TÉCNICO LISBOA

2nd Mini-Project: Routing Simulation

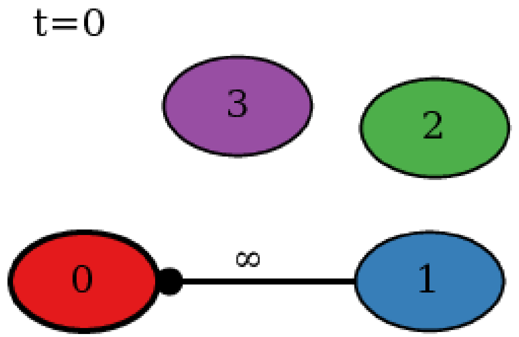
Routing Protocols

Overview

What you'll learn:

- Routing Protocols
  - Link State
  - Distance Vector (w/ & w/o RPP)
  - Path Vector
- Event Based Simulation

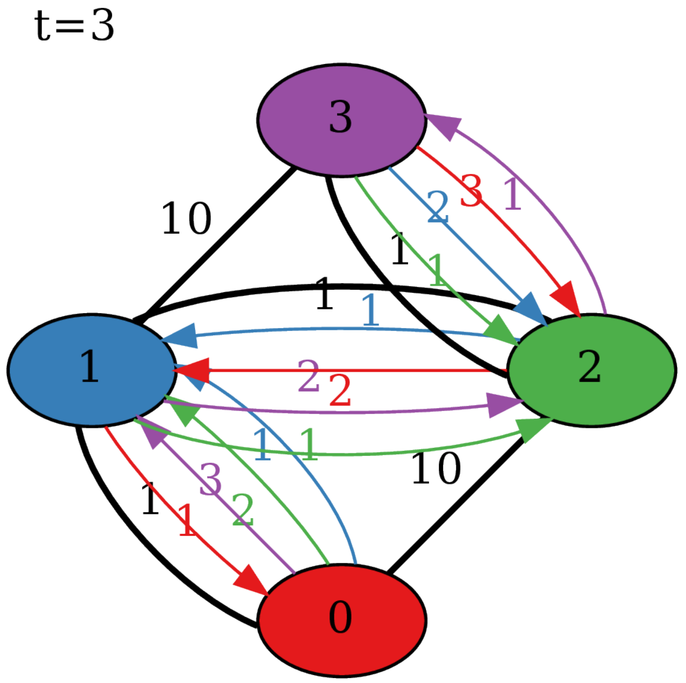
Implement Routing Protocols
in a Simulated Network



Implementing a Routing Protocol

Implement Handlers

```
void notify_link_change(
    void *state,
    node_t neighbor,
    cost_t new_cost);

void notify_receive_message(
    void *state,
    node_t sender,
    void *message);
```

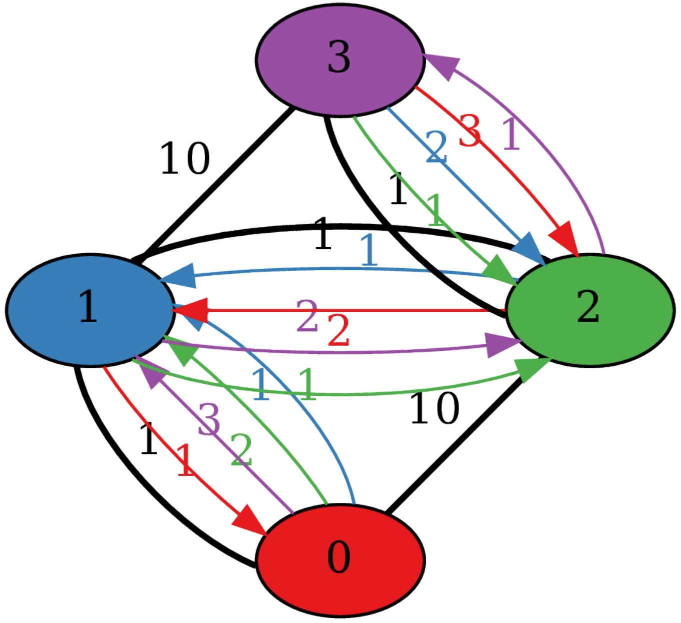


Implementing a Routing Protocol

Use API

```
Topology:
node_t get_current_node();
node_t get_first_node();
node_t get_next_node(node_t node);
node_t get_last_node();
cost_t get_link_cost(node_t neighbor);
cost_t COST_ADD(cost_t a, cost_t b)

for (node_t n = get_first_node();
     n <= get_last_node(); n = get_next_node(n)) {
  if (n != get_current_node()) {
    ...
  }
}
```

