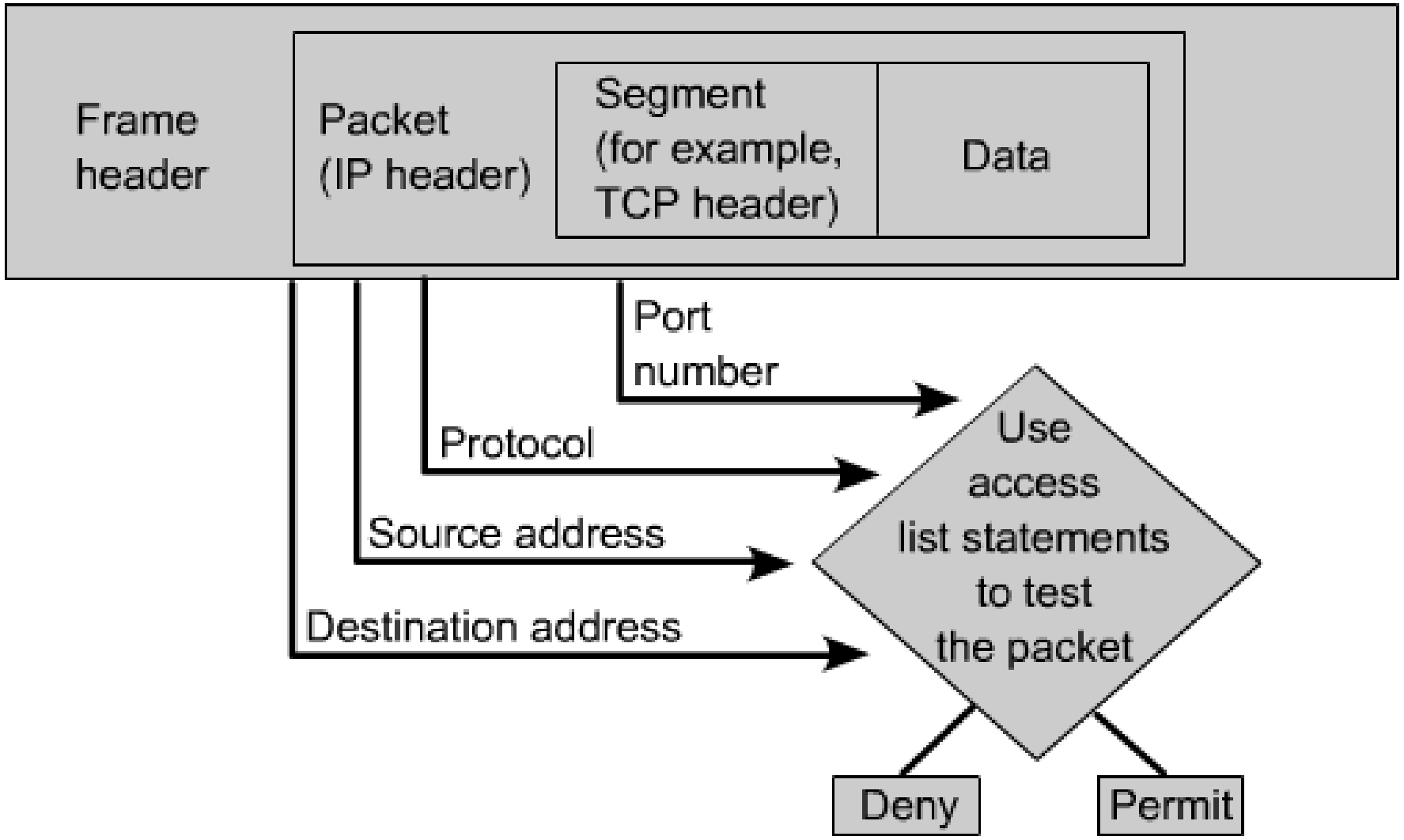
- Limit network traffic and increase network performance.
- Provide traffic flow control.
- Provide a basic level of security for network access.
- Decide which types of traffic are forwarded or blocked at the router interfaces. For example: Permit e-mail traffic to be routed, but block all telnet traffic.

Allow an administrator to control what areas a client can access on a network.

