iptable

A Lua binding to `iptable.c`, a thin wrapper around *radix.c* from the *FreeBsd* project which implements a radix tree with one-way branching removed (a level collapsed trie).

`iptable` provides some convenience functions to work with ip addresses and subnets (in CIDR notation) as well as a longest prefix matching (Lua) table. It handles both ipv4 and ipv6 addresses and/or subnets transparently.

Throughout the documentation `prefix` refers to a string that represents either an ipv4 or ipv6 address or network in CIDR notation.

Requirements and limitations

`iptable` is developed on a linux machine and support for other OS's is non-existent at this point. The following is currently used to build iptable:

```
- Lua 5.3.5  Copyright (C) 1994-2018 Lua.org, PUC-Rio
- Ubuntu 18.04 bionic
- gcc (Ubuntu 7.4.0-1ubuntu1~18.04.1) 7.4.0
- GNU Make 4.1
```

`lua_iptable.c` uses Lua 5.3's C-API, so Lua >= 5.3 is required. Additionally for testing and documentation, the following is used:

```
- valgrind-3.13.0
- busted 2.0.rc13-0
- pandoc 2.7.3
- pandoc-imagine 0.1.6
```

Installation

Install the Lua `iptable` library using make.

```
cd ~/installs
git clone https://github.com/hertogp/iptable.git
cd iptable
make test
sudo -H make install
# or
make local_install    # simply copies to ~/.luarocks/lib/lua/5.3
```

Install using luarocks

- todo.

Install only the C `iptable` library using make

Well, sort of:

```
cd ~/installs
git clone https://github.com/hertogp/iptable.git
cd iptable
make c_test
make c_lib
```

There's no `c_install` target to install the c-library, so from here it boils down to manual labor.

Usage

An iptable.new() yields a Lua table with modified indexing behaviour:

- the table utilizes 2 separate radix trees for ipv4 and ipv6 respectively
- the table handles both ipv4 or ipv6 keys transparently
- if a key is not an ipv4 or ipv6 subnet/address it is *ignored*
- ipv4 and ipv6 subnets are always in CIDR notation: address/len
- storing data always uses a subnet-key (address/mlen)
- when storing data, missing masks default to the AF's maximum mask
- when storing data, masks are always applied first to the key
- storing data is always based on an exact match which includes the mask
- retrieving data with a subnet-key, uses an exact match
- retrieving data with an address-key, uses a longest prefix match
- count/size functions use Lua arithmatic, since ipv6 space is rather large
- `mlen == -1` means some function (like `iptable.address(pfx)`) saw no mask
- it is generally safe to delete entries while iterating across the table

Example usage:

```
ipt = require"iptable".new()

ipt["10.10.10.0/24"] = {seen=0}       -- store anything in the table
ipt["10.10.10.10"] = false            -- stores to ipt["10.10.10.10/32"]
ipt["11.11.11.11/24"] = true          -- stores to ipt["11.11.11.0/24"]
ipt["acdc:1974::/32"] = "Jailbreak"   -- goes into separate radix tree
ipt[1] = 42                           -- ignored: ipt[1] -> nil
#ipt                                  -- 4 entries in total
```

```
ipt.counts()                          -- 3  1  (ipv4 and ipv6 counts)

for k,v in pairs(ipt) do              -- 10.10.10.0/24    table 0x...
    print(k,v)                        -- 10.10.10.10/32   false
                                      -- 11.11.11.0/24    true
end                                   -- acdc:1974::/32   Jailbreak
```

Quick reference

```
iptable = require "iptable"

-- Module constants

iptable.AF_INET  --  2
iptable.AF_INET6 -- 10

-- Module functions

prefix = "10.10.10.0/24"                        -- ipv4/6 address or subnet

addr,  mlen, af = iptable.address(prefix)       -- 10.10.10.0       24  2
netw,  mlen, af = iptable.network(prefix)       -- 10.10.10.0       24  2
bcast, mlen, af = iptable.broadcast(prefix)     -- 10.10.10.255     24  2
neigb, mlen, af = iptable.neighbor(prefix)      -- 10.10.11.0       24  2
invrt, mlen, af = iptable.invert(prefix)        -- 245.245.245.255 24 2
rev,   mlen, af = iptable.reverse(prefix)       -- 0.10.10.10       24  2
expl,  mlen, af = iptable.explode("2001::")     -- 2001:0000:..     -1  10

nxt,  mlen, af = iptable.incr(prefix, 257)      -- 10.10.11.1       24  2
prv,  mlen, af = iptable.decr(prefix, 257)      -- 10.10.8.255      24  2

mask = iptable.mask(iptable.AF_INET, 24)        -- 255.255.255.0
size = iptable.size(prefix)                     -- 256

binkey = iptable.tobin("255.255.255.0")         -- byte string 05:ff:ff:ff:00
prefix = iptable.tostr(binkey)                  -- 255.255.255.0
msklen = iptable.masklen(binkey)                -- 24
ipt    = iptable.new()                          -- longest prefix match table

for host in iptable.hosts(prefix[, true]) do    -- iterate across hosts in prefix
    print(host)                                 --> optionally include netw/bcast
end
```

```
-- table functions

#ipt                                          -- 0 (nothing stored yet)
ipt:counts()                                  -- 0 0 (ipv4_count ipv6_count)
for k,v in pairs(ipt) do ... end              -- iterate across k,v-pairs
for k,v in ipt:more(prefix [,true]) ... end   -- iterate across more specifics
for k,v in ipt:less(prefix [,true]) ... end   -- iterate across less specifics
for k,v in ipt:masks(af) ... end              -- iterate across masks used in af
for k,g in ipt:merge(af) ... end              -- iterate supernets & constituents
for rdx in ipt:radixes(af [,true]) ... end    -- dumps all radix nodes in tree
```

