Exposing the network: support for topology-sensitive applications

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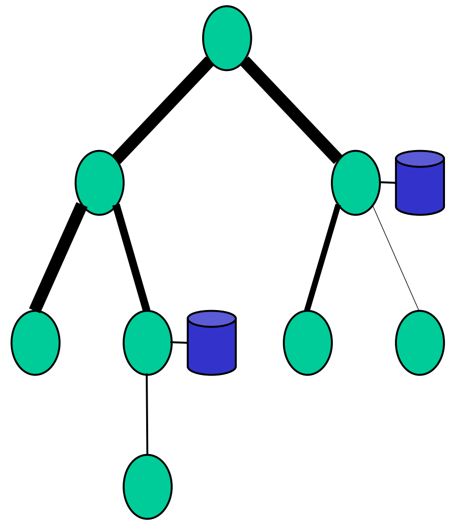
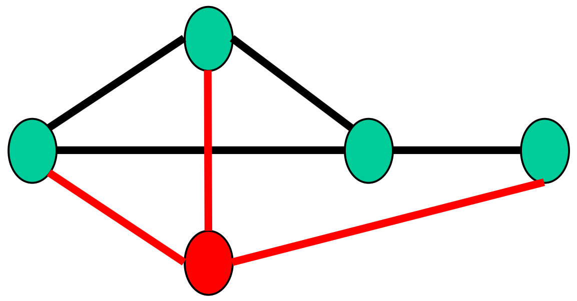
Motivation

- Repair server placement
  - determine locations for mcast repair servers



- Secure overlay creation
  - identify secure links and nodes



Key: requires knowledge of topology

Problem statement

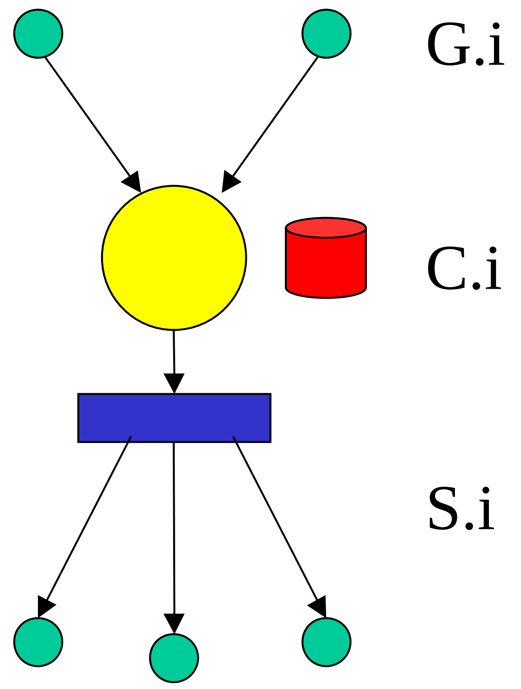
- Define service that allows:
  - constrained query and synthesis of network topology information
- Assume:
  - nodes maintain attributes for local information (including link info)
- Restrict:
  - computation functionality
  - access to node state

Outline

- Problem statement
- Solution overview
- Implementation
- Performance results
- Conclusions

Iterative GCS overview

- Gather
  - collect messages on specified channels
- Compute
  - perform computation using gathered messages, stored state, node/link attributes
- Scatter
  - send message on specified channels