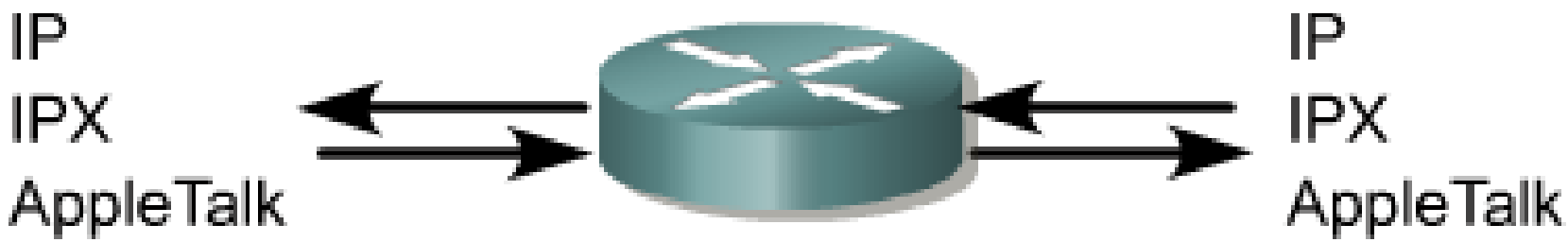
ACLs Filter Traffic Graphic



How ACLs Filter Traffic



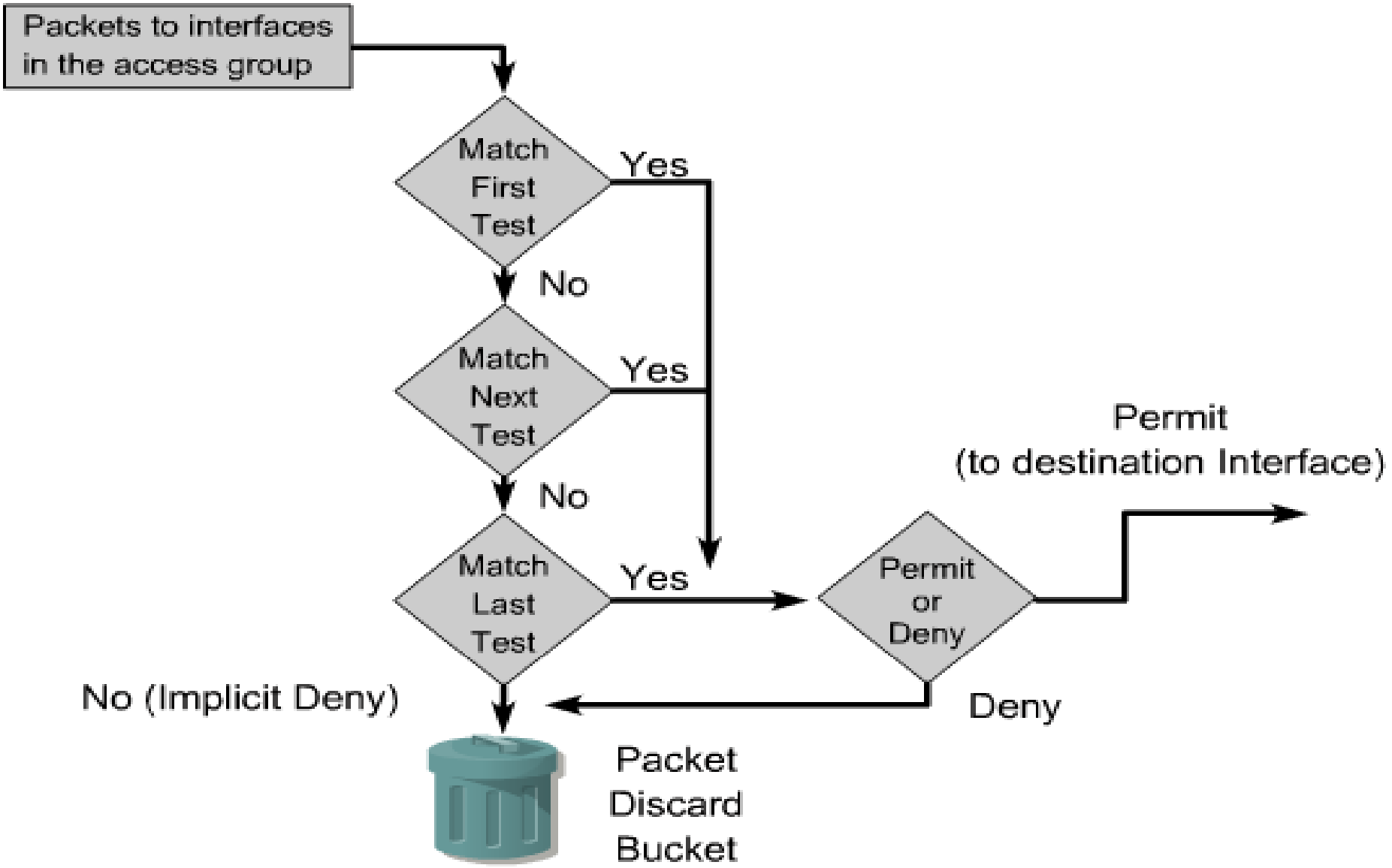
One List per Port, per Destination, per Protocol…



One list, per port, per direction, per protocol

With two interfaces and three protocols running, this router could have a total of 12 separate ACLs applied.

How ACLs work.



Creating ACLs

ACLs are created in the global configuration mode. There are many different types of ACLs including standard, extended, IPX, AppleTalk, and others. When configuring ACLs on a router, each ACL must be uniquely identified by assigning a number to it. This number identifies the type of access list created and must fall within the specific range of numbers that is valid for that type of list.

Protocol	Range
IP	1-99
Extended IP	100-199
AppleTalk	600-699
IPX	800-899
Extended IPX	900-999
IPX Service Advertising Protocol	1000-1099

Since IP is by far the most popular routed protocol, addition ACL numbers have been added to newer router IOSs.
Standard IP: 1300-1999
Extended IP: 2000-2699

The access-list command

Define the ACL by using the following command:

```
Router(config)#access-list access-list-number
   {permit | deny} {test-conditions}
```

A global statement identifies the ACL. Specifically, the 1-99 range is reserved for standard IP. This number refers to the type of ACL. In Cisco IOS Release 11.2 or newer, ACLs can also use an ACL name, such as education_group, rather than a number.

The **permit** or **deny** term in the global ACL statement indicates how packets that meet the test conditions are handled by Cisco IOS software. **permit** usually means the packet will be allowed to use one or more interfaces that you will specify later.The final term or terms specifies the test conditions used by the ACL statement.

The ip access-group command

Next, you need to apply ACLs to an interface by using the **access-group** command, as in this example:

`Router(config-if)#{protocol}` **access-group** *access-list-number* { **in** | **out** }

All the ACL statements identified by *access-list-number* are associated with one or more interfaces. Any packets that pass the ACL test conditions can be permitted to use any interface in the access group of interfaces.

ACL Example

```
Router(config)#
access-list 2 deny   172.16.1.1
access-list 2 permit 172.16.1.0  0.0.0.255
access-list 2 deny   172.16.0.0  0.0.255.255
access-list 2 permit 172.0.0.0   0.255.255.255
interface ethernet 0
  ip access-group 2 in
```

Basic Rules for ACLs

These basic rules should be followed when creating and applying access lists:

- One access list per protocol per direction.
- Standard IP access lists should be applied closest to the destination.
- Extended IP access lists should be applied closest to the source.
- Use the inbound or outbound interface reference as if looking at the port from inside the router.
- Statements are processed sequentially from the top of list to the bottom until a match is found, if no match is found then the packet is denied.
- There is an implicit deny at the end of all access lists. This will not appear in the configuration listing.
- Access list entries should filter in the order from specific to general. Specific hosts should be denied first, and groups or general filters should come last.
- Never work with an access list that is actively applied.
- New lines are always added to the end of the access list.
- A **no access-list** *x* command will remove the whole list. It is not possible to selectively add and remove lines with numbered ACLs.
- Outbound filters do not affect traffic originating from the local router.

Wildcard Mask Examples

5 Examples follow that demonstrate how a wildcard mask can be used to permit or deny certain IP addresses, or IP address ranges.

