ns-3-click: Click Modular Router Integration for NS-3

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Overview

- Click:
  - What?
  - Why?
  - How?

- ns-3-click:
  - What?
  - Why?
  - How?

- Performance Analysis and Validation
- Conclusions
- Limitations and Future Work

What is Click?

...is a software architecture for designing highly flexible and configurable routers

Click: Motivation

"...most routers have closed,
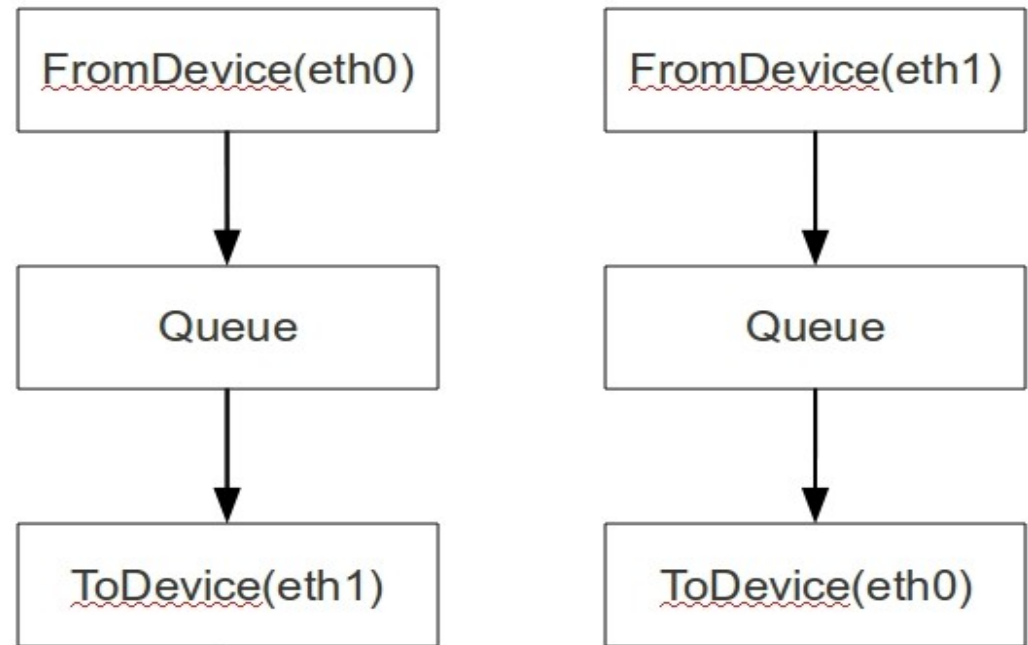static, and inflexible designs..."

"...difficult for network
administrators... to extend a
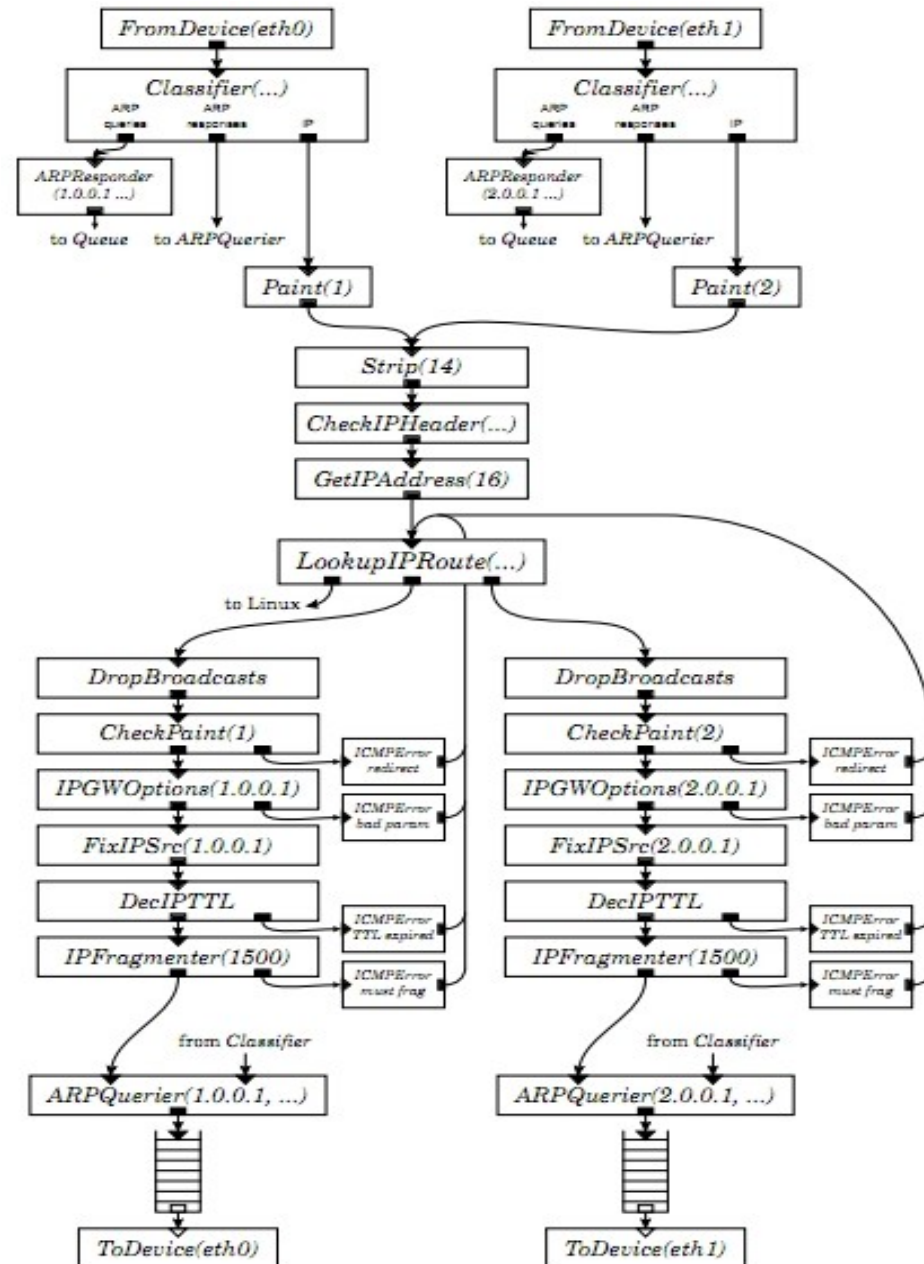router with new functions..."

