Project 5

Ad-Hoc Networking

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Slide heritage: Bernard Wong → Robert Escriva → Zhiyuan Teo

Cornell CS 4411, November 2, 2012

Announcements

- Project 4 due Saturday at 11:59 PM.
- Project 5 will be released after Saturday, due in a week from release date.
- 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

What is an “ad-hoc networking layer”?

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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).

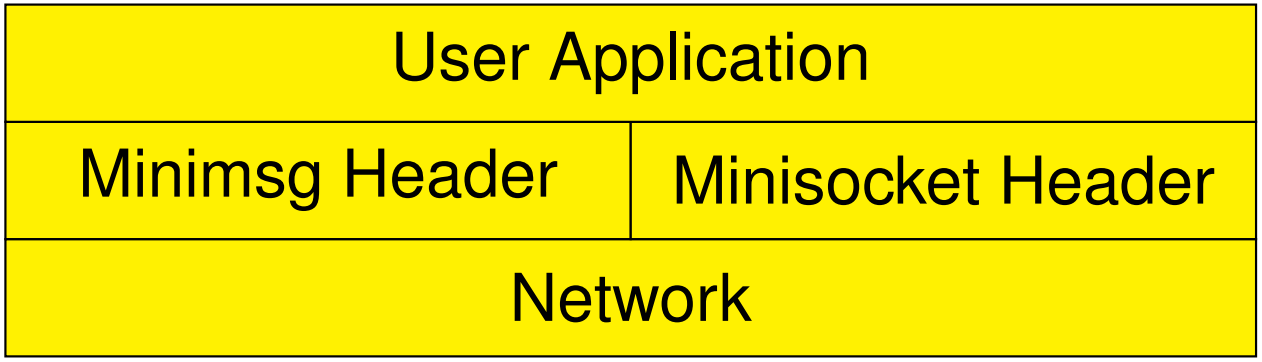
Based on Dynamic Source Routing.*

*http://www.cs.cornell.edu/People/egs/615/johnson-dsr.pdf

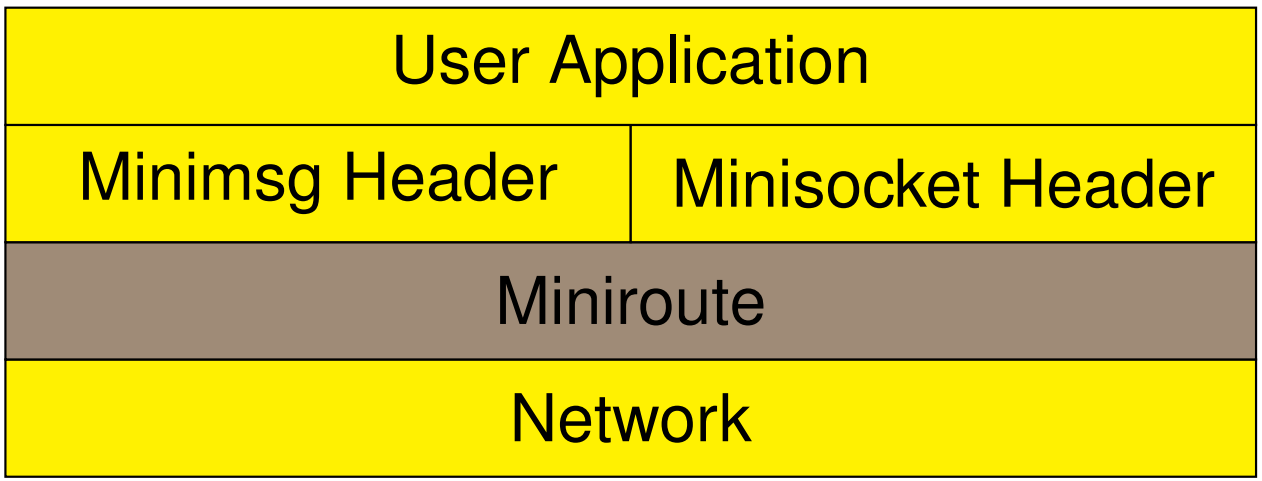
What do you mean by routing?

- 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.

