CICN
Community
Information-Centric Networking

Tutorial at ACM SIGCOMM ICN, Berlin, Germany
26th of September 2017

Tutorial agenda

- Project overview
- Vector Packet Processing
- vICN: automation of virtual ICN network deployment
- The consumer/producer socket API with applications to HTTP

CICN project overview

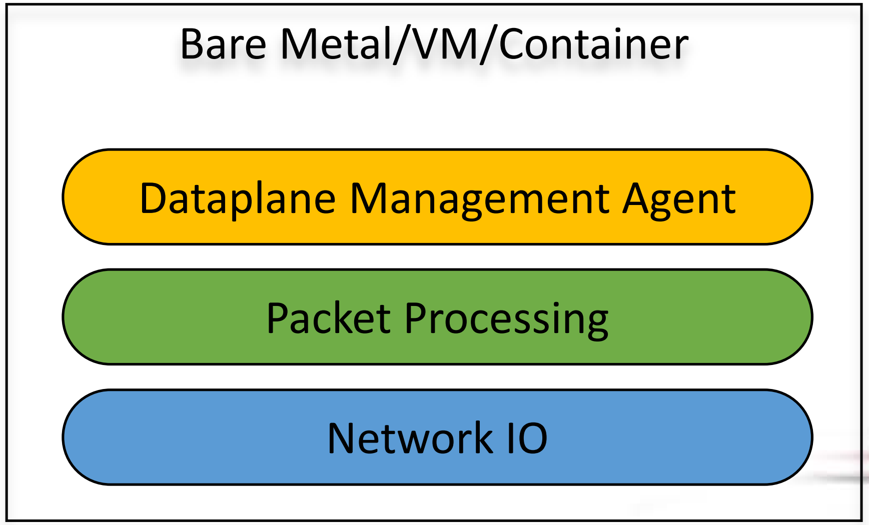
- CCNx Internet documents are specified at the ICNRG define the architecture.
- The rest is just software development, testing and experimentation.
- Focus on VPP and application development:
  - Vector Packet Processing as the Universal Data Plane for vRouting and vSwitching
  - vICN automation of virtual networks deployment
  - The Consumer/Producer Socket API and HTTP

What is FD.io (pronounced “fido”)?

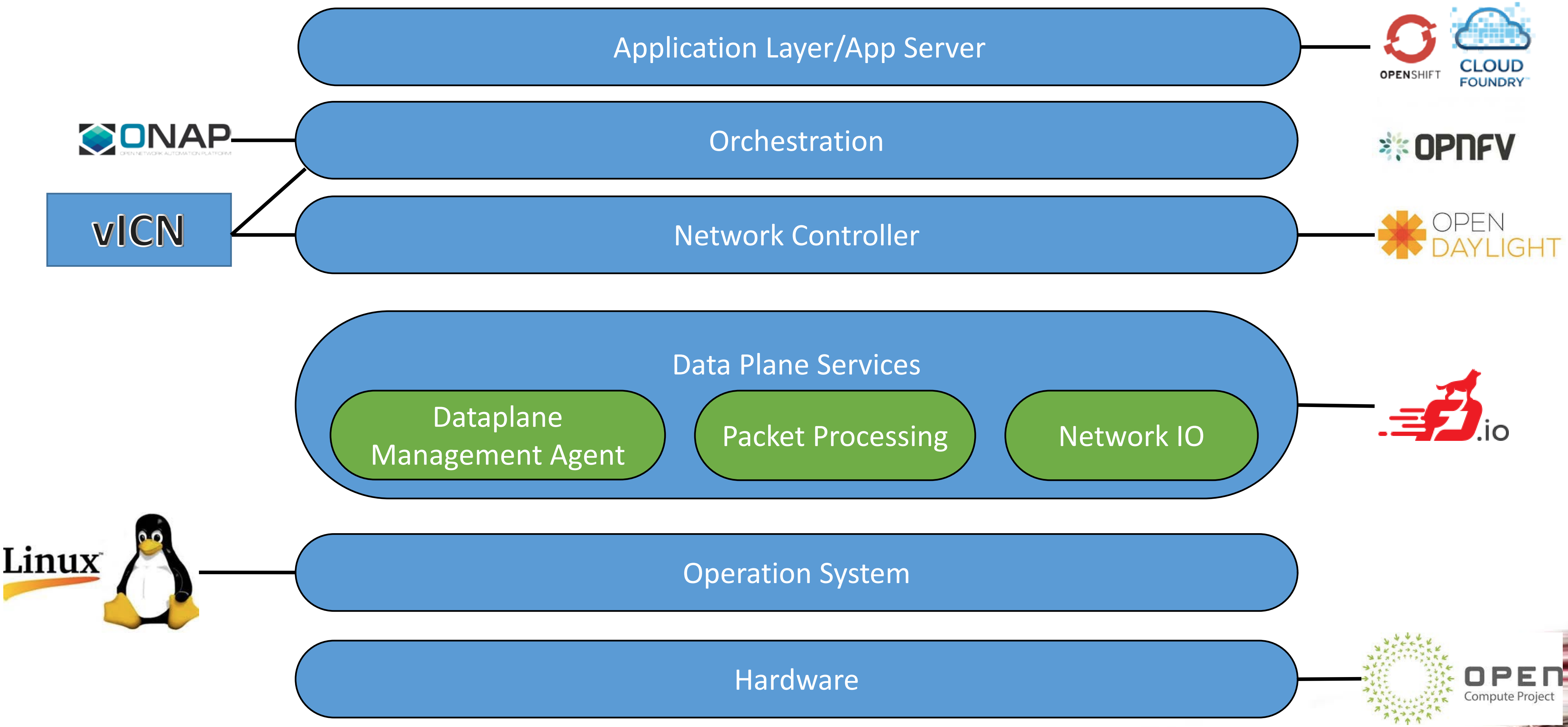
FD.io: The Universal Dataplane

- Project at Linux Foundation
  - Multi-party
  - Multi-project
- Software Dataplane
  - High throughput
  - Low Latency
  - Feature Rich
  - Resource Efficient
  - Bare Metal/VM/Container
  - Multiplatform intel ARM Power

- Fd.io Scope:
  - **Network IO -** NIC/vNIC <-> cores/threads
  - **Packet Processing –** Classify/Transform/Prioritize/Forward/Terminate
  - **Dataplane Management Agents -** ControlPlane



Fd.io in the overall stack



Application Layer/App Server

Orchestration

Network Controller

Data Plane Services

Dataplane Management Agent

Packet Processing

Network IO

Operation System

Hardware

vICN

Multiparty: Broad Membership

.io

Service Providers

AT&T

COMCAST

Network Vendors

CISCO™

ERICSSON

HUAWEI

ZTE

BROCADE

Metaswitch Networks

Chip Vendors

intel®

CAVIUM NETWORKS

Integrators

redhat.

INOCYBE OPENDAYLIGHT DISTRIBUTION

Multiparty: Broad Contribution

CISCO

intel

ERICSSON

Metaswitch Networks

IBM

6WIND

Yandex

midokura

Qiniu

HUAWEI

COMCAST

QOSMOS

ubuntu
Supported by Canonical

Linaro

PROJECT CALICO
SUPPORTED BY METASWITCH

NXP

Allegro Packets
Network Software

Netgate

ZTE

INOCYBE
OPENDAYLIGHT DISTRIBUTION

UPC

Universitat Politècnica de Catalunya (UPC)

KALRAY

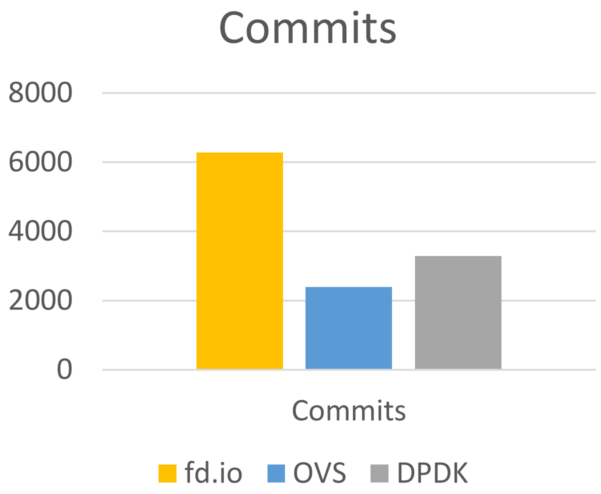
SUSE

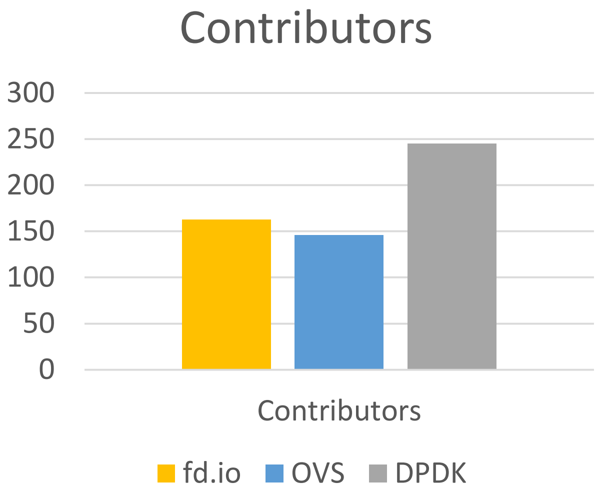
redhat

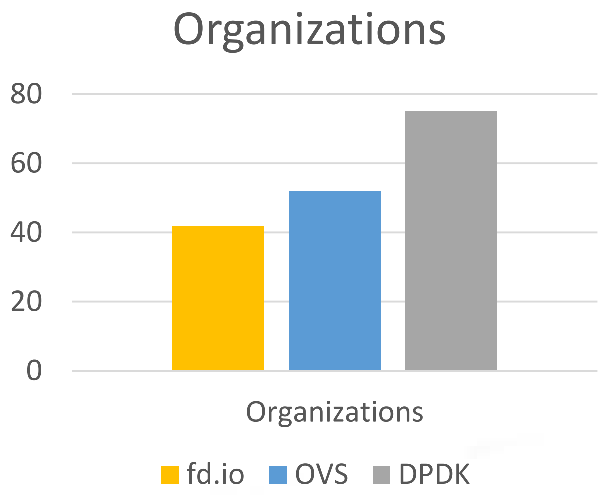
Code Activity

- In the period since its inception, fd.io has more commits than OVS and DPDK combined, and more contributors than OVS

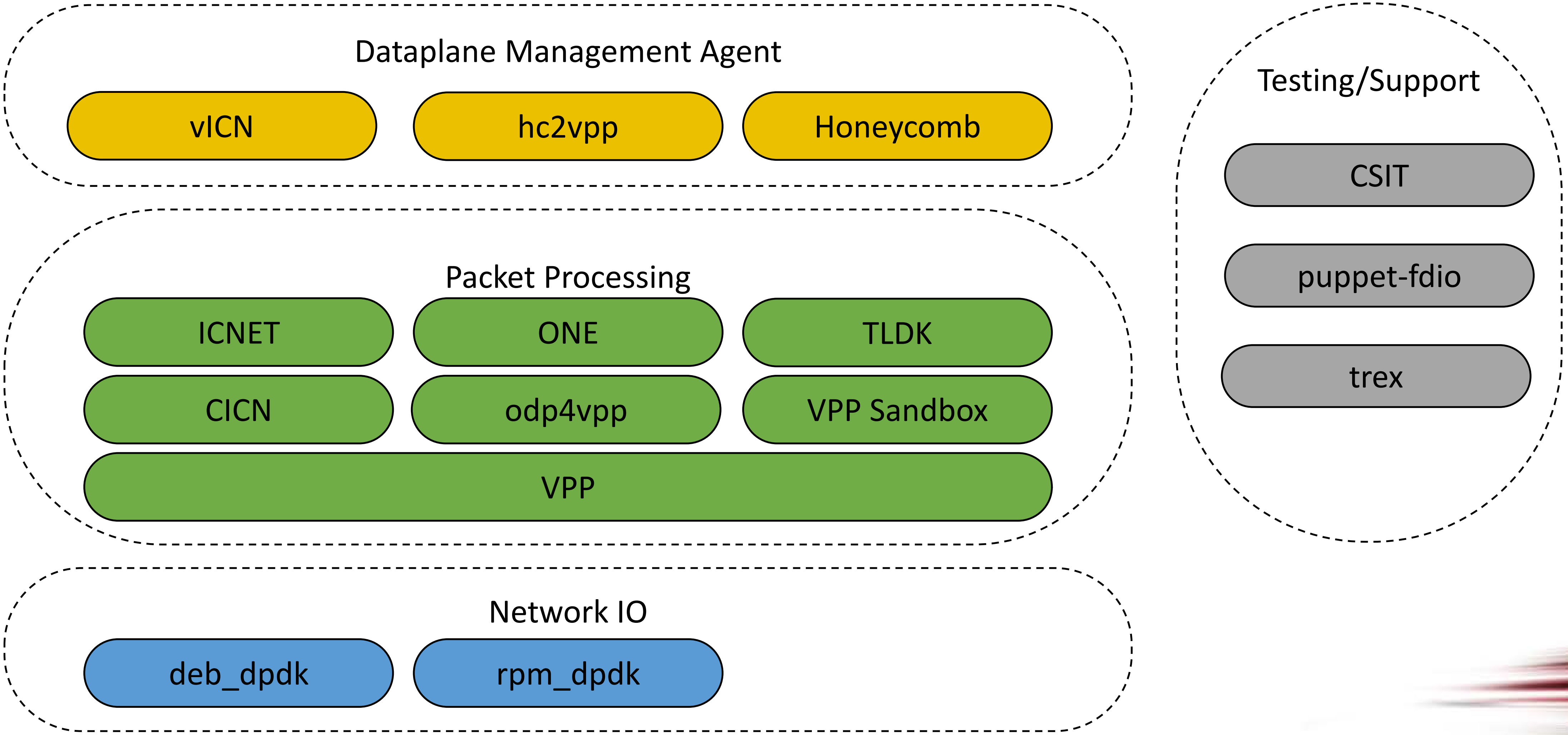
2016-02-11 to 2017-04-03	Fd.io	OVS	DPDK
Commits	6283	2395	3289
Contributors	163	146	245
Organizations	42	52	78







