Outline
Background
Routers and Elements
Implementation Philosophy
Handlers
Running Click
References
Acknowledgements

Click Concepts

Click Modular Router Concepts and Philosophy

Bart Braem Johan Bergs

University of Antwerp
iMinds - MOSAIC Research Group

October 2014

Outline

1 Background

2 Routers and Elements

3 Implementation Philosophy

4 Handlers

5 Running Click

6 References

Network coding

- Inside router: packets being processed while flowing through routers
- Classical network software: operate on packets, procedural programming style
- Code reuse? Lots of returning concepts

Click Modular Router

- Extensible toolkit for writing packet processors
- PhD thesis dr. Eddie Kohler (MIT)
- Architecture centered on elements
  - Small building blocks
  - Perform simple operations e.g. decrease TTL
- Click routers
  - Directed graphs of elements

Why not a daemon?

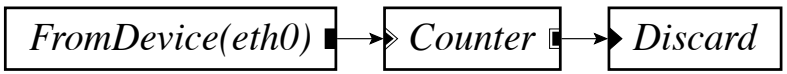
- I'll just code it as a daemon.
  - How modular is your result?
- Designing elements is hard, in the beginning
  - Follow the framework, it's there already
- Other alternatives:
  - System calls are hard
  - Which libraries for the packet formats?
  - The Linux kernel API is hard
  - Let's not talk about kernel development

This has already been done

- So have linked lists
  - Did you do real network programming before?
  - E.g., do you know how ARP really works?
- Click is never used in real life
  - It works at layer 3, it is in the network
  - Being used in production at large companies, links with e.g. Google

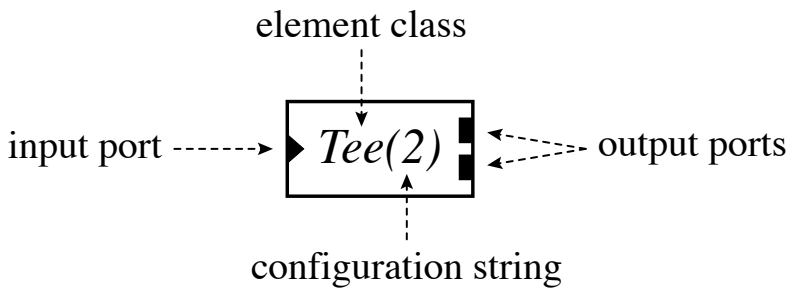
Click Routers

- Router: Elements connected by edges
- Output ports to input ports
- Describes possible packet flows
- FromDevice(eth0)->Counter->Discard;



Element Classes

- Class: element type (reuse!)
- Configuration string: initializes this instance
- Input port(s): Interface where packets arrive, triangles
- Output port(s): Interface where packets leave, squares
- Instances can be named: myTee :: Tee



Element ports I

Push port:

- Filled square or triangle
- Source initiates packet transfer: event based packet flow

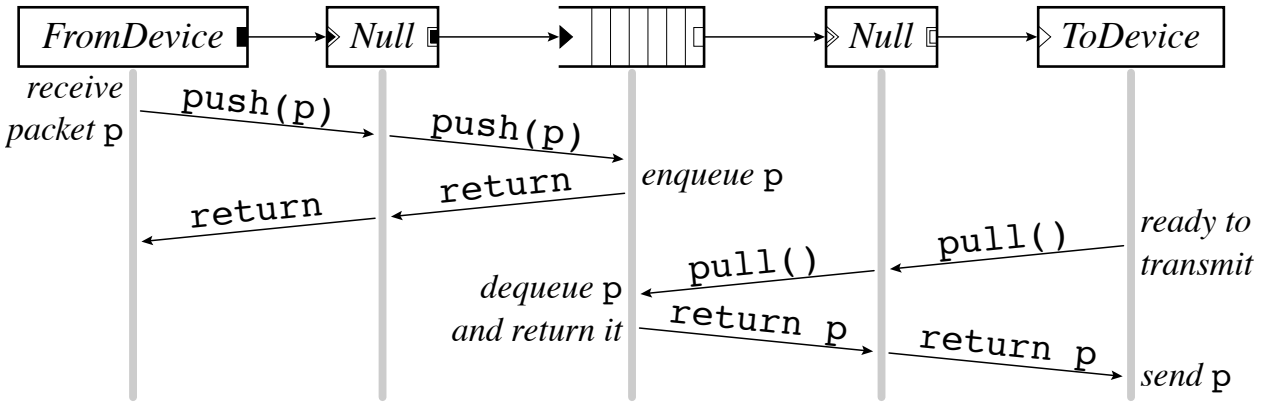
Pull port:

- Empty square or triangle
- Destination initiates packet transfer
- Used with polling, scheduling, ...

