Project 2

ECE544 Communication Networks II

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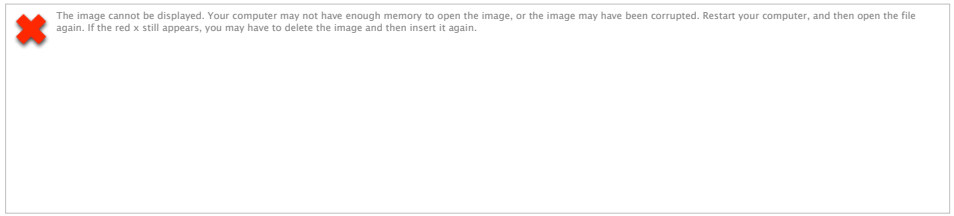
Includes teaching material from Bart Braem and Michael Voorhaen

Project Goals

- Write custom elements
- Design and implement basic network protocols
- Get familiar with the framework used in the final project

Writing Custom Elements: Element Header

- Necessary in the header:
  - Include-guard macros
  - Click element macros
  - Include click/element.hh
  - The class declaration containing 3 special methods:



Writing Custom Elements: Element Header

- Necessary in the source file:
  - Include click/config.hh first!
  - CLICK_DECLS macro
  - CLICK_ENDDECLS macro
  - EXPORT_ELEMENT macro
  - Implementations of the methods

Writing Custom Elements: SimplePushElement.hh

```
#ifndef CLICK_SIMPLEPUSHELEMENT_HH
#define CLICK_SIMPLEPUSHELEMENT_HH
#include <click/element.hh>
CLICK_DECLS
class SimplePushElement : public Element {
  public:
    SimplePushElement();
    ~SimplePushElement();
    const char *class_name() const { return "SimplePushElement";}
    const char *port_count() const { return "1/1"; }
    const char *processing() const { return PUSH; }
    int configure(Vector<String>&, ErrorHandler*);
    void push(int, Packet *);
  private:     uint32_t maxSize;
};
CLICK ENDDECLS
#endif
```

Writing Custom Elements: SimplePushElement.cc

```
#include <click/config.h>
#include <click/confparse.hh>
#include <click/error.hh>
#include "simplepushelement.hh"
CLICK_DECLS
SimplePushElement::SimplePushElement(){}
SimplePushElement::~SimplePushElement(){}

int SimplePushElement::configure(Vector<String> &conf, ErrorHandler
    *errh) {
  if (cp_va_kparse(conf, this, errh, "MAXPACKETSIZE", cpkM, cpInteger,
      &maxSize, cpEnd) < 0) return -1;
  if (maxSize <= 0) return errh->error("maxsize should be larger than 0");
  return 0;
}
```

Writing Custom Elements: SimplePushElement.cc

```
void SimplePushElement::push(int, Packet *p){
  click_chatter("Got a packet of size %d",p->length());
  if (p->length() > maxSize)  p->kill();
  else output(0).push(p);
}
CLICK_ENDDECLS
EXPORT_ELEMENT(SimplePushElement)
```

Writing Custom Elements

- Similarly you can define pull (needs to implement pull operation) and agnostic elements (needs to implement both push and pull operations)
- const char *port_count() const has to return the number of ports your element will have (it can be a flexible number, see examples)

Writing Custom Elements

- We are just scratching the surface…
- For more information:
  - Go through the following coding tutorial: http://www.pats.ua.ac.be/software/click/click-2.0/coding.pdf
  - Dr Kohler thesis: http://www.read.cs.ucla.edu/click/

Packet Formats

- Packet formats == structs
  - structs are a typical C concept, very low level
  - tempting to improve this by wrapping the packets in objects
  - attractive to create packet factories
- Do not do this, very large overhead:
  - In terms of memory and computation (allocate objects, create and delete objects)
  - In terms of code base
- Use the plain structs
  - Requires getting used to
  - Straightforward: most packet manipulation is low-level anyway