Multiproject: Fd.io Projects



Dataplane Management Agent

vICN

hc2vpp

Honeycomb

Packet Processing

ICNET

ONE

TLDK

CICN

odp4vpp

VPP Sandbox

VPP

Network IO

deb_dpdk

rpm_dpdk

Testing/Support

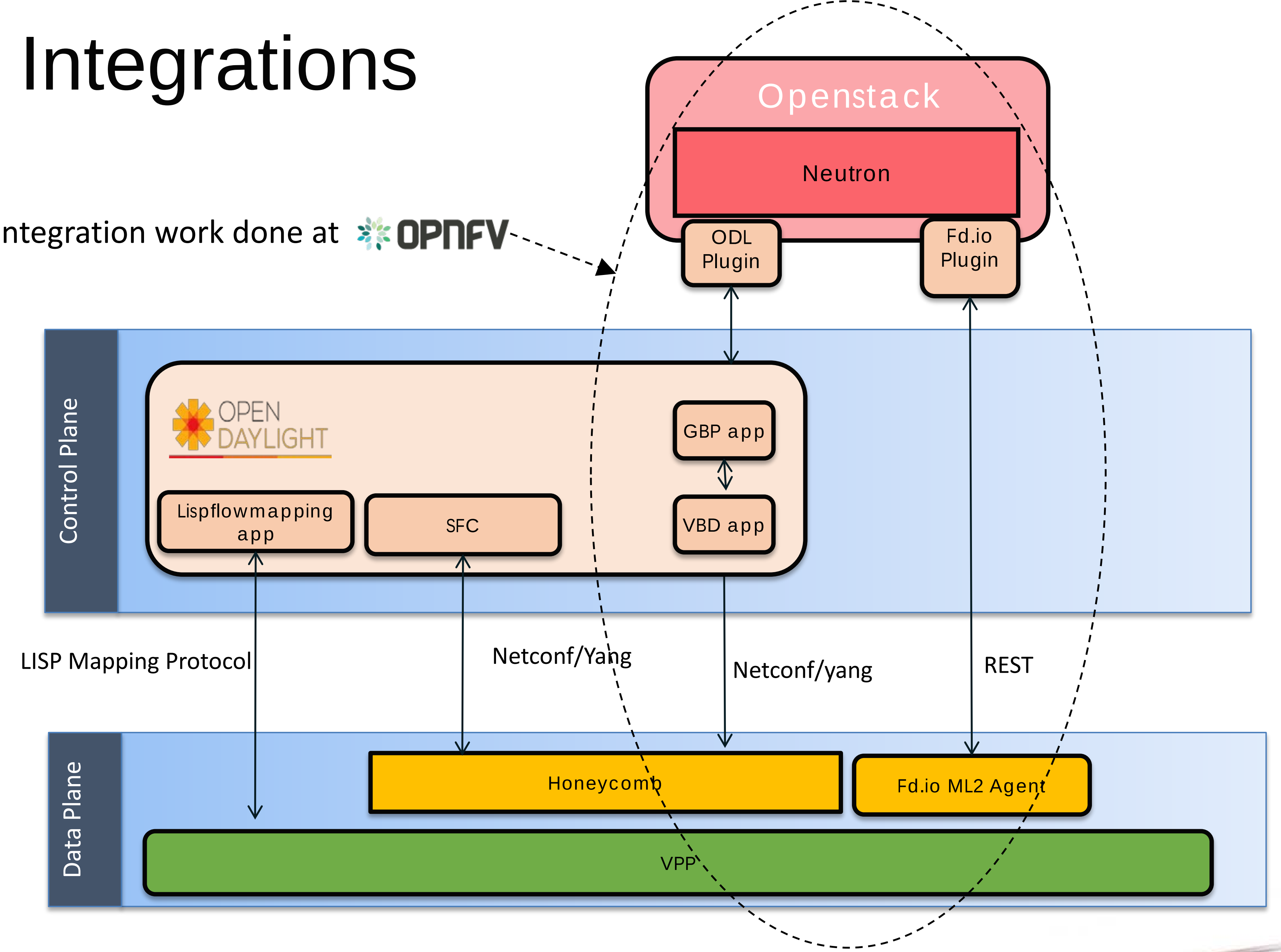
CSIT

puppet-fdio

trex

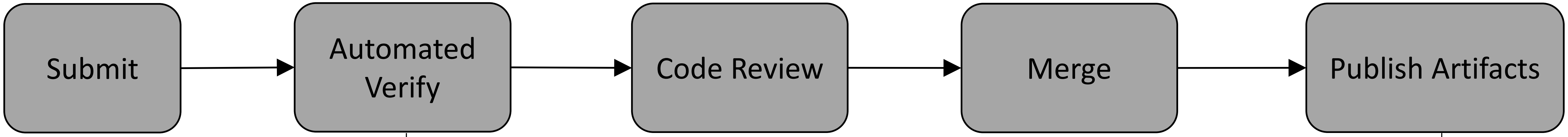
Fd.io Integrations

Integration work done at OPNFV



Continuous Quality, Performance, Usability

Built into the development process – patch by patch



Submit → Automated Verify → Code Review → Merge → Publish Artifacts

Build/Unit Testing
120 Tests/Patch

Build binary packaging for
- Ubuntu 14.04
- Ubuntu 16.04
- Centos 7

Automated Style Checking

Unit test :
- IPFIX
- BFD
- Classifier
- DHCP
- FIB
- GRE
- IPv4
- IPv4 IRB
- IPv4 multi-VRF
- IPv6
- IP Multicast
- L2 FIB
- L2 Bridge Domain
- MPLS
- SNAT
- SPAN
- VXLAN

System Functional Testing
252 Tests/Patch

DHCP – Client and Proxy
GRE Overlay Tunnels
L2BD Ethernet Switching
L2 Cross Connect Ethernet Switching
LISP Overlay Tunnels
IPv4-in-IPv6 Softwire Tunnels
Cop Address Security
IPSec
IPv6 Routing – NS/ND, RA, ICMPv6
uRPF Security
Tap Interface
Telemetry – IPFIX and Span
VRF Routed Forwarding
iACL Security – Ingress – IPv6/IPv6/Mac
IPv4 Routing
QoS Policer Metering
VLAN Tag Translation
VXLAN Overlay Tunnels

Performance Testing
144 Tests/Patch, 841 Tests

L2 Cross Connect
L2 Bridging
IPv4 Routing
IPv6 Routing
IPv4 Scale – 20k,200k,2M FIB Entries
IPv4 Scale - 20k,200k,2M FIB Entries
VM with vhost-userr
- PHYS-VPP-VM-VPP-PHYS
- L2 Cross Connect/Bridge
- VXLAN w/L2 Bridge Domain
- IPv4 Routing

COP – IPv4/IPv6 whiteless
iACL – ingress IPv4/IPv6 ACLs
LISP – IPv4-o-IPv6/IPv6-o-IPv4
VXLAN
QoS Policer
L2 Cross over
L2 Bridging

Usability

Merge-by-merge:
- apt installable deb packaging
- yum installable rpm packaging
- autogenerated code documentation
- autogenerated cli documentation

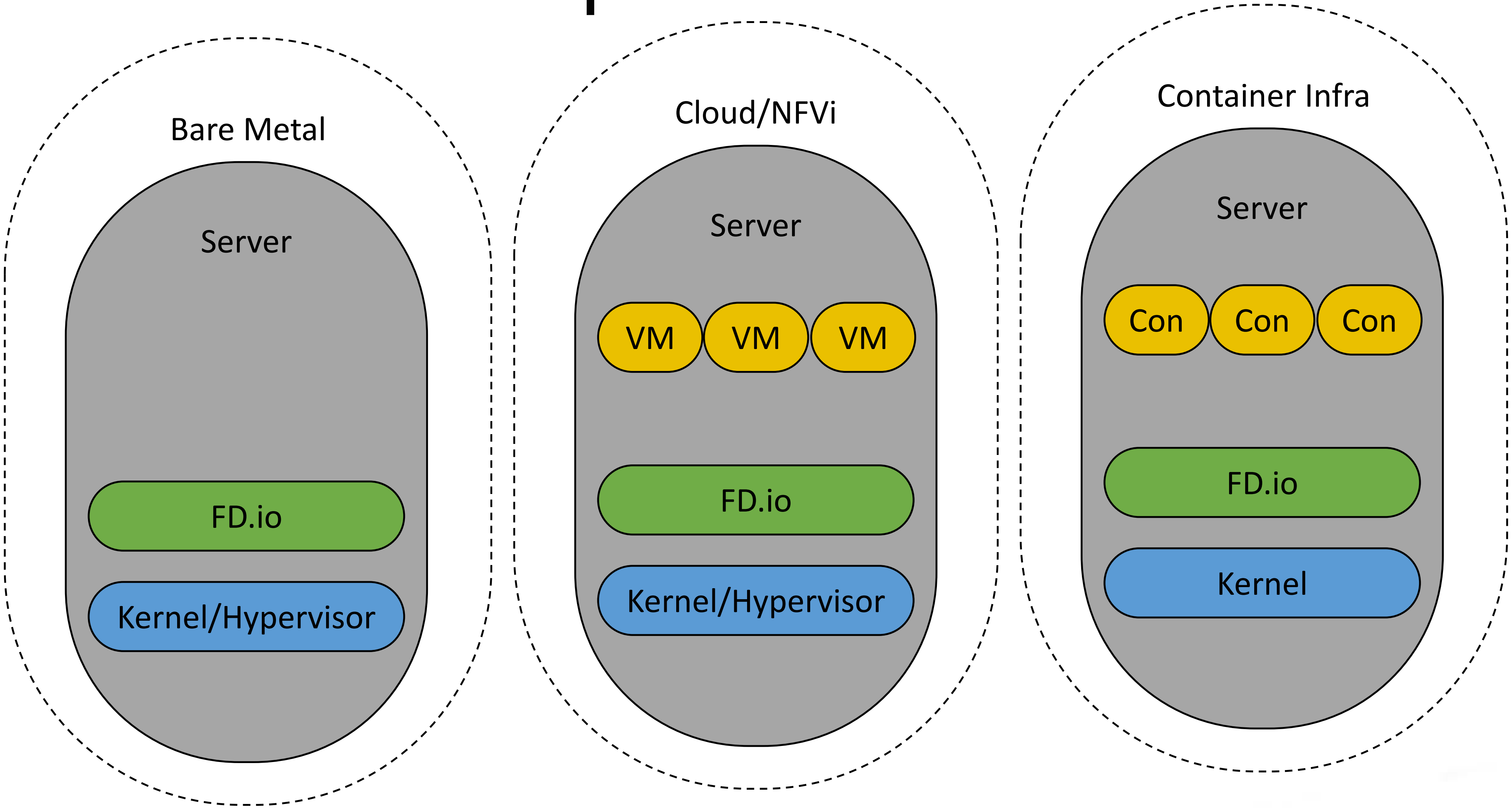
Per release:
- autogenerated testing reports
  - report perf improvements

Puppet modules
Training/Tutorial videos
Hands-on-usecase documentation

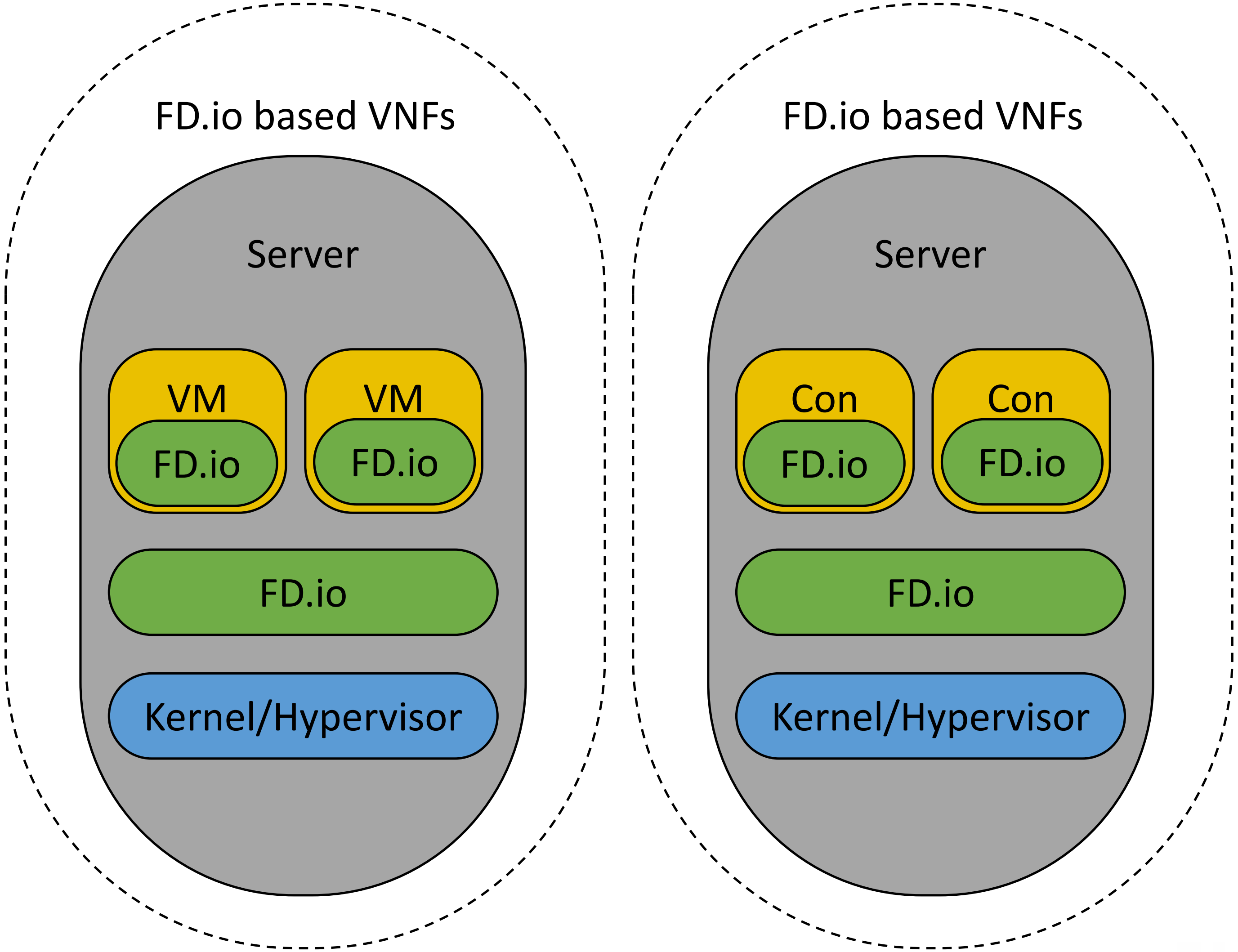
Merge-by-merge packaging feeds
Downstream consumer CI pipelines