Click: Basic idea

- Connect together independent packet processing units (called elements) to define a router configuration.

- Each router configuration is called a Click graph, defined within a Click file

Click: Sample Click Graph

Can be as simple as ->

Click: Sample Click Graph

...or as elaborate as ->

Click: OS Interaction

- Can run in kernel mode or user-level.

- ToDevice and FromDevice elements send and receive packets from a network device.

- Click file abstracts away OS specific details.

What is ns-3-click?

Allow an ns-3 node to run a Click
router on top of it and use Click
for routing

ns-3-click: Motivation

Advantages:

- Bring Click's library of elements to ns-3
(IPClassifier, AdaptiveRED, Queue, PrioSched, BandwidthShaper, NAT)

- Allow Click users to experiment with Click graphs
in a simulation environment

ns-3-click: Motivation

ns-2-click restricted to raw packets only:
- Different traffic generators?
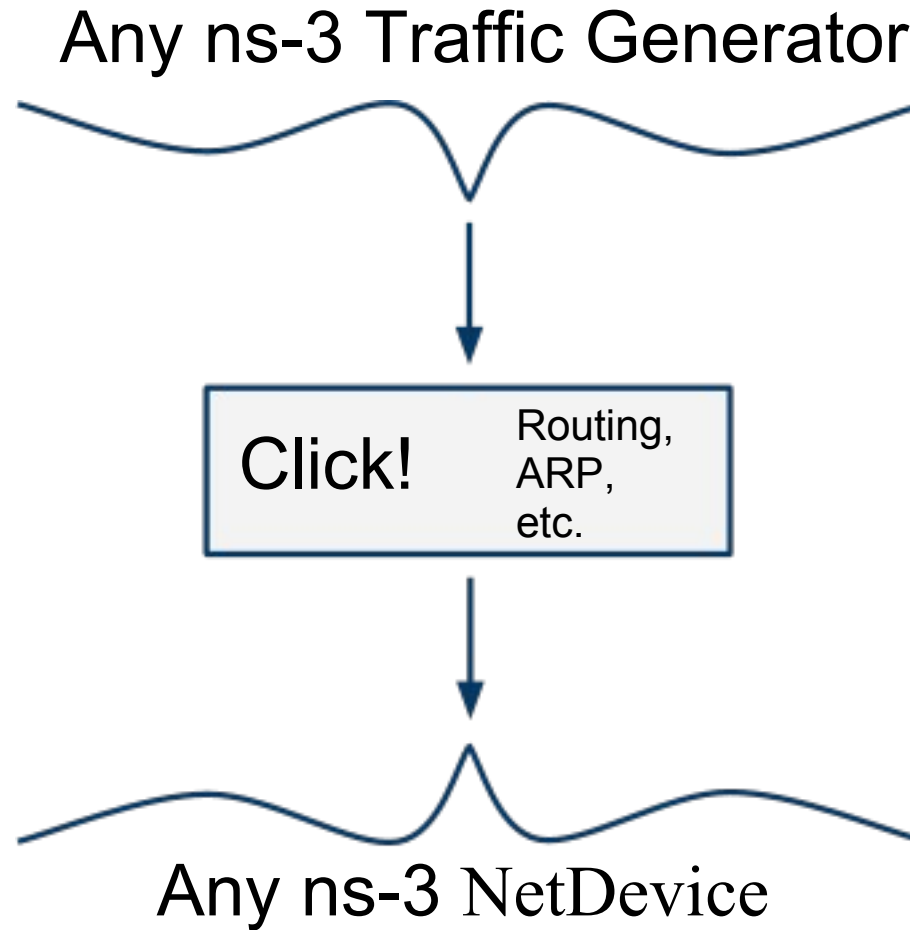- Different NetDevices?

But ns-3 is better suited for real world
integration...

ns-3-click: Motivation

ns-3 has:

- Real world packet formats
- Per device IP/MAC addresses
- Close resemblance to Linux network stack.

ns-3-click: Design Goal

Any ns-3 Traffic Generator

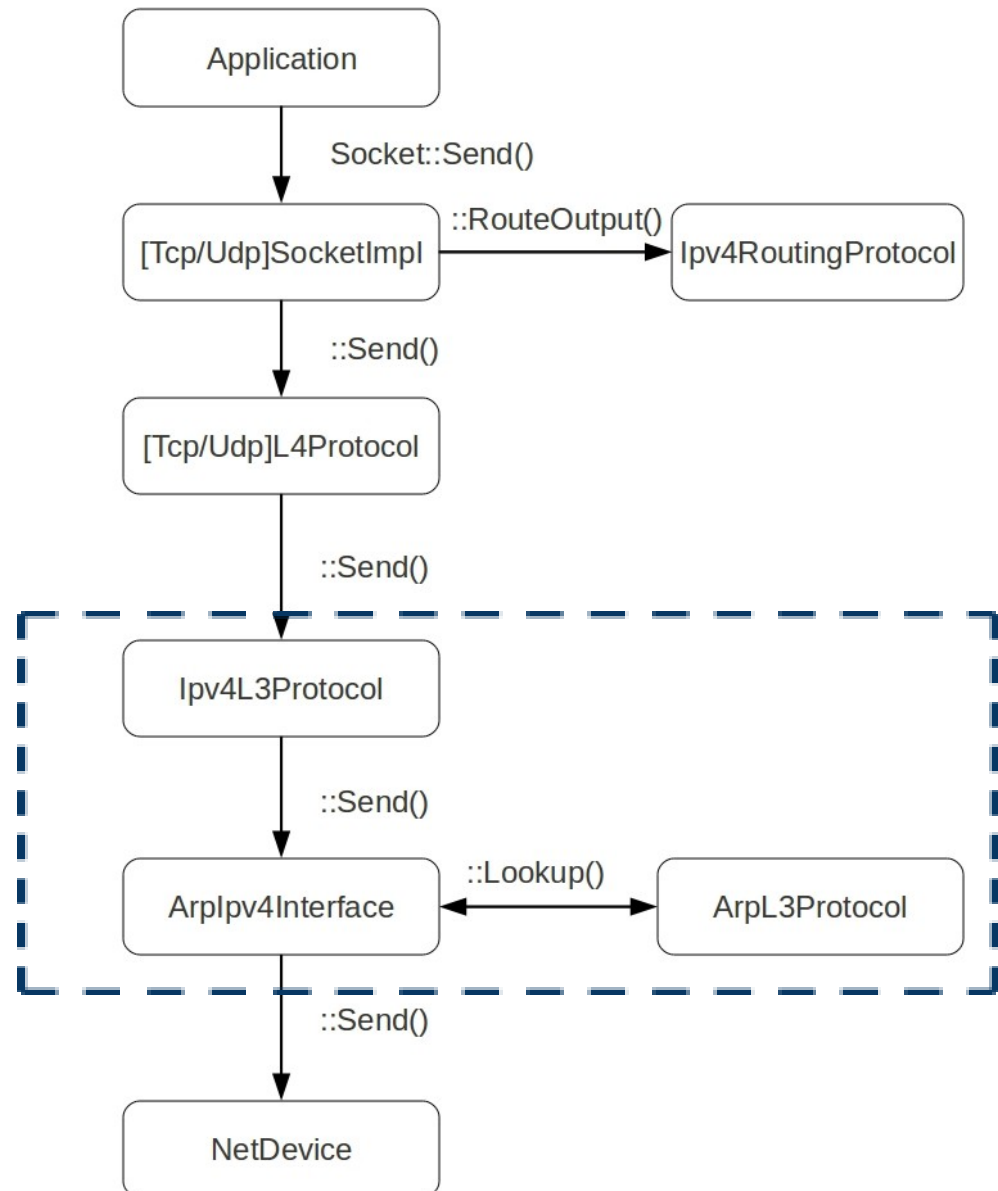| Click!	Routing, ARP, etc.