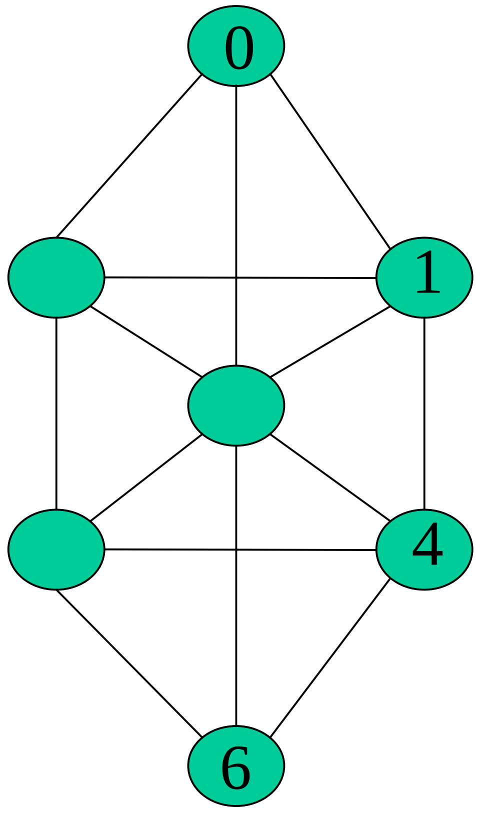


IGCS Specification

- Set of three-tuples: {(G.i, C.i, S.i)}, where tuple i describes i-th iteration
- G.i, S.i: sets of link descriptors
- C.i: computation function
  - may change local state Π (including subsequent gather and scatter sets) and create output msg
  - oMsg $\leftarrow$ C({iMsg},Σ.node,Σ.link,Π)

Example: path info retrieval (I)

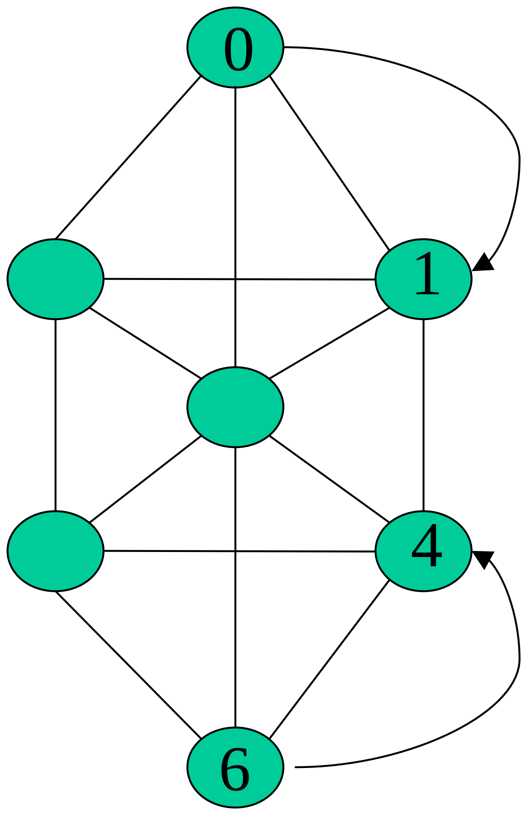
- Iteration 0 (set up)
  - messages flow from src to dst
  - compute downstream path and establish sets S.0, G.1, S.1
- Iteration 1 (work)
  - messages flow from dst to src
  - compute using message content and local state (e.g., min)



src=0, dst=6

Example: path info retrieval (II)

- Iteration 0 details:
  - copy src msg to out msg
  - record incoming link as S.1
  - lookup next hop to dst (h)
  - record h as G.1and S.0
  - scatter out msg to S.0
- Iteration 1 details:
  - wait for message on G.1
  - copy src msg to out msg
  - take min of src msg and local state
  - scatter out msg to S.1