Run on real hardware in fd.io Performance Lab

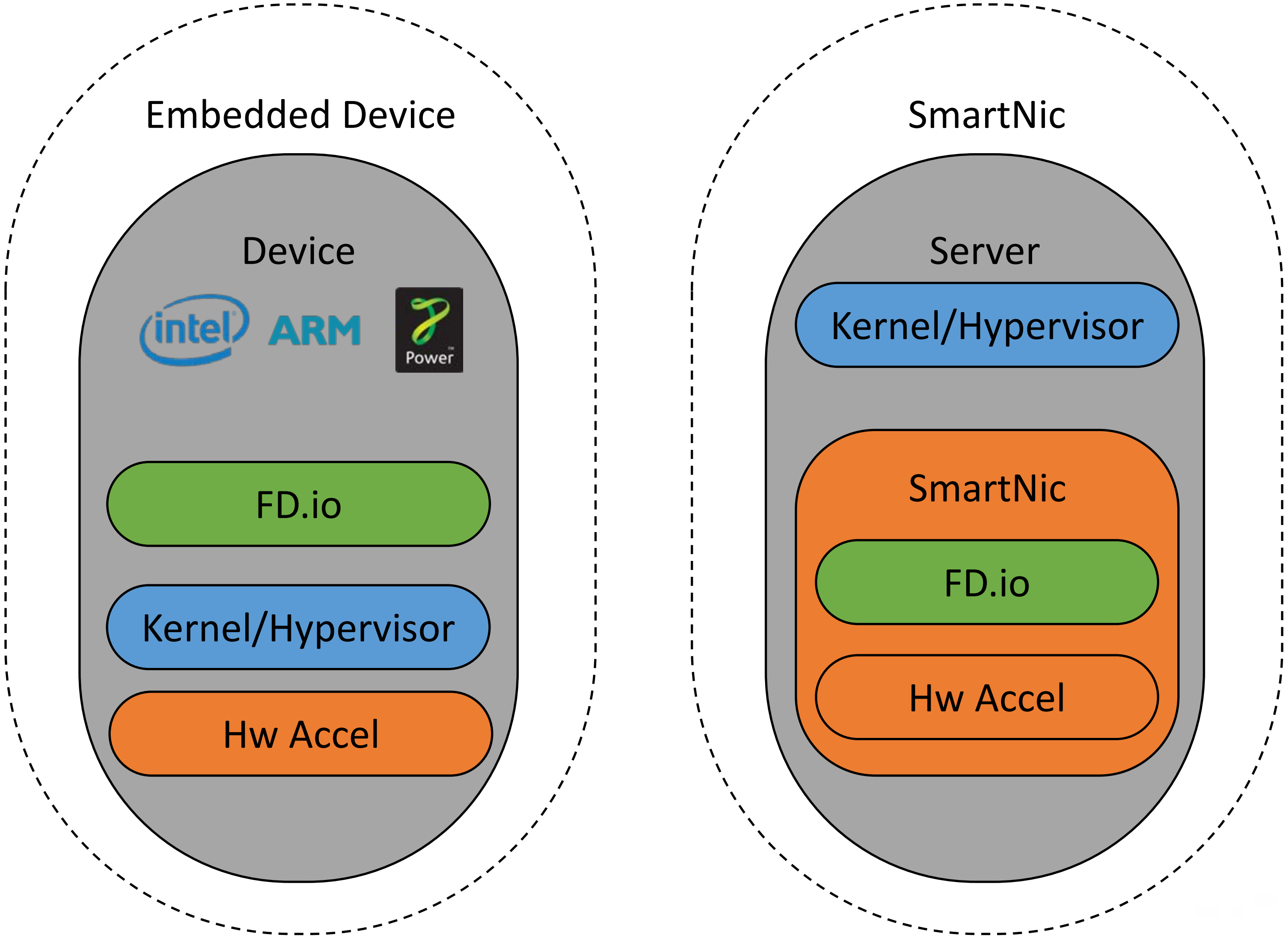
Universal Dataplane: Infrastructure



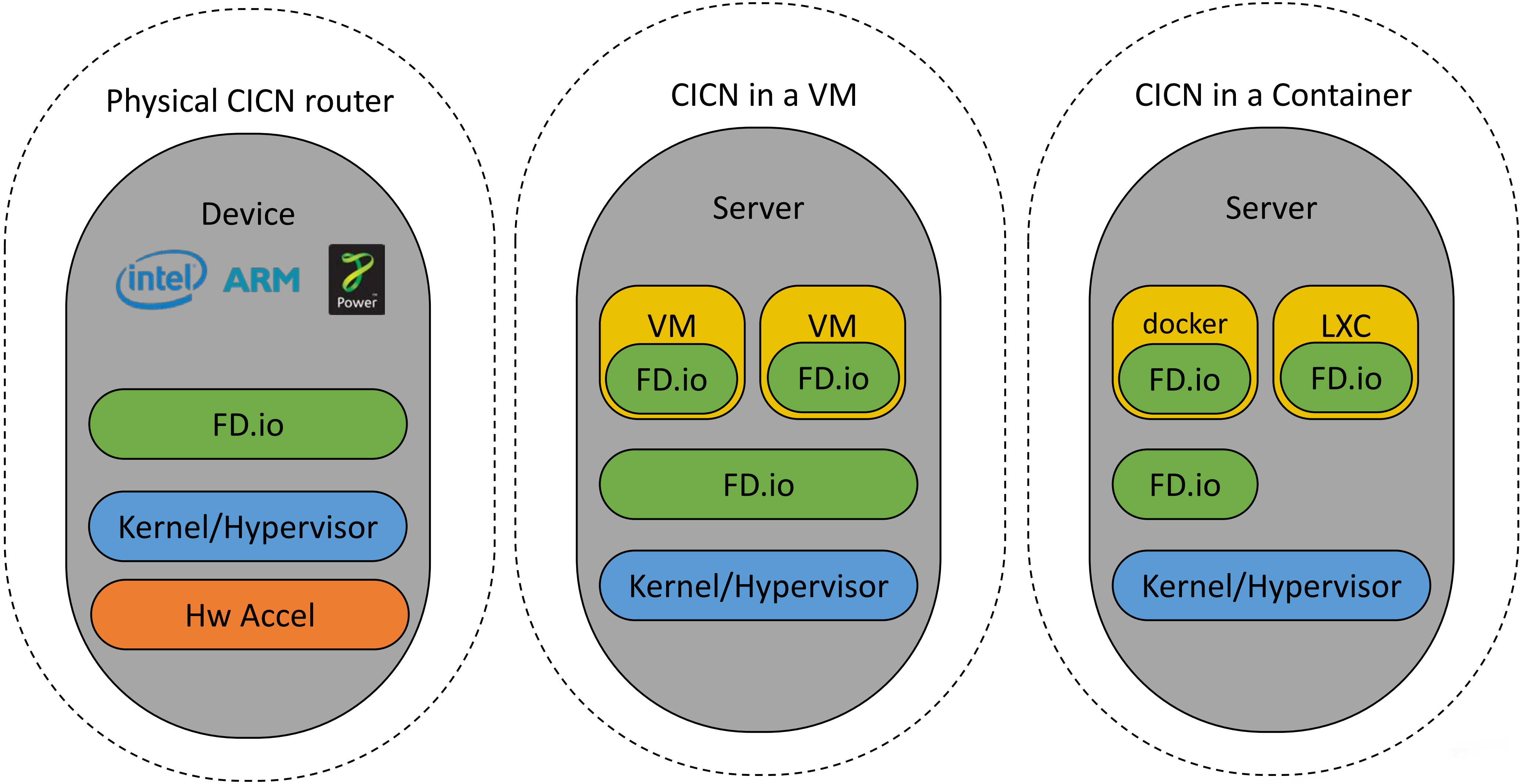
Universal Dataplane: VNFs



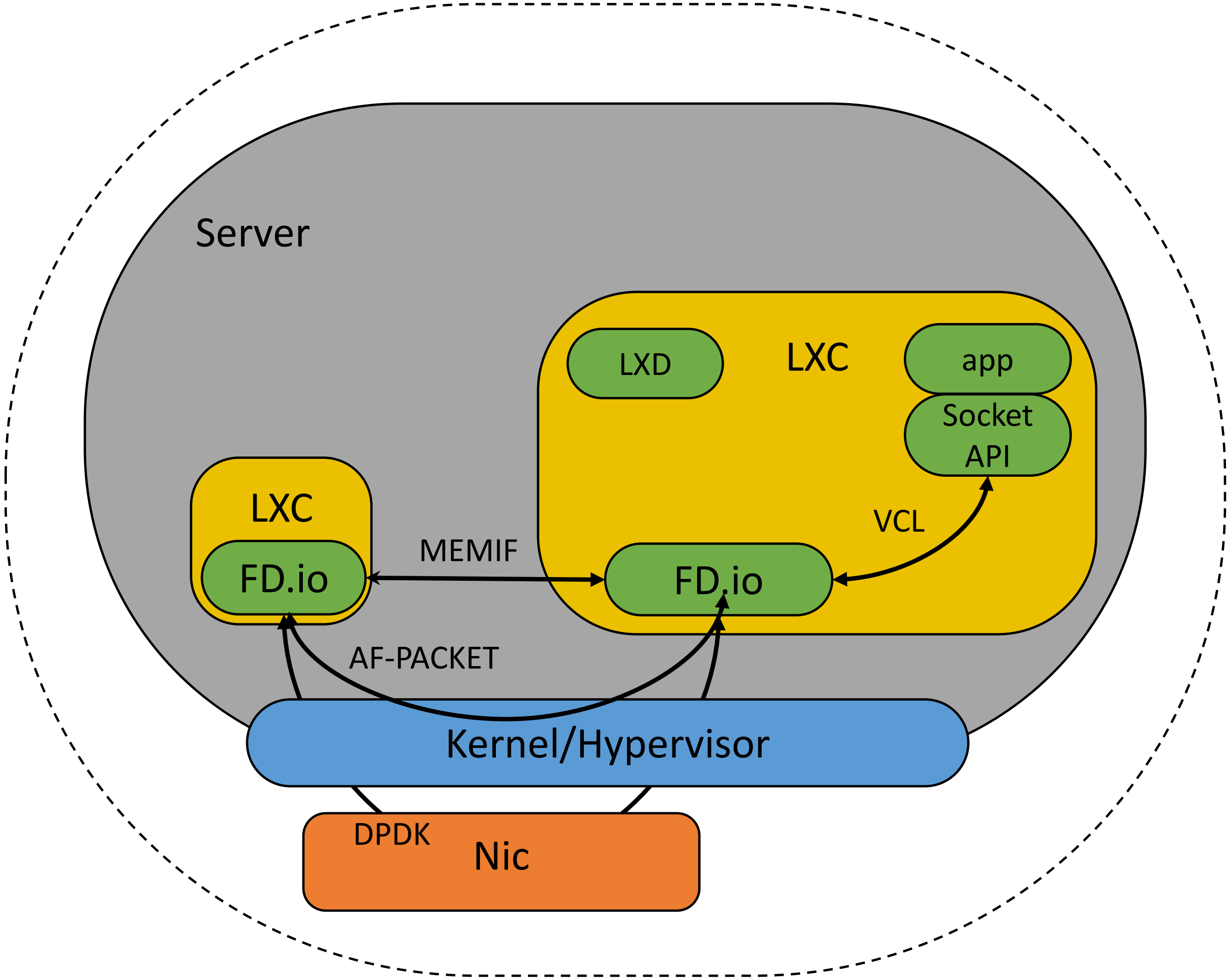
Universal Dataplane: Embedded



Universal Dataplane: CICN Example



Universal Dataplane: communication/API



Consumer/Producer Socket API

- Segmentation/Naming
- Manifest management
- Reassembly
- Flow and Congestion Control

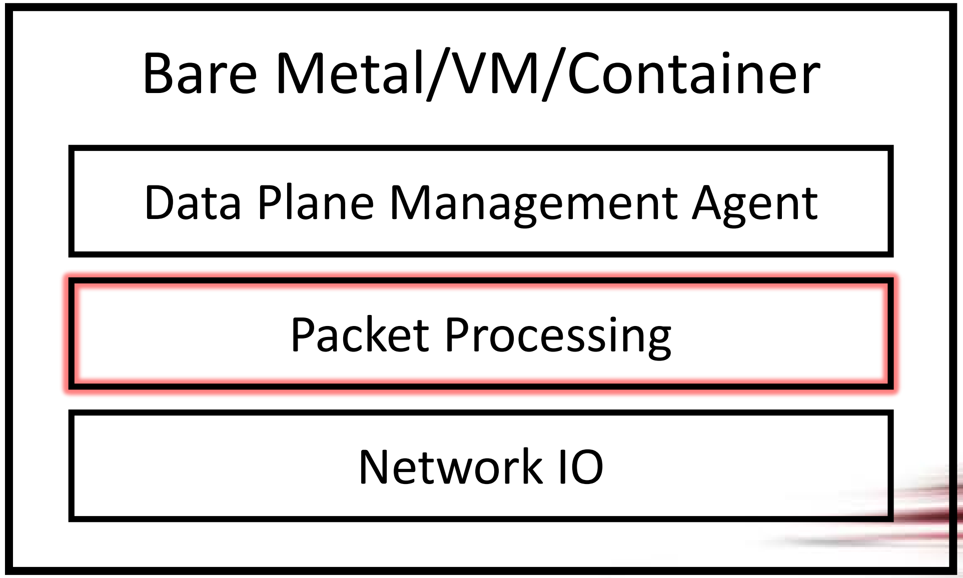
Existing drivers for links

- DPDK
- AF-PACKET
- MEMIF (SHARED MEMORY)

What is Vector Packet Processing?

An open-source software that provides out-of-the-box production quality switch/router functionality running under commodity CPUs

- High Throughput
  - 14+ Mpps per core
- Multiplatform intel ARM Power
- Feature rich
  - L2, L3, L4, local and remote programmability
- Modular and Extensible
  - Through plugins



Why VPP?

- NFV goals
  - Software flexibility without giving up to hardware level performance

- What about existing solutions?
  - Linux Kernel
    - Too slow for high throughput
    - Evolve slowly
  - Click
    - In principle similar to VPP, no V(ector)

CICN distribution

- Core libraries
  - Consumer/Producer Socket API, CCNx libs, PARC C libraries
- Server and Router
  - VPP cicn plugin for Ubuntu 16, CentOS 7
  - HTTP video server, Apache Traffic Server Plugin coming soon
- Client
  - Metis Forwarder
  - VIPER MPEG-DASH video player
  - Android 7/8, MacOS X 10.12, iOS 10/11, Ubuntu 16, CentOS 7
  - Soon Apple Store and Google Play
- vICN
  - intent-based networking
  - model driven programmable framework
  - monitoring and streaming for BigData support (PNDA.io)

Opportunities to Contribute

- Forwarding strategies
- Mobility management
- Hardware Accelerators
- vICN, configuration/management/control
- Consumer/Producer Socket API
- Reliable Transport
- Instrumentation tools
- HTTP integration

We invite you to Participate in fd.io

- Get the Code, Build the Code, Run the Code, install from binaries
- from binary packages
- Read/Watch the Tutorials
- Join the Mailing Lists
- Join the IRC Channels
- Explore the wiki
- Join fd.io as a member
- https://wiki.fd.io/view/cicn
- https://wiki.fd.io/view/vicn
- https://fd.io/

?
Q
&
A
!