Any ns-3 NetDevice

ns-3-click: Implementation

ns-3-click consists of:

- Ipv4ClickRouting: to talk to Click.
- Ipv4L3ClickProtocol: to handle layer 3 functionality.
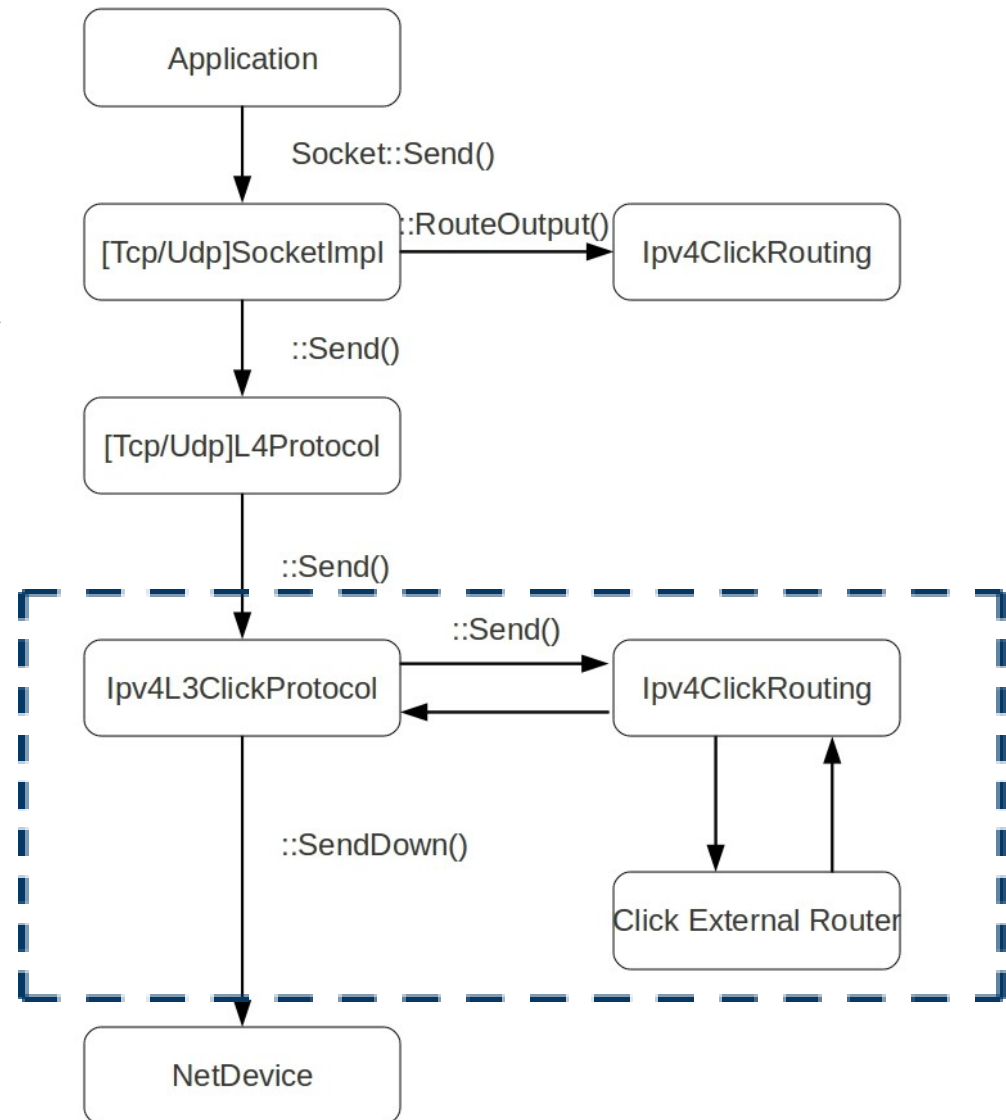
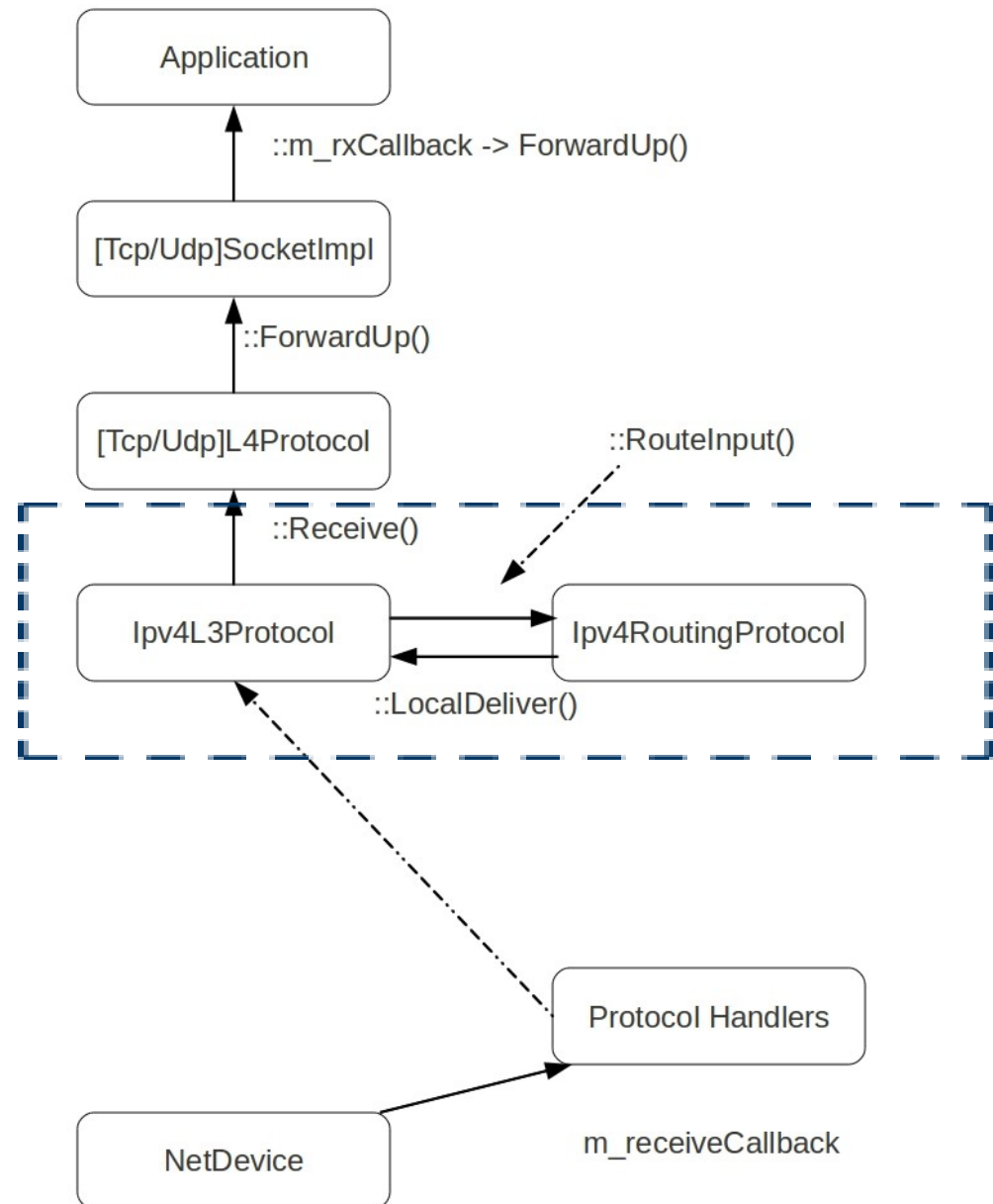# ns-3-click: Implementation

