System Administration

Week 05, Segment 3
Networking I: IPv6 Basics

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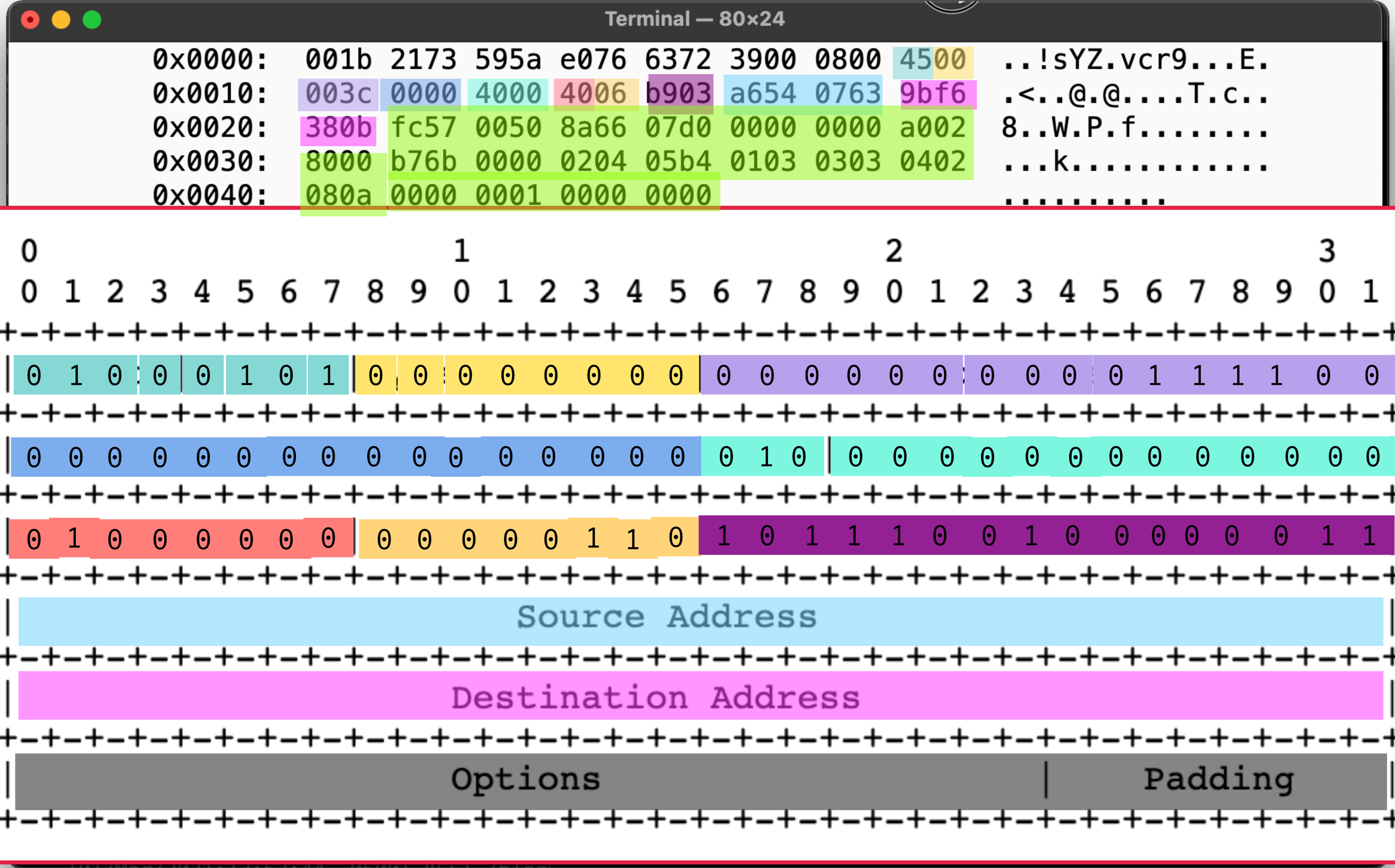
https://stevens.netmeister.org/615/