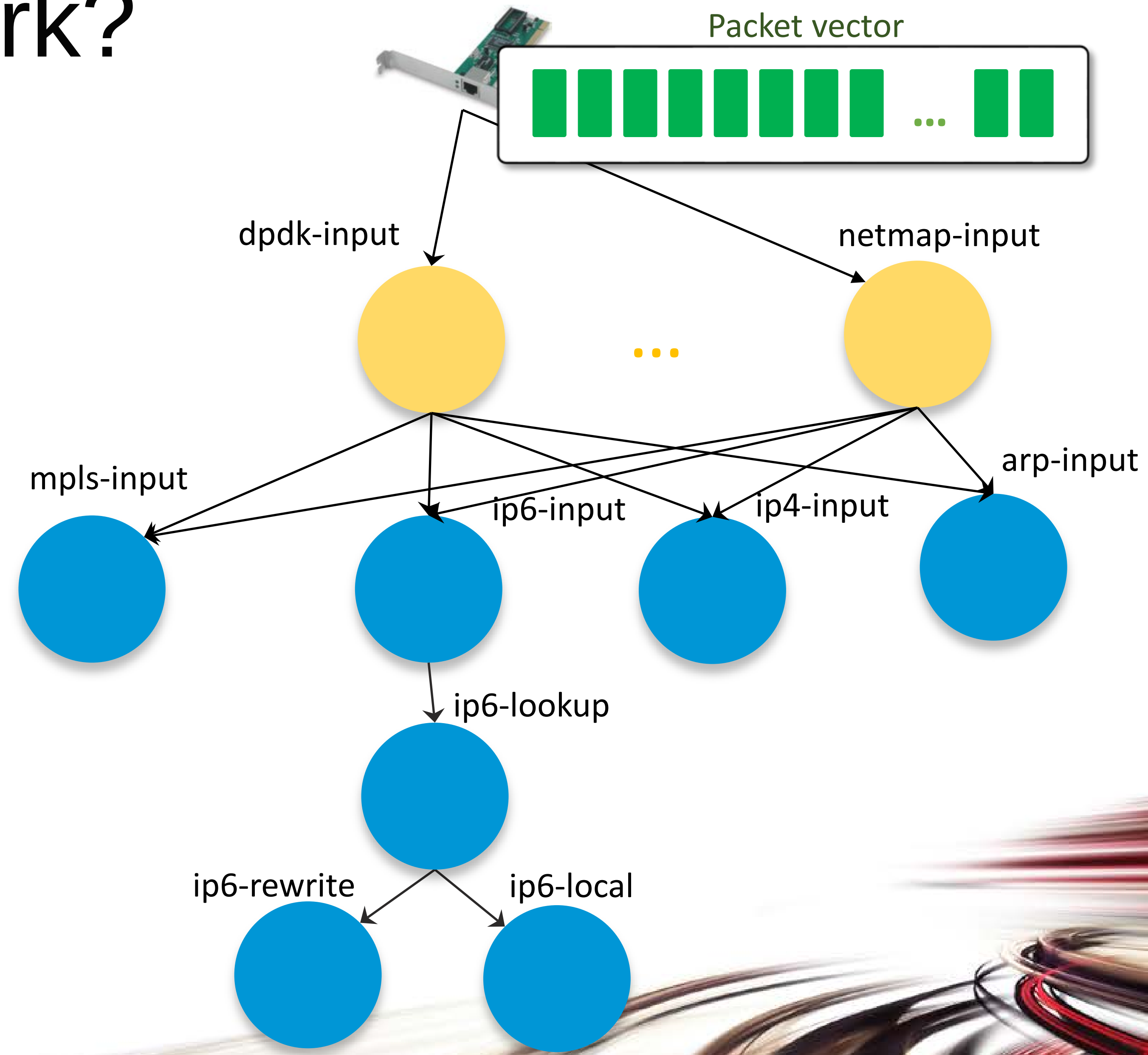
Vector Packet Processing for ICN

Alberto Compagno

Tutorial at ACM SIGCOMM ICN, Berlin, Germany
26th of September 2017

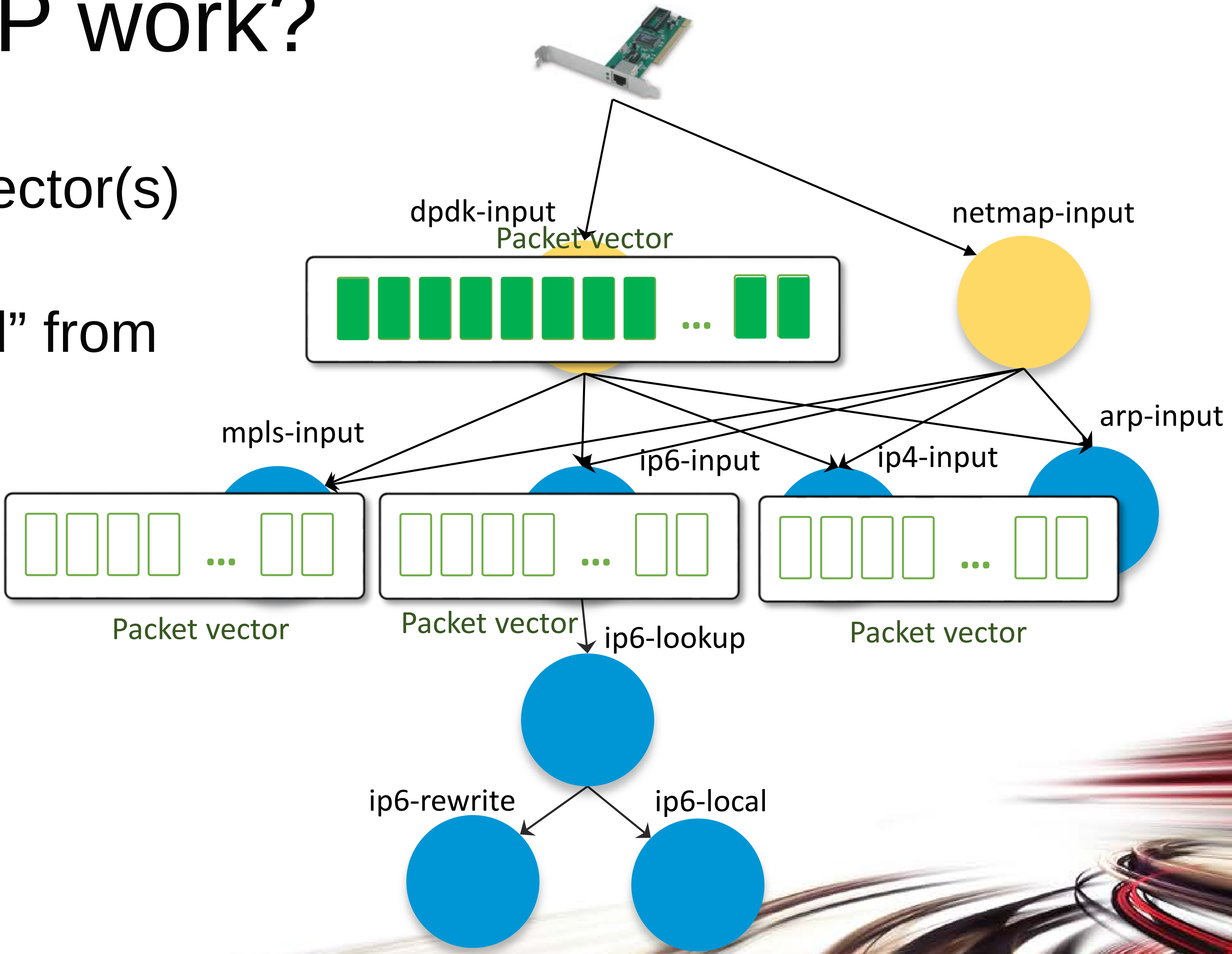
How does VPP work?

- VPP is a ‘packet processing graph’
- Nodes are
  - Small
  - Loosely coupled
- VPP processes vectors of packets
  - Passed from node to node



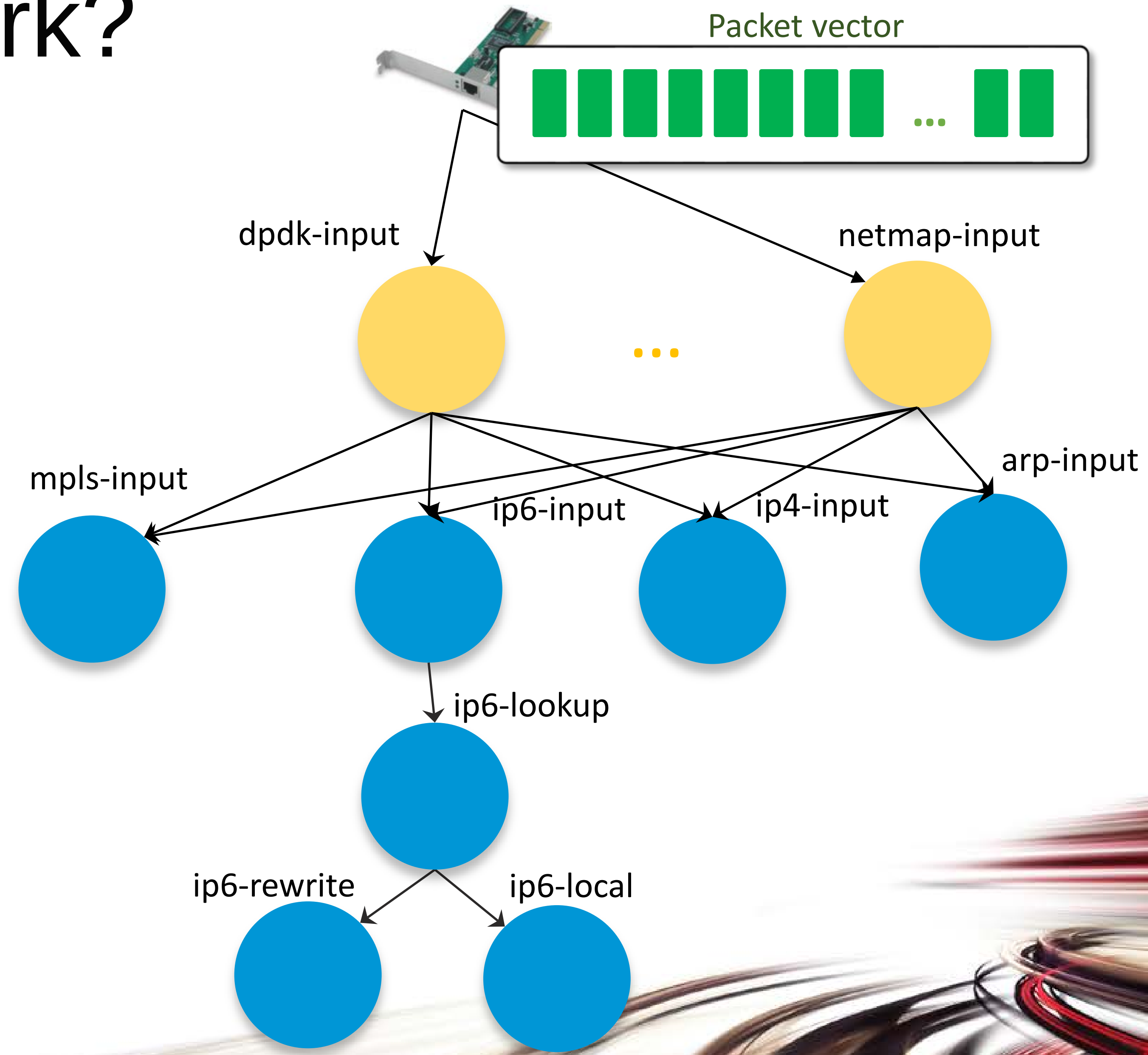
How does VPP work?

- Each node has its vector(s)
- Packets are “passed” from vector to vector



How does VPP work?

- Three types of nodes
  - Input
  - Internal
  - Process



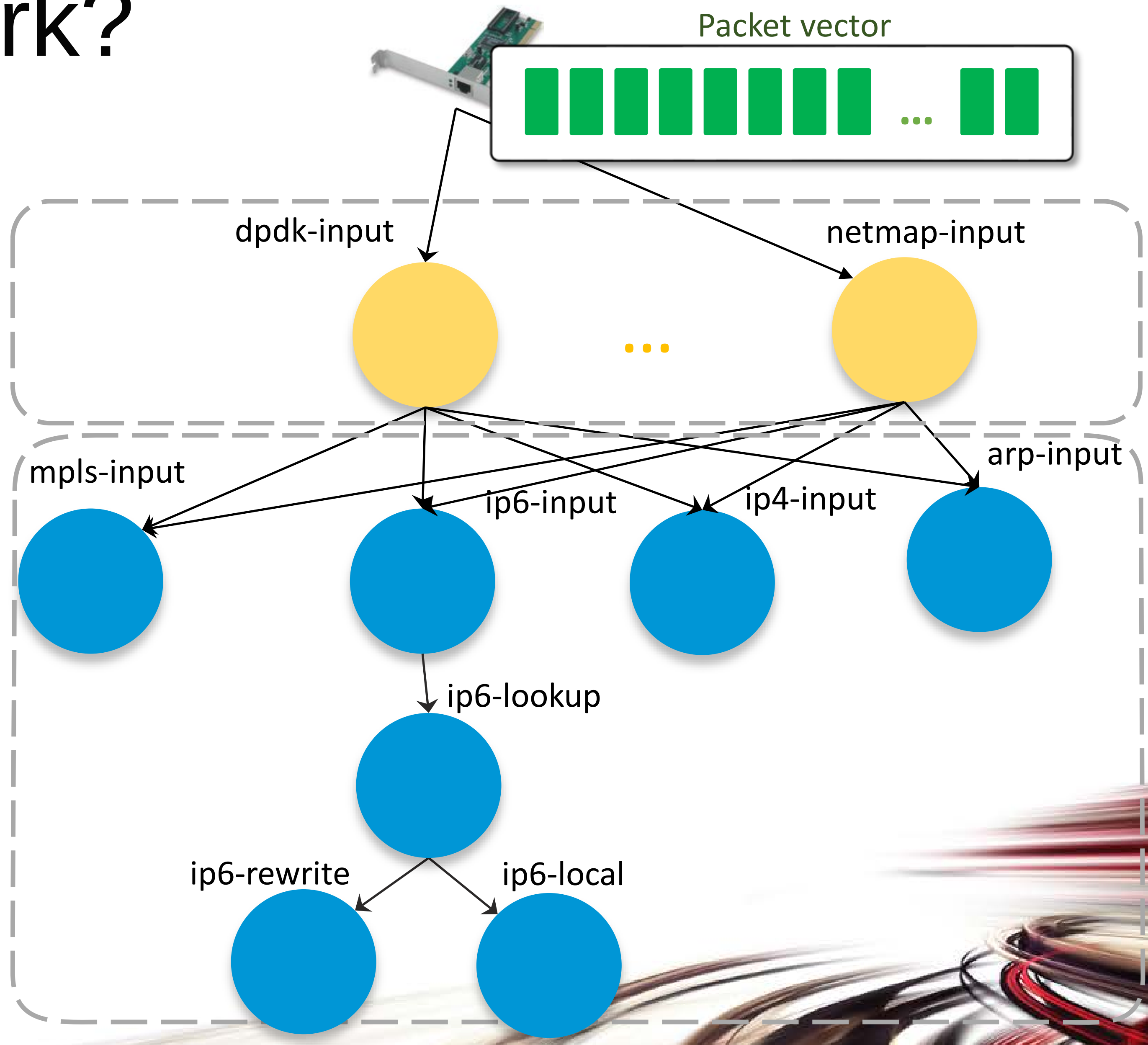
How does VPP work?

