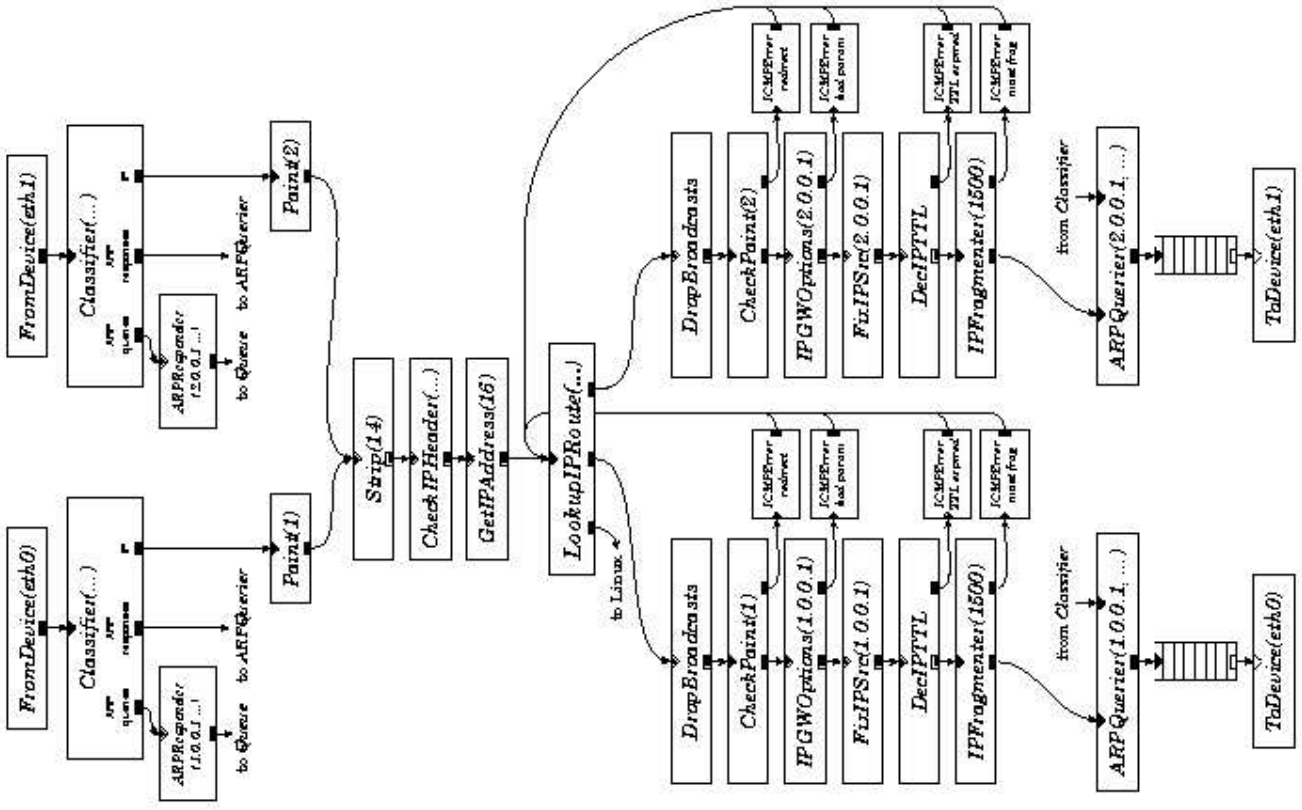


The Click Modular Router

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Element Code

```
Class NullElement : public Element { public:  
    NullElement() { add_input(); add_output(); }  
    const char *class_name() const { return "Null"; }  
    NullElement *clone() const { return new NullElement; }  
    const char *processing() const { return AGNOSTIC; }  
    void push(int port, Packet *p) { output(0).push(p); }  
    Packet *pull(int port) { return input(0).pull(); }
```

- Easy to write, most take about 120 lines of code
- New element classes can be added at run-time
- Express a single, simple idea:
 - CheckIPHeader
 - DropBroadcasts
 - DecIPTTL

Configuration Language

```
// Declare three elements
src :: FromDevice(eth0);
ctr :: Counter;
sink :: Discard;

// Connect them together
src -> ctr;
ctr -> sink;
```

- Language allows for compound elements to simplify syntax
- Only specifies connection between elements