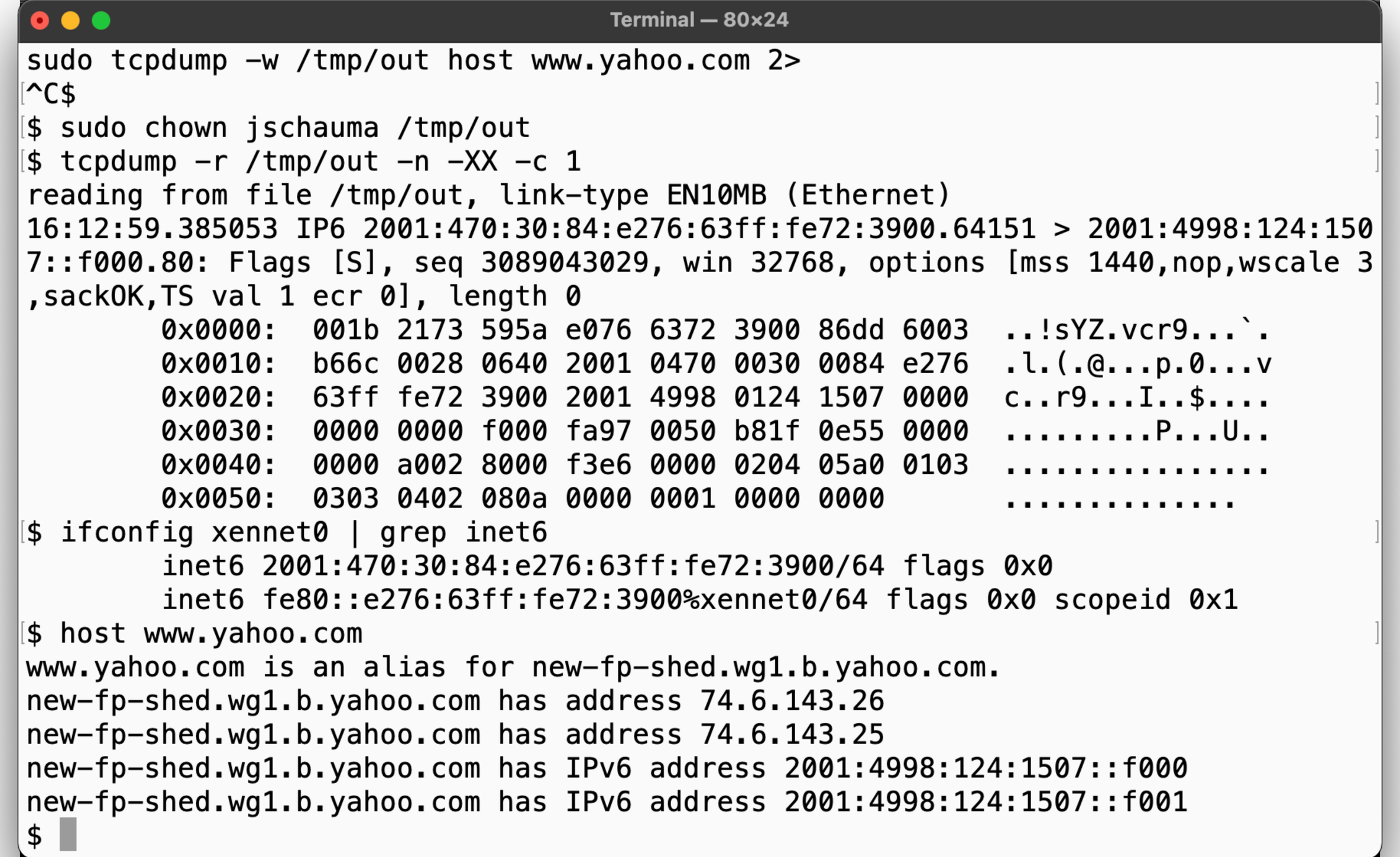

Terminal — 80×24
0x0000: 001b 2173 595a e076 6372 3900 0800 4500 ..!sYZ.vcr9...E.
0x0010: 003c 0000 4000 4006 b903 a654 0763 9bf6 .<..@.@....T.c..
0x0020: 380b fc57 0050 8a66 07d0 0000 0000 a002 8..W.P.f........
0x0030: 8000 b76b 0000 0204 05b4 0103 0303 0402 ...k............
0x0040: 080a 0000 0001 0000 0000 ....
0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
0 1 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 1 1 1 0 0 1 0 0 0 0 0 0 1 1
Source Address
Destination Address
Options
Padding

https://www.netmeister.org/blog/ec2-ipv6.html

```
Welcome to NetBSD!

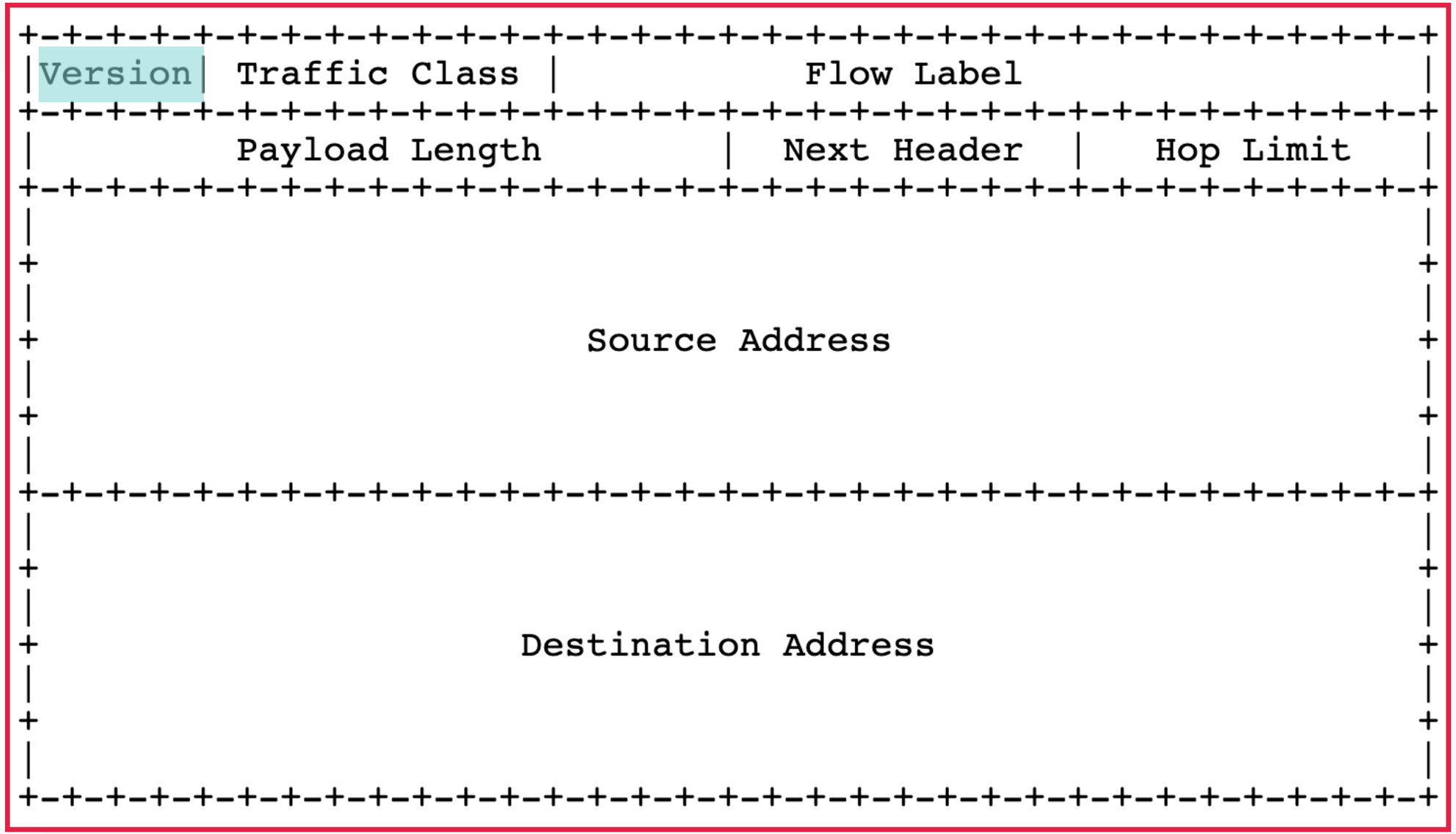
This is a development snapshot of NetBSD for testing -- user beware!

Bug reports: https://www.NetBSD.org/support/send-pr.html
Donations to the NetBSD Foundation: https://www.NetBSD.org/donations/
We recommend that you create a non-root account and use su(1) for root access.
ip-10-10-0-23# ifconfig -a
xennet0: flags=0x8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        capabilities=0x17c00<TCP4CSUM_Rx,TCP4CSUM_Tx,UDP4CSUM_Rx,UDP4CSUM_Tx>
        capabilities=0x17c00<TCP6CSUM_Rx,UDP6CSUM_Rx>
        enabled=0
        ec_capabilities=0x5<VLAN_MTU,JUMBO_MTU>
        ec_enabled=0
        address: 0e:ee:3d:28:fb:cb
        inet 10.10.0.23/26 broadcast 10.10.0.63 flags 0
        inet6 fe80::1a7e:12cc:b2c9:4809%xennet0/64 flags 0 scopeid 0x1
        inet6 2600:1f18:400c:b800:520b:e86d:1d8a:10b4/128 flags 0
lo0: flags=0x8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 33624
        status: active
        inet 127.0.0.1/8 flags 0
        inet6 ::1/128 flags 0x20<NODAD>
        inet6 fe80::1%lo0/64 flags 0 scopeid 0x2
ip-10-10-0-23#
```