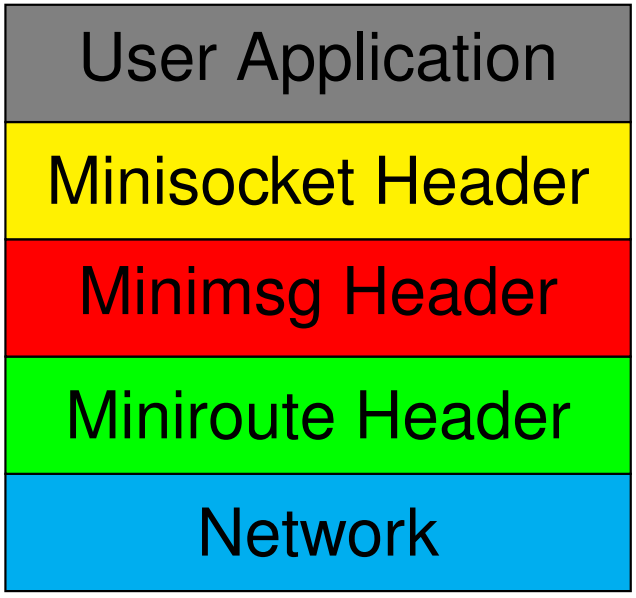
Our networking stack till now



Our networking stack after P5



The new header in pictures

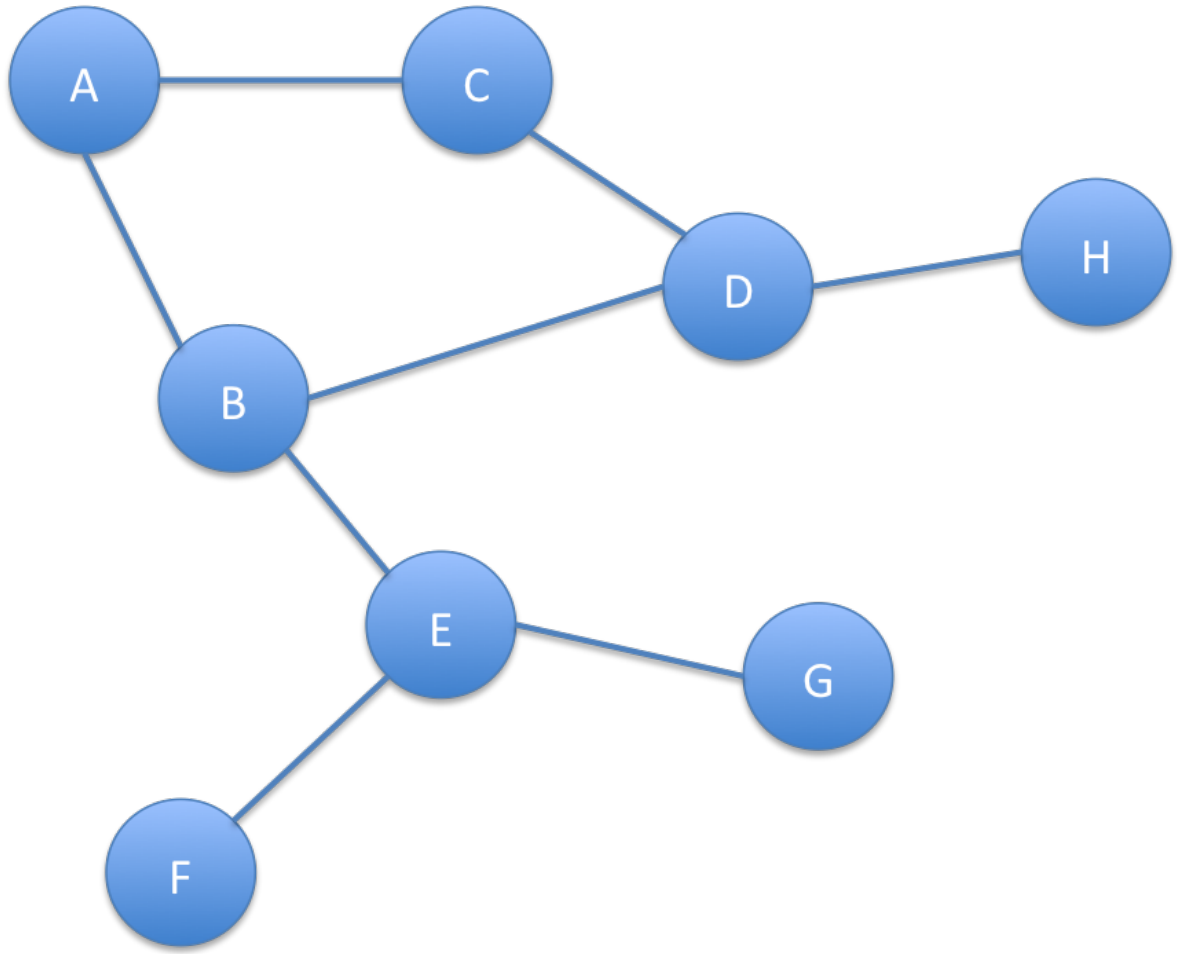


How does DSR work?

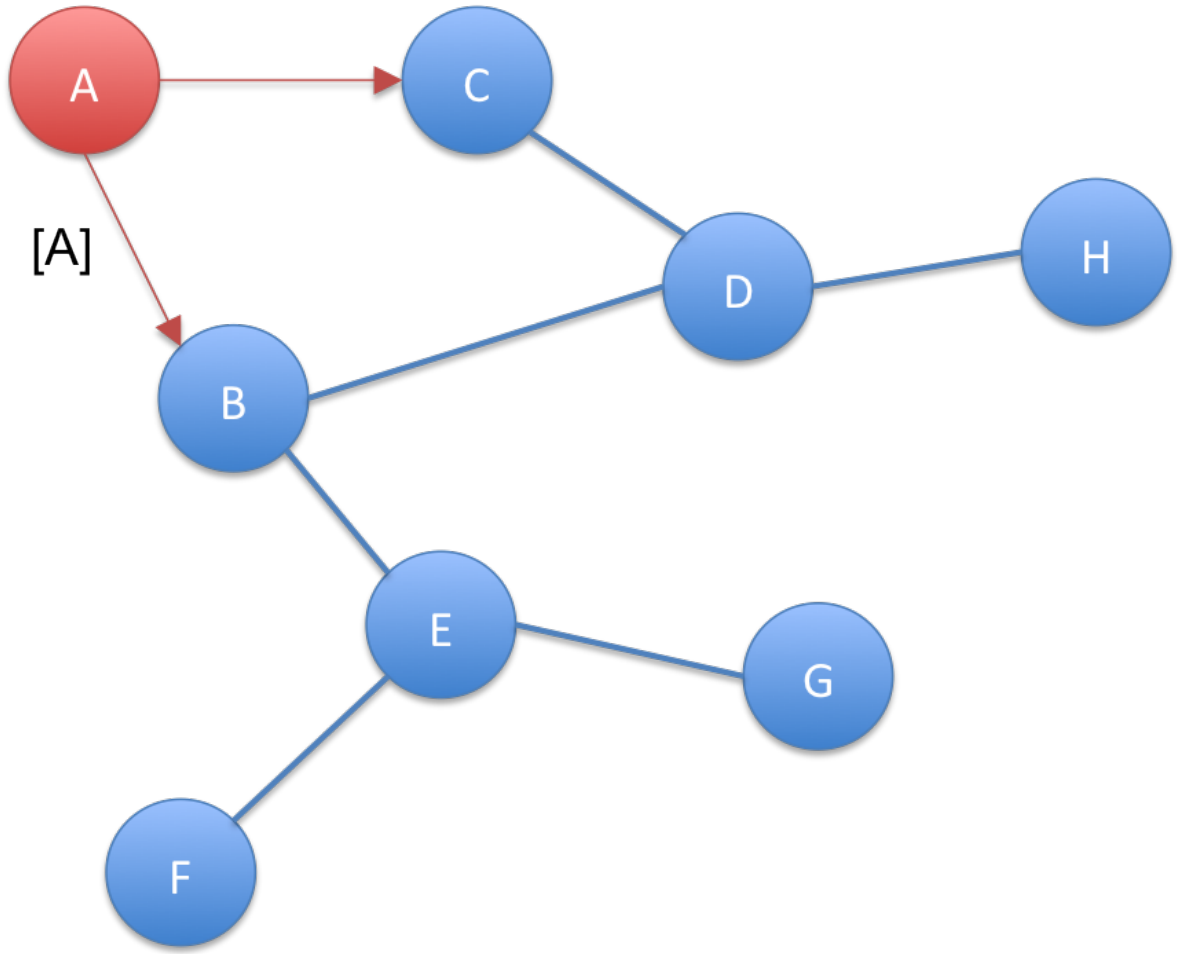
- DSR is a reactive protocol.
- When a host does not know the route a packet, it must discover the route.
  - It does so by sending a **route discover packet**[†].
- A route discover packet is broadcast to all hosts within proximity of a wireless signal.
- Hosts will re-broadcast discovery packets if 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.