src=0, dst=6

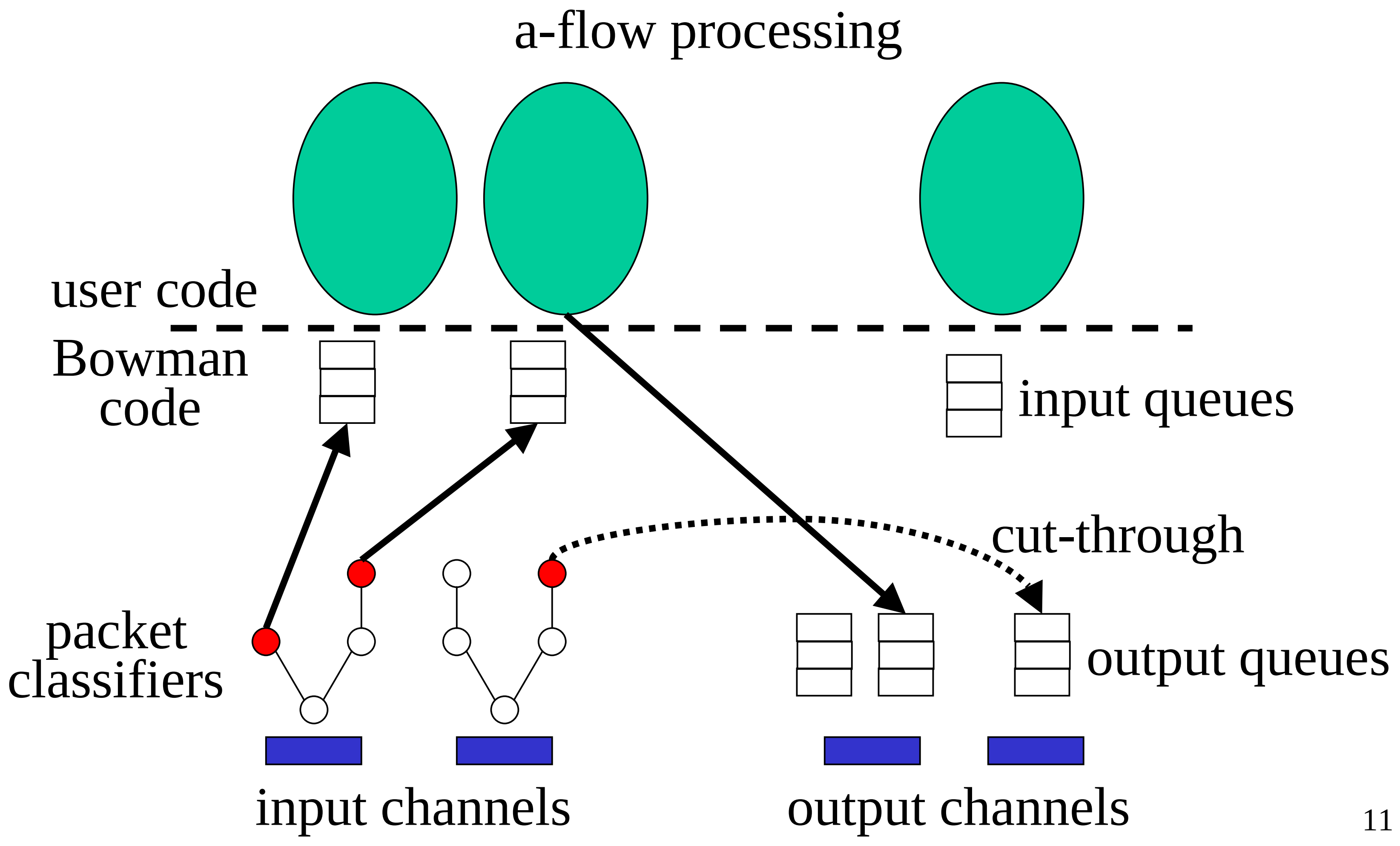
Generalizations

- Multicast tree information retrieval
  - change dst unicast address to group address
  - assume routing table lookup returns set of interfaces for multicast tree
- Repair server location
  - change computation to check if packet loss on downstream links exceeds threshold
  - record identity of links in reply message