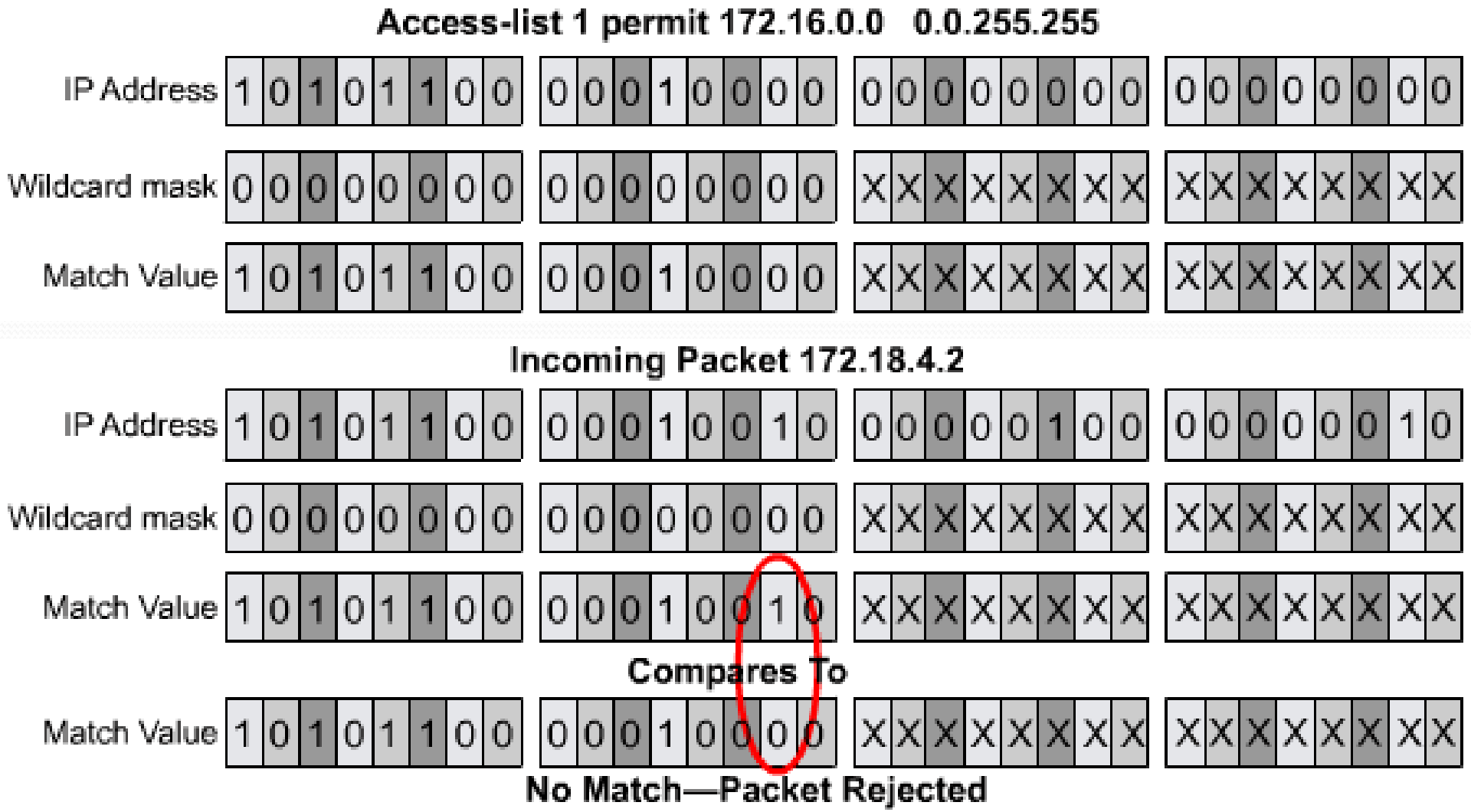
While subnet masks start with binary 1s and end with binary 0s, wildcard masks are the reverse meaning they typically start with binary 0s and end with binary 1s.

In the examples that follow Cisco has chosen to represent the binary 1s in the wilcard masks with Xs to focus on the specific bits being shown in each example.

You will see that while subnet masks were ANDed with ip addresses, wildcard masks are ORed with IP addresses.

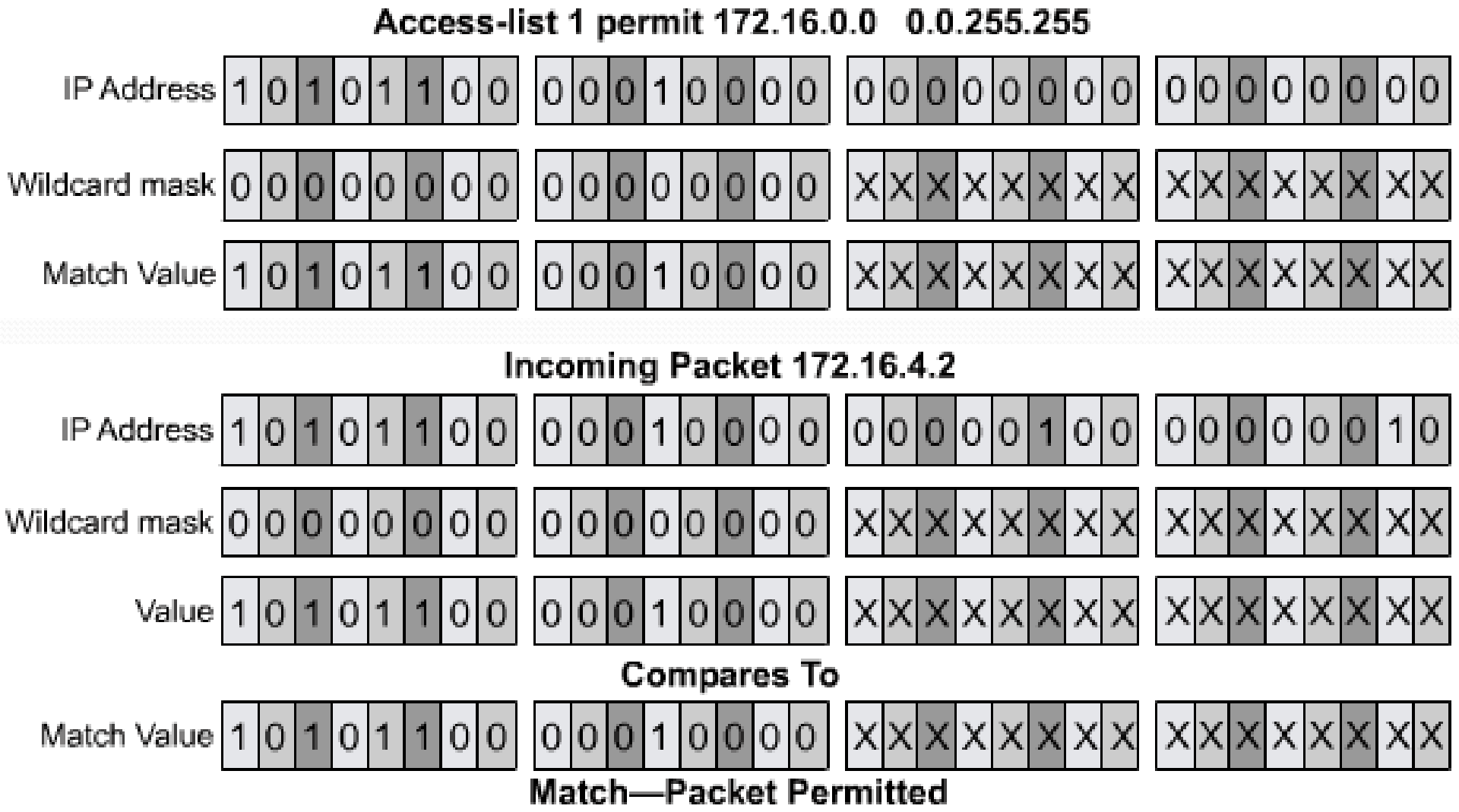
.