[†] Also called route request packet

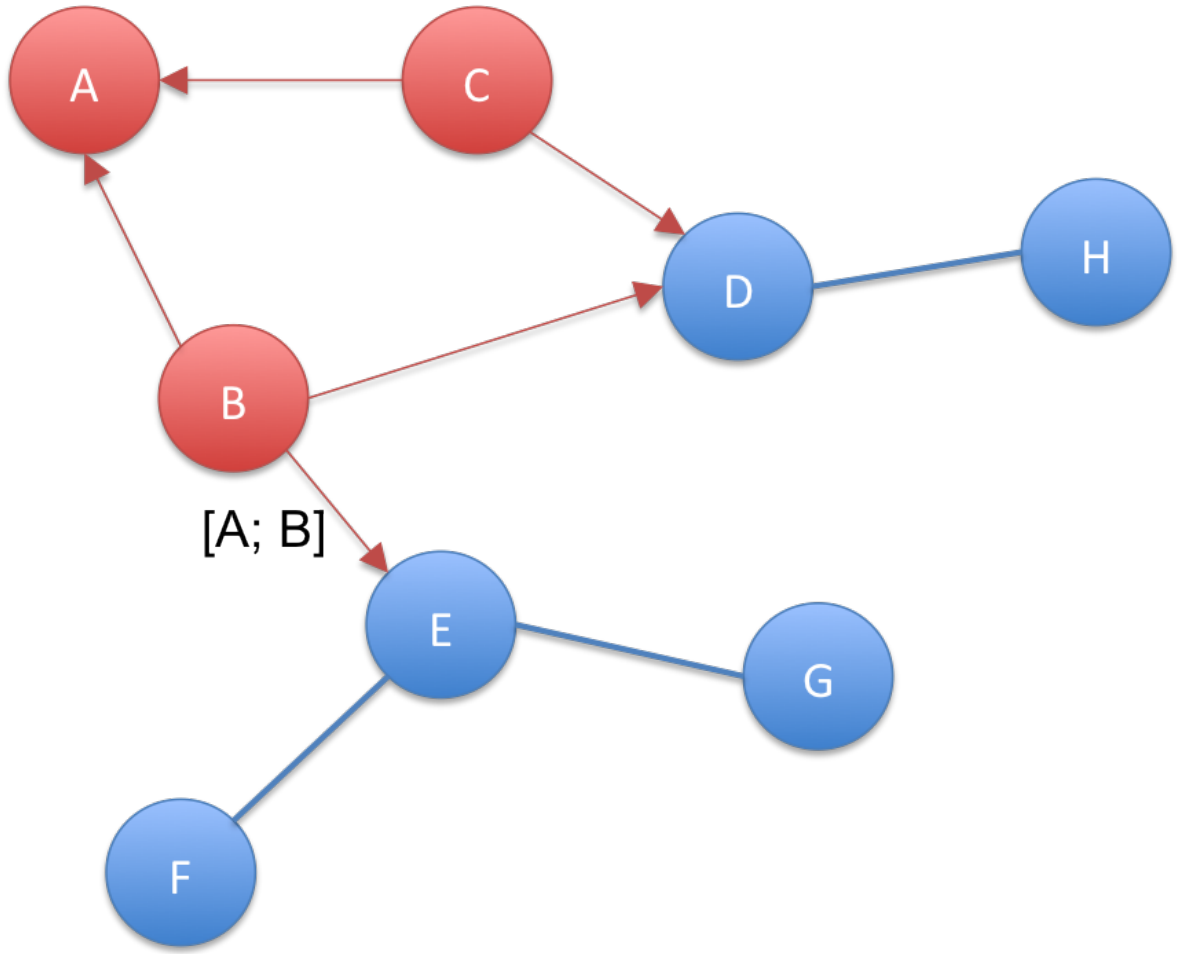
DSR in pictures



DSR in pictures: RREQ ($A \rightarrow G$)



DSR in pictures: RREQ ($A \rightarrow G$)