Agnostic port:

- Square-in-square or triangle-in-triangle
- Becomes push or pull (inner square/triangle filled or empty)

Element ports II



Push-pull violations I

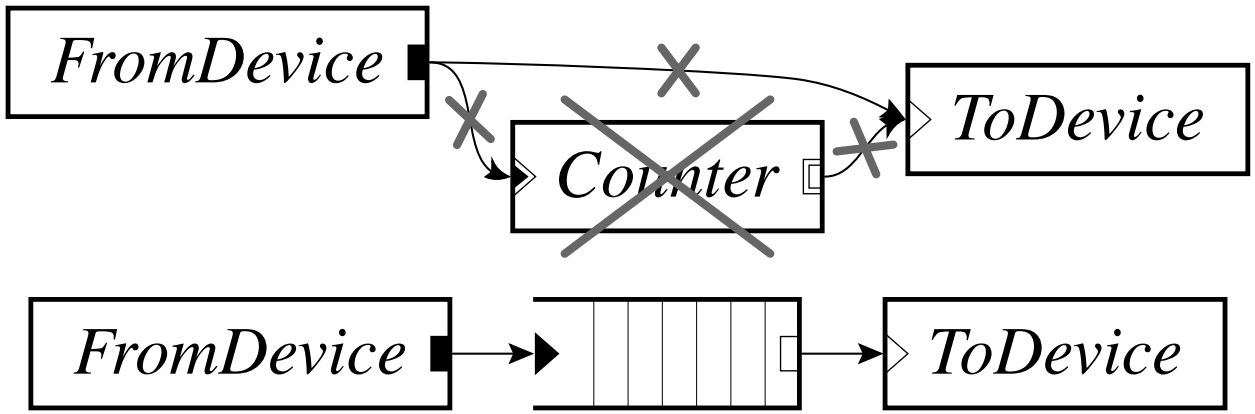
Push port

- has to be connected to push or agnostic port
- Conversion from push to pull with push-to-pull element
- E.g. queue

Pull port

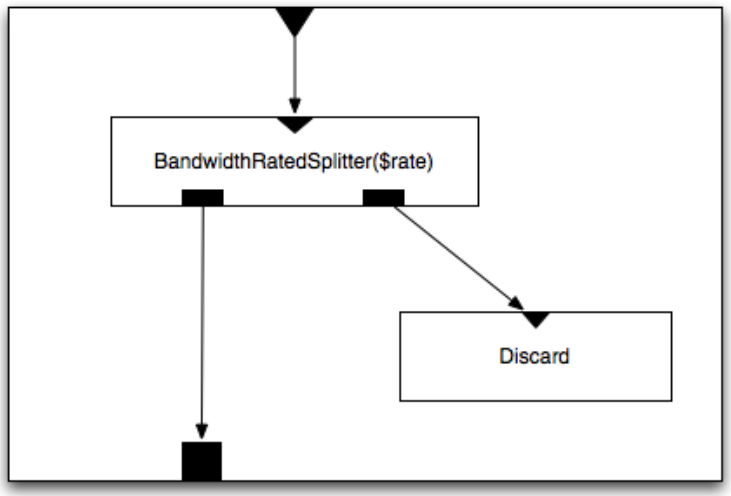
- Has to be connected to pull or agnostic port
- Conversion from pull to push with pull-to-push element
- E.g. unqueue

Push-pull violations II



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



Element classes - Routers

Element classes?