Terminal — 80×24
sudo tcpdump -w /tmp/out host www.yahoo.com 2>
^C$
$ sudo chown jschauma /tmp/out
$ tcpdump -r /tmp/out -n -XX -c 1
reading from file /tmp/out, link-type EN10MB (Ethernet)
16:12:59.385053 IP6 2001:470:30:84:e276:63ff:fe72:3900.64151 > 2001:4998:124:150
7::f000.80: Flags [S], seq 3089043029, win 32768, options [mss 1440,nop,wscale 3
,sackOK,TS val 1 ecr 0], length 0
0x0000: 001b 2173 595a e076 6372 3900 86dd 6003 ..!sYZ.vcr9...`.
0x0010: b66c 0028 0640 2001 0470 0030 0084 e276 .l.(.@...p.0...v
0x0020: 63ff fe72 3900 2001 4998 0124 1507 0000 c..r9...I..$....
0x0030: 0000 0000 f000 fa97 0050 b81f 0e55 0000 .........P...U..
0x0040: 0000 a002 8000 f3e6 0000 0204 05a0 0103 ....
0x0050: 0303 0402 080a 0000 0001 0000 0000 ....
$ ifconfig xennet0 | grep inet6
inet6 2001:470:30:84:e276:63ff:fe72:3900/64 flags 0x0
inet6 fe80::e276:63ff:fe72:3900%xennet0/64 flags 0x0 scopeid 0x1
$ host www.yahoo.com
www.yahoo.com is an alias for new-fp-shed.wg1.b.yahoo.com.
new-fp-shed.wg1.b.yahoo.com has address 74.6.143.26
new-fp-shed.wg1.b.yahoo.com has address 74.6.143.25
new-fp-shed.wg1.b.yahoo.com has IPv6 address 2001:4998:124:1507::f000
new-fp-shed.wg1.b.yahoo.com has IPv6 address 2001:4998:124:1507::f001
$

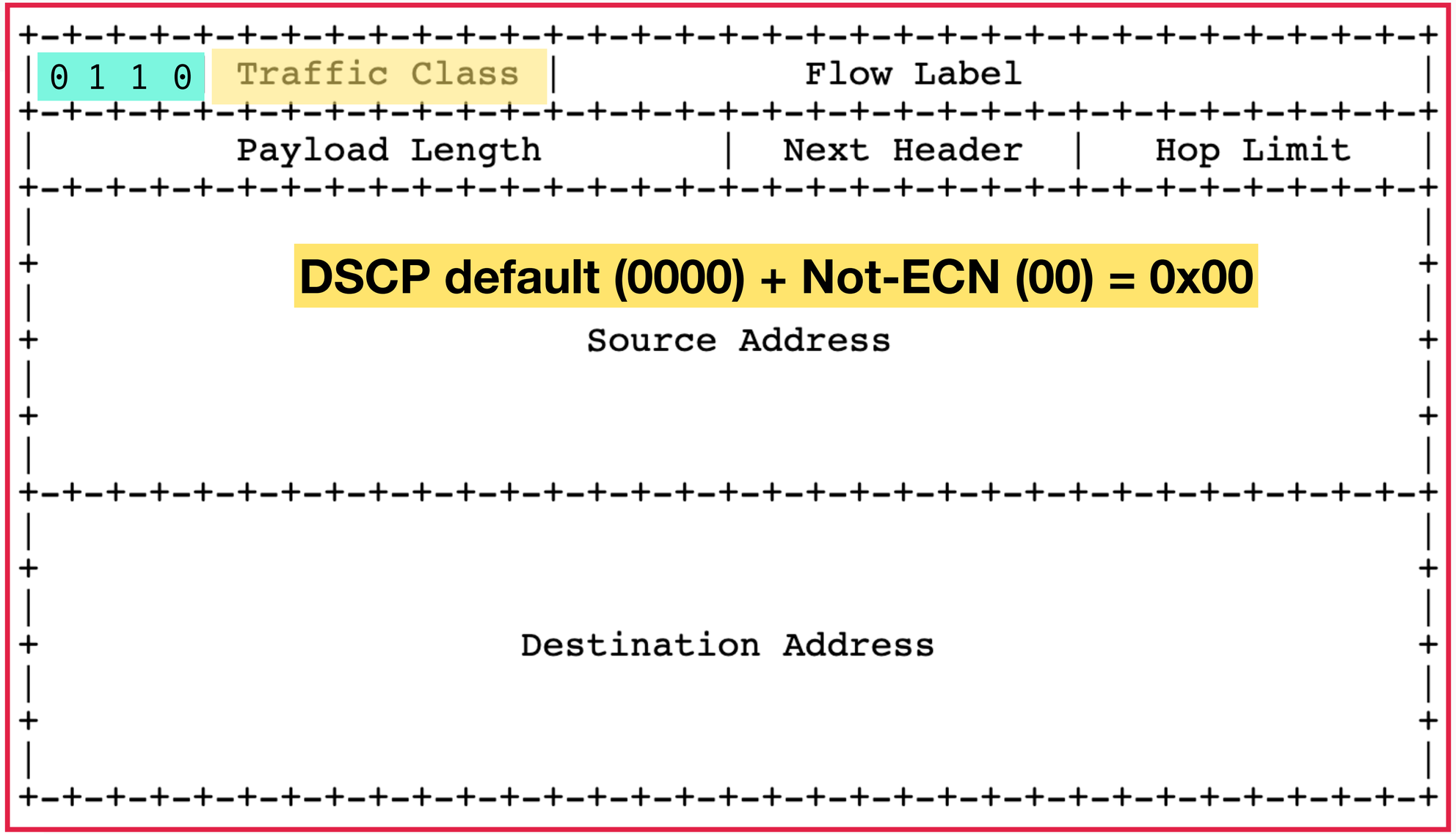
Terminal — 80×24

```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



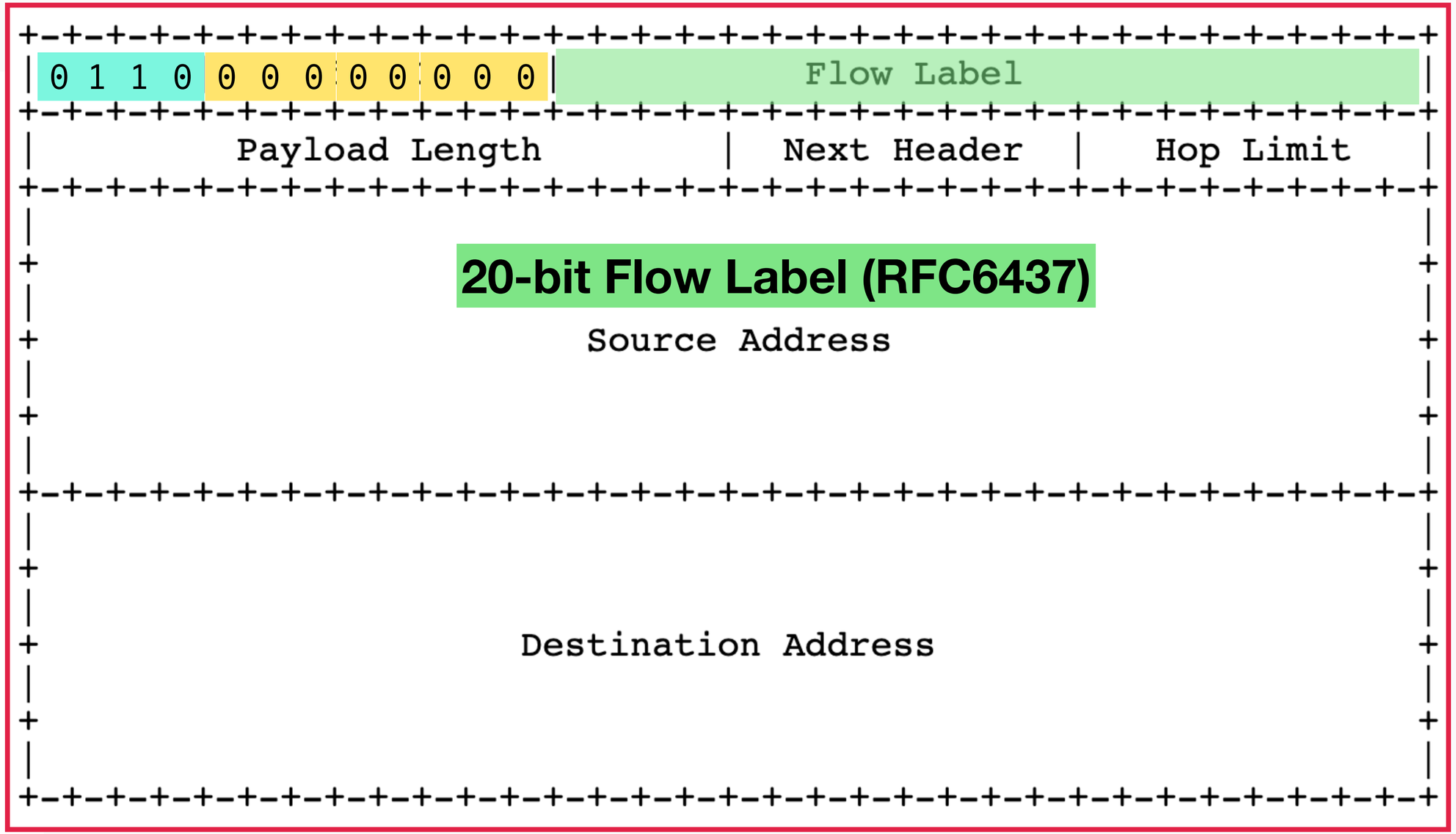
Terminal — 80×24