Notes:

- `more/less` exclude `prefix` from search results, unless 2nd arg is true
- `radixes` excludes mask nodes from iteration, unless 2nd arg is true
- `incr/decr`'s offset parameter is optional and defaults to 1
- module functions return nils on errors and set `iptable.error` to some string
- iptable never clears the iptable.error itself

Documentation

See also the `doc` directory on github.

module constants

```
iptable.AF_INET6    10
iptable.AF_INET     2
```

module functions

Requiring `iptable` yields an object with module level functions.

```
iptable = require "iptable"
```

`iptable.address(prefix)`

Returns the host address, mask length and address family for `prefix`. If `prefix` has no masklength, `mlen` will be `-1` to indicate the absence.

```
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "10.10.10.0/19"
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:700/120"
```

```
ip, mlen, af = iptable.address(pfx4)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))
ip, mlen, af = iptable.address("10.10.10.10")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.address(pfx6)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))
ip, mlen, af = iptable.address("acdc:1976::")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

print(string.rep("-", 35))

---------- PRODUCES --------------

-- ip 10.10.10.0, mlen 19, af 2
-- ip 10.10.10.10, mlen -1, af 2
-- ip 2001:db8:85a3::8a2e:370:700, mlen 120, af 10
-- ip acdc:1976::, mlen -1, af 10
-----------------------------------
```

iptable.network(prefix)

Applies the mask to the address and returns the network address, mask length and address family for `prefix`. If `prefix` has no masklength, `mlen` will be `-1` to indicate the absence and the network address is the host address itself.

```
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "10.10.10.10/19"
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:777/120"

ip, mlen, af = iptable.network(pfx4)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))
ip, mlen, af = iptable.network("10.10.10.10")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.network(pfx6)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))
ip, mlen, af = iptable.network("2001:0db8::")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

print(string.rep("-", 35))

---------- PRODUCES --------------
```

```
-- ip 10.10.0.0, mlen 19, af 2
-- ip 10.10.10.10, mlen -1, af 2
-- ip 2001:db8:85a3::8a2e:370:700, mlen 120, af 10
-- ip 2001:db8::, mlen -1, af 10
-----------------------------------
```

iptable.broadcast(prefix)

Applies the inverse mask to the address and returns the broadcast address, mask length and address family for `prefix`. If `prefix` has no masklength, `mlen` will be `-1` to indicate the absence and the broadcast address is the host address itself.

```
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "10.10.10.0/19"
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:700/120"

ip, mlen, af = iptable.broadcast(pfx4)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))
ip, mlen, af = iptable.broadcast("10.10.10.10")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.broadcast(pfx6)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))
ip, mlen, af = iptable.broadcast("2001:0db8::")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

print(string.rep("-", 35))

---------- PRODUCES --------------

-- ip 10.10.31.255, mlen 19, af 2
-- ip 10.10.10.10, mlen -1, af 2
-- ip 2001:db8:85a3::8a2e:370:7ff, mlen 120, af 10
-- ip 2001:db8::, mlen -1, af 10
-----------------------------------
```

iptable.incr(prefix [,offset])

Increment the ip address of the prefix (no mask is applied) and return the new ip address, mask length and address family. `offset` is optional and defaults to 1. Incrementing beyond valid address space yields `nil`.

```
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "10.10.10.0/19"
```

```lua
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:700/120"

ip, mlen, af = iptable.incr(pfx4)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.incr(pfx4, 10)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.incr("255.255.255.255")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.incr(pfx6, 5)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.incr("ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

print(string.rep("-", 35))

---------- PRODUCES --------------

-- ip 10.10.10.1, mlen 19, af 2
-- ip 10.10.10.10, mlen 19, af 2
-- ip nil, mlen nil, af nil
-- ip 2001:db8:85a3::8a2e:370:705, mlen 120, af 10
-- ip nil, mlen nil, af nil
-----------------------------------
```

iptable.decr(prefix [, offset])

Decrement the ip address of the prefix (no mask is applied) and return the new ip address, mask length and address family. `offset` is optional and defaults to 1. Decrementing beyond valid address space yields `nil`.

```lua
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "10.10.10.0/19"
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:700/120"

ip, mlen, af = iptable.decr(pfx4, 1)
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.decr("0.0.0.0")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.decr(pfx6, 1)
```

```
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.decr("::")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

print(string.rep("-", 35))

---------- PRODUCES --------------

-- ip 10.10.9.255, mlen 19, af 2
-- ip nil, mlen nil, af nil
-- ip 2001:db8:85a3::8a2e:370:6ff, mlen 120, af 10
-- ip nil, mlen nil, af nil
-----------------------------------
```

iptable.interval(start, stop)

Iterate across the subnets that cover, exactly, the ip address space bounded by the start and stop addresses.

```
#!/usr/bin/env lua
iptable = require"iptable"

for pfx in iptable.interval("10.10.10.0", "10.10.10.12") do
    print("-- ", pfx)
end

print(string.rep("-", 35))

---------- PRODUCES --------------

--  10.10.10.0/29
--  10.10.10.8/30
--  10.10.10.12/32
-----------------------------------
```

iptable.mask(af, mlen [, invert])