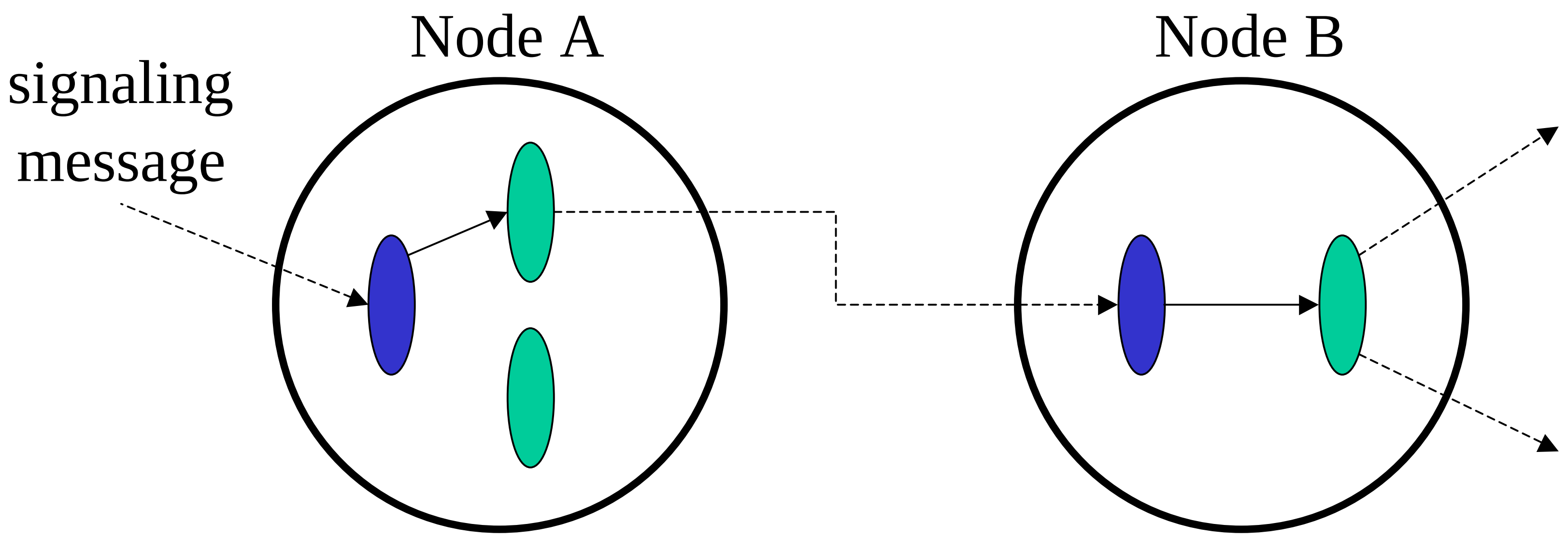
Implementation: Background

- CANEs
  - execution environment supporting composition
  - underlying program (skeleton pkt processing)
  - injected programs (customize skeleton)
- Bowman
  - active node OS (built over hostOS)
  - provides channels, a-flows, state-store,...
  - plug: Infocom paper/talk Thursday morning

Packet Processing Path



IGCS system architecture



● IGCS daemon: node-resident; parses signaling messages, initiates new instance with proper code

● IGCS instance: underlying IGCS program and injected programs for specific activity

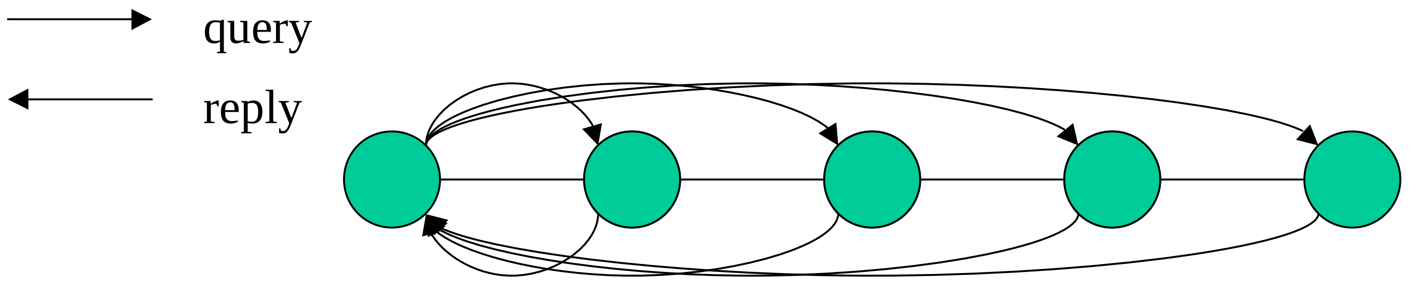
Underlying program

```
for (i = 0; i < igcs_get_iteration(); ++i) {
    /* Gather Phase */
    igcs_get_gather(i, tmp_io);
    if (tmp_io->num_ch != 0) {
      igcs_install_gather_filter(tmp_io);
      cur_in = igcs_gather_msg(tmp_io);
      c_Ep(inMsg) = cur_in;
      igcs_uninstall_gather_filter(tmp_io);
    }
    /* Compute Phase */
    igcs_raise_slot(Compute);
    /* Scatter Phase */
    igcs_get_scatter(i, tmp_io);
    igcs_scatter_msg(c_Ep(outMsg),tmp_io);
  }
```