Wildcard Mask Example #1



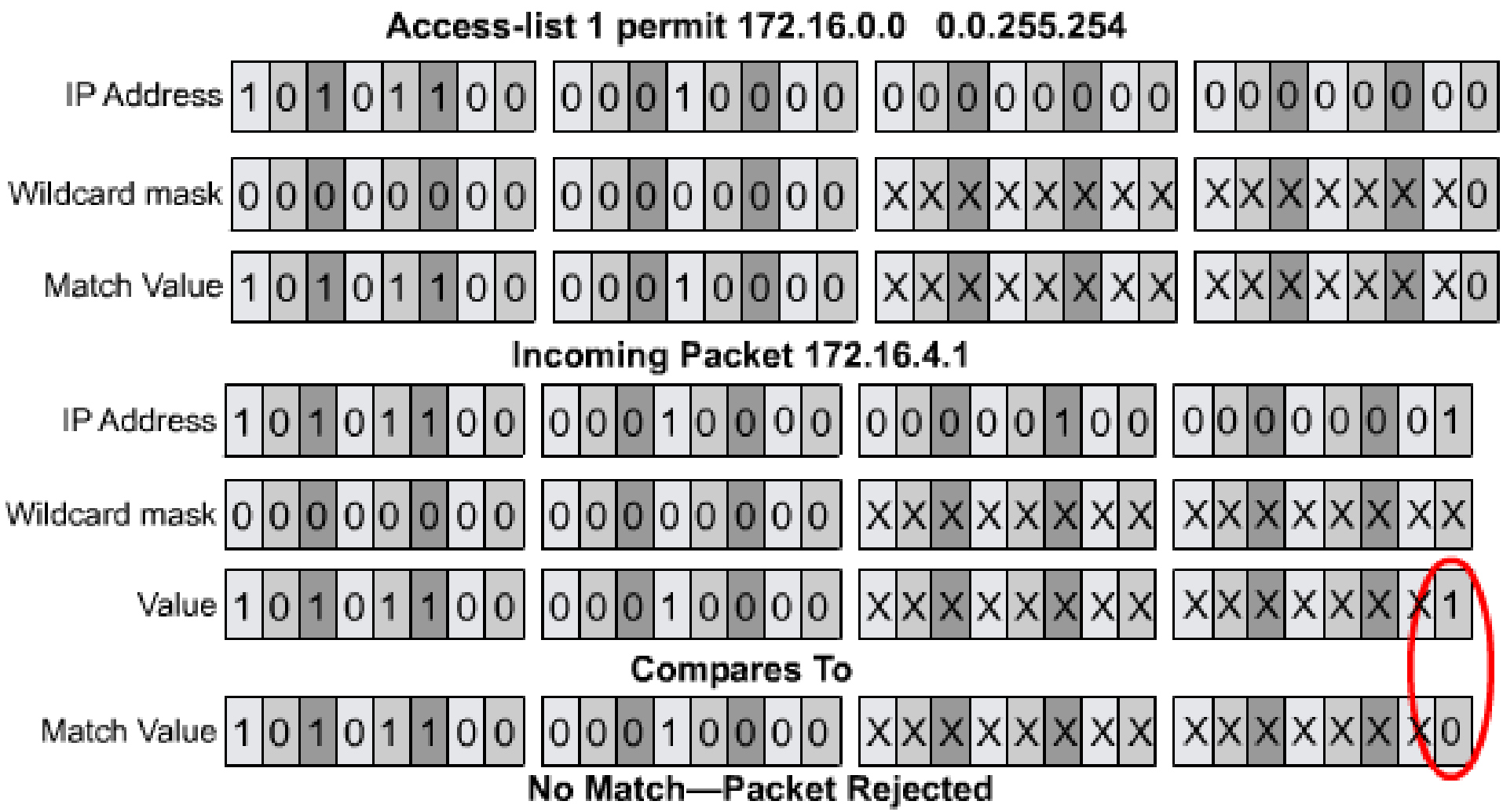
In this case, the two values do not match. In the comparison the second bit in the second octet of the two match values are different. This causes the packet to be rejected since it doesn't match.

Wildcard Mask Example #2



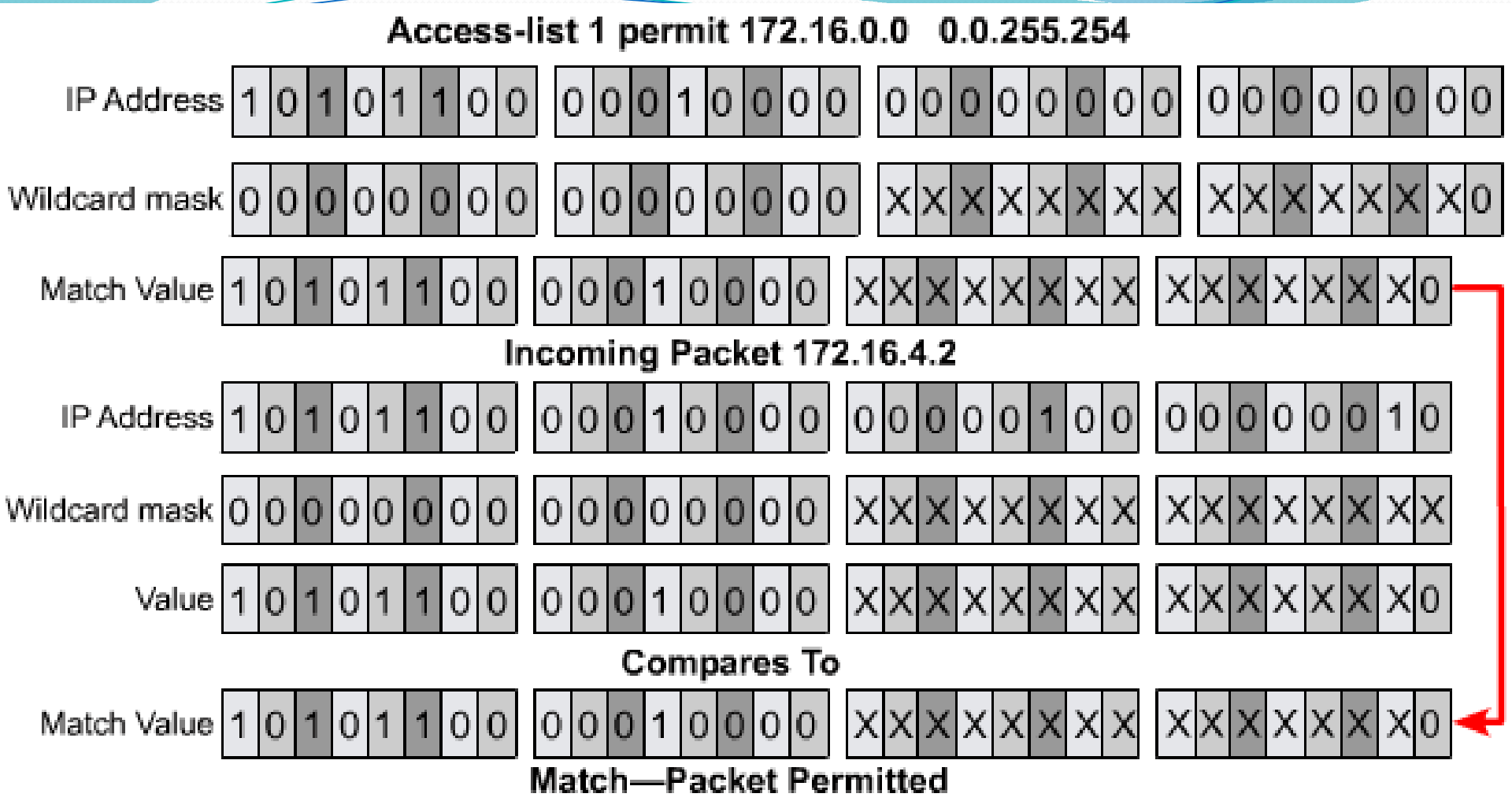
In this case, the two values match and the packet is permitted.