Extensions...Endless Options

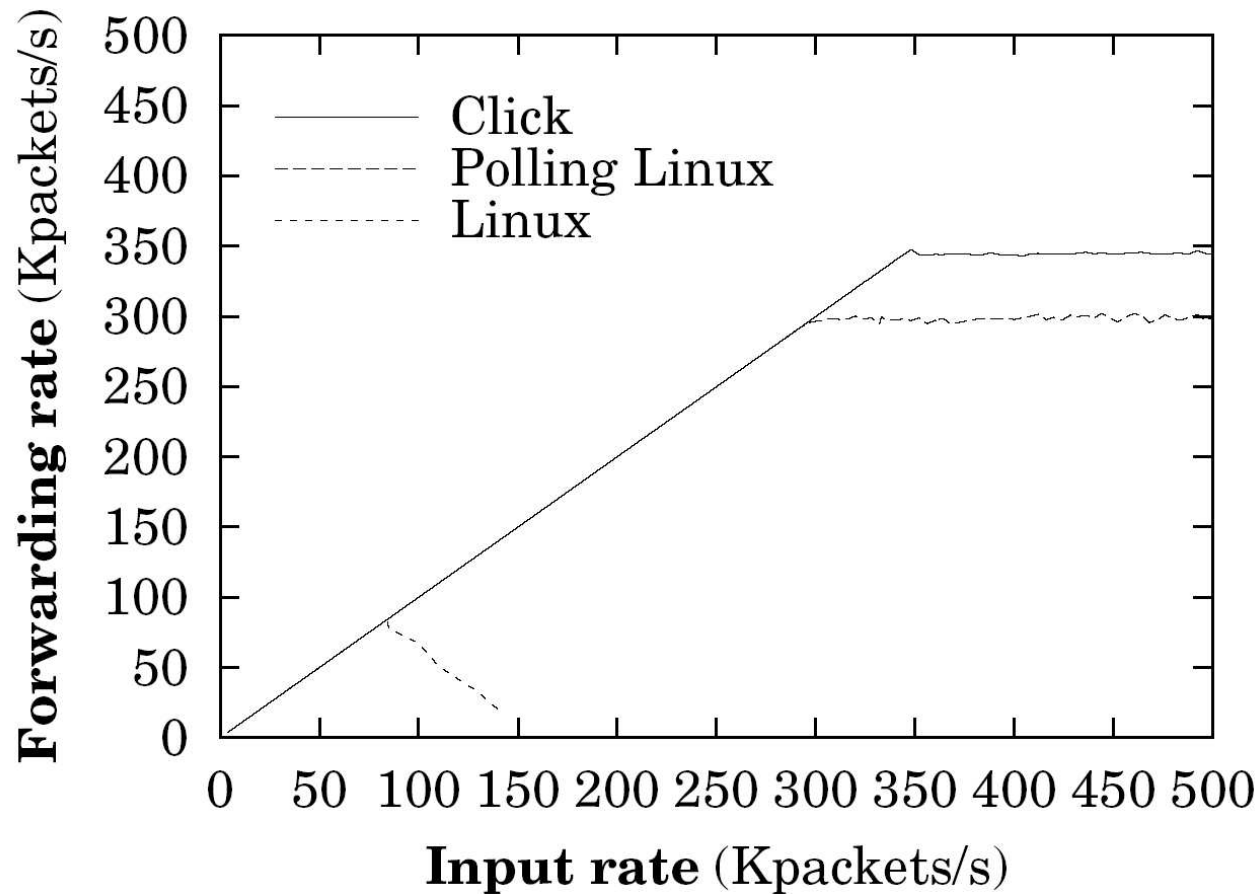
- Scheduling & dropping policies
- Queuing requirements
- Differentiated services
- IP tunneling
- Ethernet switching
- IP header compression / decompression
- IPsec
- WLAN communication
- Network address translation (NAT)
- Firewalls
- etc

How Click Runs

- 2 options: **kernel** or user-space driver
- Loading new config...
 - Normally destroys state and drops all packets
 - Hotswap possible for some changes
- Handlers (used to modify local element config)...
 - `/proc/click/<element>/<handler>`
 - View statistics
 - Change queue lengths

Optimizations

- Polling versus Interrupts yields huge gains



Optimizations (part 2)

- Avoiding virtual function call overhead
- Combining elements doesn't increase performance
 - Yet Knit claims big performance gain with flattening
 - Recall Clack from the Knit paper
- Some optimizations limit functionality

Pros & Cons

➤ Pros

- Clean, modular design and configuration
- High degree of flexibility
- Good performance on commodity hardware
- Potential platform for Active Network research

➤ Cons

- Performance comparison with commercial routers
- Element configuration may be harder than advertised

Conclusions

- Flexible, open, modular router design
- Performance appears good, but could use further study
- Project still under active development ([linux-2.4.20](#))