```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



Terminal — 80×24

```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



Terminal — 80×24

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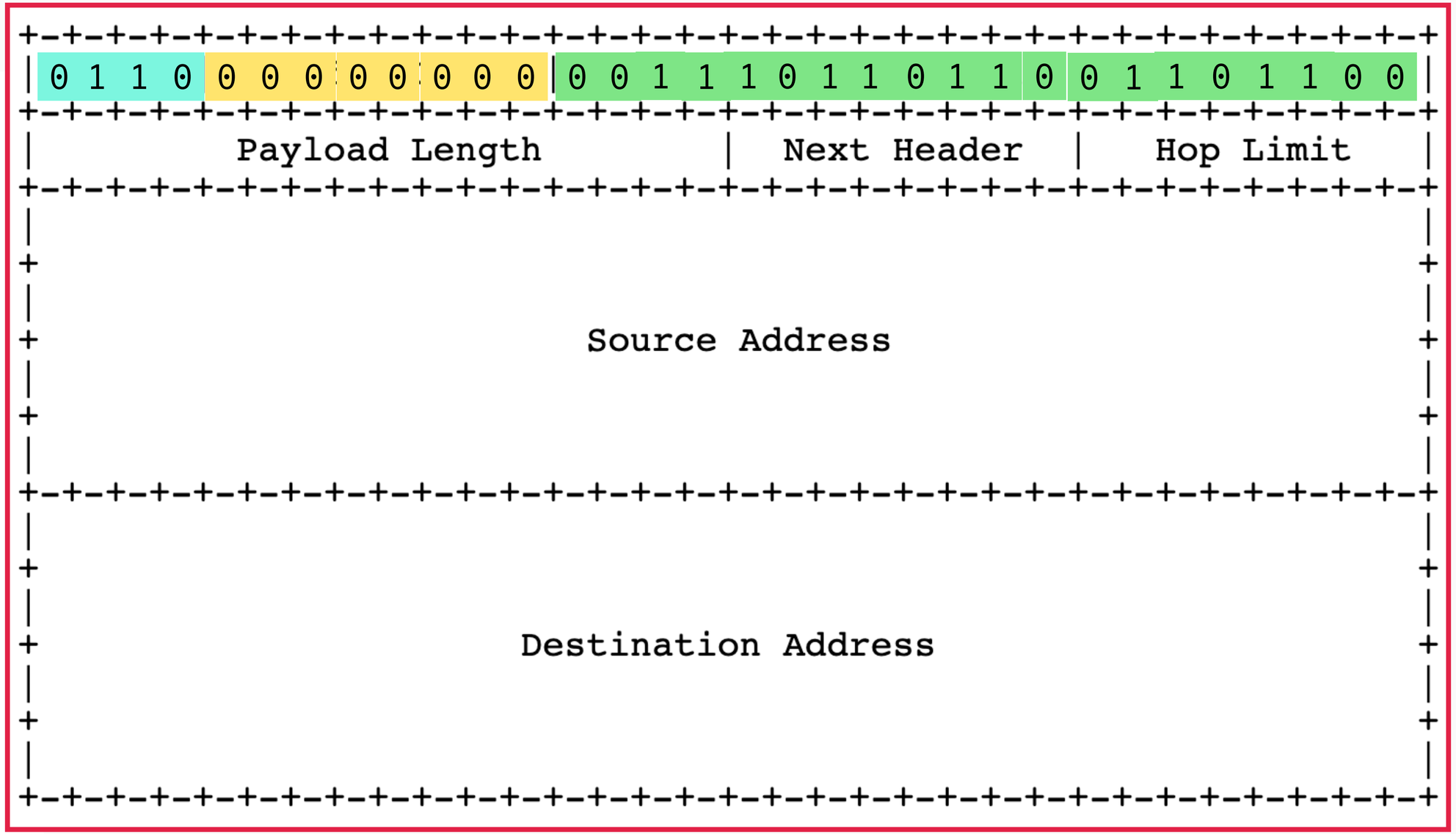
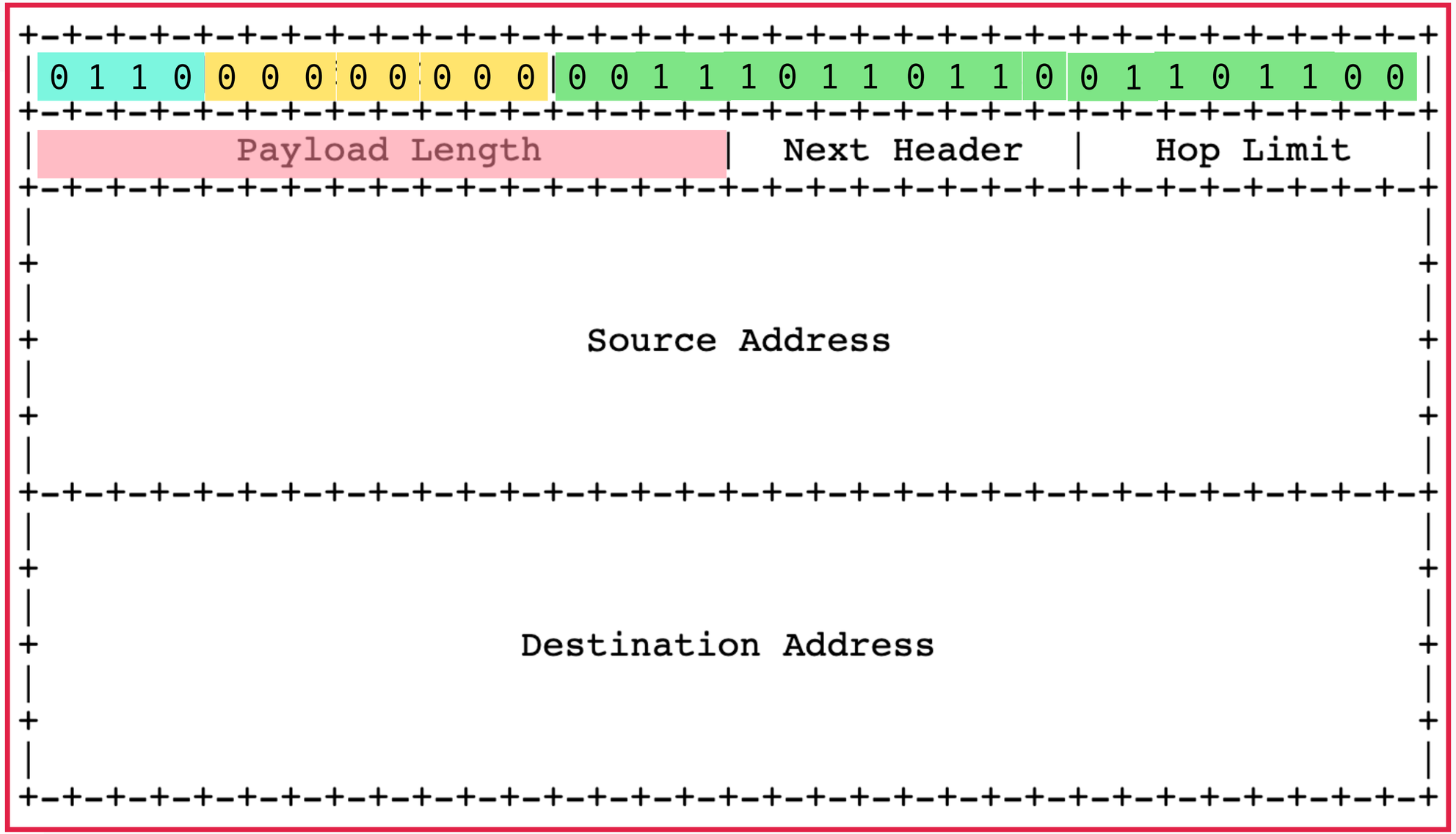
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



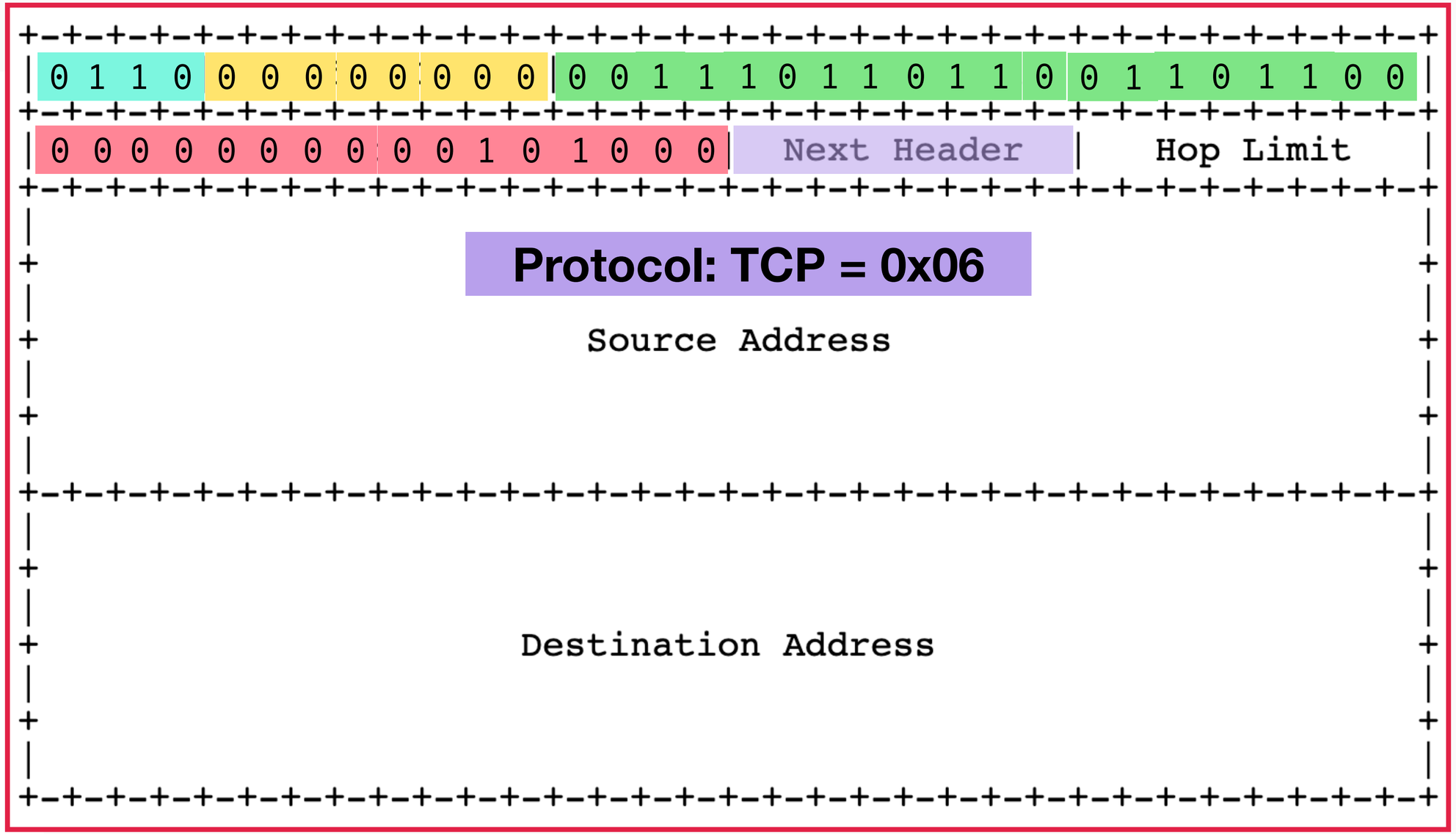
Terminal — 80×24