t=3

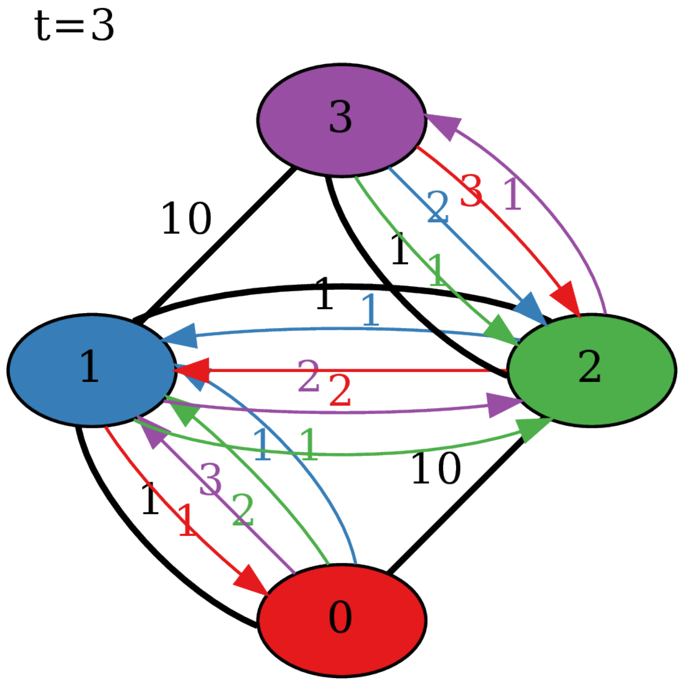


Implementing a Routing Protocol

Use API

Data Plane:

```
void set_route(
    node_t destination,
    node_t next_hop,
    cost_t cost);
```

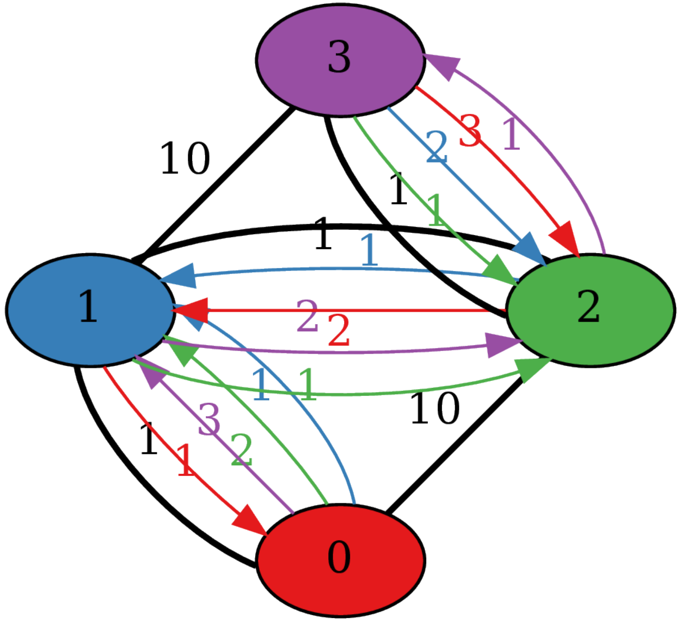


Implementing a Routing Protocol

Use API

```
Messages:
void send_message(
    node_t neighbor,
    message_t message);

data_t *data = malloc(sizeof(data_t));
data->field = value;

message_t msg;
msg.data = data;
msg.size = sizeof(data);
send_message(1, msg);
```