Wildcard Mask Example #3



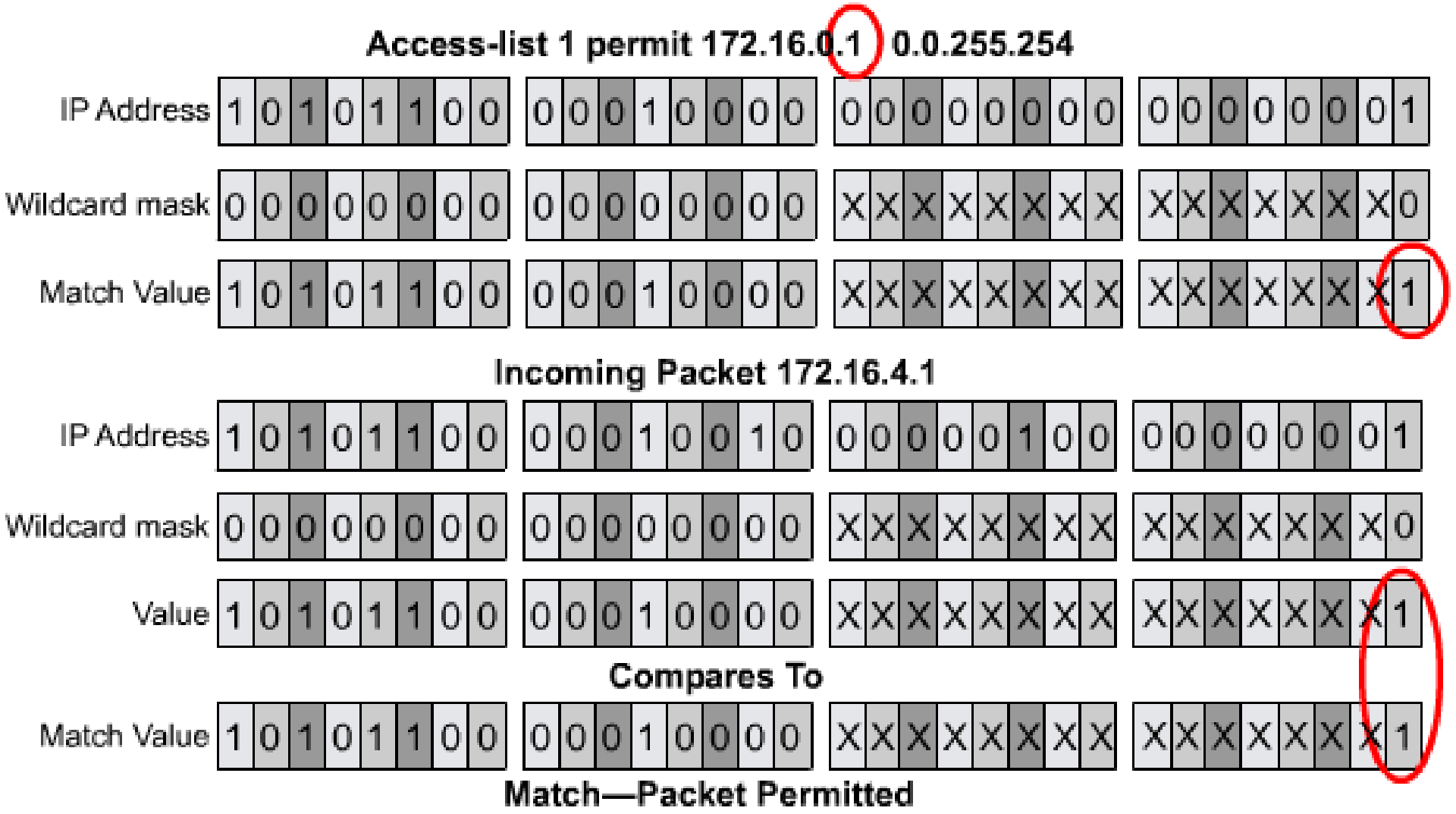
For this comparison the left most 16 bits match, but the rightmost bit does not. This causes the packet to be rejected. Remember that the match comparison must be an exact match.

Wildcard Mask Example #4 - Even IPs



With an even address the last bit position will always be zero. Since the composite value and the match value are the same the packet is accepted by the router. A question, how would the ACL statement above be changed to allow only the odd hosts in the address range of 172.16.0.0 to 172.16.255.255.

Wildcard Mask Example #5 - Odd IP#s



You permit only the odd addresses by just changing the IP address in the ACL statement to an odd number. This sets the right most bit to a one and only odd numbers will have that position be a one.

The any and host Keywords

```
Router(config)#access-list 1 permit 0.0.0.0 255.255.255.255
```

Can be written as:

```
Router(config)#access-list 1 permit any
```

```
Router(config)#access-list 1 permit 172.30.16.29 0.0.0.0
```

Can be written as:

```
Router(config)#access-list 1 permit host 172.30.16.29
```

This is the format of the any and host optional keywords in an ACL statement.

Verifying ACLs

There are many **show** commands that will verify the content and placement of ACLs on the router.

The **show ip interface** command displays IP interface information and indicates whether any ACLs are set.

The **show access-lists** command displays the contents of all ACLs on the router.

show access-list 1 shows just access-list 1.

The **show running-config** command will also reveal the access lists on a router and the interface assignment information.

Standard ACLs

Standard ACLs check the source address of IP packets that are routed.

The comparison will result in either permit or deny access for an entire protocol suite, based on the network, subnet, and host addresses.

The standard version of the **access-list** global configuration command is used to define a standard ACL with a number in the range of 1 to 99 (also from 1300 to 1999 in recent IOS).

If there is no wildcard mask. the default mask is used, which is 0.0.0.0. (This only works with Standard ACLs and is the same thing as using **host**.)

The full syntax of the standard ACL command is:

```
Router(config)#access-list access-list-number
{deny | permit} source [source-wildcard ] [log]
```

The no form of this command is used to remove a standard ACL. This is the syntax:
Router(config)#**no access-list** *access-list-number*

Extended ACLs

Extended ACLs are used more often than standard ACLs because they provide a greater range of control. Extended ACLs check the source and destination packet addresses as well as being able to check for protocols and port numbers.

The syntax for the extended ACL statement can get very long and often will wrap in the terminal window.

The wildcards also have the option of using the **host** or **any** keywords in the command.

At the end of the extended ACL statement, additional precision is gained from a field that specifies the optional Transmission Control Protocol (TCP) or User Datagram Protocol (UDP) port number.

Logical operations may be specified such as, equal (eq), not equal (neq), greater than (gt), and less than (lt), that the extended ACL will perform on specific protocols.