Create a mask for the given address family `af` and specified mask length `mlen`. Use the optional 3rd argument to request an inverted mask by supplying a true value.

```
#!/usr/bin/env lua
iptable = require"iptable"

print("--", iptable.mask(iptable.AF_INET, 19))
```

```lua
print("--", iptable.mask(iptable.AF_INET, 19, true))

print("--", iptable.mask(iptable.AF_INET6, 91))
print("--", iptable.mask(iptable.AF_INET6, 91, true))


print(string.rep("-", 35))

---------- PRODUCES --------------

--  255.255.224.0
--  0.0.31.255
--  ffff:ffff:ffff:ffff:ffff:ffe0::
--  ::1f:ffff:ffff
-----------------------------------
```

iptable.neighbor(prefix)

Get the adjacent subnet that, together with `prefix`, occupies their immediate parental supernet whose prefix length is 1 bit shorter. Returns the adjacent prefix, mask length and address family. Note that a prefix with no length has no parental supernet.

```lua
#!/usr/bin/env lua
iptable = require"iptable"
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:700/120"

print("--", iptable.neighbor("10.10.0.0/19"))
print("--", iptable.neighbor("10.10.32.0/19"))
print("--", iptable.neighbor("10.10.10.255"))
print("--", iptable.neighbor("0.0.0.0/0"))      -- nothing larger than this
print("--", iptable.neighbor(pfx6))

print(string.rep("-", 35))

---------- PRODUCES --------------

--  10.10.32.0  19  2
--  10.10.0.0   19  2
--  10.10.10.254    -1  2
--  nil
--  2001:db8:85a3::8a2e:370:600 120 10
-----------------------------------
```

iptable.size(prefix)

Return the number of hosts covered by given `prefix`. Since ipv6 subnets might have more than 2^52 hosts in it, this function uses Lua arithmatic to yield the number.

```
#!/usr/bin/env lua
iptable = require"iptable"
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:700/120"

print("--", iptable.size("10.10.10.0/24"))
print("--", iptable.size("10.10.0.0/31"))
print("--", iptable.size(pfx6))
print("--", iptable.size("2001::/0"))

print(string.rep("-", 35))

---------- PRODUCES --------------

--  256.0
--  2.0
--  256.0
--  3.4028236692094e+38
-----------------------------------
```

iptable.invert(prefix)

Invert the address of given `prefix` and return reversed address, mask length and address family. Note: the mask is NOT applied. If that's required, convert the prefix first using `iptable.network(prefix)`.

```
#!/usr/bin/env lua
iptable = require"iptable"

ip, mlen, af = iptable.invert("255.255.0.0/16")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.invert("ffff:ffff::/32")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

print(string.rep("-", 35))

---------- PRODUCES --------------
```

iptable.reverse(prefix)

Reverse the address byte of given `prefix` and return reversed address, mask length and address family. For ipv6, the nibbles are reversed as well. Note: any mask is NOT applied before reversal is done. If that's required, convert the prefix first using `iptable.network(prefix)`.

```
#!/usr/bin/env lua
iptable = require"iptable"

ip, mlen, af = iptable.reverse("255.255.0.0")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.reverse("1112:1314:1516:1718:1920:2122:2324:2526")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

-- Note: ipv6 with 4 bytes -> reversal formatted as ipv4 in ipv6
ip, mlen, af = iptable.reverse("acdc:1976::/32")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))


print(string.rep("-", 35))

---------- PRODUCES --------------
```

iptable.explode(prefix)

Explode a prefix, i.e. produce an full address string without any shorthand. Only has effect on ipv6. Embedded ipv4's are converted to hex digits as well. Any prefix length, if present, is not applied before exploding the address part of the prefix. Returns full address, prefix length and AF.

```
#!/usr/bin/env lua
iptable = require"iptable"

ip, mlen, af = iptable.explode("10.0.0.0/8")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.explode("::")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

ip, mlen, af = iptable.explode("::ffff:11.12.13.14/128")
print(string.format("-- ip %s, mlen %s, af %s", ip, mlen, af))

print(string.rep("-", 35))
```

```
---------- PRODUCES --------------
```

iptable.tobin(prefix)

Returns the binary key used internally by the radix tree for a string key like `prefix`. It's a length encoded byte string, i.e. the first byte represents the length of the entire byte string and the remaining bytes are from the prefix itself. Useful if the convenience functions fall short of what needs to be done, or to figure out the mask length of a regular mask.

```
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "10.10.0.0/19"
pfx6 = "2001:0db8:85a3:0000:0000:8a2e:0370:700/120"

bin2str = function(buf)
  local s = ""
  local len = buf:byte(1)
  for i = 1, len, 1 do
    s = string.format("%s:%02x", s, buf:byte(i));
  end
  return s:sub(2) -- skip leading ':'
end

bin4, mlen, af = iptable.tobin(pfx4)
bin6, mlen, af = iptable.tobin(pfx6)

print("--", bin2str(bin4))
print("--", bin2str(bin6))
print("--", iptable.masklen(iptable.tobin("255.255.255.252")))

print(string.rep("-", 35))

---------- PRODUCES --------------

--  05:0a:0a:00:00
--  11:20:01:0d:b8:85:a3:00:00:00:00:8a:2e:03:70:07:00
--  30
-----------------------------------
```

iptable.masklen(binary_key)

