

BASIC ROUTING MATH

Remember, the problem to be solved is that our computers need to be able to determine if a given IP address is local or remote. Local IP packets should be sent directly to the destination, while remote packets should be sent to the router.

The key fact here is that you can use a binary AND operator to calculate your net address based on just your IP address and netmask. In other words, when you take your own IP address and AND it with your netmask you get your net address. You then take the destination IP address and AND it with your netmask, and compare the result to your net address. If the result is the same as your net address, the IP is local, if not, it's remote and needs to be routed.

Firstly, lets define what we mean by an AND operation in a binary context:

A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

This probably all sounds very abstract, so lets work through an example. We are computer A, and the two computers we want to communicate with are Computers B and C.

Subnet masks are not published, they are an internal OS setting, so we do not know the recipients' netmasks, only our own. So, this is what we know:

Computer A: IP = 192.168.0.3, netmask = 255.255.255.248

Computer B: IP = 192.168.0.5

Computer C: IP = 192.168.0.9

First, let's do some conversions:

192.168.0.3 = 11000000101010000000000000000011

192.168.0.5 = 110000001010100000000000000000101

192.168.0.9 = 1100000010101000000000000000001001

255.255.255.248 = 111111111111111111111111111111000

Using the simple truth table for AND shown above, we can AND each IP address with our netmask to get the results below. Note that you need to apply the AND rule 32 times for each conversation, once for each bit. This is known in computer science as a bitwise AND operation.

IP A AND netmask = 11000000101010000000000000000000 (our net address)

IP B AND netmask = 11000000101010000000000000000000

IP C AND netmask = 1100000010101000000000000000001000

What we see here is that A and B are in the same subnet, but C is not.

You can play around with this, and see all the binary calculations using my free IP Subnet calculator.

You can use to load the IP and Netmask into the interface automatically and save yourself some copying and pasting. You can then paste IP B and IP C into the IP Test text box near the bottom of the page to see why one is local and the other is not.

If we write out all the IP addresses between 192.168.0.0 and 192.168.0.9, as well as our netmask (255.255.255.248) the pattern will hopefully become clear. For extra clarity, I've also included the imaginary separator represented by the netmask by inserting a | character into the binary strings.

```
IP in Binary (With Imaginary Separator) IP quads
11000000101010000000000000000000|000 192.168.0.0
11000000101010000000000000000000|001 192.168.0.1
11000000101010000000000000000000|010 192.168.0.2
11000000101010000000000000000000|011 192.168.0.3
11000000101010000000000000000000|100 192.168.0.4
11000000101010000000000000000000|101 192.168.0.5
11000000101010000000000000000000|110 192.168.0.6
11000000101010000000000000000000|111 192.168.0.7
11000000101010000000000000000001|000 192.168.0.8
11000000101010000000000000000001|001 192.168.0.9
11111111111111111111111111111111|000 255.255.255.248
```

Source: <https://www.bartbusschots.ie/s/2014/12/07/taming-the-terminal-part-25-of-n-ip-subnets/>