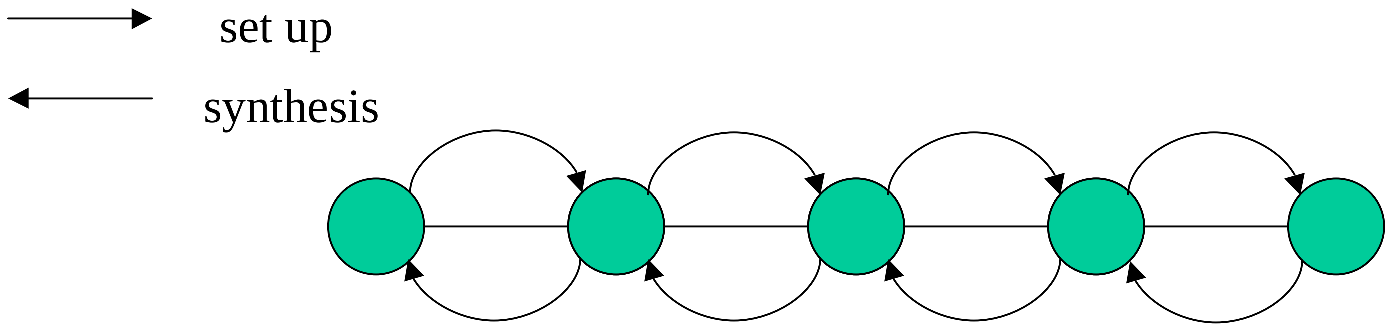
Injected program

```
memcpy(tmp_msg, (igcs_msg_t *)igcs_get_sigmsg(),
tmp_sig->len);

i = igcs_next_hop(tmp_msg->src_id);
tmp_io.num_ch = 1;
tmp_io.ch[0] = i;
igcs_set_scatter(1, &tmp_io);

igcs_get_all_vn_channel(&tmp_io);
_igcs_get_diff_channel(&tmp_io, i);
igcs_set_scatter(0, &tmp_io);
igcs_set_gather(1, &tmp_io);

tmp_msg->src_id = net_utils_local_ip_number();
tmp_msg->type = IGCS_SIG;
c_Ip(outMsg) = tmp_msg;
```

