Introduction to Click

ECE544 Communication Networks II

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Includes teaching material from Bart Braem and Michael Voorhaen

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 Click?

- Designing elements is hard, in the beginning
- Click provides a modular framework
- 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

Previous Knowledge Required

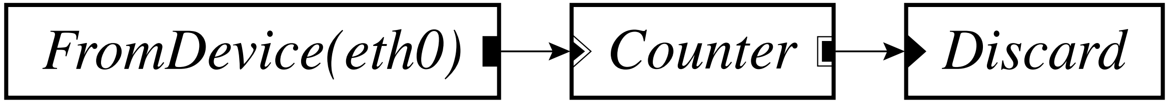
- Just a few requirements
- C++ programming
  - Language syntax
  - Object oriented programming
  - Compile a program
- Linux command line
  - Basic knowledge (e.g. run programs)
  - Basic networking tools (e.g. ifconfig)
- **Networks Theory**

Click Routers: Main Concepts

- Elements
- Ports
- Packets
- Configurations
- More…

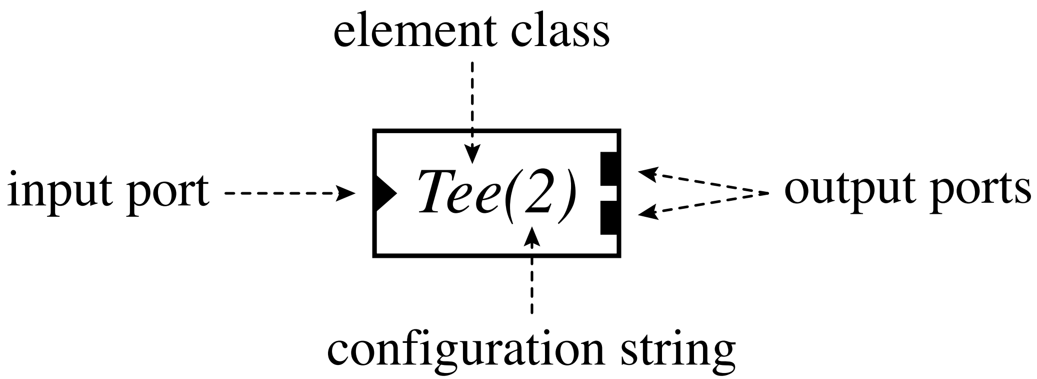
Click Routers: Main Concepts

- Router: Elements connected by edges
- Output ports to input ports
- Describes possible packet flows through directed graphs



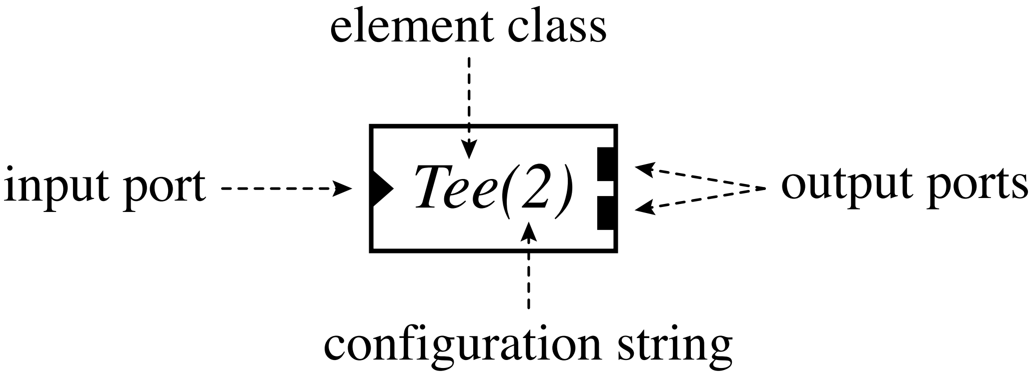
Elements

- Most important user-visible abstraction in Click
- Elements (actually element classes): C++ classes
- Element instances: C++ objects



Elements

- Input port(s): Interface where packets arrive, triangles
- Output port(s): Interface where packets leave
- Inside: packet processing!