```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



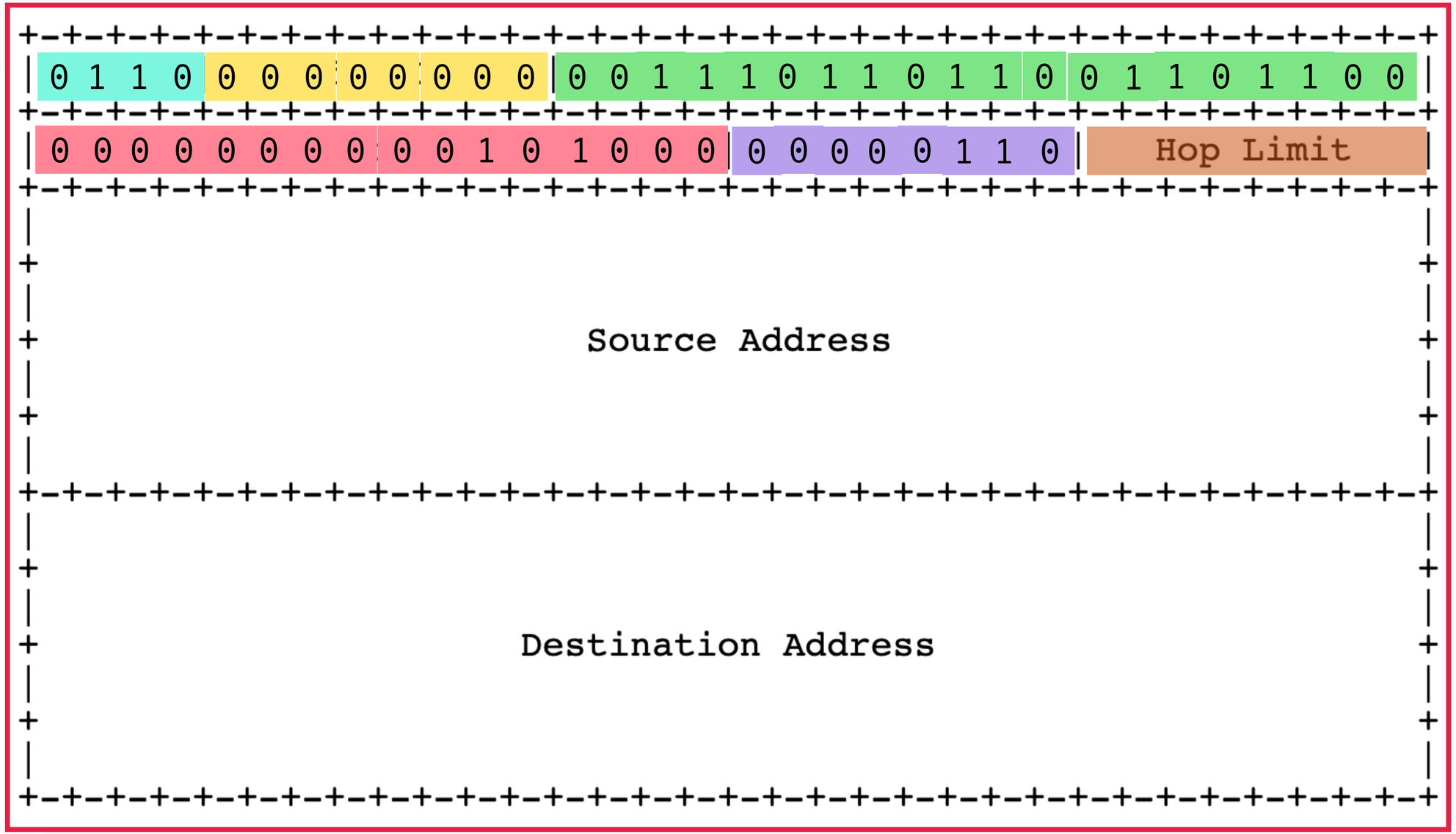
Terminal — 80×24

```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



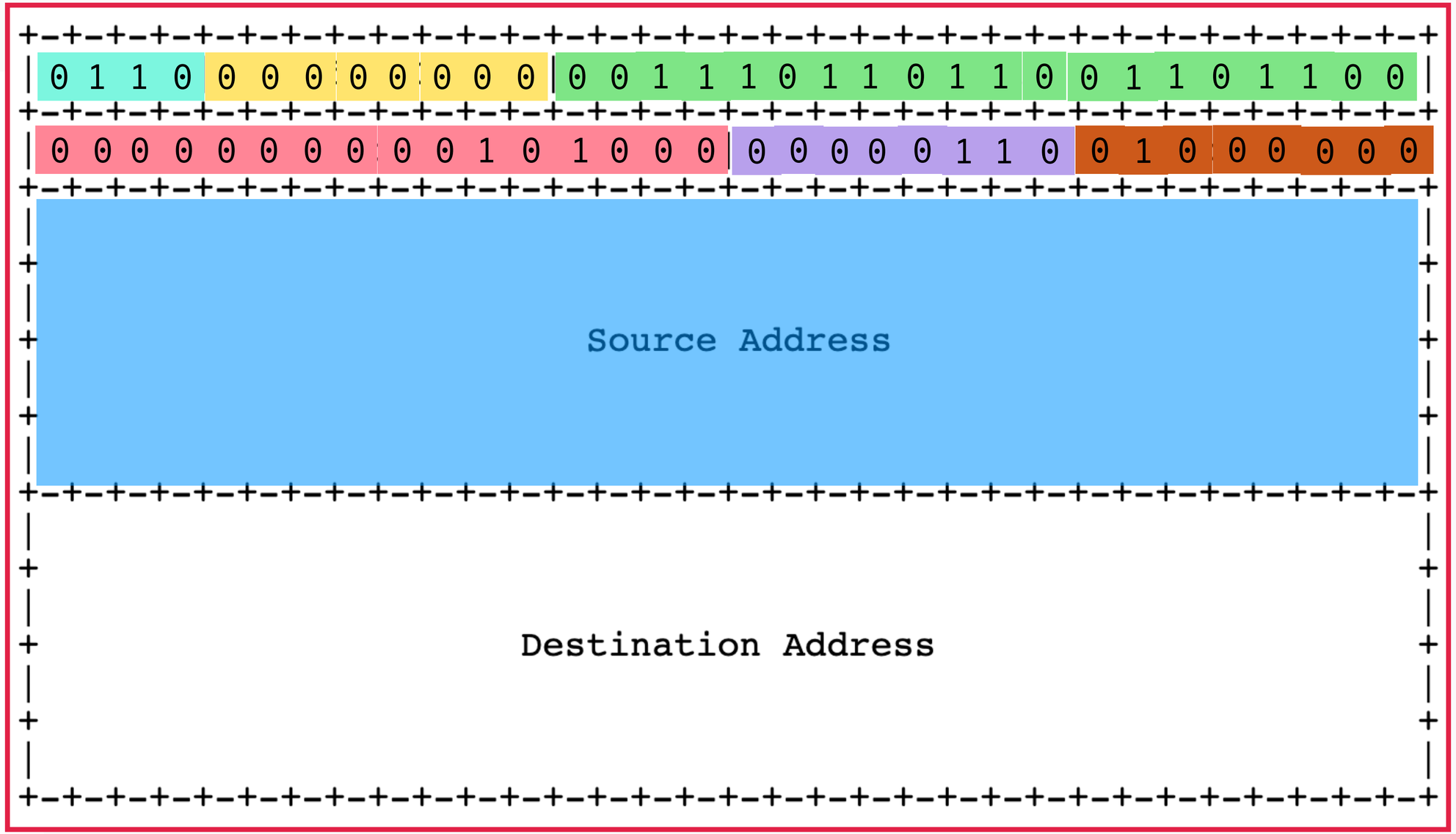
Terminal — 80×24