t=3



Implementing a Routing Protocol

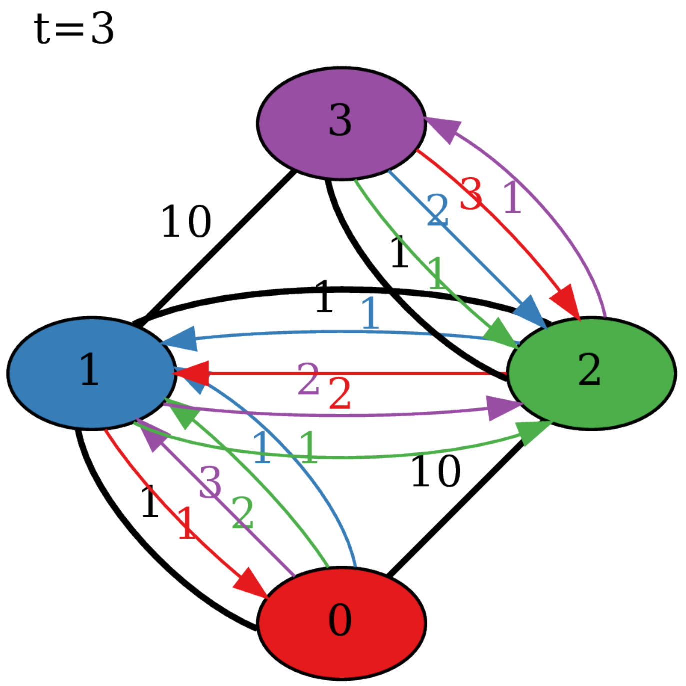
Use API

State:

<u>No Global/Static Variables!</u>

```
void *init_state() {
  state_t *s = (state_t *) malloc(sizeof(state_t));
  s->field = value;
  return s;
}
```

```
state_t *s = (state_t *) state;
s->field = value;
```



Four Routing Protocols

Distance Vector:

- Nodes exchange cost to each destination (DV)
- Bellman-Ford algorithm
- Send updates when DV changes

Distance Vector w/ Reverse Path Poisoning:

- Same, but set reverse path = ∞

Path Vector:

- Like DV, but send whole route instead of cost

Link State:

- Nodes share topology (link states)
- Dijkstra's algorithm

Link State: Sharing Topology

```
typedef struct {
  cost_t link_cost[MAX_NODES];
  int version;
} link_state_t;

typedef struct {
  link_state_t ls[MAX_NODES];
} data_t;
```

Initialization:

- Local = get_link_cost();
  Other = ∞;
  version = 0
- Send to neighbors

Link Change:

- Update local costs; version++
- Send to neighbors

Receive Message:

- Check for any newer version
- Update and send to neighbors

Running the Simulator

```
:~$ make

:~$ ls
dv-simulator   dvrpp-simulator
pv-simulator   ls-simulator

:~$ ./dv-simulator \
        --steps-dot output.dot \
        topology.net

:~$ ./dot-to-pdf.sh output.dot \
                    output.pdf
```

Four Simulators:

- dv-simulator
- dvrpp-simulator
- pv-simulator
- ls-simulator

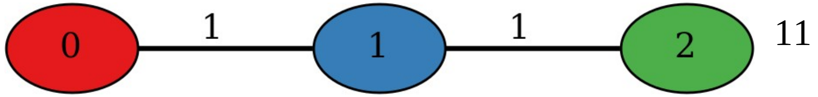
Running the Simulator

```
:~$ make

:~$ ls
dv-simulator  dvrpp-simulator
pv-simulator  ls-simulator

:~$ ./dv-simulator \
        --steps-dot output.dot \
        topology.net

:~$ ./dot-to-pdf.sh output.dot \
                    output.pdf
```

Input Topology:

- Text File
  - Each line a link change:
    `time nodeA nodeB cost`
  - Bring links up one by one
  - Change over time
- e.g. linear-3.net:

```
0 0 1 1
0 1 2 1
```



Running the Simulator

```
:~$ make

:~$ ls
dv-simulator  dvrpp-simulator
pv-simulator  ls-simulator

:~$ ./dv-simulator \
        --steps-dot output.dot \
        topology.net

:~$ ./dot-to-pdf.sh output.dot \
                    output.pdf
```

Output:

- DOT File, convert to PDF
- TMI, Filter:

```
--epoch-steps
--final-dot <dot-file>
--hide-future-messages
--show-routes-for <node>
--steps-dot <dot-file>
```