Packet Formats Example

- Define the packet header

```
struct MyPacketFormat{
  uint8_t type; // 8 bit = 1 byte
  uint32_t lifetime; // 32 bit = 4 bytes
  in_addr destination; // IP address
};
```

- Cast a packet to access the header

```
MyPacketFormat* format=(MyPacketFormat*)packet->data();
format->type = 0;
format->lifetime = htonl(counter);
format->destination = ip.in_addr();
```

Compile the New Elements

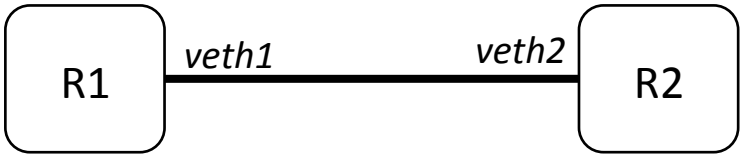
- All elements are stored in /elements/ directory
  - Yours should be put in elements/local
  - Put the .hh and .cc files there
- Go to the base click folder
- To make those elements available:
  - make elemlist
  - make
- Notice new elements being compiled, solve any compilation problems and use your elements

Compound Elements

- Group elements in larger elements
- Configuration with variables
- Pass configuration to the internal elements, can be anything (constant, integer, elements, IP address, ...)
- Motivates reuse
- No need to use in these projects, but you will be using one indirectly (more on this later)

Hands On With Our Framework

- To simplify your life, we will provide you with an abstracted concept of router port.
- This will allow you to implement your own protocols on top of the click framework.
- You already got briefly introduced to some of these tools:
  - Remember the createNet1 script?
- This creates a pair of linked interfaces (veth1 and veth2).



Hands On With Our Framework

- *Port abstraction*: defines one end of a link
- Everything that gets into veth1 arrives unchanged to veth2
- Abstraction obtained through the provided element:
  - elements/routerport.click
- At the beginning of your configuration file:
  - require(library /home/comnetsii/elements/ routerport.click);
- *RouterPort* is a push element with one input and one output port

Hands On With Our Framework

- RouterPort takes 5 parameters: device name, local ip, remote ip, local mac, remote mac
- Example:
  - Element that sends every one second a hello message into the port
  - Prints all packets received and discard them

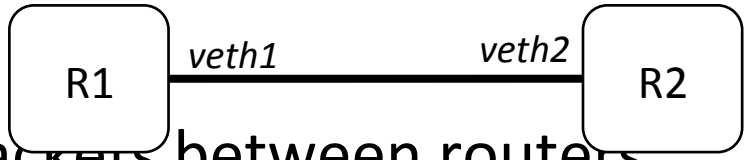
```
require(library /home/cometsii/elements/routerport.click);

rp :: RouterPort(DEV $dev, IN_ADDR $in_addr, OUT_ADDR $out_addr, IN_PORT $in_port, OUT_PORT $out_port, IN_MAC $in_mac, OUT_MAC $out_mac
);

RatedSource(DATA "hello", RATE 1) -> rp;

rp -> Print(Received, MAXLENGTH -1) -> Discard;
```

Hands On With Our Framework

- Important note: all our scripts, generate pair of interfaces belonging to the same subnet
- Connect only interfaces on the same subnet
- Feel free to look at what is used in the compound element

Hands On With Our Framework

- Generate a small network of two routers
  - $ createNet1



- Exchange packets between routers
  - Start two click instances using the example found in:
    - examples/router/printer.click
  - Make sure to set the 5 parameters appropriately given the generated interfaces
  - E.g.:
    - $ sudo ~/click/userlevel/click printer.click dev=veth1 in_addr=192.168.1.1 out_addr=192.168.1.2 in_port=10000 out_port=10001 in_mac=08:00:27:9a:04:e5 out_mac=08:00:27:3e:0b:11