ns-3 packet path for **sending** a packet

ns-3-click: Implementation
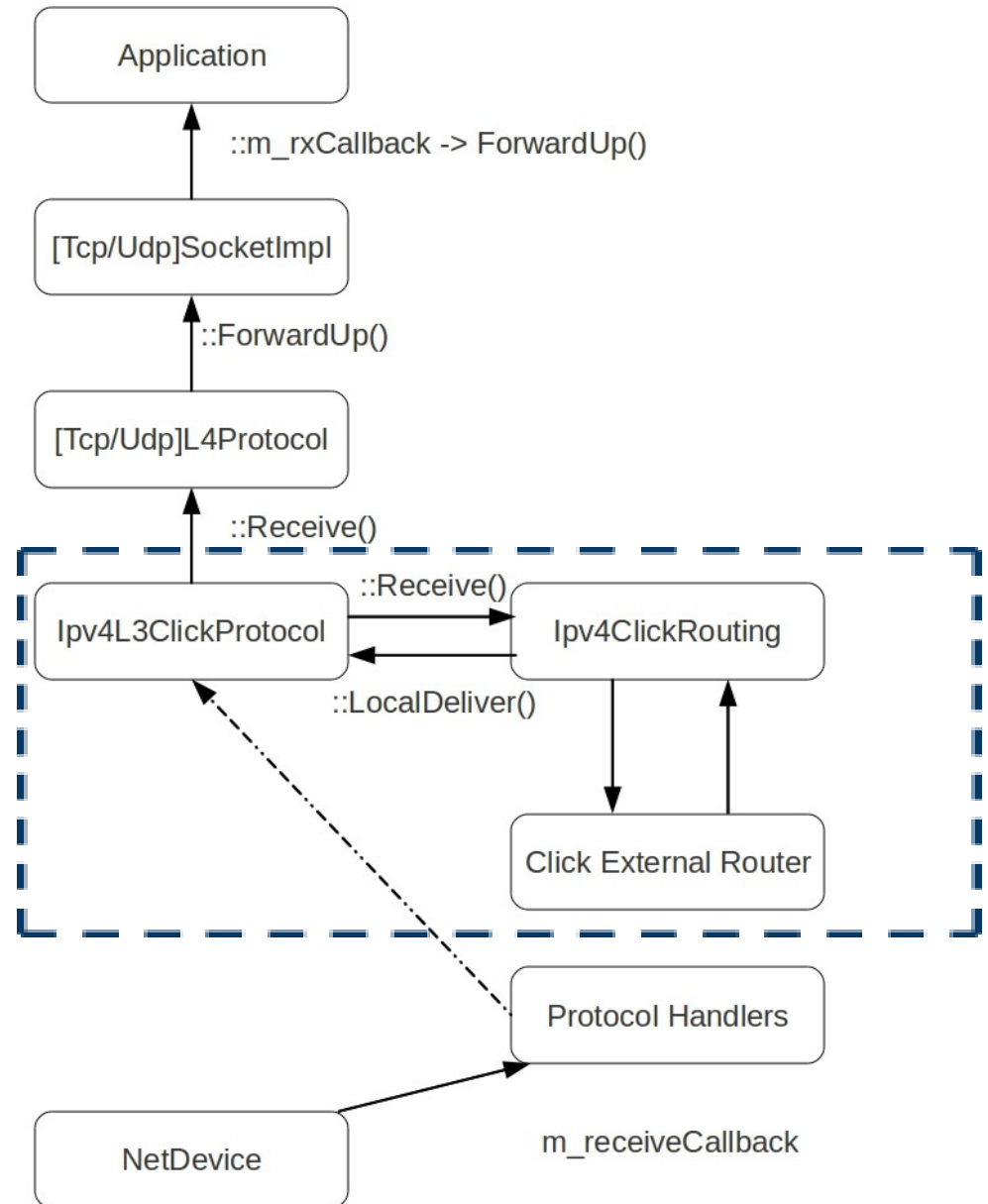
ns-3-click packet path for **sending** a packet

ns-3-click: Implementation

Application

::m_rxCallback -> ForwardUp()