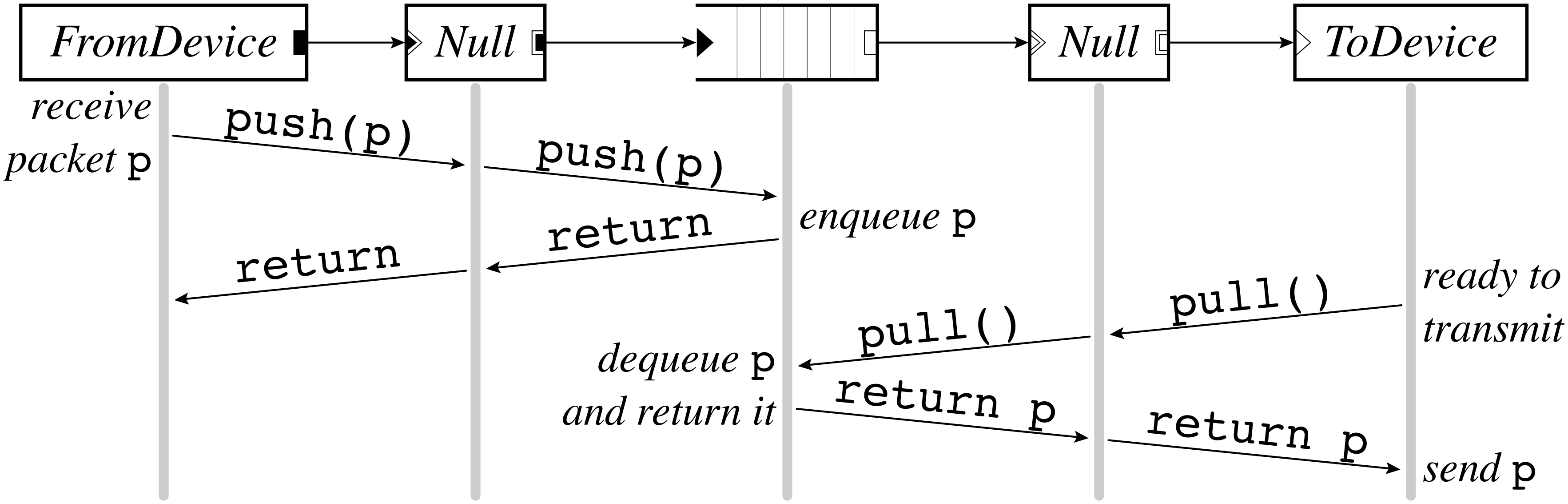
Elements

- Lots of available elements to start with
- Write your own elements with the provided interfaces:
  - Receive configuration values
  - Receive packets
  - Etc. (we will see this in detail later)

Ports

- 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)

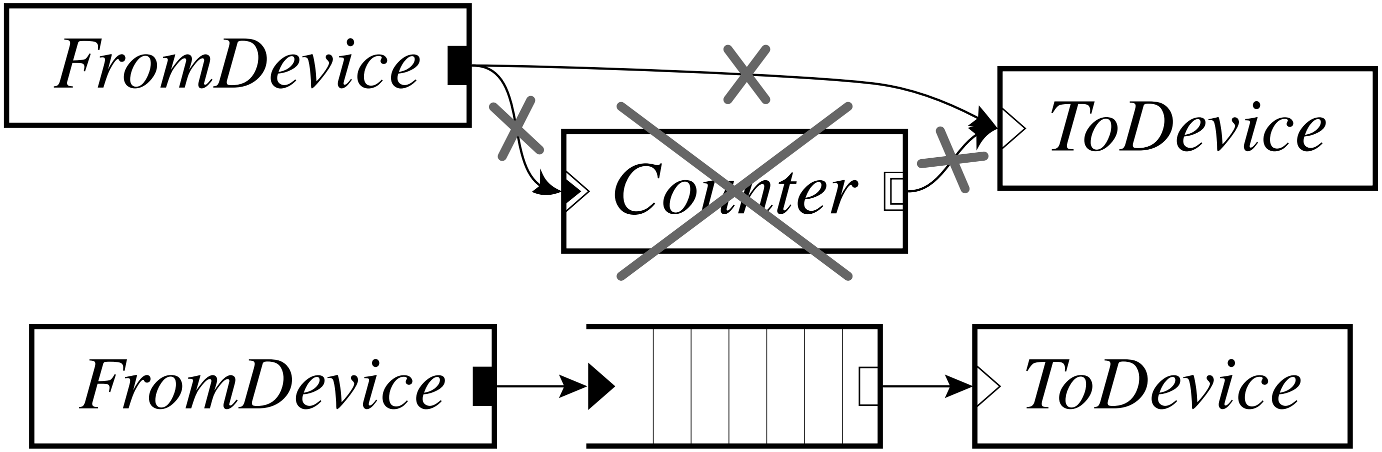
Ports


FromDevice
Null
Null
ToDevice
receive packet p
push(p)
push(p)
enqueue p
return
return
ready to transmit
pull()
pull()
dequeue p and return it
return p
return p
send p

Push-Pull Violations

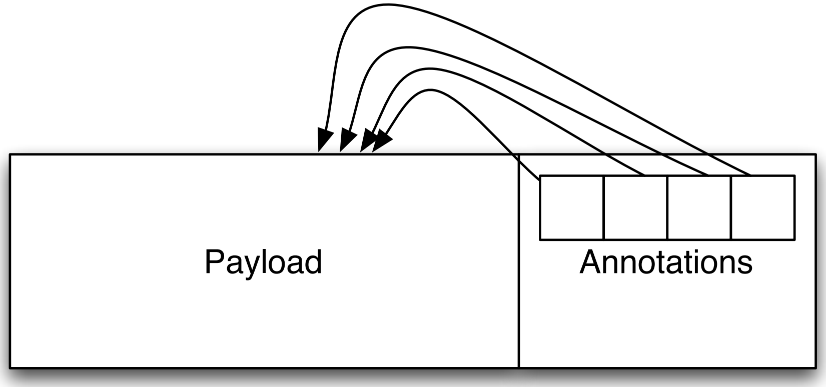
- Push port
  - has to be connected to push or agnostic port
  - Conversion from push to pull with push-to-pull element
  - E.g. queue
- Pull port
  - Has to be connected to pull or agnostic port
  - Conversion from pull to push with pull-to-push element
  - E.g. unqueue

Push-Pull Violations



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



Configuration

- Text files describing the Click graph:
- Elements with their configurations
- Connections between elements

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

or

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

Configuration

- 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;
```

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 Example

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

More…

- Compound elements
- Handlers
- Etc.

References

- Click website: http://www.read.cs.ucla.edu/click/
- Element documentation (by name or category)
- Programming Concepts
- Doxygen documentation (Internals documentation)
- Dr. Eddie Kohler's PhD thesis: comprehensive documentation of every concept
  - link