Given a binary key, `masklen` will return the number of consecutive 1-bits starting from the left. Only useful if the binary key was derived from an actual mask and not a subnet prefix.

```lua
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "255.255.253.0"
pfx6 = "ffff:fffe::"

bin2str = function(buf)
  local s = ""
  local len = buf:byte(1)
  for i = 1, len, 1 do
    s = string.format("%s:%02x", s, buf:byte(i));
  end
  return s:sub(2) -- skip leading ':'
end

bin4, mlen4, af4 = iptable.tobin(pfx4)
bin6, mlen6, af6 = iptable.tobin(pfx6)

print("--", iptable.masklen(bin4), "consecutive 1's in:", bin2str(bin4))
print("--", iptable.masklen(bin6), "consecutive 1's in:", bin2str(bin6))

print(string.rep("-", 35))

---------- PRODUCES --------------

--  22  consecutive 1's in: 05:ff:ff:fd:00
--  31  consecutive 1's in: 11:ff:ff:ff:fe:00:00:00:00:00:00:00:00:00:00:00
-----------------------------------
```

iptable.tostr(binary_key)

The reciprocal to `tobin` turns a binary key back into a string key.

```lua
#!/usr/bin/env lua
iptable = require"iptable"
pfx4 = "255.255.253.0"
pfx6 = "ffff:fffe::"

bin2str = function(buf)
  local s = ""
  local len = buf:byte(1)
  for i = 1, len, 1 do
    s = string.format("%s:%02x", s, buf:byte(i));
  end
  return s:sub(2) -- skip leading ':'
end
```

```lua
bin4, mlen4, af4 = iptable.tobin(pfx4)
bin6, mlen6, af6 = iptable.tobin(pfx6)

print("--", iptable.tostr(bin4), " == ", pfx4)
print("--", iptable.tostr(bin6), " == ", pfx6)

print(string.rep("-", 35))

---------- PRODUCES --------------

--  255.255.253.0    ==     255.255.253.0
--  ffff:fffe::  ==     ffff:fffe::
-----------------------------------
```

iptable.hosts(prefix)

Iterate across the hosts in a given prefix. Optionally include the network and broadcast addresses as well.

```lua
#!/usr/bin/env lua
iptable = require"iptable"

print("-- Hosts in 10.10.10.0/30:")
for pfx in iptable.hosts("10.10.10.0/30") do
    print(string.format("--> %s", pfx))
end

print("\n-- Including netw/bcast")
for pfx in iptable.hosts("10.10.10.0/30", true) do
    print(string.format("--> %s", pfx))
end

print(string.rep("-", 35))

---------- PRODUCES --------------

-- Hosts in 10.10.10.0/30:
--> 10.10.10.1
--> 10.10.10.2

-- Including netw/bcast
--> 10.10.10.0
--> 10.10.10.1
--> 10.10.10.2
--> 10.10.10.3
-----------------------------------
```

`iptable.new()`

Constructor method that returns a new ipv4,ipv6 lookup table. Use it as a regular table with modified indexing:

- *exact* indexing is used for assignments or when the index has a masklength
- *longest prefix match* if indexed with a bare host address

table functions

Basic operations

An iptable behaves much like a regular table, except that it ignores non-ipv4 and non-ipv6 keys silently, when assigning to a key it is always interpreted as a subnet (missing masks are added as max masks for the address family in question), lookups are exact if the key has a mask and only use longest prefix match when the lookup key has no mask. For assignments, the mask (as supplied of as a default value) is always applied before storing the key, value pair in the internal radix tree(s). Hence, iterating across an iptable always shows keys to be actual subnets with a mask, in CIDR notation.

```
#!/usr/bin/env lua
acl = require"iptable".new()
acl["10.10.10.0/24"] = true
acl["10.10.10.8/30"] = false

print("--> 1 exact match for prefix 10.10.10.0/24  ->", acl["10.10.10.0/24"])
print("--> 2 longest prefix match for 10.10.10.9   ->", acl["10.10.10.9"])
print("--> 3 longest prefix match for 10.10.10.100 ->", acl["10.10.10.100"])
print("--> 4 exact match for prefix 10.10.10.10/30 ->", acl["10.10.10.10/30"])
print(string.format("--> 5 acl has %s entries", #acl))

print(string.rep("-", 35))

---------- PRODUCES --------------

--> 1 exact match for prefix 10.10.10.0/24  ->  true
--> 2 longest prefix match for 10.10.10.9   ->  false
--> 3 longest prefix match for 10.10.10.100 ->  true
--> 4 exact match for prefix 10.10.10.10/30 ->  false
--> 5 acl has 2 entries
-----------------------------------
```

ipt:more(prefix [,inclusive])

Given a certain **prefix**, which need not be present in the iptable, iterate across more specific subnets actually present in the table. The optional second argument will include the given search **prefix** if found in the results, if its value is true. The default value for **inclusive** is **false**.

```
#!/usr/bin/env lua
ipt = require"iptable".new()
ipt["10.10.0.0/16"] = 1
ipt["10.10.9.0/24"] = 2
ipt["10.10.10.0/24"] = 3
ipt["10.10.10.0/25"] = 4
ipt["10.10.10.0/26"] = 5
ipt["10.10.10.128/30"] = 6

-- search more specifics only

for pfx in ipt:more("10.10.10.0/24") do
    print("-- exclusive search ->", pfx)
end
print()

-- search includes starting search prefix (if present)

for pfx in ipt:more("10.10.10.0/24", true) do
    print("-- inclusive search ->", pfx)
end

print(string.rep("-", 35))

---------- PRODUCES --------------

-- exclusive search ->  10.10.10.0/26
-- exclusive search ->  10.10.10.0/25
-- exclusive search ->  10.10.10.128/30

-- inclusive search ->  10.10.10.0/26
-- inclusive search ->  10.10.10.0/25
-- inclusive search ->  10.10.10.0/24
-- inclusive search ->  10.10.10.128/30
-----------------------------------
```

ipt:less(prefix)