Input nodes

- Read packets from RX buffer
- Create the packet vector

Internal nodes

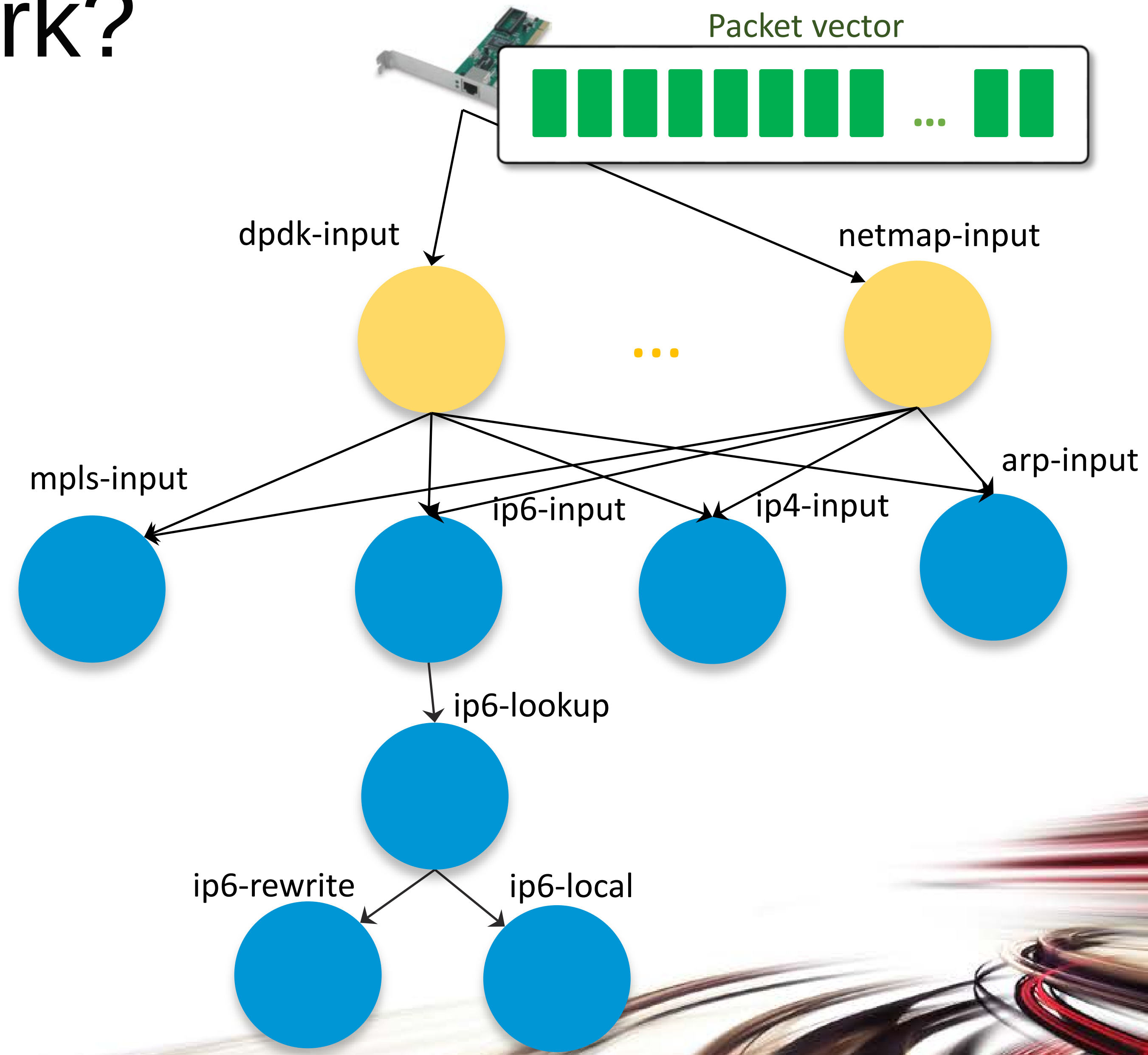
- Process packets
- Called from other nodes
- Can be leaf (drop or TX)



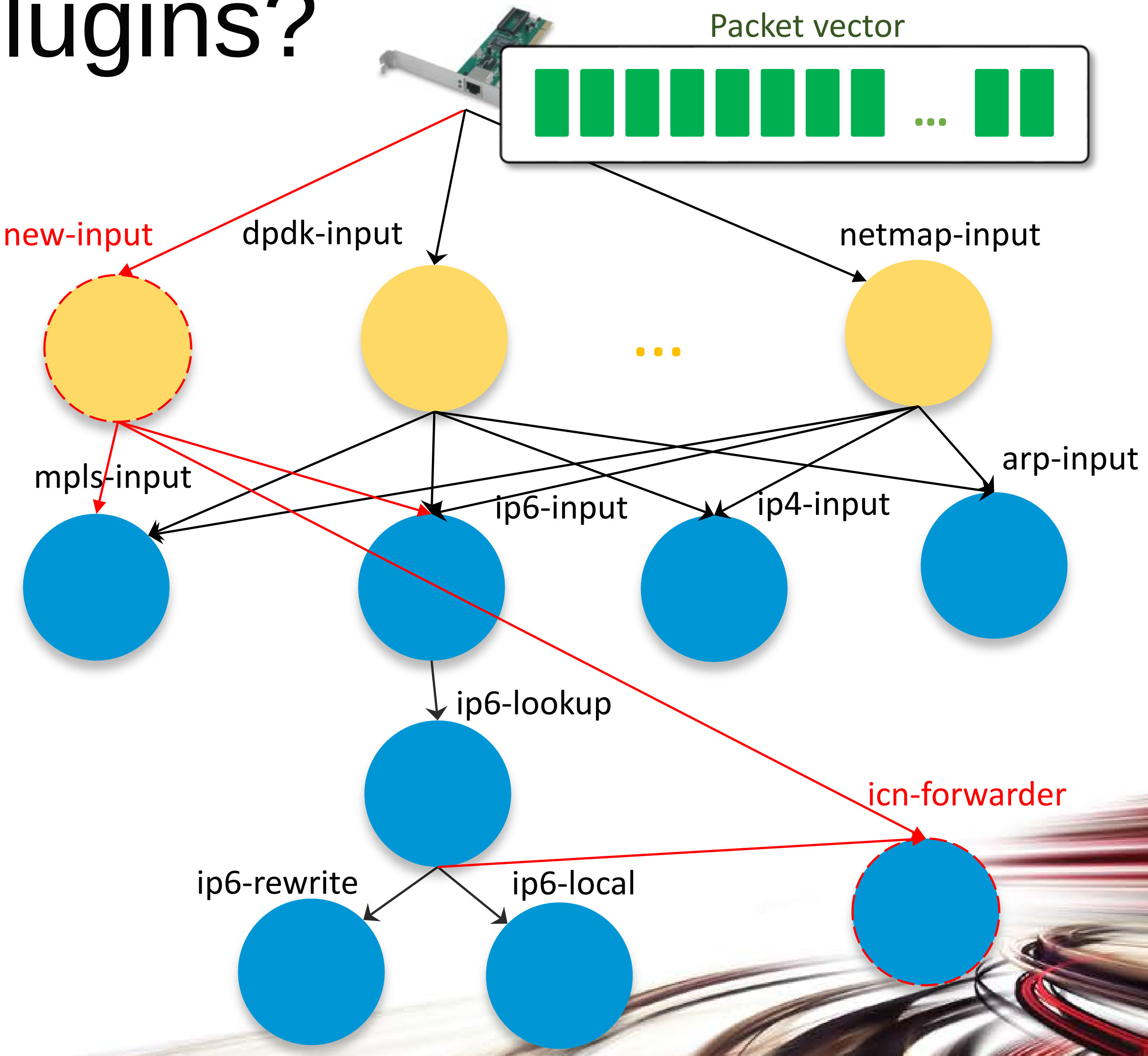
How does VPP work?

Process nodes

- Not part of the processing graph
- Run in background
- React to timer/event



Extend VPP with plugins?



Plugins are first class citizen

They can:

- Add nodes
- Add api
- Rearrange the graph

How does VPP accelerate packet processing?

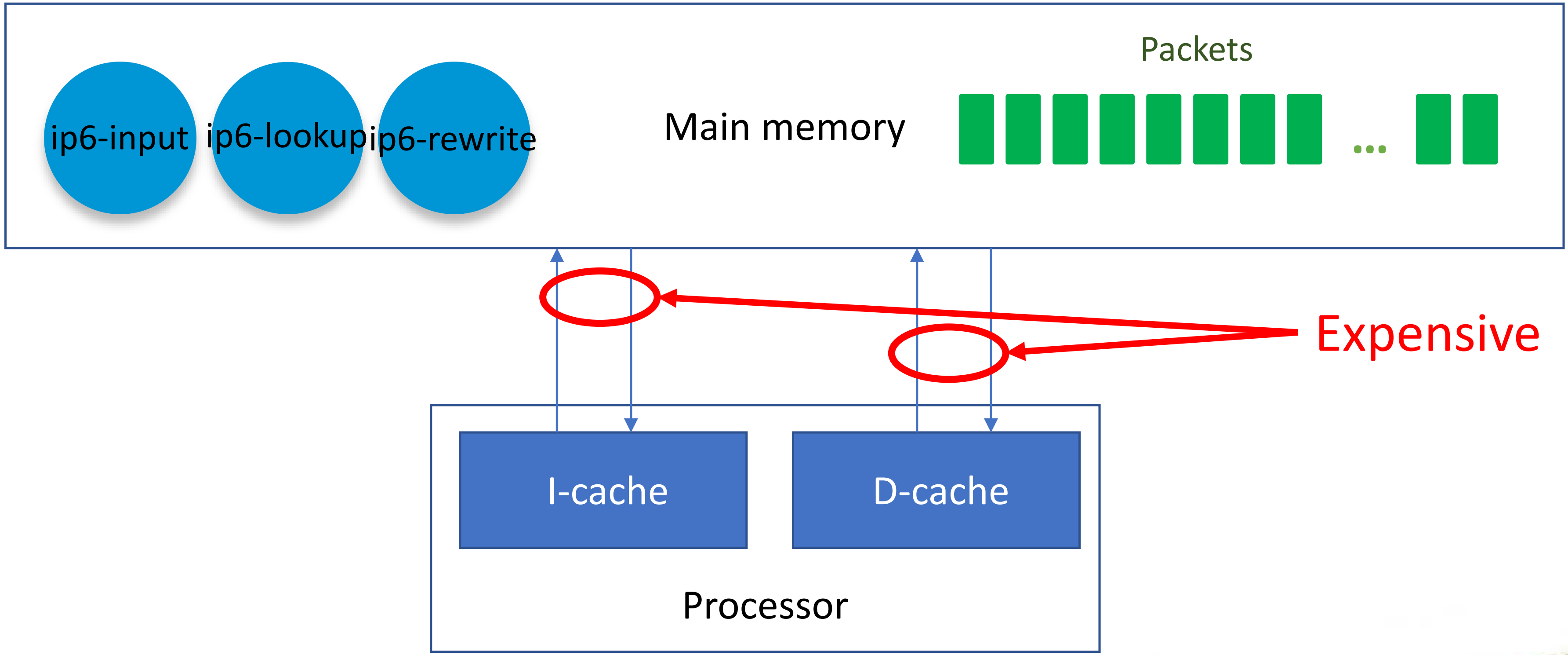
Accelerating packet processing

- Kernel bypass
- Code Design (Multi-loop, Branch prediction, Function flattening, Lock-free structures, Numa aware)
- Reduce cache misses

Reduce cache misses – Why?

