Project 5: Miniroute

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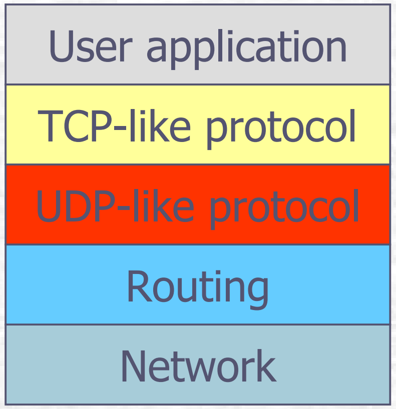
What is Miniroute?

- It is an ad-hoc networking layer
  - What is ad-hoc networking?
    - Ad-hoc networking allows multi-hop wireless communication without the need for infrastructure
  - Why would I want this?
    - Removes infrastructure costs
    - Allows quick deployment
    - Possibly more reliable (no single point of failure)
- Based on Dynamic Source Routing (DSR)
  - 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 necessary be meant for you
  - Previously, these packets would be dropped, now they should be routed to the destination
- How do I do this?
  - Add a routing layer in BETWEEN the network layer and the transport layer
  - This means your minimsg/minisockets works on top of it and for the most part do not need to be modified



How does the routing protocol work?

- DSR is a reactive protocol
  - When a host wants to deliver a packet to a destination host where the route to the destination is unknown, it will send a route discovery packet
  - A route discovery packet is broadcasted to any hosts that can hear it (within proximity of wireless signal)
  - These hosts in turn will re-broadcast the discovery packet if it is not the destination, while attaching itself as part of the route
  - When the destination is reached, the collected routing path is reversed, and a reply message is sent back along this reversed path

How does the routing protocol work?

- e.g. a route (which is stored in the routing header) may contain A->B->C where C is the destination, at which point host C will flip the route to C->B->A and send a reply back to host A
- If the source receives a reply, it will add this route into its route cache (as route discovery is expensive), and use this route to send the data
- Route cache expires in 3 seconds, to prevent stale cache entries (due to host movement)
- Route discovery has to be performed again when route expires
  - Is there a better way of doing this other than timeouts? (Yes!)

How does the routing protocol work?

- How does this protocol terminate if the destination host cannot be reached?
  - A TTL (time to live) field is decremented on each re-broadcast (TTL initialized to MAX_ROUTE_LENGTH)
  - A host receiving a packet with TTL of 0 and is not the destination host should not re-broadcast it
  - To prevent redundant re-broadcasts, route discovery ids are assigned per route discovery packet
  - A host should not re-broadcast a discovery request that it had broadcasted before
    - This means each host needs to somehow keep track of what discovery packets its seen in the past

What needs to be implemented?

- In minimsg/minisockets, replace network_send_pkt with miniroute_send_pkt
- Network handler needs to be updated
  - Must recognize the miniroute header
  - Routing control packets must be passed off to routing thread
  - For data packets, if destination reached, simply deliver packet to ports/socket
  - Otherwise, again must deliver to routing thread

What needs to be implemented?

- Routing thread needs to be created
  - Contains state machine to handle and route packets
  - network_bcast_packet() provided for broadcasting
- Route cache table needed
  - Must contain SIZE_OF_ROUTE_CACHE entries
  - Route cache needs to be invalidated after timeout
    - This can be done with or without alarms
  - Should be somewhat efficient, as SIZE_OF_ROUTE_CACHE can potentially be large
    - Aim for average access time of O(1) or O(logN)
    - Think hash table, scatter table, tree

What needs to be implemented?

- A table containing recent node discovery packet ids that the host has heard is needed
  - In order to eliminate redundant broadcasts
- Write an Instant Messenger application using miniroute
  - Requires reading keyboard input from user
    - Add read.c, read.h and read_private.h
    - Include “read_private.h” to minithread.c
    - Add miniterm_initialize to minithread_system_initialize
    - Use miniterm_read() to read data from the keyboard

Additional changes

- In network.h
  - Set BCAST_ENABLED to 1
  - Set BCAST_ADDRESS
    - 192.168.1.255 for ad-hoc network (see instructions for setting an ad-hoc network)
    - x.y.z.255 for CSUGLAB
  - For debugging purposes
    - Set BCAST_TOPOLOGY_FILE
    - Provide a topology file (see project description)
      - Allows testing without wireless
    - Use only in CSUGLAB (not for Tablets)

Tablets?

- Yup, you'll finally use them
  - Only real way to test an ad-hoc routing is through wireless
- Can compile and run tests like CSUGLAB desktops
- Setup tablet to use the wireless card
  - Set to ad-hoc mode
  - Specify an IP address for your tablets based on your group
    - 192.168.1.${GROUPID}
  - Set Subnet Mask to 255.255.255.0
  - Set Gateway to 192.168.1.254

Additional Requirements

- At any host, there must be at most a single routing discovery request for any destination at any one time
  - Multiple threads should not trigger multiple routing discovery requests for the same destination
  - Only one cache entry for each destination (unless…)
- Use the route reply packets with the latest information (use seq_no for this)
- Use the structures and data-types provided in miniroute.h
  - Allows everyone to participate in the routing (i.e. routing should work across groups)
  - However, minimsg/minisockets do not have to interoperate across groups

Additional Requirements

- Furthermore, routing interoperability requires the routing header entries to be in network order
  - Every short, int, long must be translated to network order before being sent, and translated to host order after being received
  - Translation functions provided in network.c

For the ambitious…

- Lots of optimization opportunities
- 1) Routing cache does not need to have a timeout
  - If a host detects a broken link in the route path, it can send back an error message to the source host and the source host can purge the cache entry and re-perform discovery
  - Requires the integrity of each hop to be verified
  - Can be done via hop to hop acknowledgements
    - Very very inefficient
  - Can have each routing host eavesdrop, waiting for the next hop to forward the packet
    - Replace unicast hop to hop sends with broadcasts
    - Requires additional filtering work in the network handler

For the ambitious…

- 2) Localized route patching
  - Instead of sending a error message back to the source host if a particular hop to hop communication fails, have the hop that identified the route breakage to perform a new route discovery
  - It can then patch the route, thus allowing it to continue routing the packet to the destination host
  - Route cache on both source/destination should also be eventually updated
- 3) Aggressive caching
  - There are lots of unexploited opportunities for caching
  - Every reply/request/data packet that is routed through a host is an opportunity
    - Have to be careful, only some of the route data is worth caching, and is different depending on whether it is a reply/request/data packet

For the ambitious…

- 4) Redundant routes
  - By keeping additional routes to a destination, packets can be quickly re-routed if the primary route breaks
  - Re-routing using the redundant routes can be done when the source receives an error
  - Redundant routes can be embedded into the header (in some tree format), allowing localized re-routing
- 5) Hybrid proactive/reactive routing protocol
  - See Professor Sirer's SHARP: http://www.cs.cornell.edu/courses/cs414/2004SP/papers/sharp.pdf