CS444/544
Programming Project 5 - Shrub
Due: Friday, April 25 (11:59pm)

This assignment is intended to tie together all of the concepts that we've discussed so far. You're going to again use the Twig framework to build a small routing operating system called "*shrub*" (like Juniper, but much smaller). Your *Shrub* operating system can be used for either a router (a machine with multiple interfaces) or a host (with a single interface).
On either type of machine, it must:

1. Maintain an IP routing table that it will use when sending IP packets

2. Receive RIP announcements (see RFC 1058) and use them to populate its routing table

3. Respond to ICMP echo requests

4. Implement a server on the UDP time port

5. Implement a server on the UDP echo port

6. You may find that implementing this with multiple threads is easier, but should consider the tradeoffs

On machines with multiple interfaces, it must also:

1. Broadcast RIP routing packets and implement the RIP protocol to build an internal routing table (see -r below)

2. Route packets between its various interfaces using its routing table

3. Send ICMP time exceeded messages in response to hop count expirations (so that mtr will work)

4. Send ICMP destination unreachable messages in response to appropriate packet delivery/forwarding problems

Your Shrub program must support the following options:

-i IPv4addr_masklength

For example, if the argument `-i 172.31.10.254_24` is given, then Shrub should assume that it has IP address `172.31.10.254/24` on that interface and that it should use the following file for reading and writing packets:

- `172.31.10.0_24.dmp`

Note that the host-part of the IP address was removed from the file name.

Every Shrub machine needs to have at least 1 interface listed. If only one interface is listed, then the Shrub machine should act as a **host**. If multiple interfaces are listed, it should operate as a **router**.

–default-route IFACE_SPEC Makes the given interface spec (as in 172.31.10.254_24) be the default route for a computer (only works on routers, not hosts)

-d

To print debugging information (more detailed output). In particular, this option must do the following:

1. When specified at least once, all changes to the routing table must cause the entire table to be printed

2. When specified at least once, a message should be printed when a packet TTL expires

3. When specified at least once, a message should be printed when UDP echo messages are responded to

-r SECONDS

Specify the number of seconds between RIP updates (to make it faster to converge).

-h Print a quick summary of the command line arguments and exit. This information should also be printed if you don't understand one of the command line arguments.

Working with the packet dump files

1. The fd used for writing must include the last option "`| O_APPEND`"

2. A process will see files that it wrote itself, so you'll need to ignore those

3. If the packet dump file doesn't exist when Shrub tries to open it, that shrub instance should create it and write an appropriate file header to it (for when no external shim instance is providing an external connection)

Non-Requirements and Extra Credit

Hardware Addresses. We are going to ignore HW addresses. Just use whatever HW address you choose for outgoing packets

ARP. Since we're ignoring HW addresses, you don't need to implement ARP. You can implement ARP as extra credit, in which case you'll probably want to make HW addresses that are a function of your IP address.