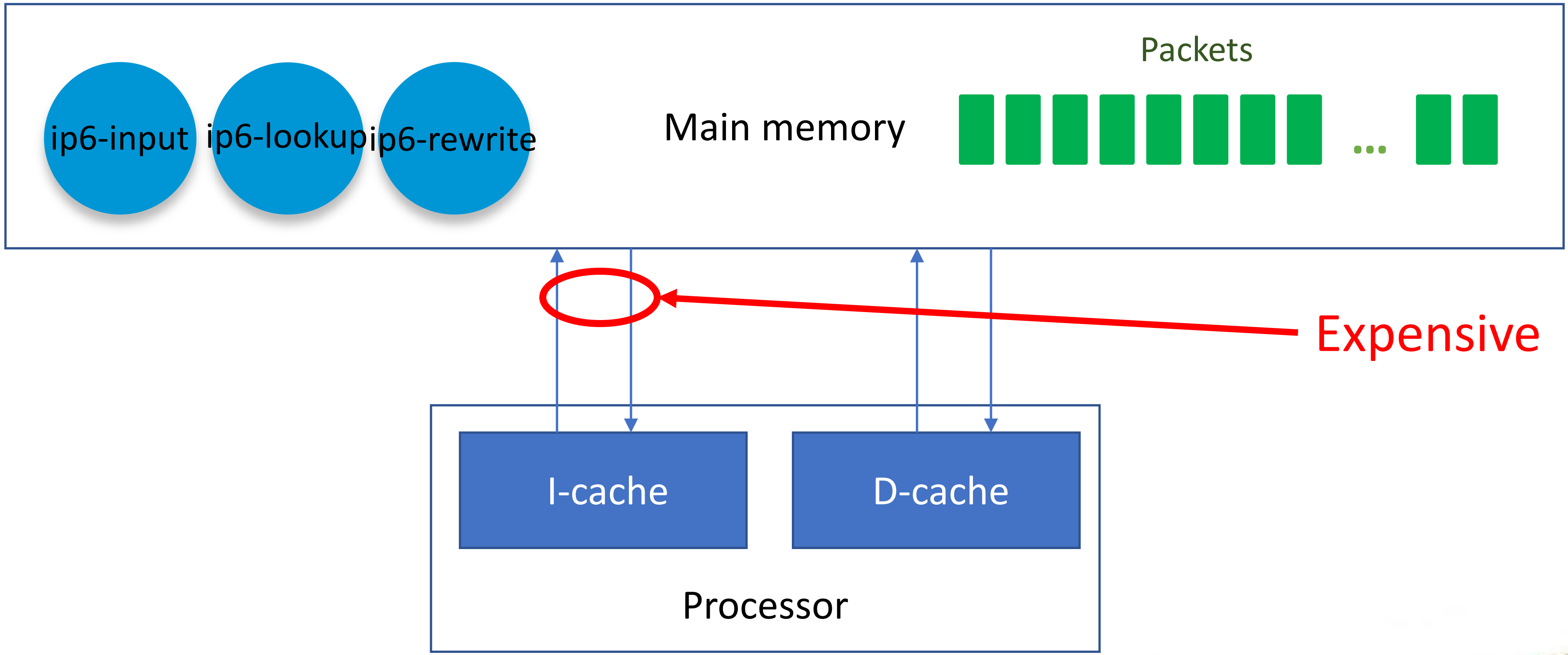
- 14 Mpps on 3.5GHz CPU = 250 cycles/packet
- Cache hit:
  - ~2-30 cycles
- Cache miss (main memory)
  - ~140 cycles