Given a certain `prefix`, which need not be present in the iptable, iterate across less specific subnets actually present in the table. The optional second argument will include the given search `prefix` if found in the results, if its value is true. The default for `inclusive` is `false`.

```
#!/usr/bin/env lua
ipt = require"iptable".new()

ipt["10.10.0.0/16"] = 1
ipt["10.10.9.0/24"] = 2
ipt["10.10.10.0/24"] = 3
ipt["10.10.10.0/25"] = 4
ipt["10.10.10.0/26"] = 5
ipt["10.10.10.128/30"] = 6

-- search less specifics only

for pfx in ipt:less("10.10.10.0/25") do
    print("-- exclusive search ->", pfx)
end
print()

-- search includes starting search prefix (if present)

for pfx in ipt:less("10.10.10.0/25", true) do
    print("-- inclusive search ->", pfx)
end

print(string.rep("-", 35))

---------- PRODUCES --------------

-- exclusive search ->  10.10.10.0/24
-- exclusive search ->  10.10.0.0/16

-- inclusive search ->  10.10.10.0/25
-- inclusive search ->  10.10.10.0/24
-- inclusive search ->  10.10.0.0/16
-----------------------------------
```

ipt:merge(af)

Iterate across pairs of subnets present in the iptable that could be combined into their parent supernet. The iterator returns the supernet in CIDR notation

and a regular table that contains the key,value pairs for both the supernet's constituents as well as the supernet itself, should that exist (which need not be the case). Useful when trying to minify a list of prefixes.

```
#!/usr/bin/env lua
iptable = require "iptable"
ipt = iptable.new()

ipt["10.11.0.0/16"] = 1
ipt["10.10.9.0/24"] = 2
ipt["10.10.10.0/24"] = 3
ipt["10.10.10.0/25"] = 4
ipt["10.10.10.128/25"] = 5
ipt["10.10.10.0/30"] = 6
ipt["10.10.10.4/30"] = 7

-- find adjacent prefixes

for supernet, grp in ipt:merge(iptable.AF_INET) do
    print(string.format("-- supernet %s contains:", supernet))
    for subnet, val in pairs(grp) do
        print(string.format("   -- %s -> %s", subnet, val))
    end
end

print(string.rep("-", 35))

---------- PRODUCES --------------

-- supernet 10.10.10.0/29 contains:
   -- 10.10.10.0/30 -> 6
   -- 10.10.10.4/30 -> 7
-- supernet 10.10.10.0/24 contains:
   -- 10.10.10.128/25 -> 5
   -- 10.10.10.0/25 -> 4
   -- 10.10.10.0/24 -> 3
-- supernet 10.10.10.0/29 contains:
   -- 10.10.10.4/30 -> 7
   -- 10.10.10.0/30 -> 6
-- supernet 10.10.10.0/24 contains:
   -- 10.10.10.0/25 -> 4
   -- 10.10.10.128/25 -> 5
   -- 10.10.10.0/24 -> 3
-----------------------------------
```

ipt:masks(af)

An `iptable` utilizes two radix trees internally, one for ipv4 subnets and one for ipv6 subnets. `ipt:masks(af)` will iterate across the actual masks used in the tree for the given address family `af`. No idea when this might be useful, but there you have it.

```
#!/usr/bin/env lua
iptable = require "iptable"
ipt = iptable.new()

ipt["10.10.0.0/16"] = 1
ipt["10.10.9.0/24"] = 2
ipt["10.10.10.0/24"] = 3
ipt["10.10.10.0/25"] = 4
ipt["10.10.10.0/26"] = 5
ipt["10.10.10.128/30"] = 6

-- iterate across masks in the trie
for pfx in ipt:masks(iptable.AF_INET) do
    print("-- mask ->", pfx)
end

print(string.rep("-", 35))

---------- PRODUCES --------------

-- mask ->  255.255.0.0
-- mask ->  255.255.255.0
-- mask ->  255.255.255.128
-- mask ->  255.255.255.192
-- mask ->  255.255.255.252
-----------------------------------
```

ipt:counts()

Returns the number of ipv4 subnets and ipv6 subnets present in the iptable.

```
#!/usr/bin/env lua
iptable = require "iptable"
ipt = iptable.new()

ipt["10.10.0.0/16"] = 1
ipt["10.10.9.0/24"] = 2
ipt["10.10.10.0/24"] = 3
ipt["10.10.10.0/25"] = 4
```

```
ipt["10.10.10.0/26"] = 5
ipt["10.10.10.128/30"] = 6
ipt["2001::dead:beef/120"] = 1
ipt["2002::dead:beef/120"] = 2
ipt["2003::dead:beef/120"] = 3

af4, af6 = ipt:counts()

print("-- num of ipv4 prefixes", af4)
print("-- num of ipv6 prefixes", af6)

print(string.rep("-", 35))

---------- PRODUCES --------------

-- num of ipv4 prefixes 6
-- num of ipv6 prefixes 3
-----------------------------------
```

ipt:radixes(af[, masktree])