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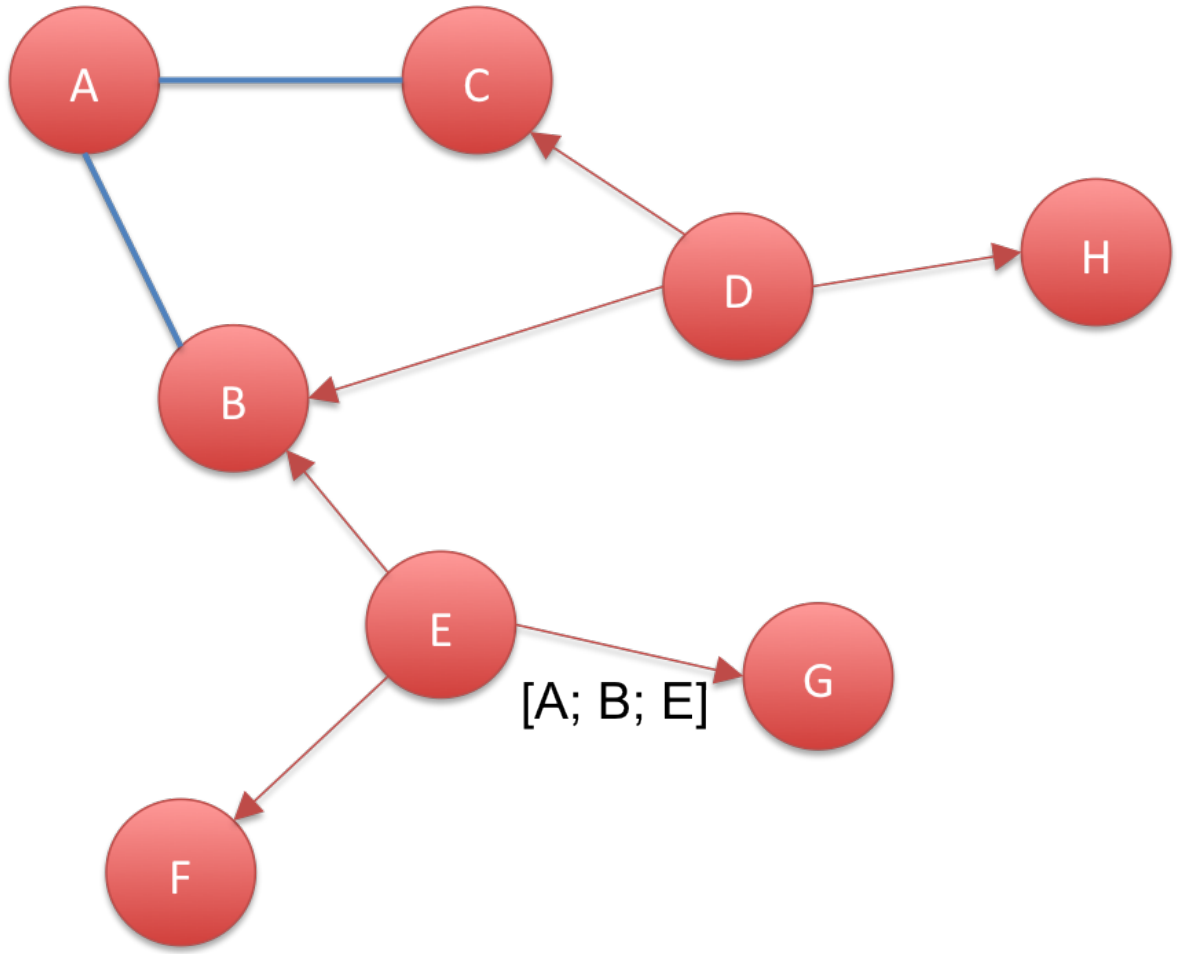