```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



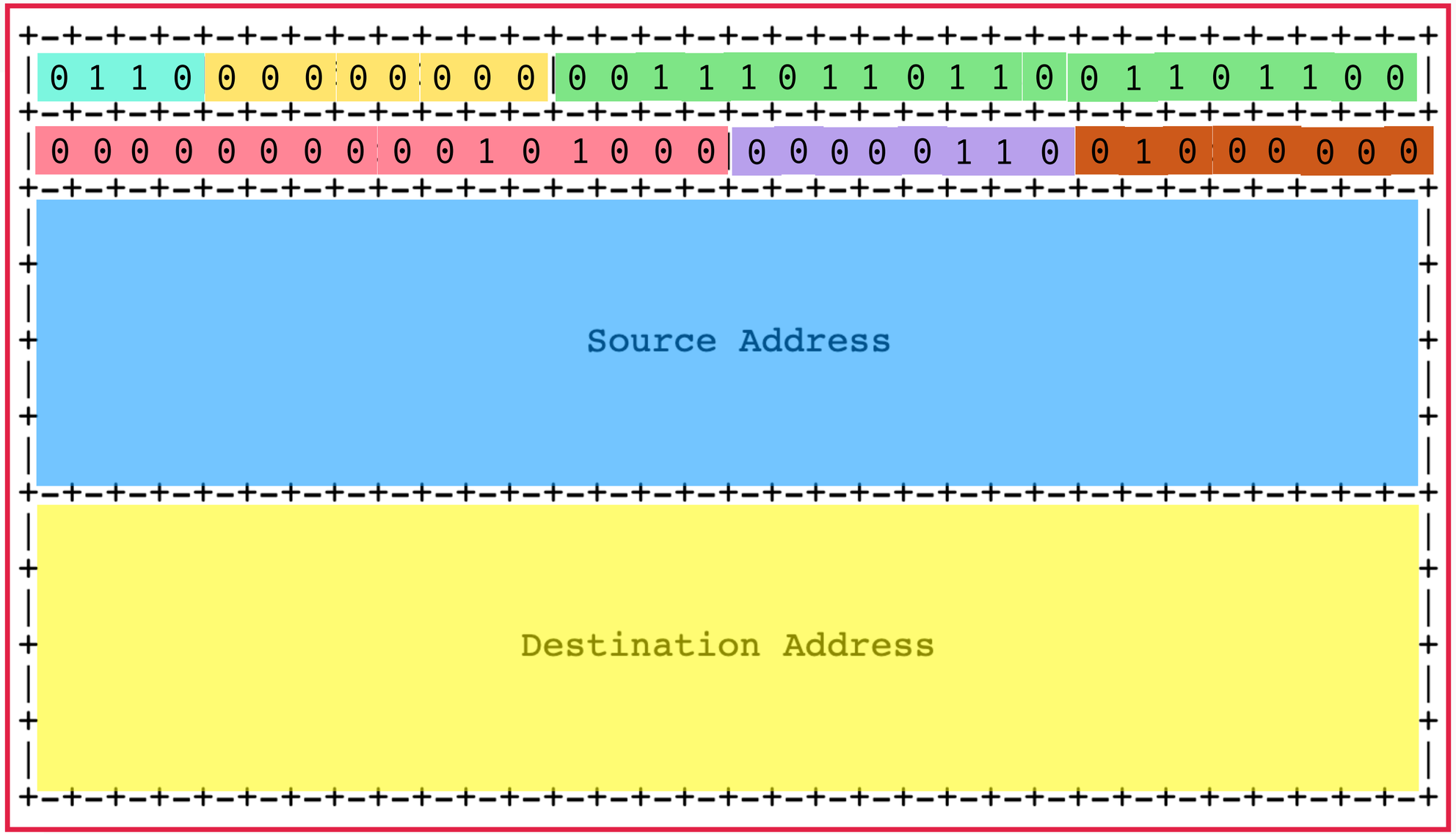
Terminal — 80×24

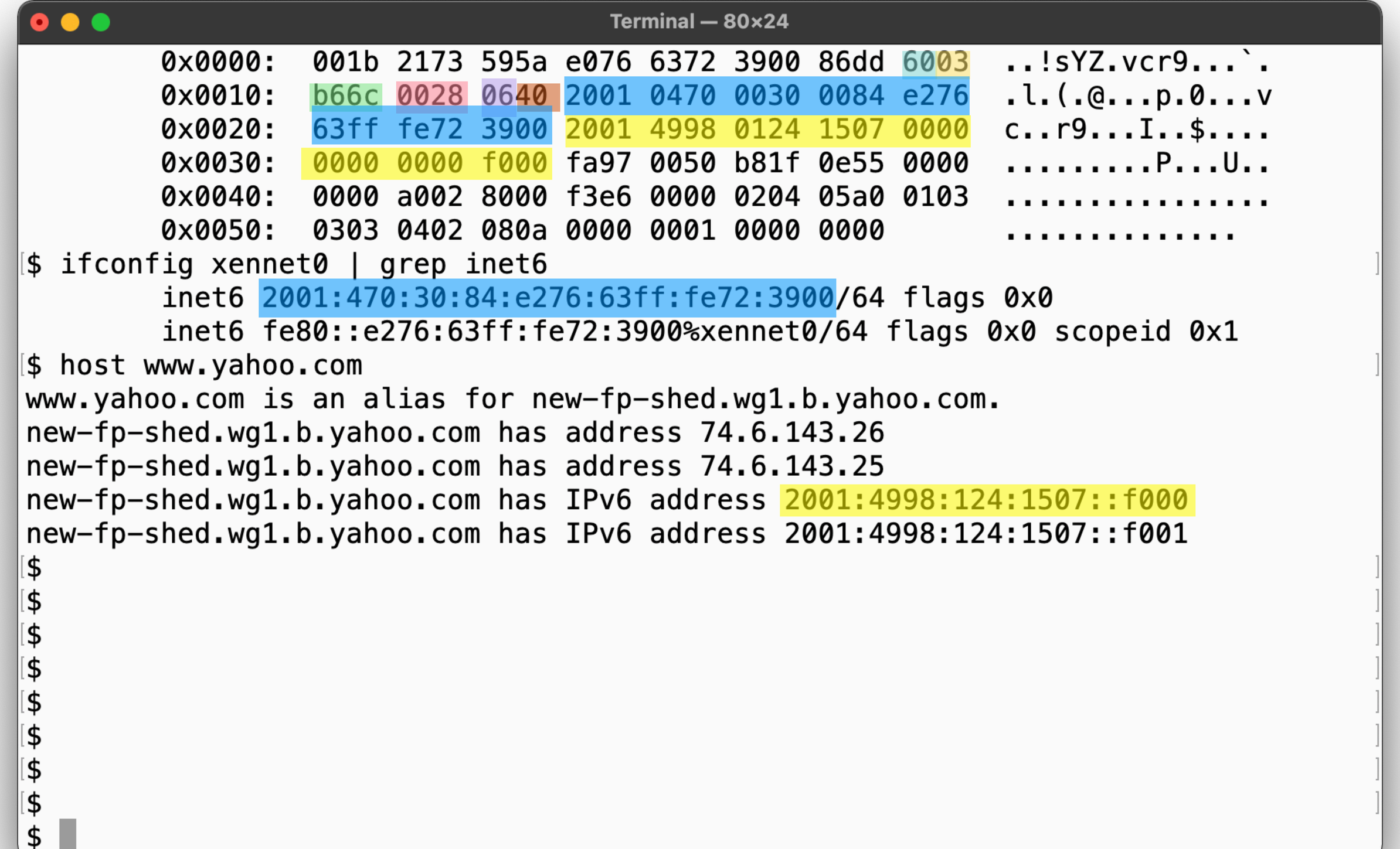
```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```



Terminal — 80×24