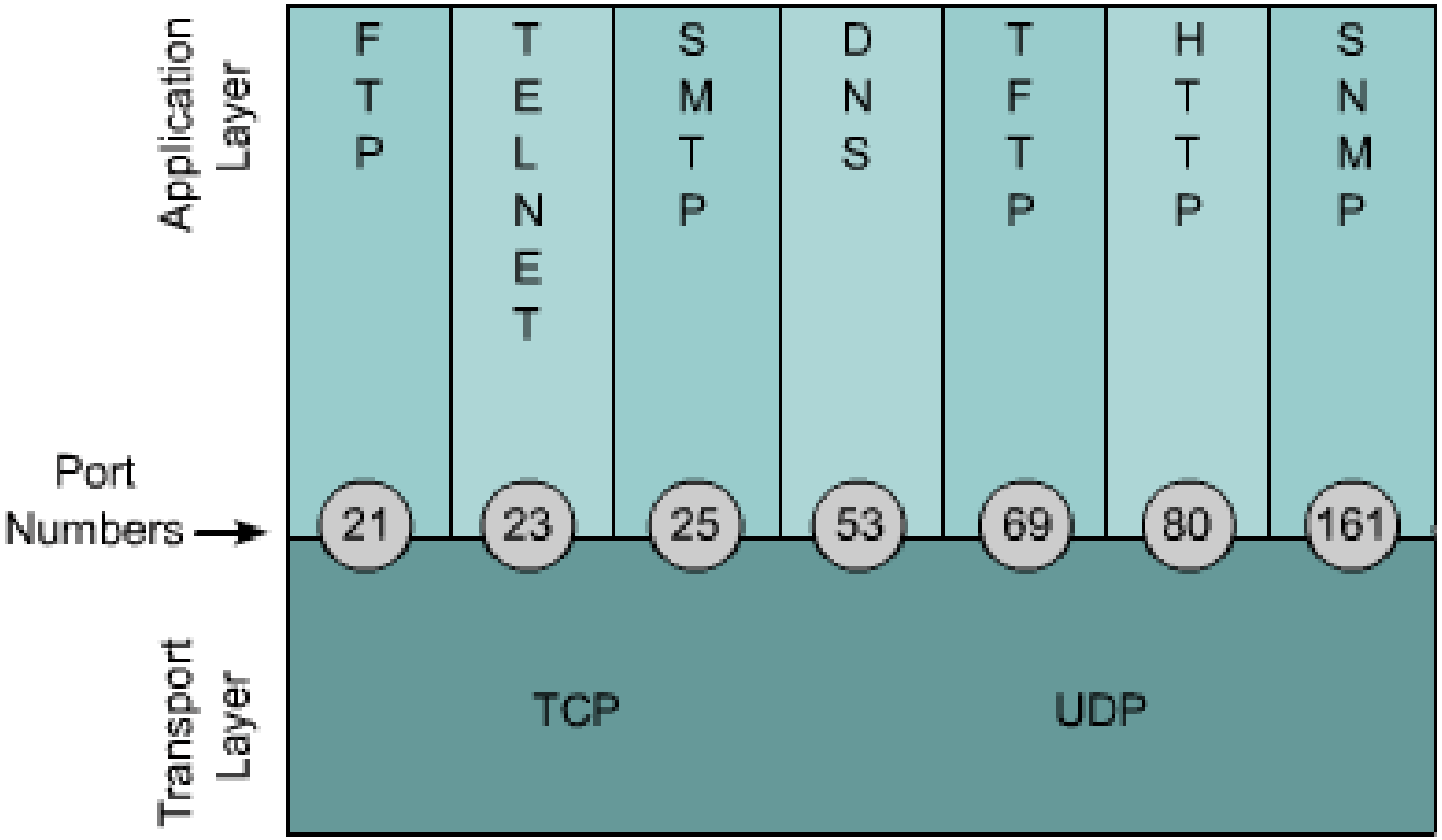
Extended ACLs use an access-list-number in the range 100 to 199 (also from 2000 to 2699 in recent IOS)

Extended ACL Syntax

```
Router(config)#access-list access-list-number {permit | deny}
protocol source
[source-mask destination destination-mask operator operand]
[established]
```

Paramter	Description
access-list-number	Identifies the list using a number in the range 100 to 199.
permit | **deny**	Indicates whether this entry allows or blocks the specified address.
protocol	The protocol, such as IP, TCP, UDP, ICMP, GRE, or IGRP.
source and **destination**	Identifies source and destination addresses.
source-mask and *destination-mask*	Wildcard mask; zeros indicate positions that must match, ones indicate do not care positions.
operator operand	lt, gt, eq, neq (less than, greater than, equal, not equal), and a port number.
established	Allows TCP traffic to pass if the packet uses an established connection (for example, has ACK bits set).

Well Known Port Numbers



Don’t forget that WWW or HTTP is **80** and POP3 is **110**.

Extended ACL Example

This extended ACL will allow people in network 200.100.50.0 to surfing the internet, but not allow any other protocols like email, ftp, etc.

access-list 101 permit tcp 200.100.50.0 0.0.0.255 any eq 80

or

access-list 101 permit tcp 200.100.50.0 0.0.0.255 any eq www

or

access-list 101 permit tcp 200.100.50.0 0.0.0.255 any eq http

NOTE: Just like all Standard ACLs end with an implicit "deny any", all Extended ACLs end with an implicit "deny ip any any" which means deny the entire internet from

ip access-group

The **ip access-group** command links an existing standard or extended ACL to an interface.

Remember that only one ACL per interface, per direction, per protocol is allowed.

The format of the command is:

```
Router(config-if)#ip access-group
access-list-number {in | out}
```

Named ACLs

IP named ACLs were introduced in Cisco IOS Software Release 11.2, allowing standard and extended ACLs to be given names instead of numbers.

The advantages that a named access list provides are:

- Intuitively identify an ACL using an alphanumeric name.
- Eliminate the limit of 798 simple and 799 extended ACLs
- Named ACLs provide the ability to modify ACLs without deleting them completely and then reconfiguring them.

Named ACLs are not compatible with Cisco IOS releases prior to Release 11.2.

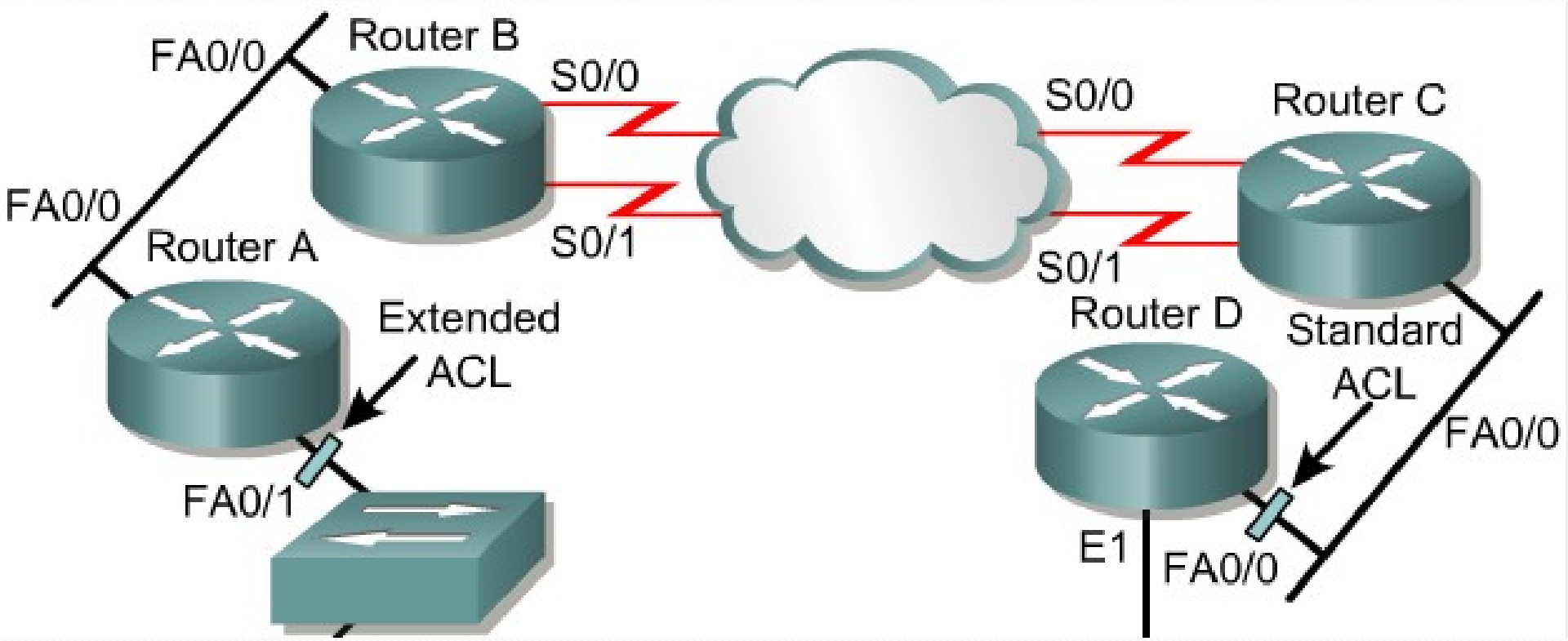
The same name may not be used for multiple ACLs.