[Tcp/Udp]SocketImpl

::ForwardUp()

ns-3 packet path for **receiving** a packet

[Tcp/Udp]L4Protocol

::RouteInput()

::Receive()

Ipv4L3Protocol ⟷ Ipv4RoutingProtocol

::LocalDeliver()

Protocol Handlers

NetDevice

m_receiveCallback

ns-3-click: Implementation

ns-3-click packet path for **receiving** a packet

ns-3-click: Usage

Code:

```
ClickInternetStackHelper clickhelper;
clickhelper.SetClickFile (node, "router.click");
clickhelper.SetRoutingTableElement ("rt");
clickhelper.Install (node);
```
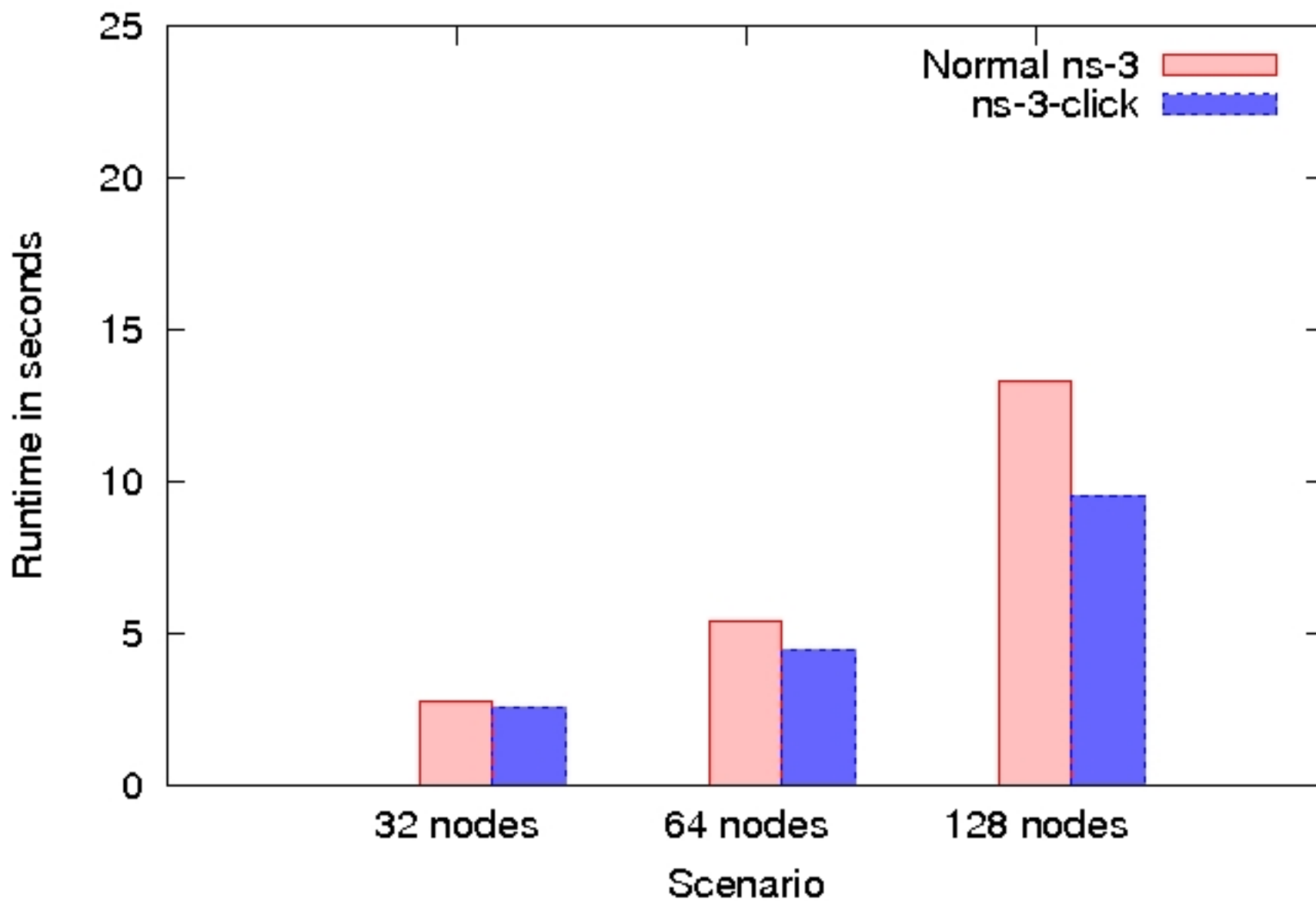
Performance Analysis