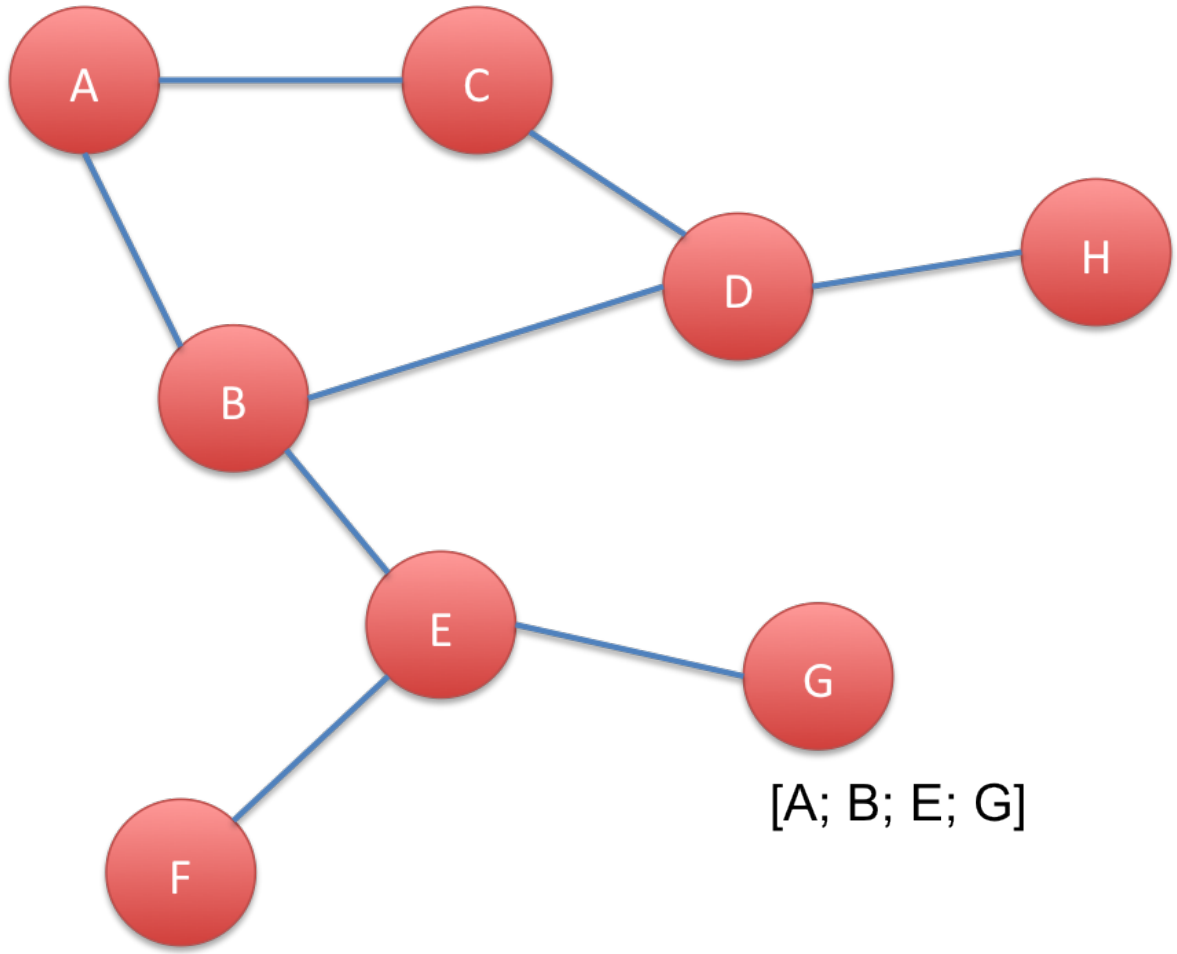
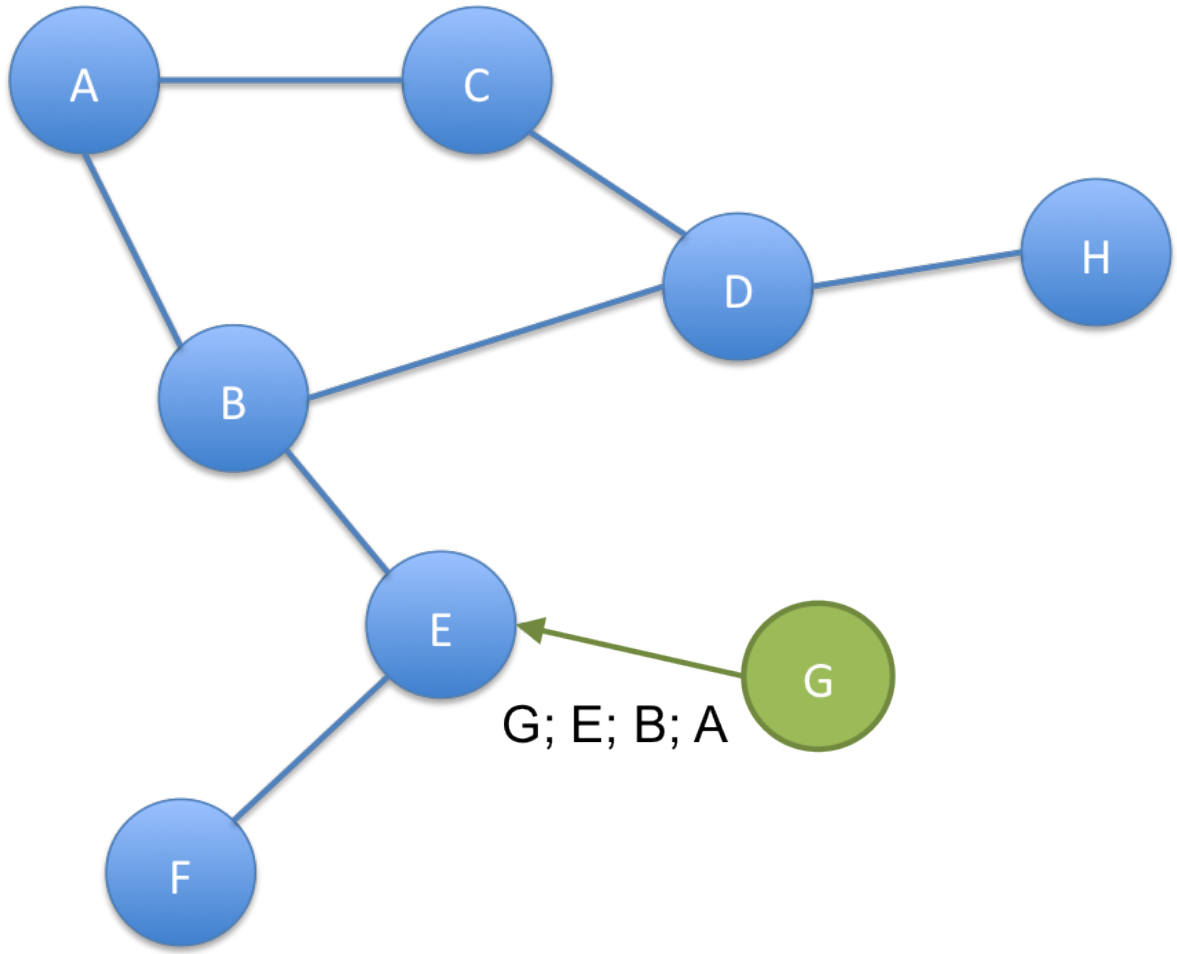