Hands On With Our Framework

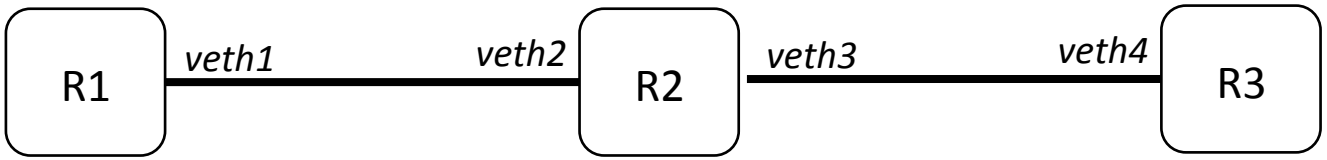
- Writing end-host applications.
- Download package: http://www.winlab.rutgers.edu/comnet2/Projects/project2.tar
- The package provides a similar port concept for developing at the application layer
- Examples on how to use it:
  - http://www.winlab.rutgers.edu/comnet2/Projects/project_index.html

Exercise 1

- Write an element that change the content of every packet into another
- The new content should be configurable from the configuration script
- Use the RouterPort elements to build your network

Exercise 1

- Use provided script to create 4 virtual interfaces
  - Run: $ createNet2
- Obtained topology:



- Tips:
  - You can reuse previous exercises to implement R1 and R3
  - You have to implement your own element to change the content in R2

Exercise 2

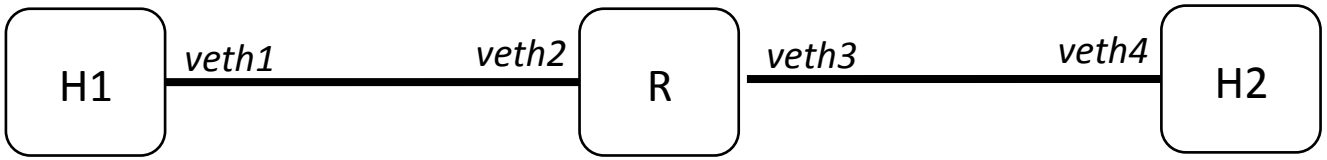
- Design a protocol to transport a file from one end of a communication link to the other over an unreliable link.
- Requires fragmentation and reassembly.
- Choose the ARQ protocol you prefer (stop&wait, go-back N, selective ACK, etc.) or design your own. The design with better performance will receive extra credits.
- Use the program diff to check

Exercise 2

- Use the application layer package to implement the end host applications.
- Implement one sender and one receiver

Exercise 2

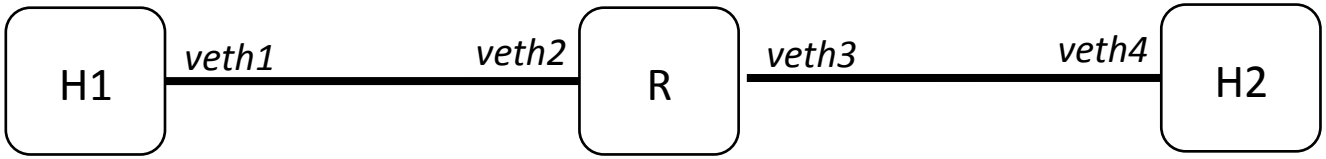
- Use provided script to create 4 virtual interfaces
  - Run: $ createNet2
- Obtained topology:



- Tips:
  - R only needs to forward packets. (i.e. you only need 2 elements, the 2 RouterPorts)

Exercise 3

- Replace router R from the previous exercise with a new implementation that uses the Lossy*RouterPort* element



- Tips:
  - You can find the new element in the same folder as the previous one.

Exercise 3

- Write a small README file that describes the your implemented protocol and its performance.
- It should include (but not limited to):
  - Your designed protocol
  - Packet and signaling formats
  - Purpose and functions of each new class/element you implemented
  - Performance results (no need for complex graphs, just an analysis on the performance based on protocol characterization and experiments)

General Info

- Due: March 27th
- Submission instructions:
  - Submit a single archive (zip or tar.gz) to bronzino@winlab.rutgers.edu with subject "ECE544 Project 2"
  - Include in the archive 3 folders named "exercise1", "exercise2", "exercise3". They should contain only files that you implemented (i.e. click configuration files, new elements and applications).
  - **Do not** include the whole click resources or binary files!