```
0x0000:  001b 2173 595a e076 6372 3900 86dd 6003  ..!sYZ.vcr9...`.
0x0010:  b66c 0028 0640 2001 0470 0030 0084 e276  .l.(.@...p.0...v
0x0020:  63ff fe72 3900 2001 4998 0124 1507 0000  c..r9...I..$....
0x0030:  0000 0000 f000 fa97 0050 b81f 0e55 0000  .........P...U..
```




Terminal — 80×24
0x0000: 001b 2173 595a e076 6372 3900 86dd 6003 ..!sYZ.vcr9...`.
0x0010: b66c 0028 0640 2001 0470 0030 0084 e276 .l.(.@...p.0...v
0x0020: 63ff fe72 3900 2001 4998 0124 1507 0000 c..r9...I..$....
0x0030: 0000 0000 f000 fa97 0050 b81f 0e55 0000 .........P...U..
0x0040: 0000 a002 8000 f3e6 0000 0204 05a0 0103 ....
0x0050: 0303 0402 080a 0000 0001 0000 0000 ....
$ ifconfig xennet0 | grep inet6
inet6 2001:470:30:84:e276:63ff:fe72:3900/64 flags 0x0
inet6 fe80::e276:63ff:fe72:3900%xennet0/64 flags 0x0 scopeid 0x1
$ host www.yahoo.com
www.yahoo.com is an alias for new-fp-shed.wg1.b.yahoo.com.
new-fp-shed.wg1.b.yahoo.com has address 74.6.143.26
new-fp-shed.wg1.b.yahoo.com has address 74.6.143.25
new-fp-shed.wg1.b.yahoo.com has IPv6 address 2001:4998:124:1507::f000
new-fp-shed.wg1.b.yahoo.com has IPv6 address 2001:4998:124:1507::f001
$
$
$
$
$
$
$
$
$

IPv4 Basics

IPv4 addresses are 32-bit numbers

```
10011011  11110110  00111000  00001011
```

IPv6 Basics

IPv6 addresses are 128-bit numbers

```
00100000  00000001  01001001  10011000
00000001  00100100  00010101  00000111
00000000  00000000  00000000  00000000
00000000  00000000  11110000  00000000
```

IPv6 Basics

IPv6 addresses consist of 8 16-bit fields in case-insensitive, hexadecimal, colon-separated words

```
0010000000000001    01001001 10011000
              2001  : 4998  :

0000000100100100    00010101 00000111
              0124  : 1507  :

0000000000000000    00000000 00000000
              0000  : 0000  :

0000000000000000    11110000 00000000
              0000  : F000
```

IPv6 Basics

IPv6 addresses consist of 8 16-bit fields in case-insensitive, hexadecimal, colon-separated words

```
2001:4998:0124:1507:0000:0000:0000:F000
```

IPv6 Basics

Leading zeros in a field are optional

```
2001:4998:124:1507:0:0:0:F000
```

IPv6 Basics

Successive fields of 0 represented as ::,

but only once in an address

```
2001:4998:124:1507::F000
```

IPv6 Basics

Successive fields of 0 represented as ::,

but only once in an address

`2031:0000:0000:030F:0000:0000:0000:130B`

IPv6 Basics

Successive fields of 0 represented as ::,

but only once in an address

```
2031::30F:0:0:0:130B
```

IPv6 Basics

Successive fields of 0 represented as ::,

but only once in an address

```
2031:0:0:30F::130B
```

IPv6 Basics

Successive fields of 0 represented as ::,

but only once in an address

~~2031::30F::130B~~

IPv6 Basics

Successive fields of 0 represented as ::,

but only once in an address

```
2031:0:0:30F::130B

2031::30F:0:0:0:130B

2031:0000:0000:30F:0000:0000:0000:130B
```

IPv6 Basics

Special cases:

- Loopback address: `::1`
- IPv4-mapped addresses: `::ffff:74.6.143.25`
- Separating IP and port now requires brackets: `74.6.143.25:80`

  `[2001:4998:124:1507::f000]:80`

IPv6 Address Scope

- Link-local (e.g., `fe80::e276:63ff:fe72:3900%xennet0`)
  - Generated on the host within `fe80::/10`
  - Used on a single link
  - Packets with link-local source or destination addresses are not forwarded to other links
- Unique Local (`fc00::/7`, although practically `fd00::/8`)
  - Used for private IPv6 networks
  - Not globally routable
  - Applications similar to RFC 1918
- Global (e.g., `2001:4998:124:1507::f000`)
  - A globally unique address
  - Packets with global addresses can be forwarded to any part of the global network


Terminal — 80×24
Address ID (masked) - 0:0:0:0:0:0:0:f000/72
Prefix address - ffff:ffff:ffff:ffff:ff00:0:0:0
Prefix length - 72
Address type - Aggregatable Global Unicast Addresses
Network range - 2001:4998:0124:1507:0000:0000:0000:0000 -
2001:4998:0124:1507:00ff:ffff:ffff:ffff
-
$ sipcalc 2001:4998:124:1507::f000/64
-[ipv6 : 2001:4998:124:1507::f000/64] - 0
[IPV6 INFO]
Expanded Address - 2001:4998:0124:1507:0000:0000:0000:f000
Compressed address - 2001:4998:124:1507::f000
Subnet prefix (masked) - 2001:4998:124:1507:0:0:0:0/64
Address ID (masked) - 0:0:0:0:0:0:0:f000/64
Prefix address - ffff:ffff:ffff:ffff:0:0:0:0
Prefix length - 64
Address type - Aggregatable Global Unicast Addresses
Network range - 2001:4998:0124:1507:0000:0000:0000:0000 -
2001:4998:0124:1507:ffff:ffff:ffff:ffff
-
$

Explore IPv6

- Does your ISP provide you with an IPv6 address? Does your local Wifi Access Point?
- Did you set up your AWS account to provision dual-stack instances?
- Which popular services are not available via IPv6? Why not?

Coming up: IP space allocation and IPv4 space exhaustion, or:

Why do we even need IPv6?

Links

- IPv6 Wikipedia Page:
  https://en.wikipedia.org/wiki/IPv6

- Creating AWS IPv4/IPv6 Dual Stack EC2 Instances:
  https://www.netmeister.org/blog/ec2-ipv6.html

- Unique local addresses:
  https://tools.ietf.org/html/rfc4193