- Elements (actually element classes): C++ classes
- Element instantations: C++ objects

Click Routers:

- Click router configurations (or short Click routers): text files
- parsed when starting Click, Click builds object graph of elements

Click Graphs

Text files describing the Click graph:

- Elements with their configurations
- Compound elements
- Connections between elements

```
src :: FromDevice(eth0); ctr :: Counter;
sink :: Discard;
src -> ctr; ctr -> sink;
```

or

```
FromDevice(eth0) -> Counter -> Discard;
```

Input and output ports

Identified by number (0,1,..)

- Input port: -> [nr1]Element ->
- Output port: -> Element[nr2] ->
- Both: -> [nr1]Element[nr2] ->
- Only one port: number can be omitted

Motivates instance naming

```
mypackets::IPClassifier(dst host $myaddr,-);
FromDevice(eth0) -> mypackets;
mypackets[0]-> Print(mine)->[0]Discard;
mypackets[1]-> Print("the others") -> Discard;
```

Compound elements in Click scripts

```
elementclass DumbRouter { $myaddr |
mypackets :: IPClassifier(dst host $myaddr,-);
input[0]-> mypackets;mypackets[0]-> [1]output;
mypackets[1]-> [0]output;
}
u :: DumbRouter(1.2.3.4);
FromDevice(eth0)-> u;
u[0]-> Discard;
u[1]-> ToDevice(eth0);
```

Element Configuration

Listed in click script

- First required arguments
- Then optional arguments
- Then arguments by keyword (after keyword)

Lots of data types supported

- Integers
- Strings e.g. "data"
- IP addresses 143.129.77.30
- Elements

Element Configuration Examples

- SimpleElement("data")
- SimpleElement("data",ACTIVE false)
- SimpleElement("moredata",800)
- SimpleElement("data",800,DATASIZE 67, SOURCE 1.2.3.4)

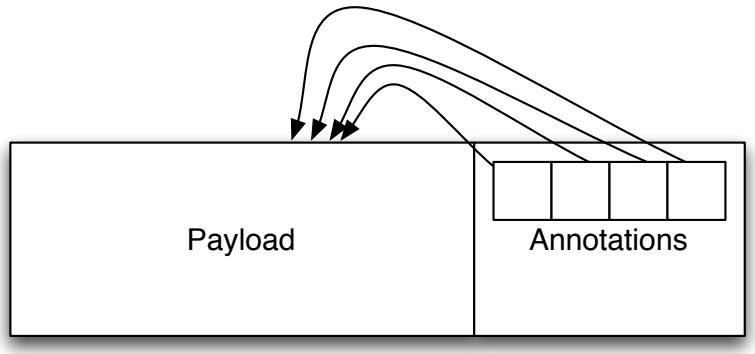
Packets

Packet consists of payload and annotations, payload:

- raw bytes (char*)
- Access with struct*

Annotations: metadata to simplify processing, "post-its"

- E.g. start of IP header or TCP header
- Paint annotations
- User defined annotations



Handlers

Like function calls to an element

- ReadHandler: request a value from an element
- WriteHandler: pass a string to an element
- (There is no ReadWriteHandler: you can't call a ReadHandler with arguments)

Can be called from other elements or through socket

- Take a look at Pokehandlers!

Use the source

- Source code: Open source
- Runs on Linux, Mac OS X, BSD and partially in Windows
- Makefile based
- Very little external dependencies (in-kernel)

Kernel module

- Completely overrides Linux routing
- High speed, requires root permissions
- Crashing Click = crashing kernel = crashing system

Userlevel

- Runs as a daemon on a Linux system
- Easy to install and still fast
- Recommended for this course

nsclick

- Runs as a routing agent within the ns-2 network simulator
- Multiple routers on 1 system
- Difficult to install but less hardware needed

References

- Click website: `http://www.read.cs.ucla.edu/click/`
- Element documentation (by name or category)
- Programming Concepts
- Doxygen documentation ('Internals documentation')

Click PhD thesis

PhD thesis: comprehensive documentation of every concept
Interesting chapters:

- Introduction
- Architecture: elements, packets, connections, push and pull, element implementation
- Language: syntax, configuration strings, compound elements

Click mailinglist:
`https://amsterdam.lcs.mit.edu/mailman/listinfo/click`
(Large source of information, mainly for Click developers)

A big thank you to Michael Voorhaen, one of the original authors of these slides.