Named ACL Example

```
Rtl(config)#ip access-list extended server-access
Rtl(config-ext-nacl)#permit TCP any host 131.108.101.99 eq
smtp
Rtl(config-ext-nacl)#permit UDP any host 131.108.101.99 eq
domain
Rtl(config-ext-nacl)#deny ip any any log
Rtl(config-ext-nacl)#^Z
Applying the named list:
Rtl(config)#interface fastethernet 0/0
Rtl(config-if)#ip access-group server-access out
Rtl(config-if)#^Z
```

Placing ACLs

The general rule is to put the extended ACLs as close as possible to the source of the traffic denied. Standard ACLs do not specify destination addresses, so they should be placed as close to the destination as possible. For example, in the graphic a standard ACL should be placed on Fa0/0 of Router D to prevent traffic from Router A.



Standard ACLs: Permitting/Denying Hosts, Networks and Subnets

Permitting a Single Host

Router(config)# **access-list 1 permit 200.100.50.23 0.0.0.0**
or
Router(config)# **access-list 1 permit host 200.100.50.23**
or
Router(config)# **access-list 1 permit 200.100.50.23**

(The implicit “deny any” ensures that everyone else is denied.)

Router(config)# **int e0**
Router(config-if)# **ip access-group 1 in**
or
Router(config-if)# **ip access-group 1 out**

Denying a Single Host

Router(config)# **access-list 1 deny 200.100.50.23 0.0.0.0**
Router(config)# **access-list 1 permit 0.0.0.0 255.255.255.255**
or
Router(config)# **access-list 1 deny host 200.100.50.23**
Router(config)# **access-list 1 permit any**

(The implicit “deny any” is still present, but totally irrelevant.)

Router(config)# **int e0**
Router(config-if)# **ip access-group 1 in**
or
Router(config-if)# **ip access-group 1 out**

Permitting a Single Network

Class C

Router(config)# **access-list 1 permit 200.100.50.0 0.0.0.255**

or

Class B

Router(config)# **access-list 1 permit 150.75.0.0 0.0.255.255**

or

Class A

Router(config)# **access-list 1 permit 13.0.0.0 0.255.255.255**

(The implicit “deny any” ensures that everyone else is denied.)

Router(config)# **int s0**

Denying a Single Network

Class C

Router(config)# **access-list 1 deny 200.100.50.0 0.0.0.255**
Router(config)# **access-list 1 permit any**

or

Class B

Router(config)# **access-list 1 deny 150.75.0.0 0.0.255.255**
Router(config)# **access-list 1 permit any**

or

Class A

Router(config)# **access-list 1 deny 13.0.0.0 0.255.255.255**
Router(config)# **access-list 1 permit any**

(The implicit “deny any” is still present, but totally irrelevant.)

Permitting a Class C Subnet

Network Address/Subnet Mask: 200.100.50.0/28
Desired Subnet: 3rd

Process:
32-28=4 2^4 = 16
1st Usable Subnet address range it 200.100.50.16-31
2nd Usable Subnet address range it 200.100.50.32-47
3rd Usable Subnet address range it 200.100.50.48-63

Subnet Mask is 255.255.255.240 Inverse Mask is 0.0.0.15
or subtract 200.100.50.48 from 200.100.50.63 to get 0.0.0.15

Router(config)# **access-list 1 permit 200.100.50.48 0.0.0.15**

Denying a Class C Subnet

Network Address/Subnet Mask: 192.68.72.0/27
Undesired Subnet: 2nd

Process:
32-27=5 2^5=32
1st Usable Subnet address range it 192.68.72.32-63
2nd Usable Subnet address range it 192.68.72.64-95

Subnet Mask is 255.255.255.224 Inverse Mask is 0.0.0.31
or subtract 192.68.72.64 from 192.68.72.95 to get 0.0.0.31

Router(config)# **access-list 1 deny 192.68.72.64 0.0.0.31**
Router(config)# **access-list 1 permit any**

(The implicit “deny any” is still present, but totally

Permitting a Class B Subnet

Network Address/Subnet Mask: 150.75.0.0/24
Desired Subnet: 129th

Process:
Since exactly 8 bits are borrowed the 3rd octet will denote the subnet number.
129th Usable Subnet address range it 150.75.129.0-255

Subnet Mask is 255.255.255.0 Inverse Mask is 0.0.0.255
or subtract 150.75.129.0 from 150.75.129.255 to get 0.0.0.255

Router(config)# **access-list 1 permit 150.75.129.0 0.0.0.255**

Denying a Class B Subnet

Network Address/Subnet Mask: 160.88.0.0/22
Undesired Subnet: 50th

Process:
32-22=10 (more than 1 octet) 10-8=2 2^2=4
1st Usable Subnet address range it 160.88.4.0-160.88.7.255
2nd Usable Subnet address range it 160.88.8.0-160.88.11.255

50 * 4 = 200 50th subnet is 160.88.200.0-160.88.203.255

Subnet Mask is 255.255.252.0 Inverse Mask is 0.0.3.255
or subtract 160.88.200.0 from 160.88.203.255 to get 0.0.3.255

Permitting a Class A Subnet

Network Address/Subnet Mask: 111.0.0.0/12
Desired Subnet: 13th

Process:
32-12=20 20-16=4 2^4=16
1st Usable Subnet address range is 111.16.0.0-111.31.255.255
13*16=208
13th Usable Subnet address range is 111.208.0.0-111.223.255.255

Subnet Mask is 255.240.0.0 Inverse Mask is 0.15.255.255
or subtract 111.208.0.0 from 111.223.255.255 to get 0.15.255.255

Router(config)# **access-list 1 permit 111.208.0.0 0.15.255.255**

Denying a Class A Subnet

Network Address/Subnet Mask: 40.0.0.0/24
Undesired Subnet: 500th

Process:
Since exactly 16 bits were borrowed the 2nd and 3rd octet will denote the subnet.