Reduce cache misses



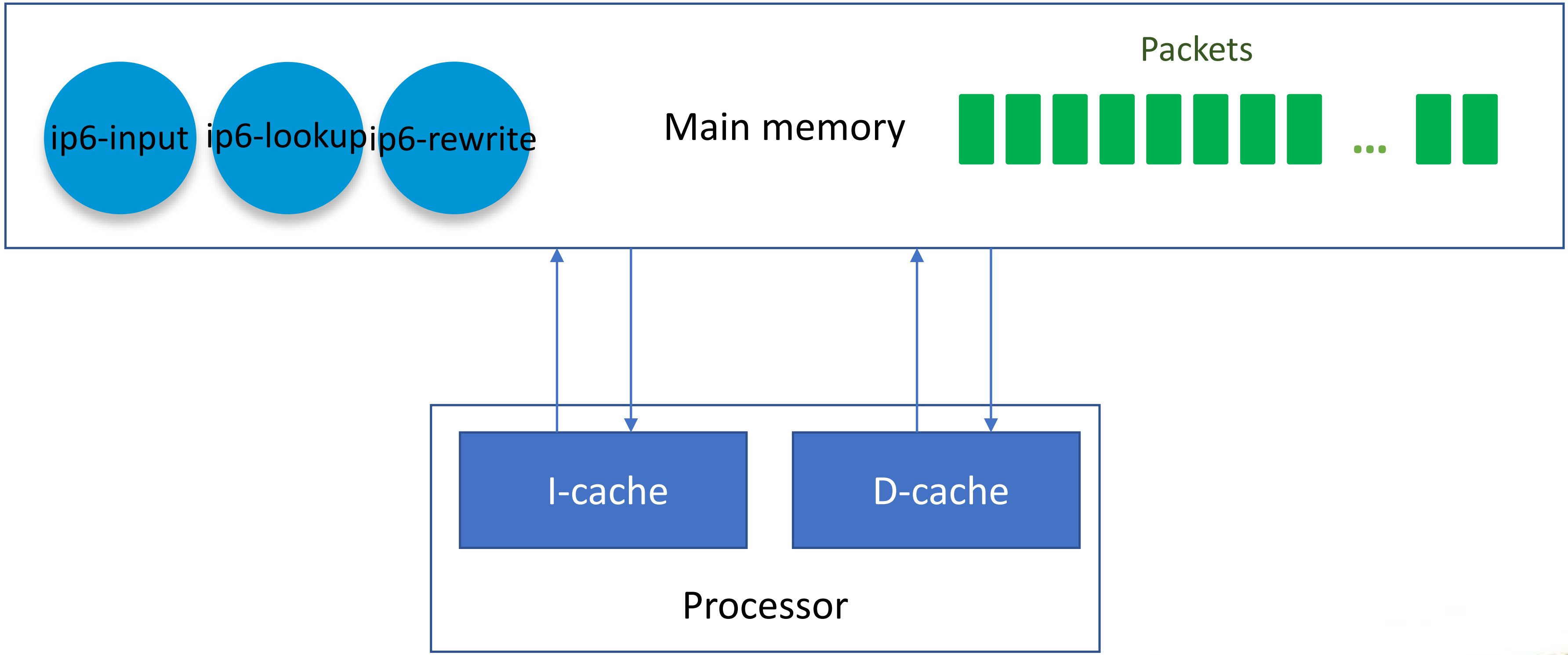
Reduce cache misses – I-cache

Let’s compare scalar processing with vector processing



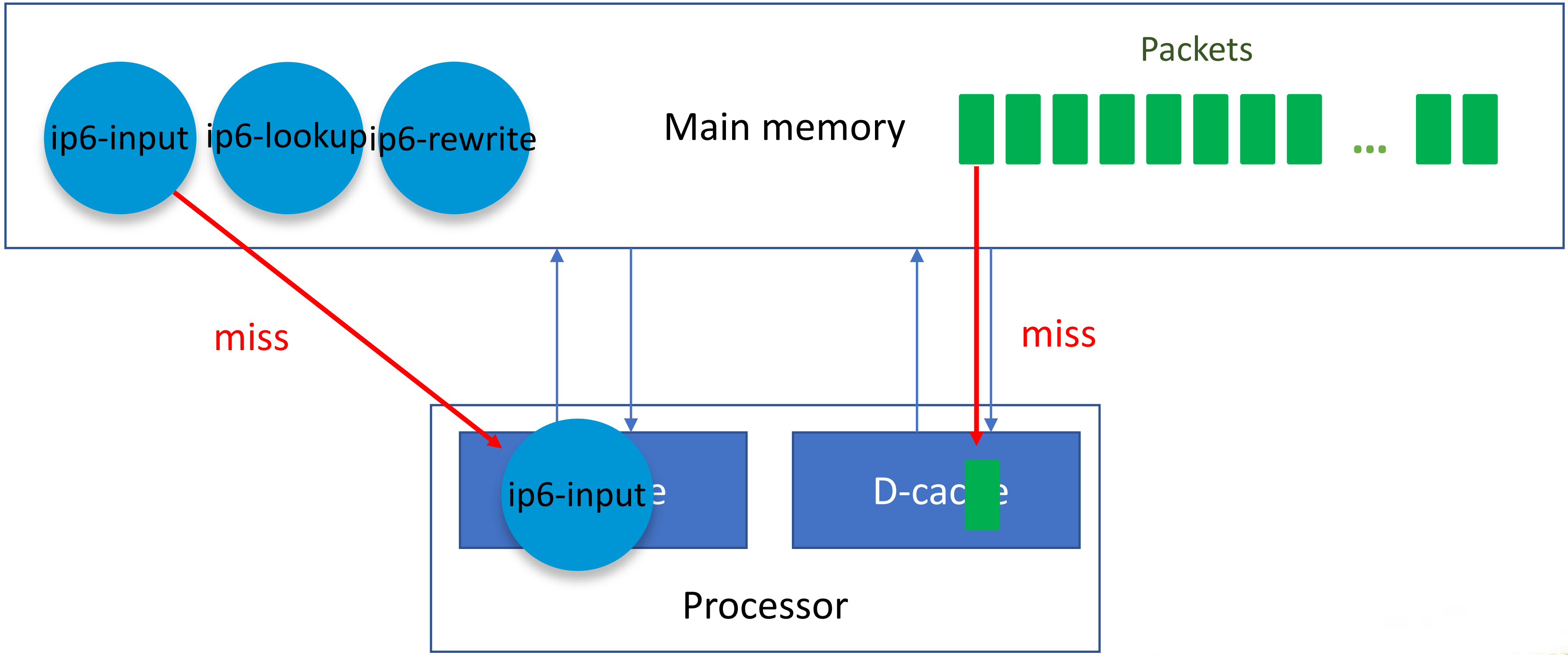
Scalar Packet Processing

- Process one packet at a time



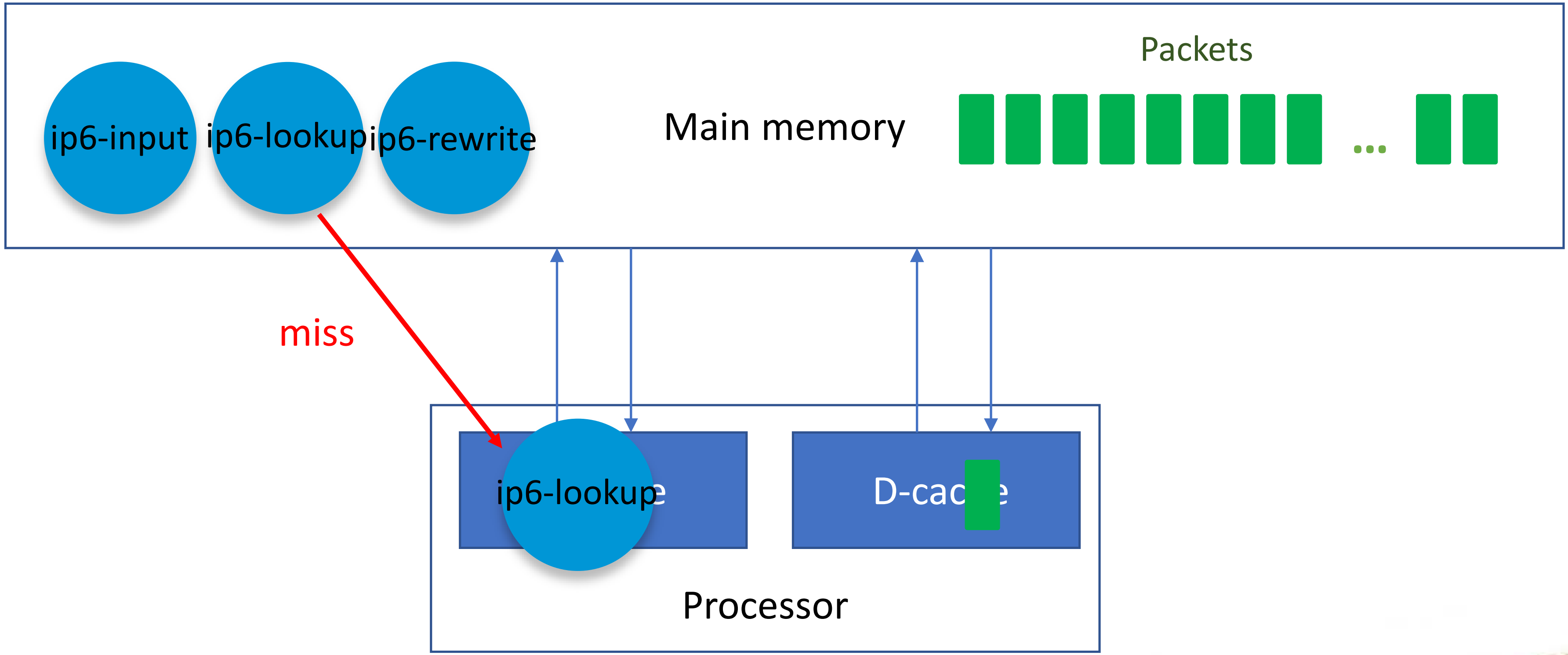
Scalar Packet Processing

- Process one packet at a time



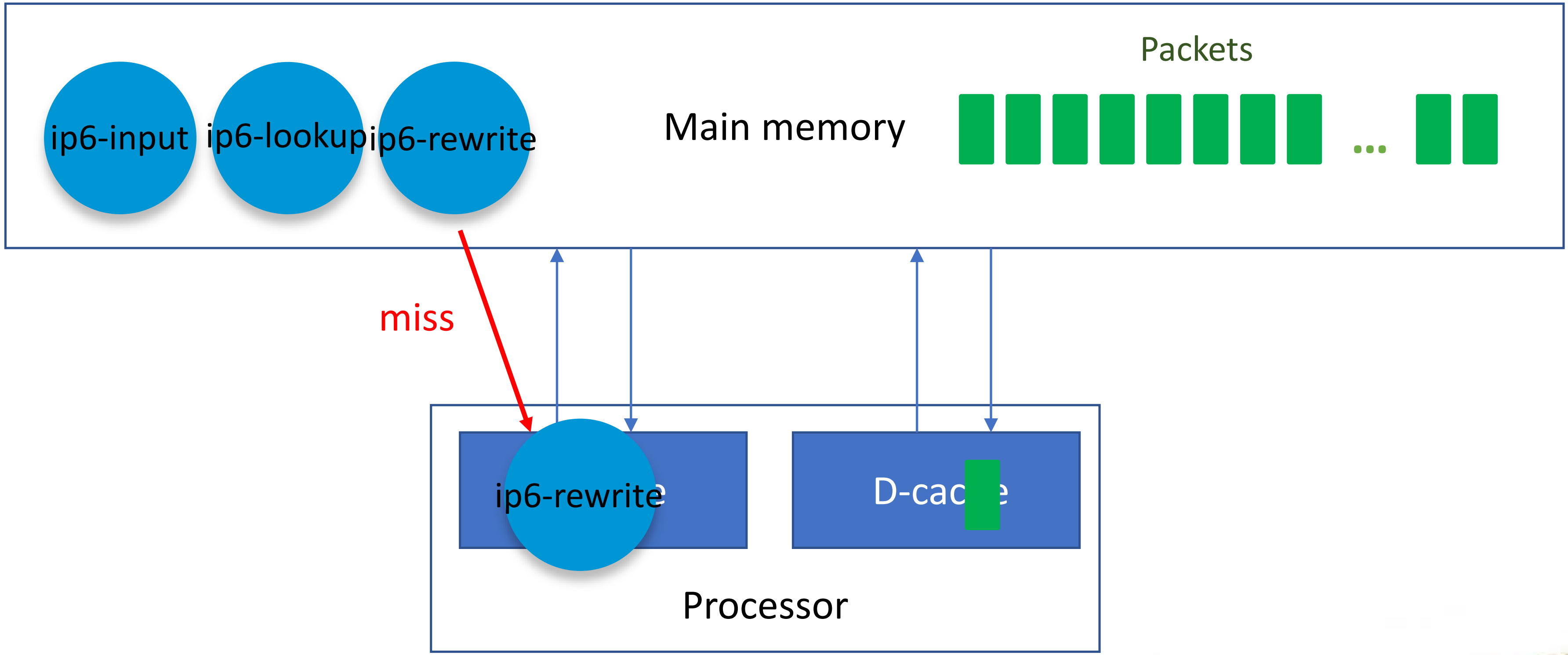
Scalar Packet Processing

- Process one packet at a time



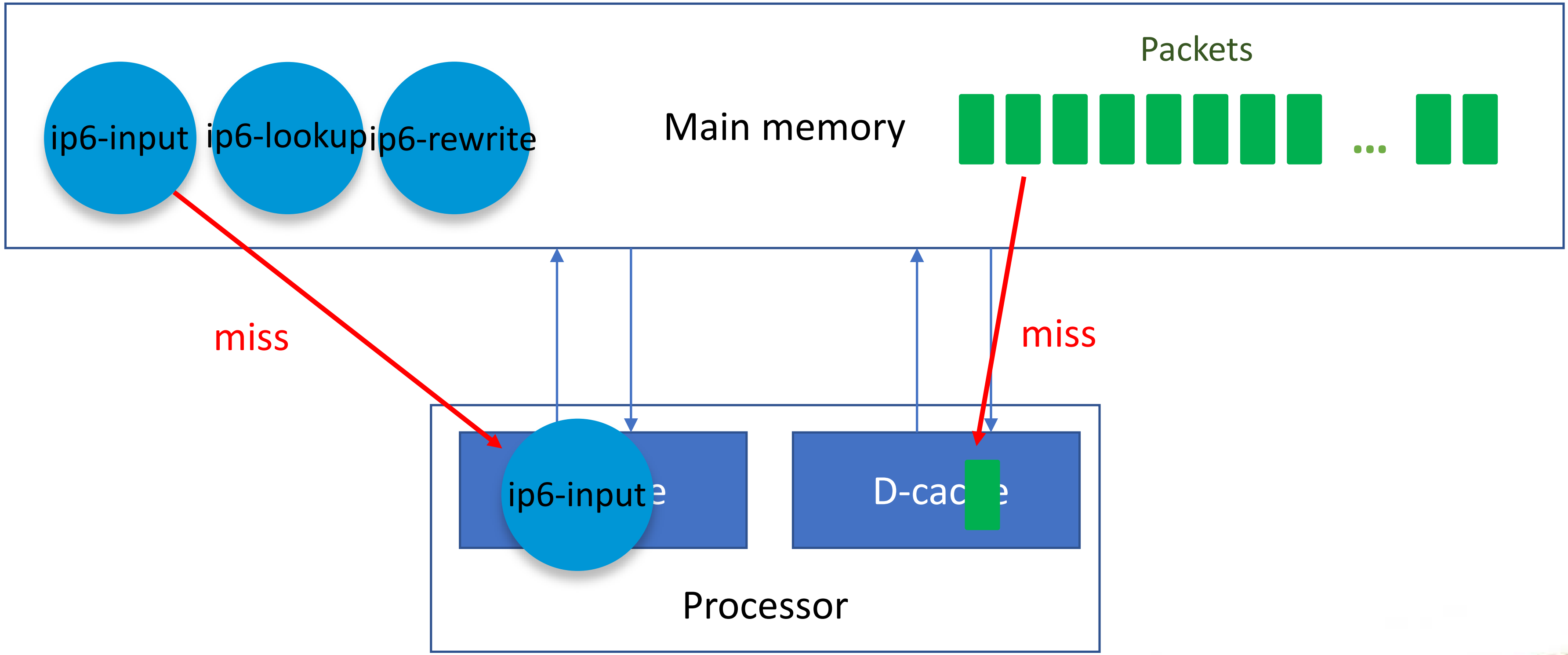
Scalar Packet Processing

- Process one packet at a time



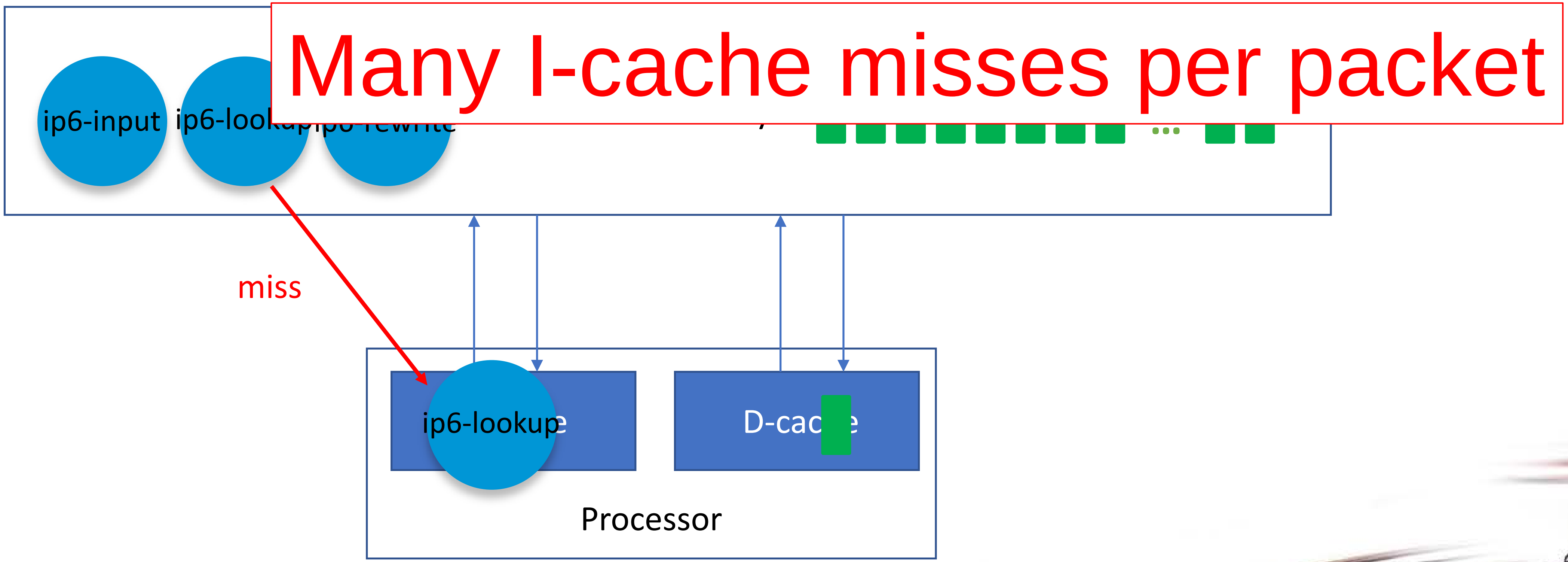
Scalar Packet Processing

- Process one packet at a time



Scalar Packet Processing

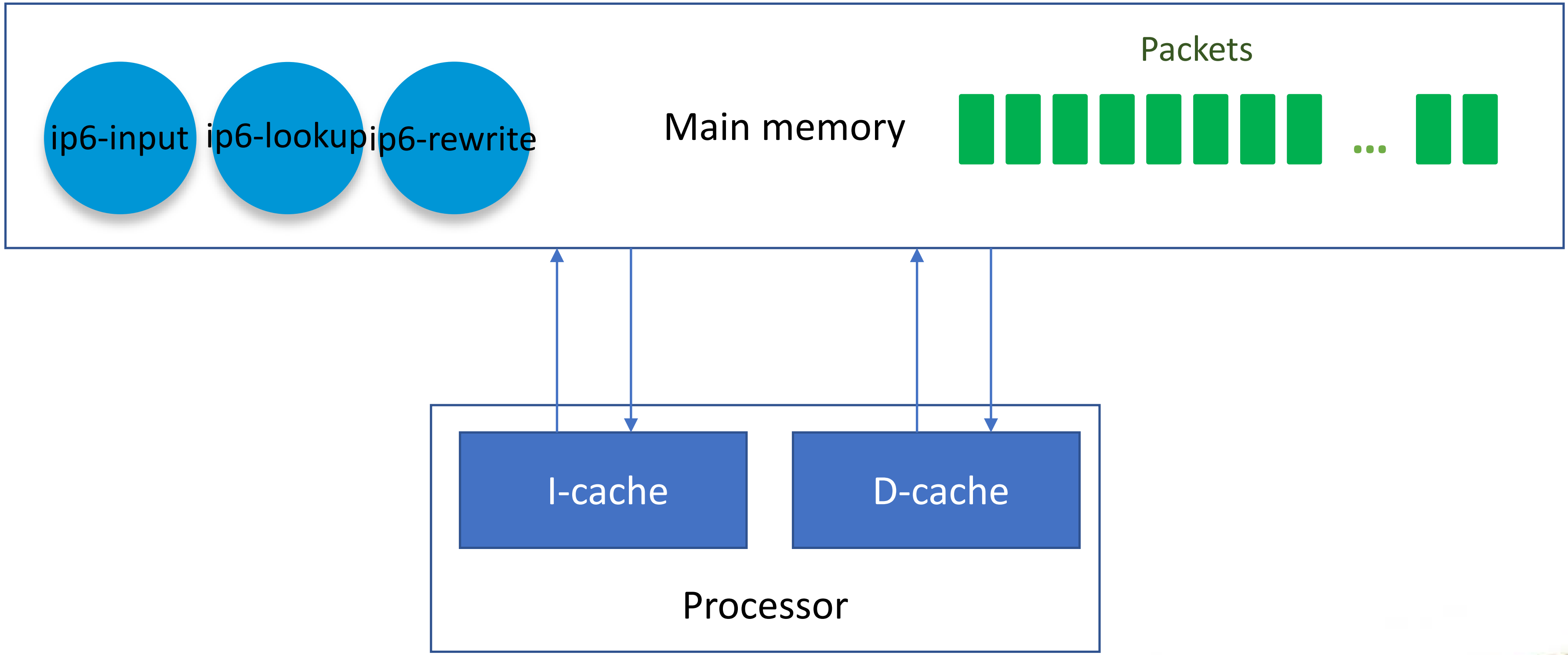
- Process one packet at a time



Many I-cache misses per packet

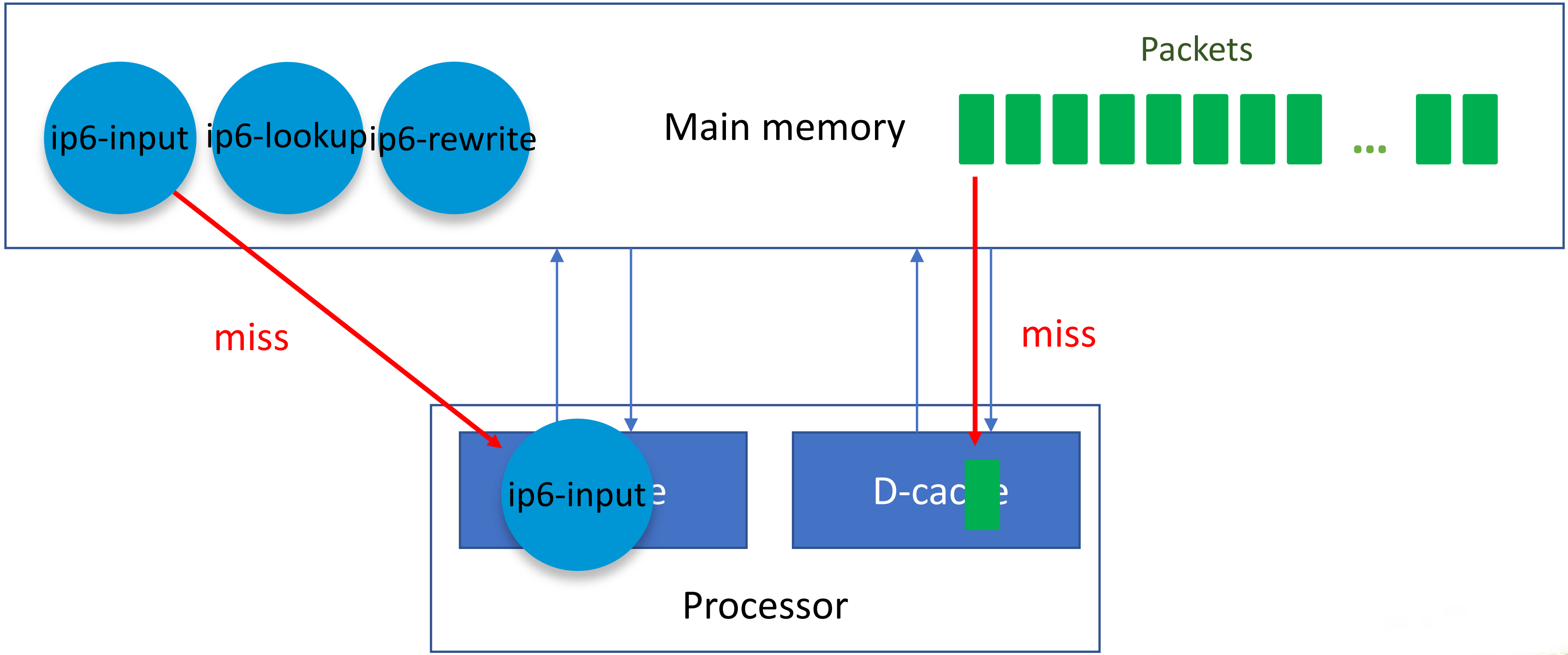
Vector Packet Processing