Iterate across the radix nodes of the radix tree for the given address family `af`. Only really useful to graph the radix trees while debugging or for educational purposes. The radix nodes are returned by the iterator encoded as Lua tables. Look at the `ipt2dot.lua` and `ipt2smalldot.lua` scripts to see how to decode/interpret the radix node tables.

```
#!/usr/bin/env lua
iptable = require "iptable"
ipt = iptable.new()

ipt["10.10.0.0/16"] = 1
ipt["2003::dead:beef/120"] = 1

-- dump radix nodes in the radix trie
for rdx in ipt:radixes(iptable.AF_INET | iptable.AF_INET6) do
    print("-- tree exclusive", rdx._NAME_)
end
print()

-- also include the mask-tree
for rdx in ipt:radixes(iptable.AF_INET | iptable.AF_INET6, true) do
    print("-- tree inclusive", rdx._NAME_)
end

print(string.rep("-", 35))
```

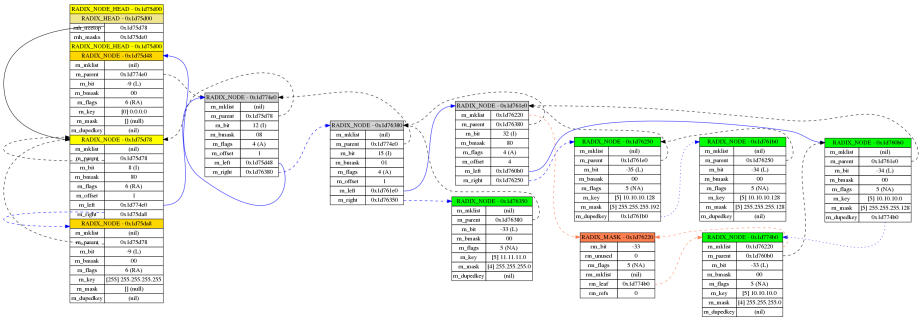
```
---------- PRODUCES --------------
-- tree exclusive   RADIX_NODE_HEAD
-- tree exclusive   RADIX_NODE
-- tree exclusive   RADIX_NODE

-- tree inclusive   RADIX_NODE_HEAD
-- tree inclusive   RADIX_NODE
-- tree inclusive   RADIX_NODE
-- tree inclusive   RADIX_MASK_HEAD
-- tree inclusive   RADIX_NODE
-- tree inclusive   RADIX_NODE
-----------------------------------
```

Examples:

Radix tree graphs

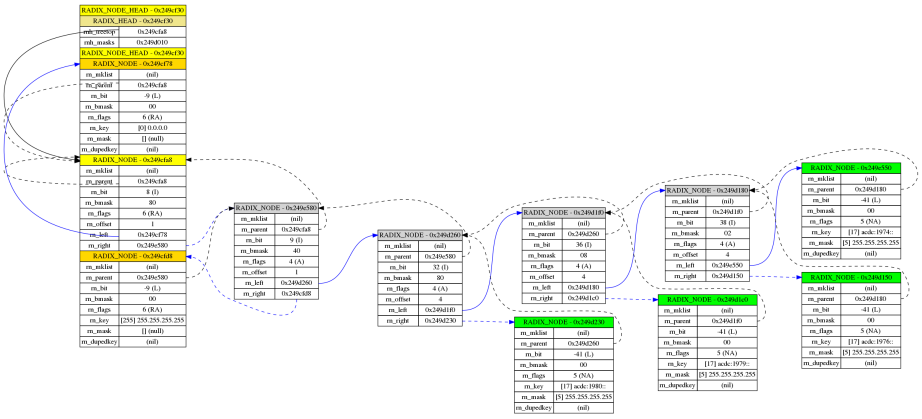
Graph an IPv4 tree

```
#!/usr/bin/env lua
iptable = require "iptable"
dotify = require "src.lua.ipt2dot"

ipt = iptable.new()
ipt["10.10.10.0/24"] = 1
ipt["10.10.10.0/25"] = 2
ipt["10.10.10.128/25"] = 3
ipt["10.10.10.128/26"] = 4
ipt["11.11.11.0/24"] = 2

imgfile = arg[1]
dotfile = imgfile:gsub("...$", "dot")
dottext = dotify(ipt, iptable.AF_INET)

fh = io.open(dotfile, "w")
fh:write(table.concat(dottext, "\n"))
fh:close()

os.execute(string.format("dot -Tpng %s -o %s", dotfile, imgfile))
print(string.rep("-",35))

---------- PRODUCES --------------
```