Experiment 1: ns-3-click with Csma

- Nodes with a CsmaNetDevice each, arranged in a star topology.
- Central router routes using Ipv4StaticRouting (ns-3), and StaticIPLookup element (ns-3-click).
- N = 32, 64, 128.
- UdpClient/Server application. N/2 clients, N/2 servers. 1024 bytes generated every 0.05 seconds.
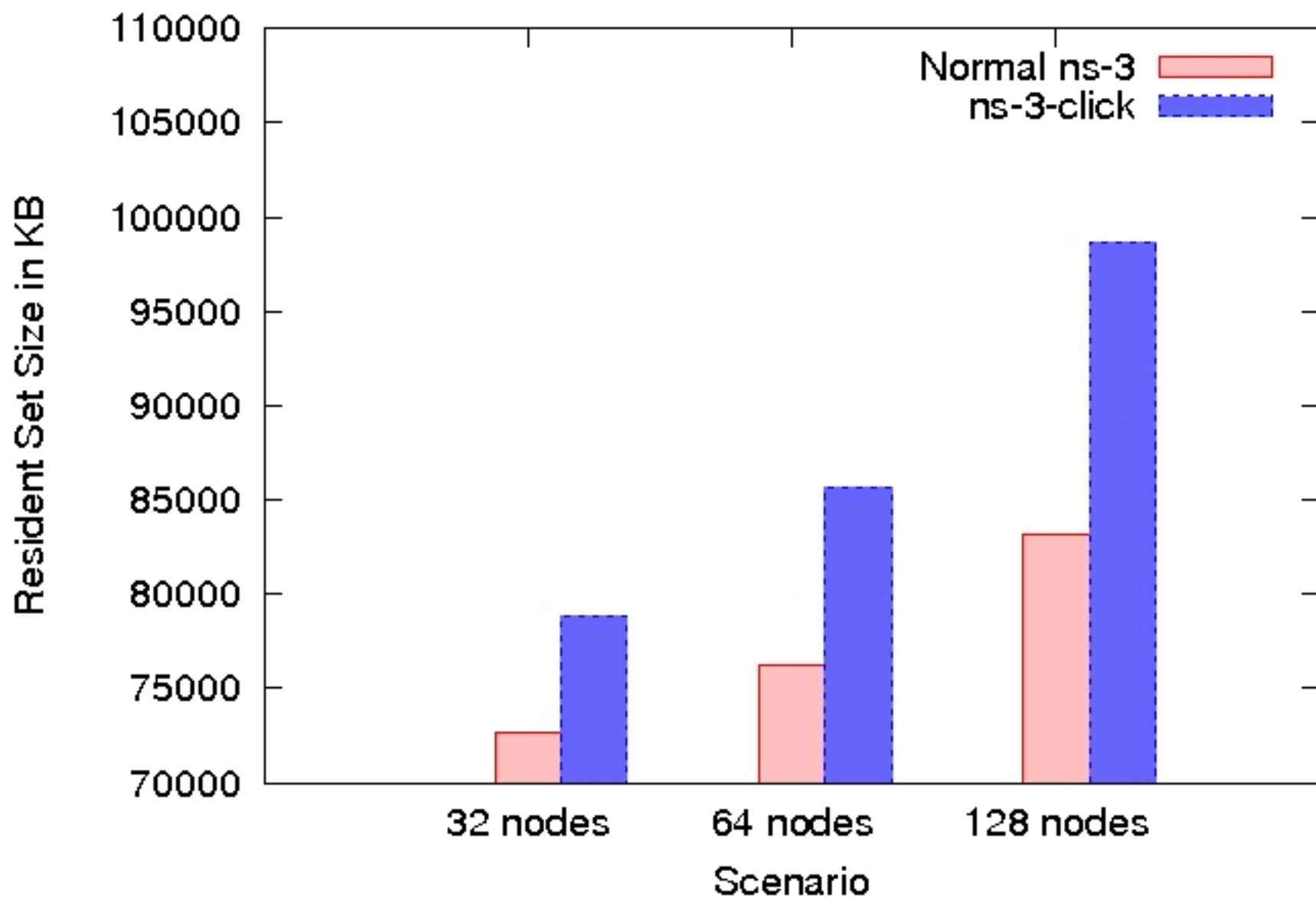- Total simulation time 100s.

Results



Runtime of ns-3 versus ns-3-click

Results

Validation

Experiment 2: ns-3-click with Bandwidth Shaping

- Nodes with a CsmaNetDevice each, arranged in a star topology.
- Central router routes using Ipv4StaticRouting (ns-3), and StaticIPLookup element (ns-3-click). **Central router also performs bandwidth shaping**.
- N = 32, 64, 128.
- UdpClient/Server application. N/2 clients, N/2 servers. 1024 bytes generated every 0.05 seconds.
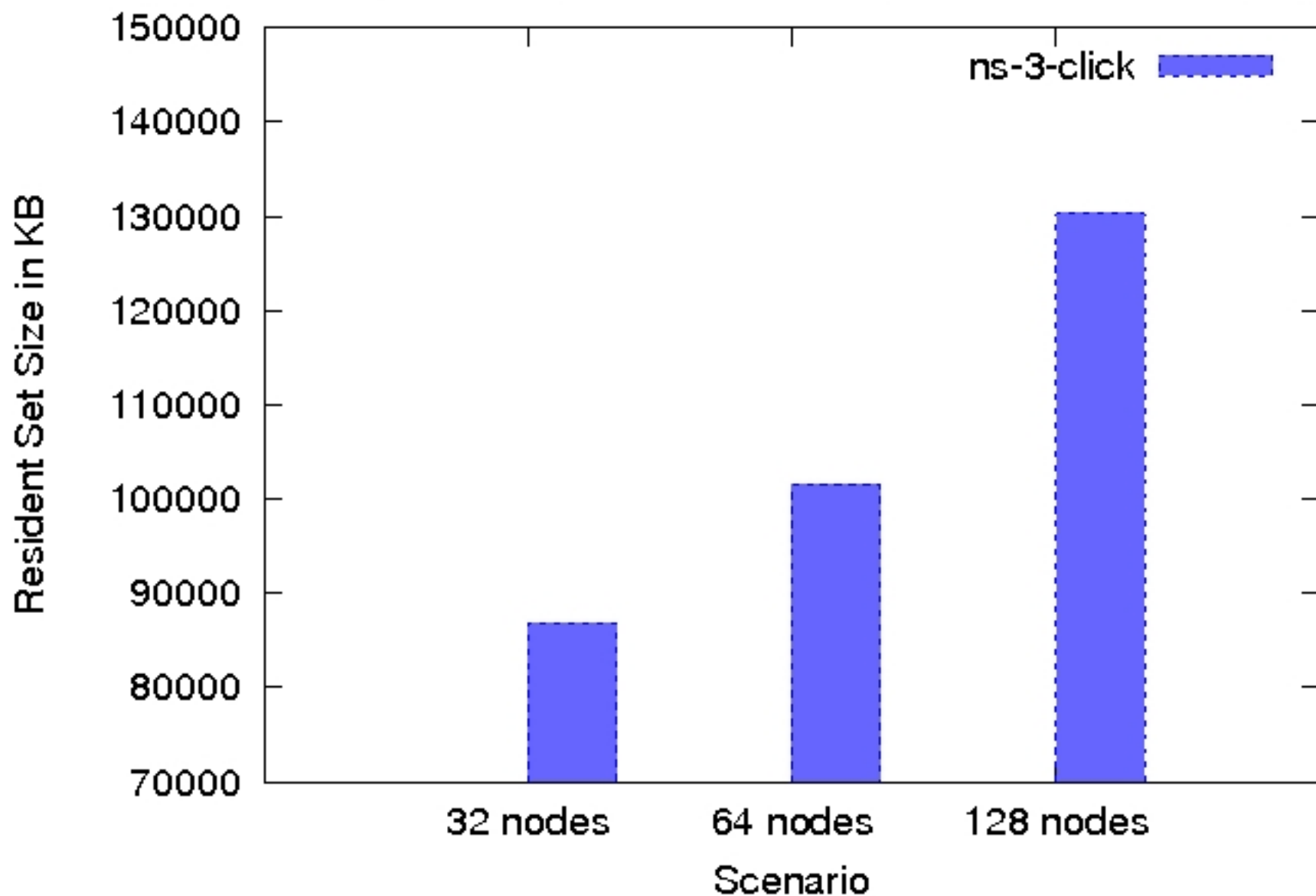- Total simulation time 100s.