Event Based Simulation

- Event Queue
  - Sorted by event time
  - Initialized with link changes from topology file
- Event Loop
  - Remove top event, process it
  - Add new events
    - Messages delivered next time epoch
  - Run until none left

- Simulation State
  - Dumped periodically
    - Each event, epoch, final
  - Outputted as pretty graph
- Caveats
  - No unnecessary messages
    - Will run forever
  - Can generate a lot of events
    - Limit to debug: `--max-events <limit>`

Submission

- Develop your code on: https://gitlab.rnl.tecnico.ulisboa.pt/
- Implement: dv.c, dvrpp.c, pv.c, ls.c
- Do not change other files
- No build artifacts
- Tag submission as project2-submission:

```
:~$ git tag project2-submission
:~$ git push origin project2-submission
```

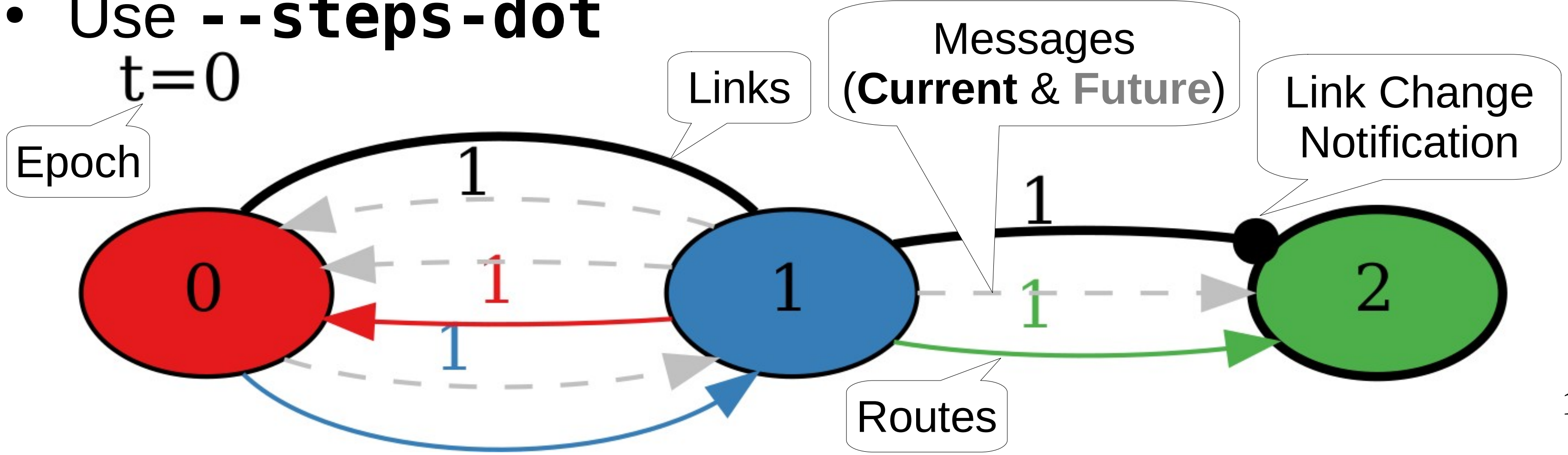
```
:~$ git clone <repo URL> .
:~$ git checkout project2-submission
:~$ ls
routing-simulator.cpp Makefile dvrpp.c
routing-simulator.h ls.c dv.c pv.c
:~$ make
:~$ ls
(...)
dv-simulator dvrpp-simulator
pv-simulator ls-simulator
```

Nightly Builds

- Coming soon to a repo near you…
- Runs nightly
  - Simple tests – does not preclude running your own
  - Runs on main branch and generates build-report.md
    - Don’t forget to pull
  - On request: must delete and push to rerun next time

Advice: Debugging

- Standard output/error will be ignored during grading
  - `printf("At time %d, Node %d: …", get_current_time(), get_current_node(), …)`
- Use **`--steps-dot`**



Improv

- Routing Protocol
  - DV, DVRPP, PV, LS
- Topology
  - linear-3
  - diamond
  - count-to-infinity
  - custom