Announcements

- Project 4 due Wednesday at 11:59PM.
- Project 5 will be due November 21 at 11:59PM.
- Web page is being updated frequently; check for updates.
There are three kinds of death in this world. There’s heart death, there’s brain death, and there’s being off the network.

Guy Almes
1. The 1,000 Foot Picture

2. Project Scope

3. Implementation
What is an “ad-hoc networking layer”? 
What is an “ad-hoc networking layer”?

Ad-hoc networking enables wireless communication without the need for infrastructure

What is it useful for?

- Removes infrastructure costs.
- Allows quick deployment.
- Potentially more reliable (no single point of failure).

Based on Dynamic Source Routing.*

*http://www.cs.cornell.edu/People/egs/615/johnson-dsr.pdf
What do you mean by routing?

- Packets that arrive at your machine may not be meant for you.
- Packets not meant for you should be routed to their destination.
- Add a routing layer between the network and transport layer.
- Both minimsg and minisocket implementations should work on top of miniroute.
The new header in pictures

User Application
Minisocket Header
Minimsg Header
Miniroute Header
Network
How does DSR work?

- DSR is a reactive protocol.
- When a host does not know the route a packet, it must discover the route.
  - It does so by sending a route discover packet.
- A route discover packet is broadcast to all hosts within proximity of a wireless signal.
- Hosts will re-broadcast discovery packets if they are not the destination.
  - The host will add itself to the constructed route.
- The destination will send a route reply packet along the reverse route.
Routing protocol (common case)

- If a route contains $A \rightarrow B \rightarrow C$ where $A$ is the source, $C$ is the destination, $C$ will flip the route to $C \rightarrow B \rightarrow A$ to send a reply to host $A$.
- Upon receiving a reply, it will add this route into its route cache, and use it to send data.
- Route cache entries expire in 3 seconds to prevent stale cache entries.
- Route discovery must be performed again upon route expiration.
  - Is there a better way to do this?
How does the protocol terminate?
- By tracking a time-to-live (\(\texttt{ttl}\)) value.

What should the \(\texttt{ttl}\) be initialized to?

What happens when \(\texttt{ttl} = 0\)?

How do we prevent redundant re-broadcasts?
- We can re-use a trick you’ve seen before.

How do we prevent loops?
Project 5

Implementation

What do you need to implement?

- Convert calls to `network_send_pkt` to `miniroute_send_pkt`.
- Update the network handler.
  - Interpret the miniroute header.
  - Handle routing control packets.
  - Deliver packet as usual if the destination has been reached.
Routing Cache

- The cache must be able to hold \( \text{SIZE_OF_ROUTE_CACHE} \) entries.
- Old items are invalidated after timeout.
  - Alarms may be used, but it can be done without.
- This should be somewhat efficient, as you may increase \( \text{SIZE_OF_ROUTE_CACHE} \) to be large.
  - Aim for \( O(1) \) or \( O(\log n) \) bound on operations.
  - Think in terms of hash tables, scatter tables, and trees.
Additional implementation requirements

- Need to track recently seen discovery packets.
  - Eliminate redundant broadcasts.
- Write an Instant Messenger application that runs on miniroute.
  - Read input from the user (look at read*).
  - Add miniterm_initialize to your system initialize functions.
  - miniterm_read will let you read from the keyboard.
Set `BCAST_ENABLED` to 1.

Set `BCAST_ADDRESS`:
- 192.168.1.255 for ad-hoc network (see instructions for setting up an ad-hoc network).
- x.y.z.255 for CSUGLAB.

When debugging:
- Set `BCAST_TOPOLOGY_FILE`.
- Provide a topology file (see project description).
  - Test without wireless.
- Use only in CSUGLAB.
Additional requirements

- Only put one routing discover request per destination on the network at any one time.
  - Multiple threads should not trigger multiple routing discovery requests for the same destination.

- Use the latest route reply packet (use the `seq_no` for this).

- Use the structures and data-types provided in `miniroute.h`:
  - Allows all groups to route an arbitrary group’s packets.
  - It’s unlikely `minimg` and `minisockets` will be groupwise-compatible.
Routing interoperability requires headers be in network byte order.

Use the same endianness conversion you used in project 4.
Feeling ambitious?

Remove the routing cache timeout:
- Instead, detect broken links and perform re-perform discovery.
- Requires verifying that hops work.
- Hop-to-hop acknowledgements are very† inefficient.
- Take advantage of broadcasting to see when the next host forwards the packet.
  - Faster (less sends).
  - Requires more work.

† very
Localized route patching.

- When hop-to-hop communication fails, have the hop that detects the failure perform a new route discovery.
- Patch the route on the failed packet to allow it to route successfully.
- Source and destination should be updated to reflect new route.
Feeling even more ambitious?

Cache aggressively

- There are lots of opportunities to cache more.
- Every packet presents the chance to update the cache.
  - Just because you can does not mean you should.
  - Some data is not worth caching.
Feeling *even more* ambitious?

Redundant routes

- Keep multiple routes to the same destination in cache.
- When the source receives an error, the backup route may be used.
- Consider how you could extend the header to encode multiple routes.
If you eat and breath this stuff

- Hybrid proactive/reactive routing protocols
- See Professor Sirer’s SHARP†

Concluding thoughts

- Have some fun with this project.
- It’s much less work than P4, and much more fun too.
- Come see the TAs in office hours$\S$.

$\S$ some of the TAs get lonely