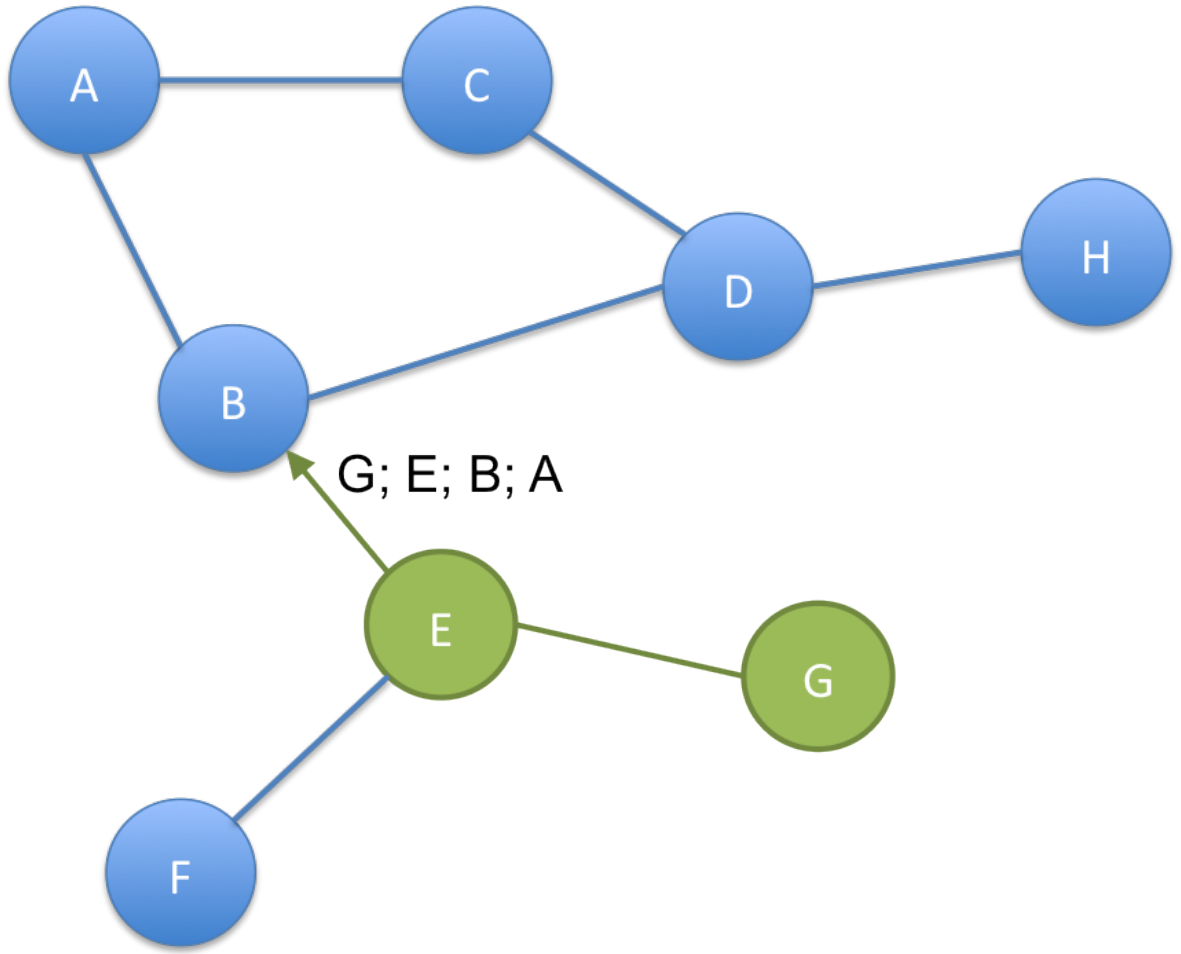
DSR in pictures



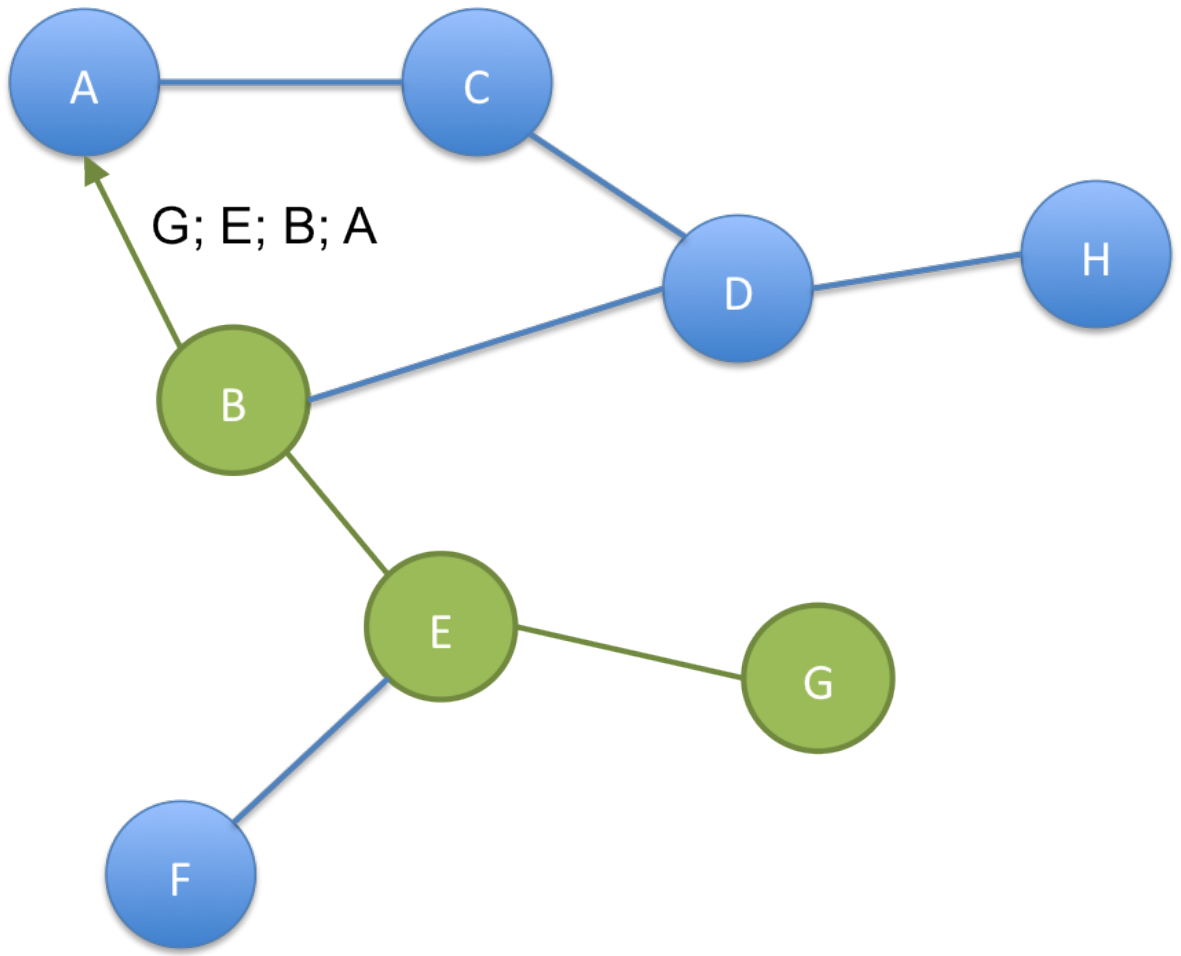
DSR in pictures: RREP



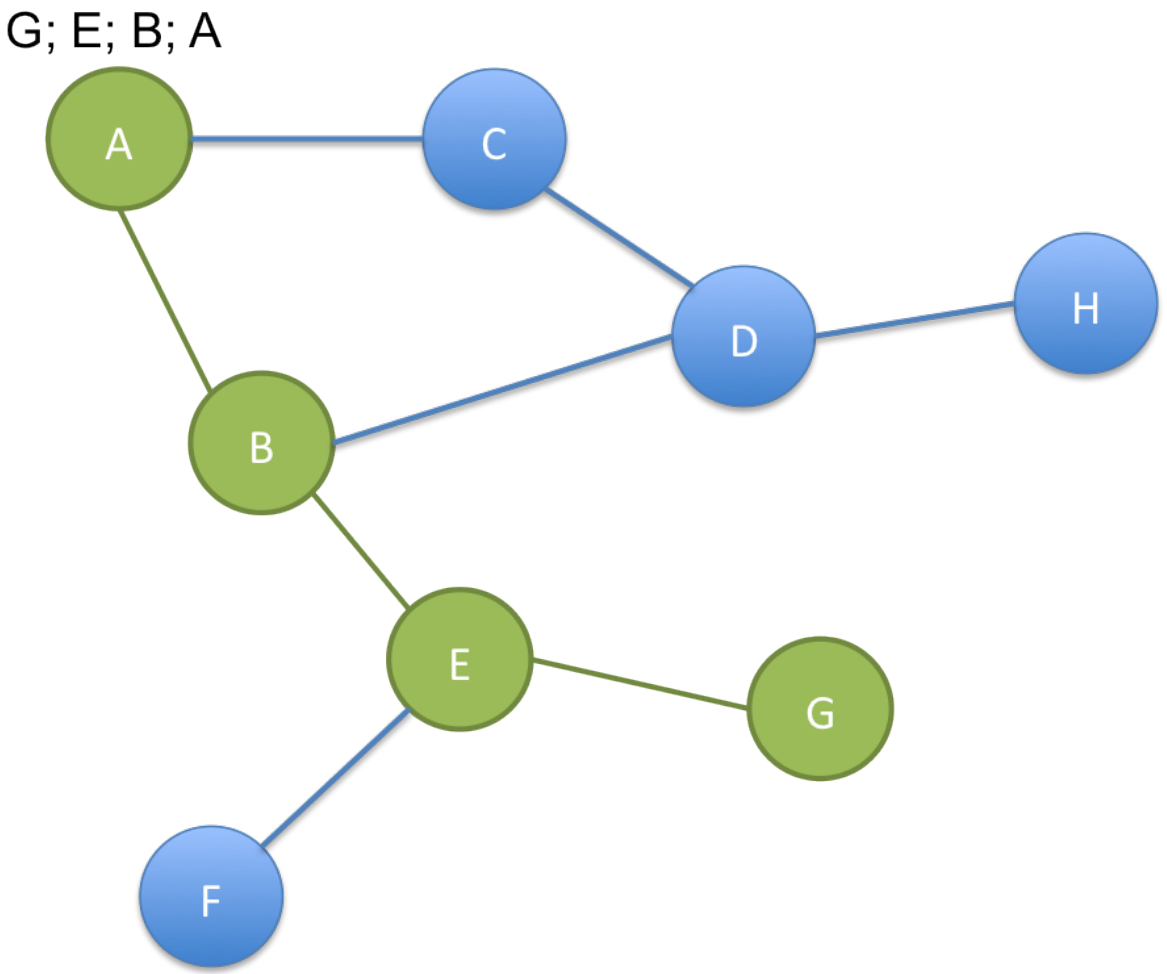
DSR in pictures: RREP



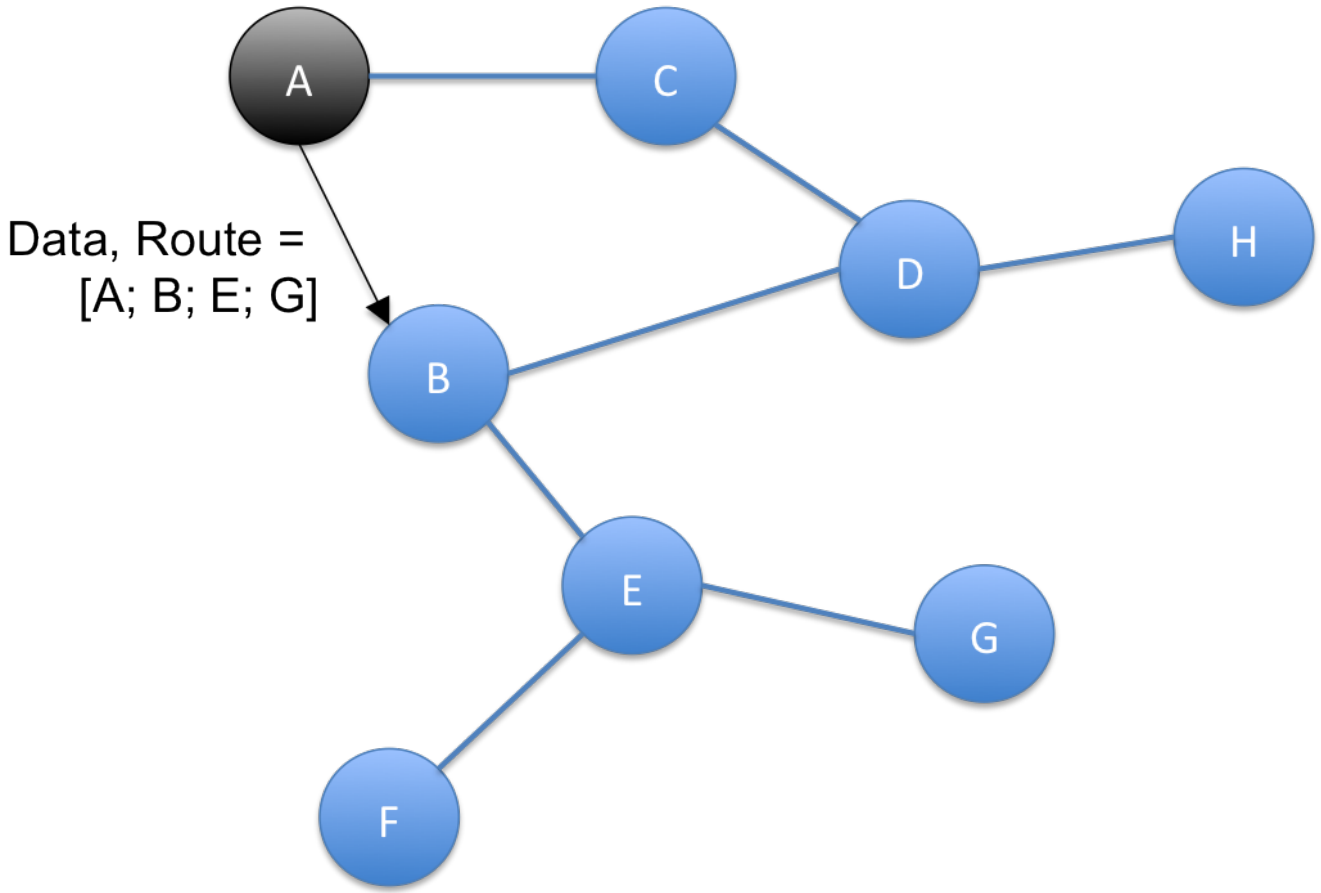
DSR in pictures: RREP



DSR in pictures: RREP



DSR in pictures: Data



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, A 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?

Routing protocol (failure conditions)

- How does the protocol terminate?
  - By tracking a time-to-live (`ttl`) value.
- What should the `ttl` be initialized to?
- What happens when `ttl` = 0?
- How do we prevent loops?

What do you need to implement?

- Change calls to `network_send_pkt` to `miniroute_send_pkt`.
  - But your `miniroute_send_pkt` function may still `network_send_pkt` for unicasts.
- Update the network handler.
  - Interpret the miniroute header.
  - Handle routing control packets.
  - Deliver `minimsg/minisocket` packet as usual if the destination has been reached.

Routing Cache

- The cache must be able to hold `SIZE_OF_ROUTE_CACHE` entries.
- Old items are invalidated after timeout.