1st Usable Subnet address range is 40.0.1.0-40.0.1.255
255th Usable Subnet address range is 40.0.255.0-40.0.255.255
256th Usable Subnet address range is 40.1.0.0-40.1.0.255
300th Usable Subnet address range is 40.1.44.0-40.1.44.255
500th Usable Subnet address range is 40.1.244.0-40.1.244.255

Standard ACLs: Permitting/Denying Ranges of Addresses that cross subnets.

Permit 200.100.50.24-100 Plan A

```
access-list 1 permit host 200.100.50.24
access-list 1 permit host 200.100.50.25
access-list 1 permit host 200.100.50.26
access-list 1 permit host 200.100.50.27
access-list 1 permit host 200.100.50.28
:      :      :      :      :      :      :      :
access-list 1 permit host 200.100.50.96
access-list 1 permit host 200.100.50.97
access-list 1 permit host 200.100.50.98
access-list 1 permit host 200.100.50.99
access-list 1 permit host 200.100.50.100
```

This would get very tedious!

Permit 200.100.50.24-100 Plan B

access-list 1 permit 200.100.50.24 0.0.0.7 *(24-31)*

access-list 1 permit 200.100.50.32 0.0.0.31

(32-63)

access-list 1 permit 200.100.50.64 0.0.0.31

(64-95)

access-list 1 permit 200.100.50.96 0.0.0.3 *(96-99)*

access-list 1 permit host 200.100.50.100 *(100)*

Permit 200.100.50.16-127 Plan A

access-list 1 permit 200.100.50.16 0.0.0.15

(16-31)

access-list 1 permit 200.100.50.32 0.0.0.31

(32-63)

access-list 1 permit 200.100.50.64 0.0.0.63

(64-127)

(The implicit “deny any” ensures that everyone else is denied.)

Permit 200.100.50.16-127 Plan B

access-list 1 deny 200.100.50.0 0.0.0.15 *(0-15)*

access-list 1 permit 200.100.50.0 0.0.0.127 *(0-127)*

First we make sure that addresses 0-15 are denied.

Then we can permit any address in the range 0-127.

Since only the first matching statement in an ACL is applied an address in the range of 0-15 will be denied by the first statement before it has a chance to be permitted by the second.

Permit 200.100.50.1,5,13,29,42,77

access-list 1 permit host 200.100.50.1
access-list 1 permit host 200.100.50.5
access-list 1 permit host 200.100.50.13
access-list 1 permit host 200.100.50.29
access-list 1 permit host 200.100.50.42
access-list 1 permit host 200.100.50.77

Sometimes a group of addresses has no pattern and the best way to deal with them is individually.

(The implicit “deny any” ensures that everyone else is denied.)

Extended ACLs: Permitting/Denying Source Addresses, Destination Addresses, and Protocols

Permit Source Network

access-list 101 permit ip 200.100.50.0 0.0.0.255

0.0.0.0 255.255.255.255

or

access-list 101 permit ip 200.100.50.0 0.0.0.255 any

Implicit deny ip any any

Deny Source Network

access-list 101 deny ip 200.100.50.0 0.0.0.255

0.0.0.0 255.255.255.255

access-list 101 permit ip 0.0.0.0 255.255.255.255

0.0.0.0 255.255.255.255

or

access-list 101 deny ip 200.100.50.0 0.0.0.255 any
access-list 101 permit ip any any

Implicit deny ip any any is present but irrelevant.

Permit Destination Network

access-list 101 permit ip 0.0.0.0 255.255.255.255 200.100.50.0 0.0.0.255

or

access-list 101 permit ip any 200.100.50.0 0.0.0.255

Implicit deny ip any any

Deny Destination Network

access-list 101 deny ip 0.0.0.0 255.255.255.255

200.100.50.0 0.0.0.255

access-list 101 permit ip 0.0.0.0 255.255.255.255

0.0.0.0 255.255.255.255

or

access-list 101 deny ip any 200.100.50.0 0.0.0.255
access-list 101 permit ip any any

Implicit deny ip any any is present but irrelevant.

Permit one Source Network to another Destination Network

Assume the only traffic you want is traffic from network 200.100.50.0 to network 150.75.0.0

access-list 101 permit ip 200.100.50.0 0.0.0.255 150.75.0.0 0.0.255.255

Implicit deny ip any any

To allow 2 way traffic between the networks add this statement:

access-list 101 permit ip 150.75.0.0 0.0.255.255

Deny one Source Network to another Destination Network

Assume you want to allow all traffic EXCEPT from network 200.100.50.0 to network 150.75.0.0

access-list 101 deny ip 200.100.50.0 0.0.0.255 150.75.0.0 0.0.255.255

access-list 101 permit ip any any

To deny 2 way traffic between the networks add this statement:

access-list 101 deny ip 150.75.0.0 0.0.255.255 200.100.50.0 0.0.0.255

Deny FTP

Assume you do not want anyone FTPing on the network.

access-list 101 deny tcp any any eq 21

access-list 101 permit ip any any

or

access-list 101 deny tcp any any eq ftp

access-list 101 permit ip any any

Deny Telnet

Assume you do not want anyone telnetting on the network.

access-list 101 deny tcp any any eq 23

access-list 101 permit ip any any

or

access-list 101 deny tcp any any eq telnet

access-list 101 permit ip any any

Deny Web Surfing

Assume you do not want anyone surfing the internet.

access-list 101 deny tcp any any eq 80

access-list 101 permit ip any any

or

access-list 101 deny tcp any any eq www

access-list 101 permit ip any any

You can also use http instead of www.

Complicated Example #1

Suppose you have the following conditions:

- No one from Network 200.100.50.0 is allowed to FTP anywhere
- Only hosts from network 150.75.0.0 may telnet to network 50.0.0.0
- Subnetwork 100.100.100.0/24 is not allowed to surf the internet

access-list 101 deny tcp 200.100.50.0 0.0.0.255 any eq 21

access-list 101 permit tcp 150.75.0.0 0.0.255.255 50.0.0.0 0.255.255.255 eq 23

access-list 101 deny tcp any any eq 23

access-list 101 deny tcp 100.100.100.0 0.0.0.255 any eq 80

access-list 101 permit ip any any

Complicated Example #2

Suppose you are the admin of network 200.100.50.0. You want to permit Email only between your network and network 150.75.0.0. You wish to place no restriction on other protocols like web surfing, ftp, telnet, etc.

- Email server send/receive Protocol: SMTP, port 25
- User Check Email Protocol: POP3, port 110

This example assumes the your Email server is at addresses 200.100.50.25

access-list 101 permit tcp 200.100.50.0 0.0.0.255 150.75.0.0 0.0.255.255 eq 25
access-list 101 permit tcp 150.75.0.0 0.0.255.255 200.100.50.0 0.0.0.255 eq 25
access-list 101 permit tcp 200.100.50.0 0.0.0.255 200.100.50.0 0.0.0.255 eq 110
access-list 101 deny tcp any any smtp
access-list 101 deny tcp any any pop3