Results

Runtime of ns-3-click (with Bandwidth Shaping)
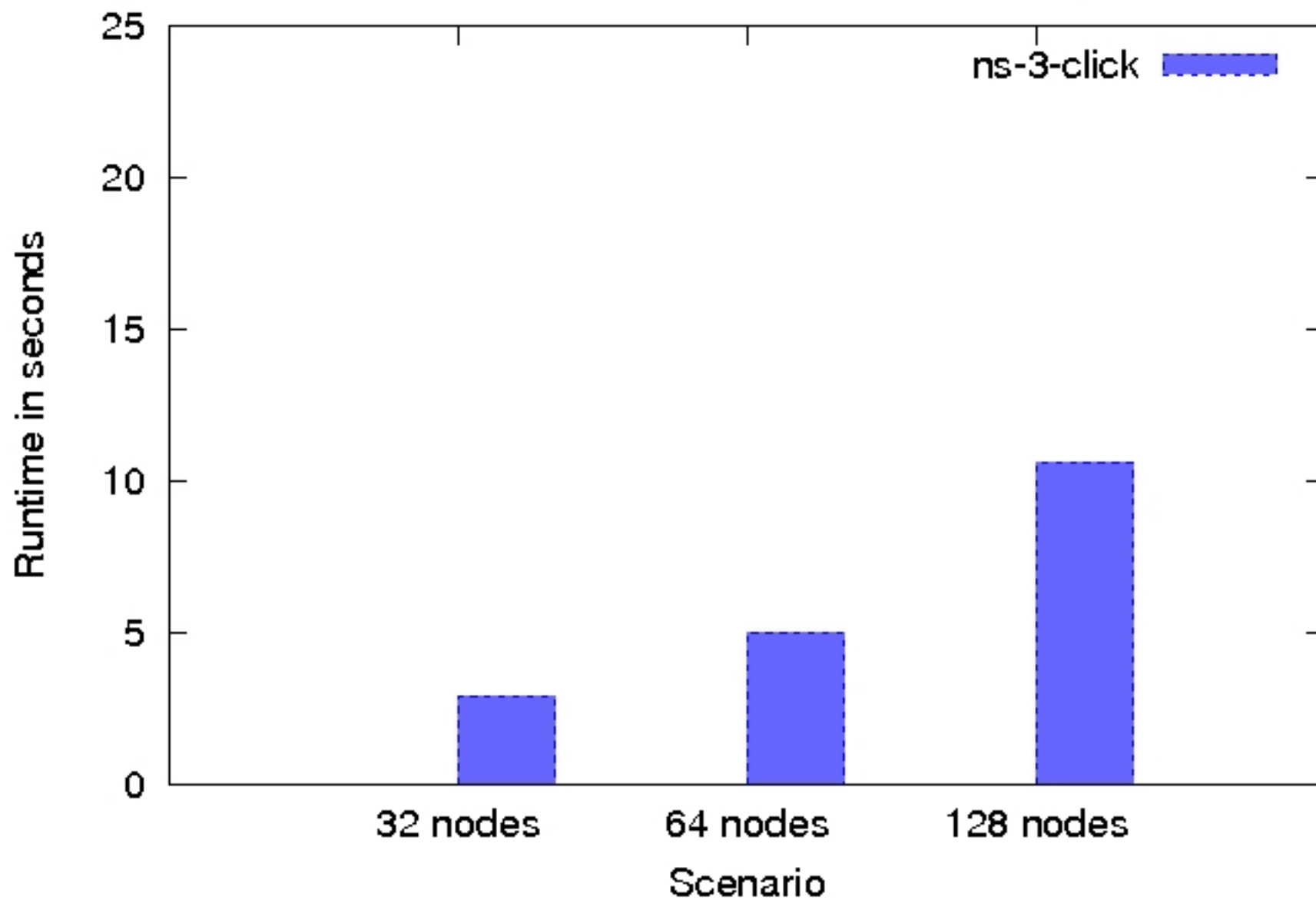
Results

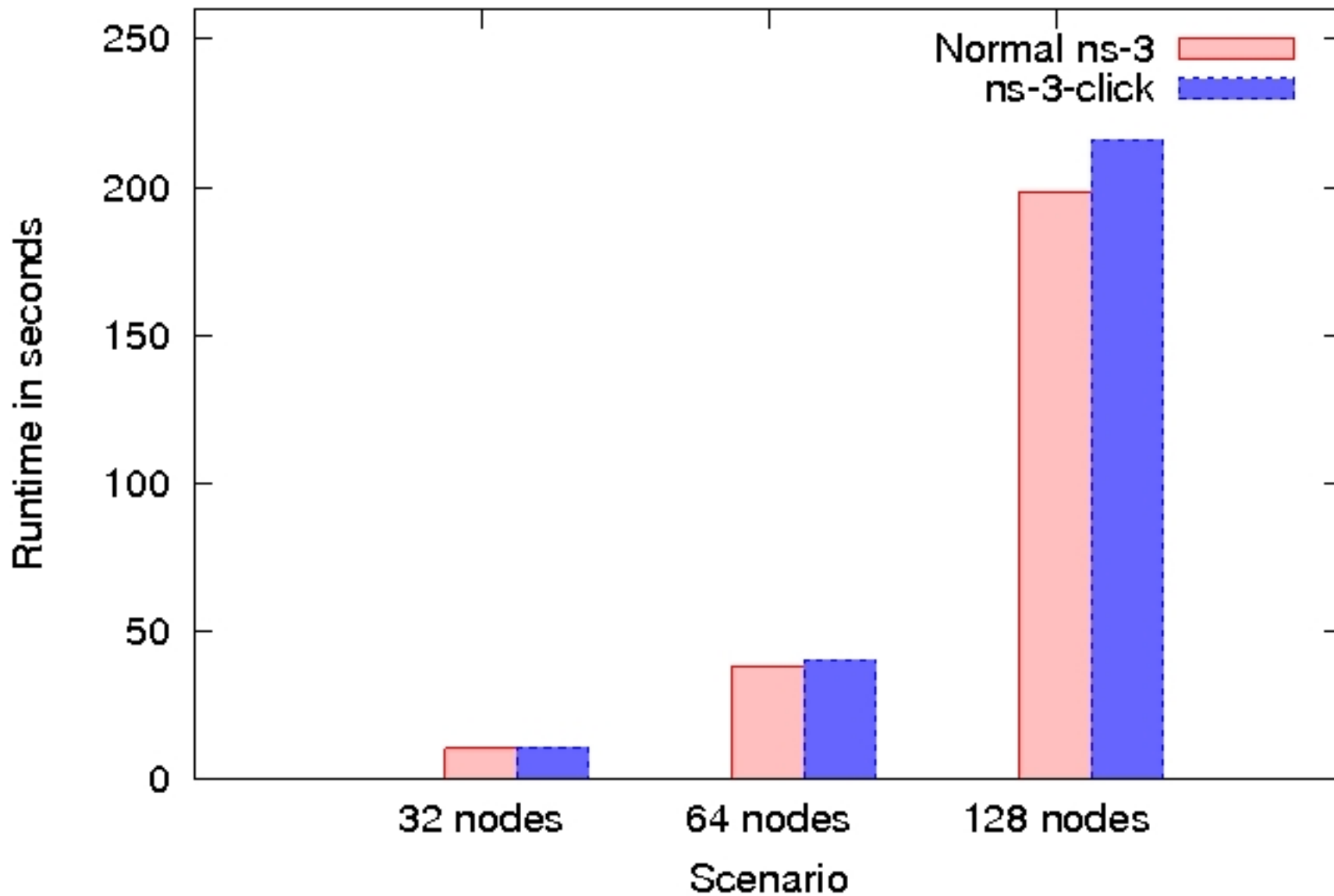Memory Consumption of ns-3-click (with Bandwidth Shaping)