  - Alarms may be used, but it can be done without.
- Cache access should be efficient, as you may increase `SIZE_OF_ROUTE_CACHE` to be large.
  - Aim for $O(1)$ cache operations.
  - Our suggestion – hash table (we have provided a hash function for network addresses).

`miniroute_send_pkt` requirements

- Allow only one route discovery request per destination on the network at any one time.
  - Block threads if `miniroute_send_pkt()` was called and route isn't in the cache.
  - Multiple threads should not trigger multiple routing discovery requests for the same destination.
  - Unblock all threads waiting on a route when that reply arrives.

Miniroute packets

- Use the header format provided in `miniroute.h`
  - Routing interoperability requires headers be in network byte order – use same packing/unpacking functions as before.
  - `MAX_NETWORK_PKT_SIZE` still the same – may have to change P3/P4 code.
- Try running `network6.c` over `miniroute`
  - Test interoperability with friends.

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.

Broadcast information

- Set `BCAST_ENABLED` to 1.
- Set `BCAST_ADDRESS`:
  - 192.168.1.255 for ad-hoc network (Google for instructions on how to setup an ad-hoc network).
  - x.y.z.255 for CSUG lab.
- When debugging:
  - Set `BCAST_TOPOLOGY_FILE` to 1.
  - Provide a topology file (see project description).
    - Test without wireless.
  - Use only in CSUG lab.

Feeling ambitious?

Remove the routing cache timeout.

- Instead, detect broken links and re-perform discovery.
- Requires verifying that hops work.
- Take advantage of broadcasting to see when the next host forwards the packet.
  - Faster (less sends).
  - Requires more work.

Feeling more ambitious?

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.
  - Some data is not worth caching.

Feeling *even more* ambitious?

Keep redundant routes in cache.

- Keep multiple routes to the same destination in cache.
- When the source receives an error, the backup route may be used.

If you eat and breathe this stuff

- Hybrid proactive/reactive routing protocols
- See Professor Sirer's SHARP[‡]

[‡] http://www.cs.cornell.edu/courses/cs414/2004SP/papers/sharp.pdf

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[§].

[§] some of the TAs get lonely

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