Graph an IPv6 tree

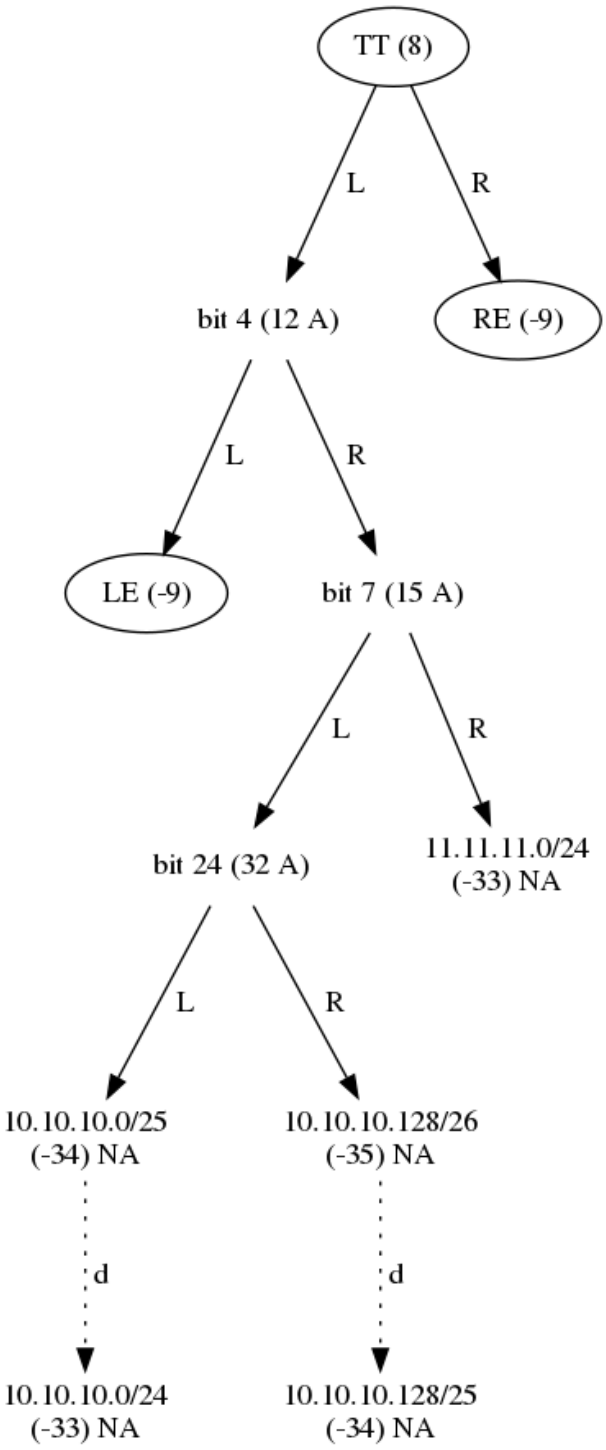
```
#!/usr/bin/env lua
iptable = require "iptable"
dotify = require "src.lua.ipt2dot"

ipt = iptable.new()
ipt["acdc:1974::/32"] = "Can I sit next to you?"
ipt["acdc:1976::/32"] = "Jailbreak"
ipt["acdc:1979::/32"] = "Highway to hell"
ipt["acdc:1980::/32"] = "Touch too much"

imgfile = arg[1]
dotfile = imgfile:gsub("...$", "dot")
dottext = dotify(ipt, iptable.AF_INET6)

fh = io.open(dotfile, "w")
fh:write(table.concat(dottext, "\n"))
fh:close()

os.execute(string.format("dot -Tpng %s -o %s", dotfile, imgfile))
print(string.rep("-",35))

---------- PRODUCES --------------
```



Alternate radix tree graphs

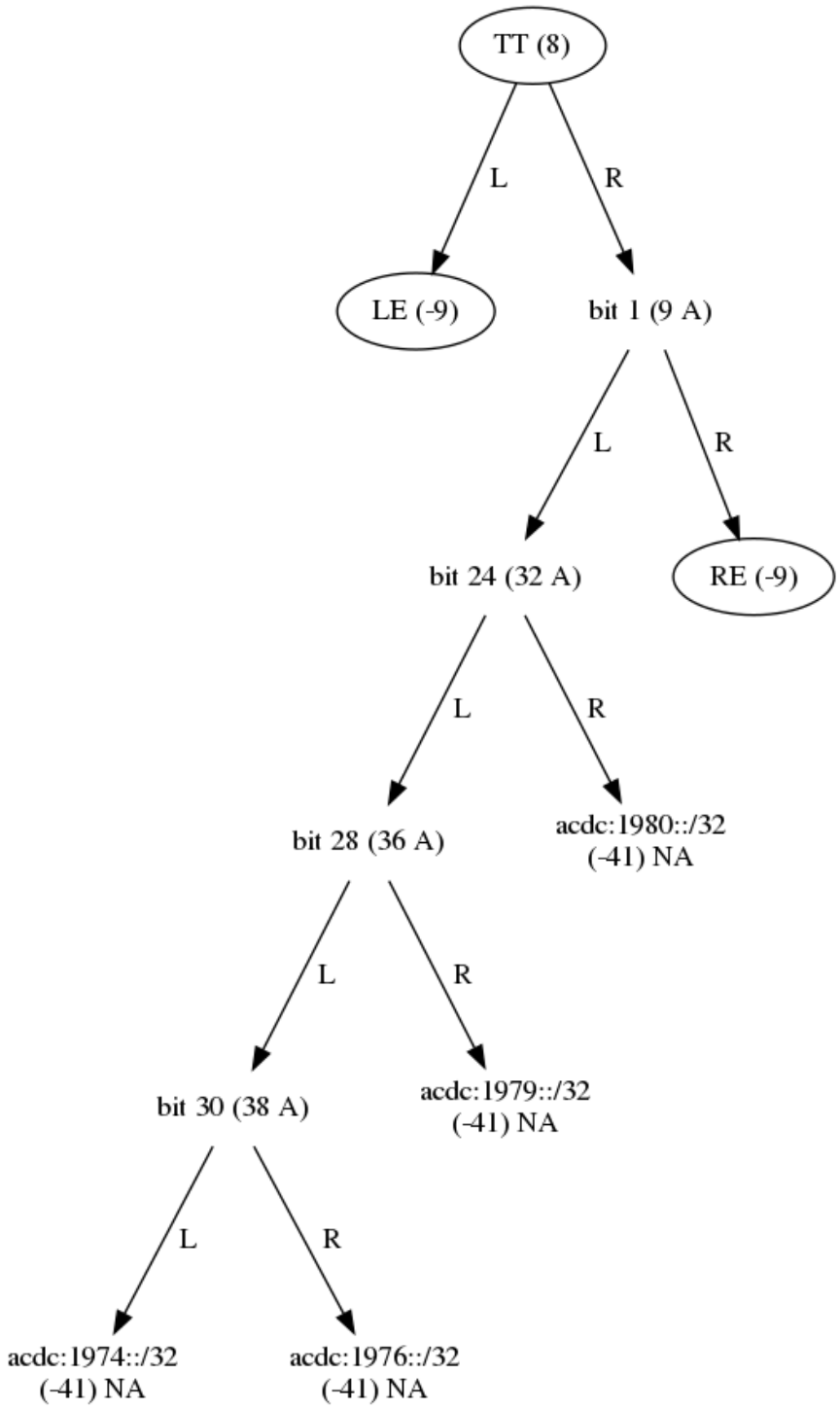
Graph an IPv4 tree

```
#!/usr/bin/env lua
iptable = require "iptable"
dotify = require "src.lua.ipt2smalldot"

ipt = iptable.new()
ipt["10.10.10.0/24"] = 1
ipt["10.10.10.0/25"] = 2
ipt["10.10.10.128/25"] = 3
ipt["10.10.10.128/26"] = 4
ipt["11.11.11.0/24"] = 2

imgfile = arg[1]
dotfile = imgfile:gsub("...$", "dot")
dottext = dotify(ipt, iptable.AF_INET)

fh = io.open(dotfile, "w")
fh:write(table.concat(dottext, "\n"))
fh:close()

os.execute(string.format("dot -Tpng %s -o %s", dotfile, imgfile))
print(string.rep("-",35))

---------- PRODUCES --------------
```