Performance Analysis

Experiment 3: ns-3-click with Wifi

- Nodes with a **WifiNetDevice** each, **arranged in a N/2 x 2 grid**.
- N = 32, 64, 128.
- UdpClient/Server application. **1 client and 1 source, separated diametrically**. 1024 bytes generated every 0.05 seconds.
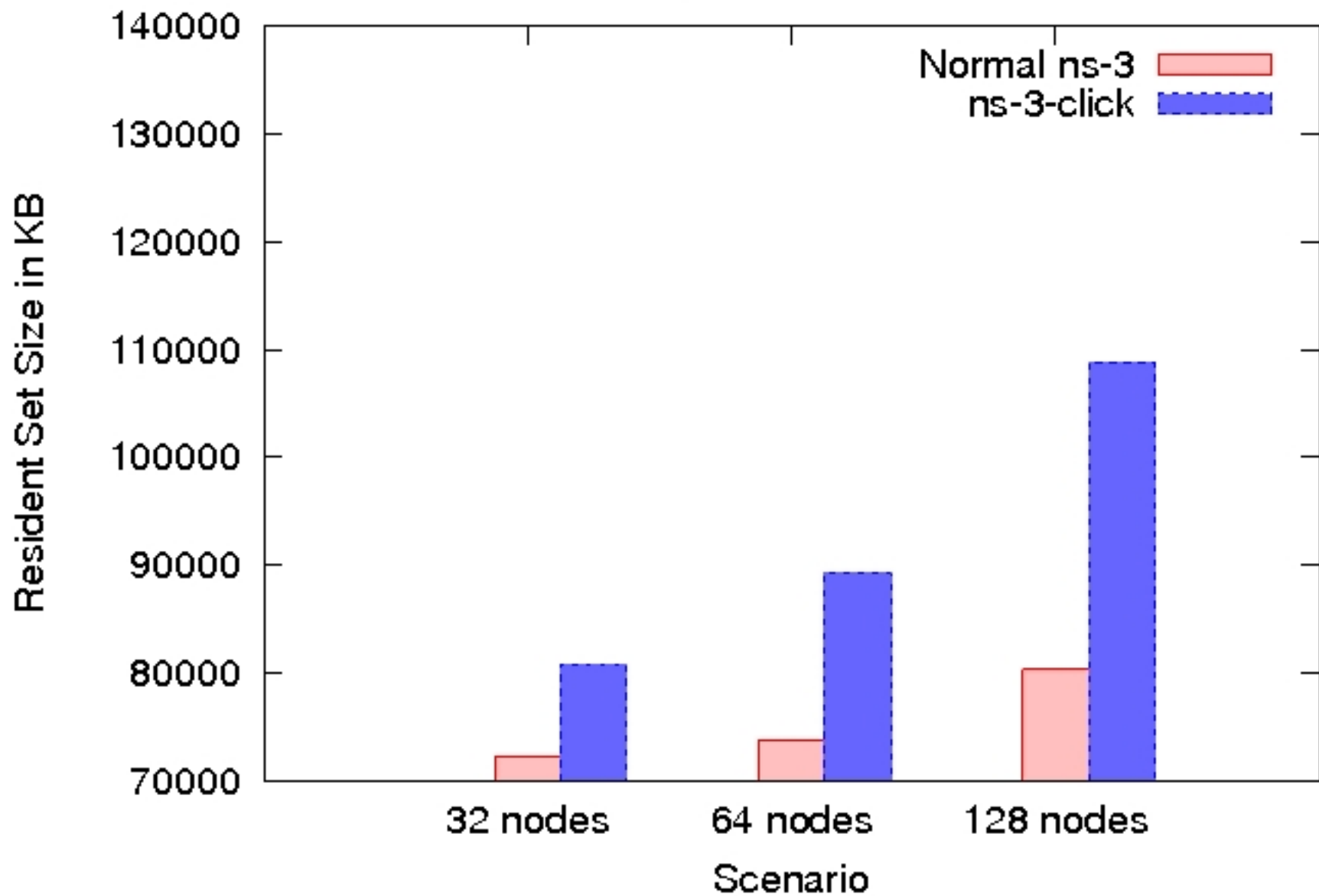- Total simulation time 100s.

Results

Runtime of ns-3 versus ns-3-click

Results

Memory Consumption of ns-3 versus ns-3-click

Conclusions

- ns-3-click allows a user to run Click routers on top of ns-3 nodes.

- ns-3-click brings in [almost all of] Click's extensive set of features into ns-3.

Limitations and Future Work

- ns-3-click is presently confined to layer 3 only.

- Support usage of Click's MAC models in ns-3. (Click-MAC GSoC proposal)

Questions?