Experiment

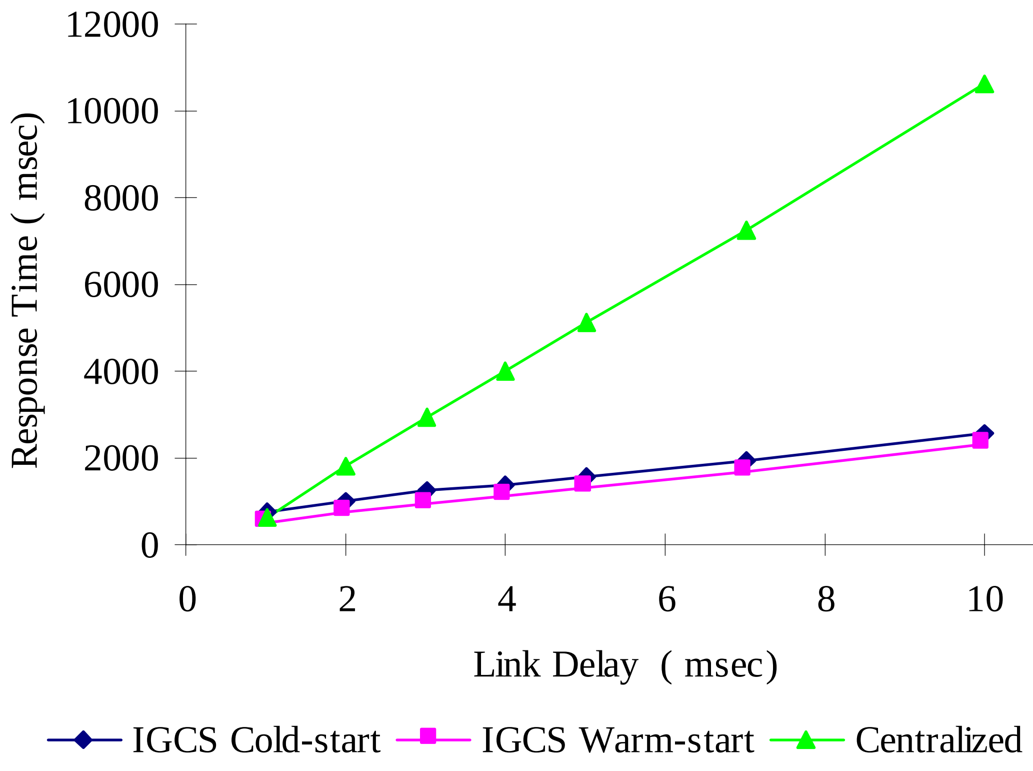


Centralized algorithm

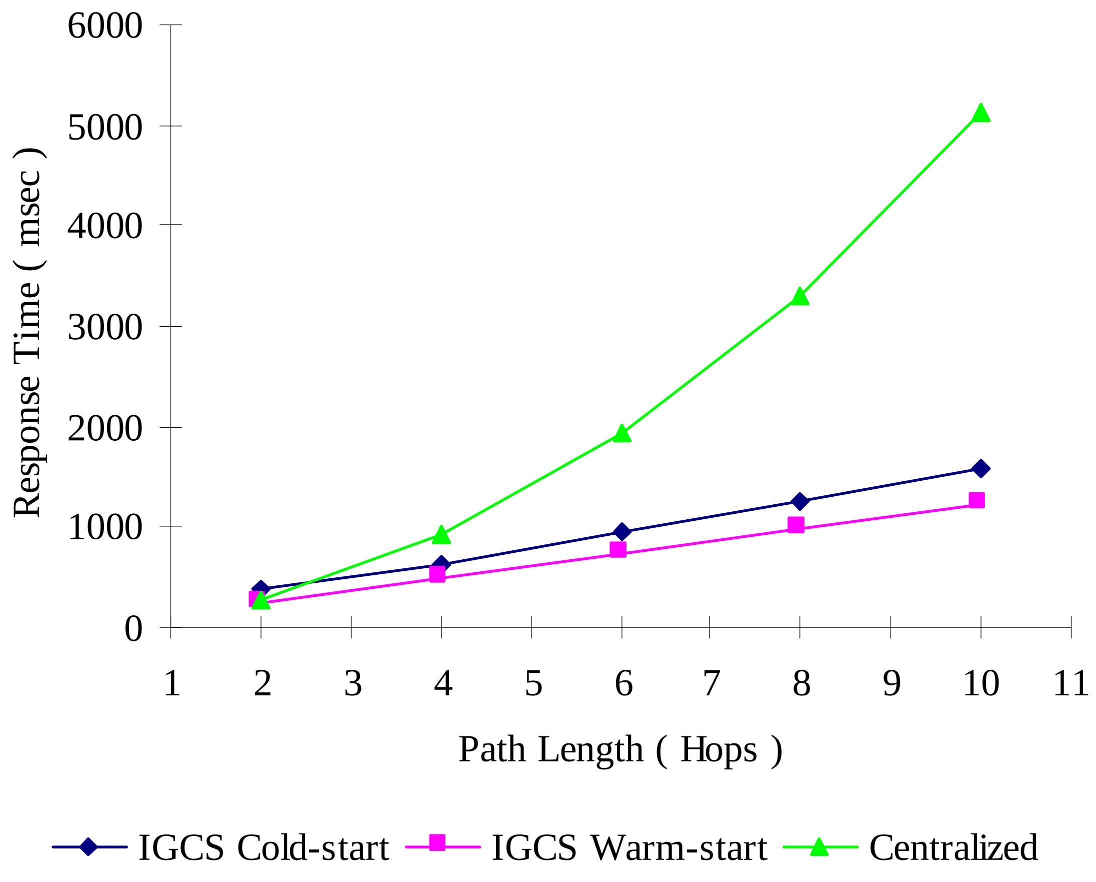


IGCS algorithm

Effect of link delay



Effect of path length



Concluding remarks

- IP provides black box to network topology
- Selectively opening the box makes some useful functionality possible (or easier)
- Key is to balance flexibility with performance and security
- Open issues: access control for node and link state, route changes during computations, integration w/virtual topos