TT (8)
L
R
bit 4 (12 A)
RE (-9)
L
R
LE (-9)
bit 7 (15 A)
L
R
bit 24 (32 A)
11.11.11.0/24
(-33) NA
L
R
10.10.10.0/25
(-34) NA
10.10.10.128/26
(-35) NA
d
d
10.10.10.0/24
(-33) NA
10.10.10.128/25
(-34) NA

Graph an IPv6 tree

```
#!/usr/bin/env lua
iptable = require "iptable"
dotify = require "src.lua.ipt2smalldot"

ipt = iptable.new()
ipt["acdc:1974::/32"] = "Can I sit next to you?"
ipt["acdc:1976::/32"] = "Jailbreak"
ipt["acdc:1979::/32"] = "Highway to hell"
ipt["acdc:1980::/32"] = "Touch too much"

imgfile = arg[1]
dotfile = imgfile:gsub("...$", "dot")
dottext = dotify(ipt, iptable.AF_INET6)

fh = io.open(dotfile, "w")
fh:write(table.concat(dottext, "\n"))
fh:close()

os.execute(string.format("dot -Tpng %s -o %s", dotfile, imgfile))
print(string.rep("-",35))

---------- PRODUCES --------------
```


TT (8)
L
R
LE (-9)
bit 1 (9 A)
L
R
bit 24 (32 A)
RE (-9)
L
R
bit 28 (36 A)
acdc:1980::/32
(-41) NA
L
R
bit 30 (38 A)
acdc:1979::/32
(-41) NA
L
R
acdc:1974::/32
(-41) NA
acdc:1976::/32
(-41) NA

Minify list of prefixes

Minifying a list of prefixes is done in two steps. First keep merging subnets into their parental supernet, until no merging takes place anymore. Second, remove any remaining subnets that weren't merged but lie inside another subnet in the table.

```
#!/usr/bin/env lua
iptable = require "iptable"

-- fill a table with list of prefixes
ipt = iptable.new()
ipt["10.10.10.0/25"] = true
ipt["10.10.10.128/25"] = true
ipt["10.10.11.0/25"] = true
ipt["10.10.11.128/25"] = true
ipt["11.11.11.0"] = true
ipt["11.11.11.1"] = true
ipt["11.11.11.2"] = true
ipt["11.11.11.3"] = true
ipt["11.11.11.4"] = true

for k,_ in pairs(ipt) do
    print("-- original ->", k)
end
print()

changed = true
while (changed) do
    changed = false
    for supernet, grp in ipt:merge(iptable.AF_INET) do
        for subnet, _ in pairs(grp) do
            ipt[subnet] = nil         -- delete subnets, possibly supernet too
        end
        ipt[supernet] = true          -- ensure supernet's existence
        changed = true                -- further merging might now be possible
    end
end

for prefix, _ in pairs(ipt) do
    for subnet, _ in ipt:more(prefix, false) do
        ipt[subnet] = nil             -- remove all more specifics
    end
end

for k, _ in pairs(ipt) do
```

```
    print("-- minified ->", k)
end

print(string.rep("-",35))

---------- PRODUCES --------------
```