- Every node process the full packet vector



Vector Packet Processing

- Every node process the full packet vector



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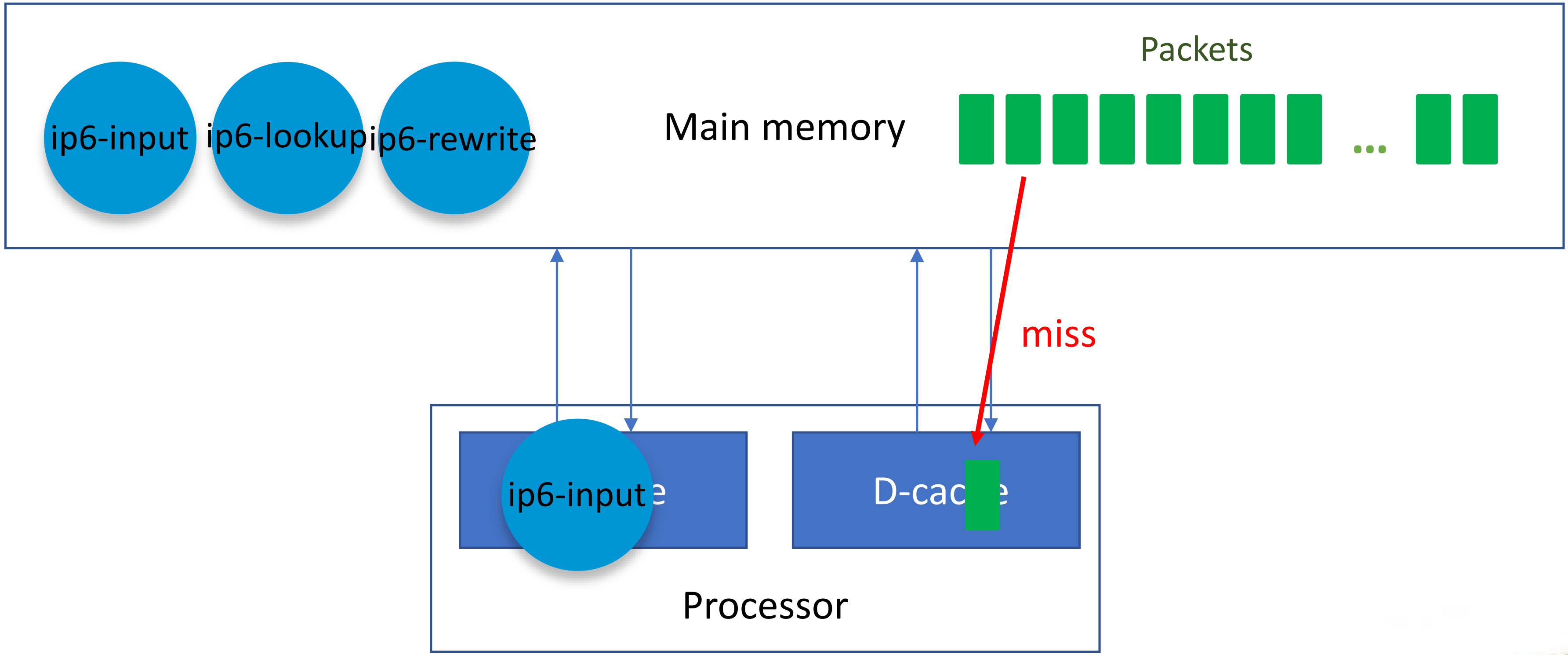

Vector Packet Processing

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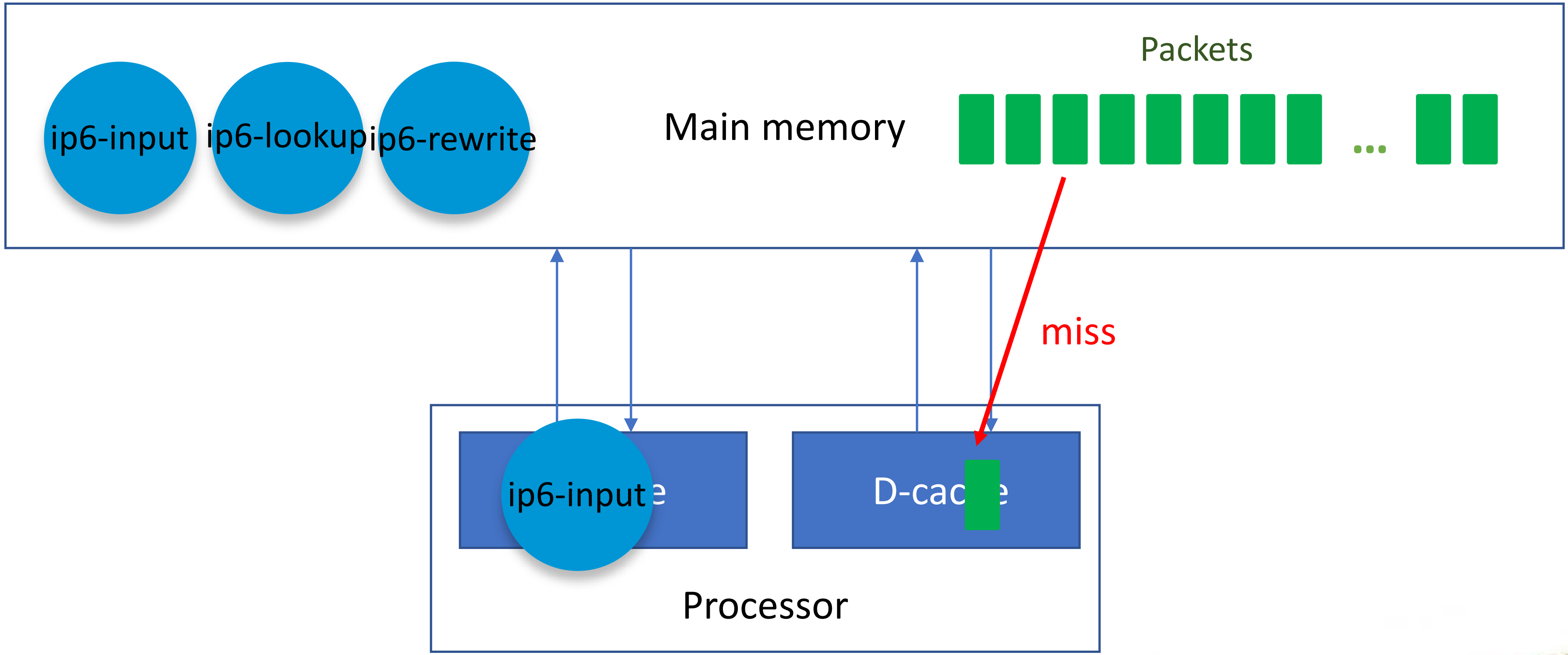
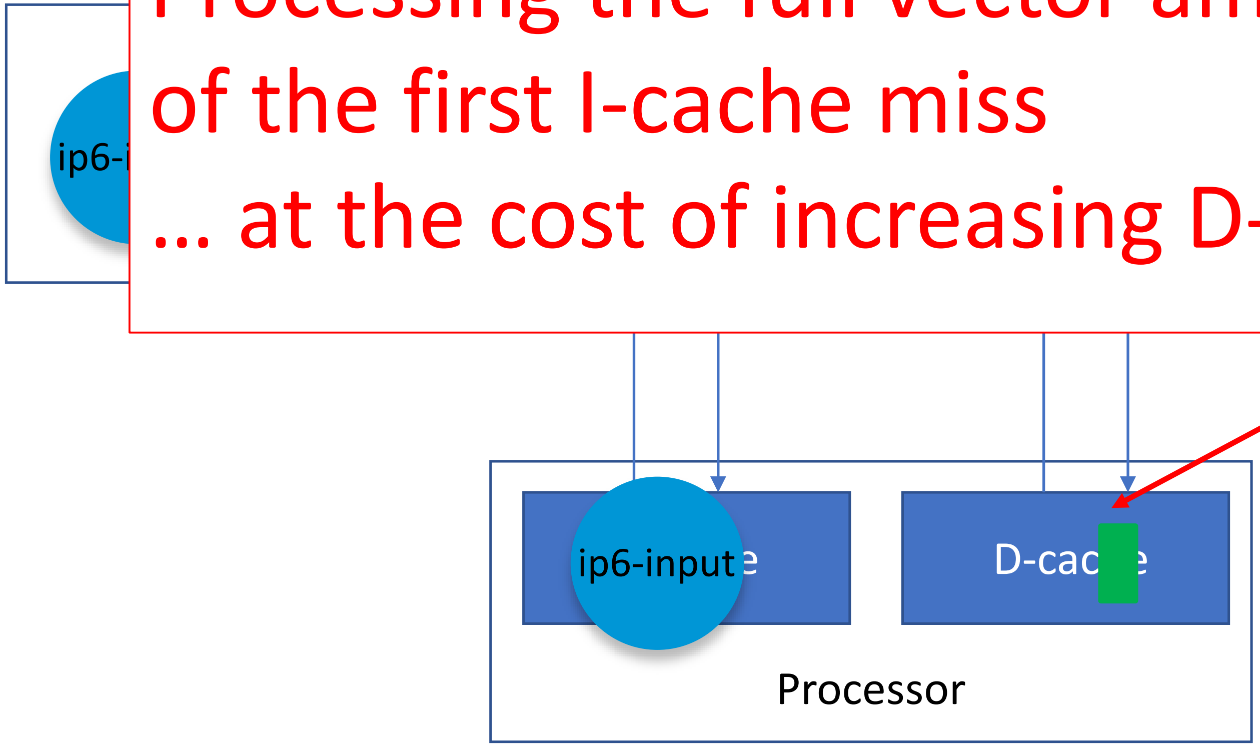


Vector Packet Processing

- Every node process the full packet vector

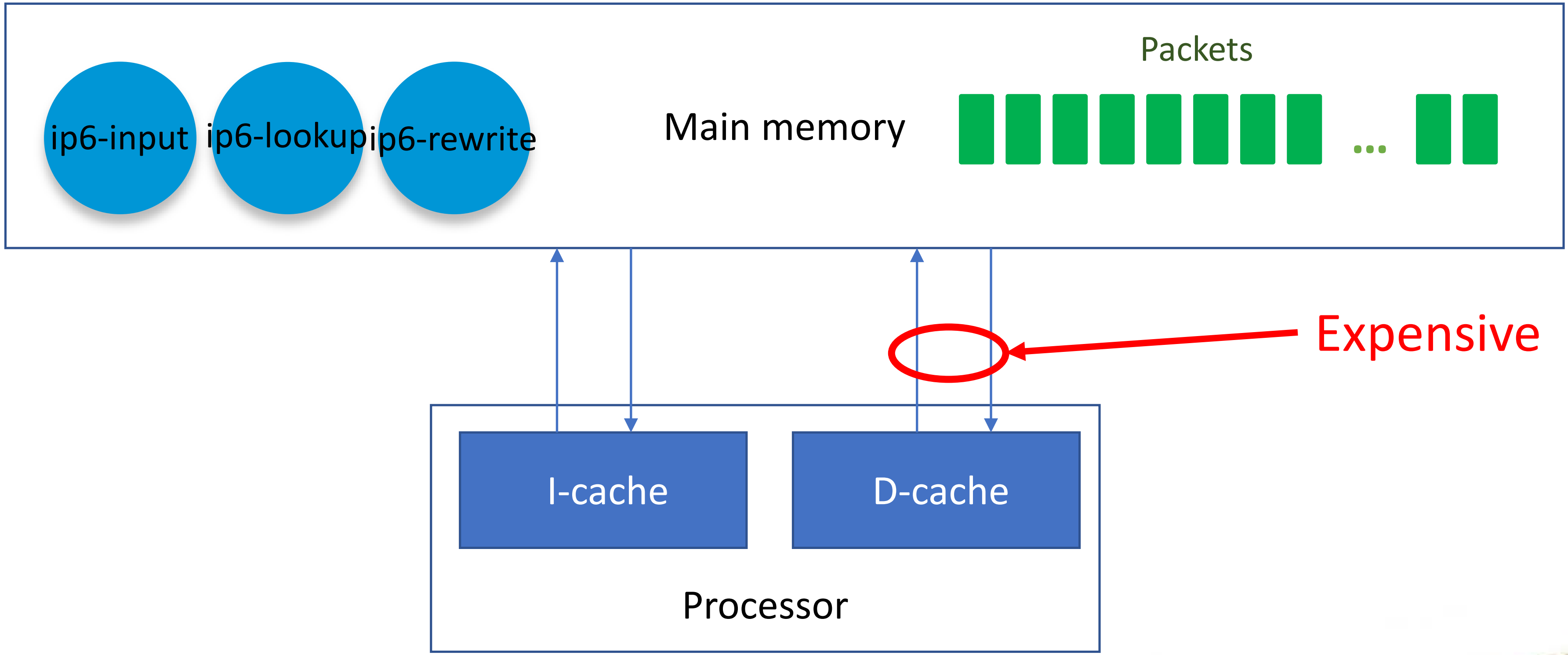


Processing the full vector amortizes the cost of the first I-cache miss

… at the cost of increasing D-cache misses

Reduce cache miss – D-cache

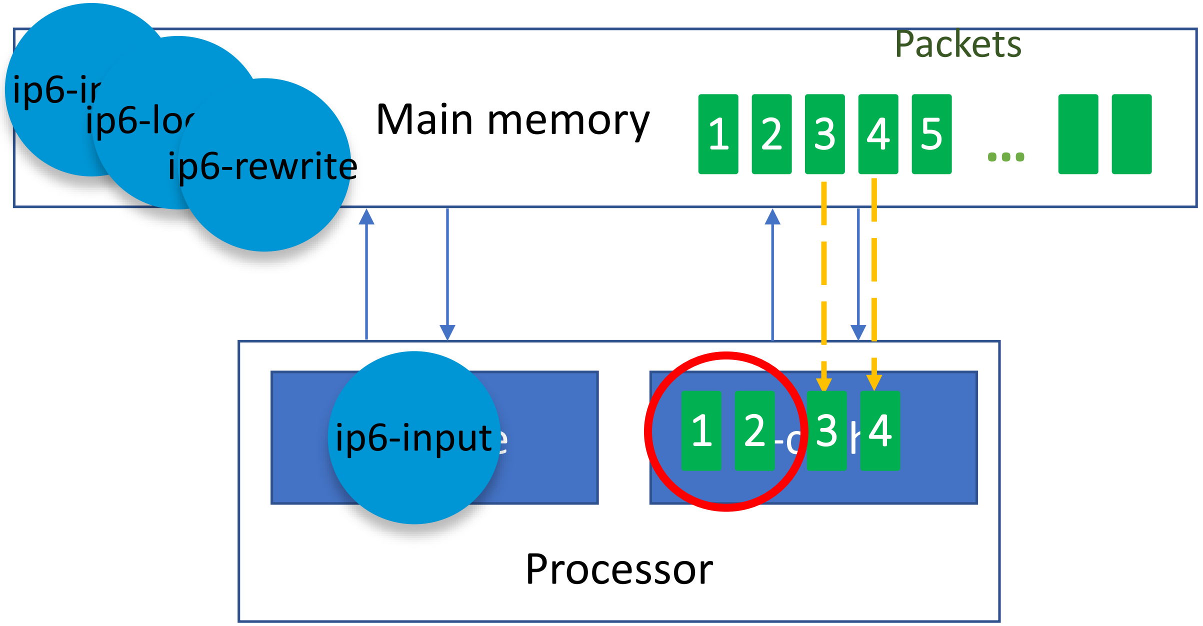
VPP pre-fetches data into D-cache



Reduce cache miss – D-cache

Example: Processing packet 1 & 2

Might have a cache miss for packet 1 & 2



VPP node pseudocode

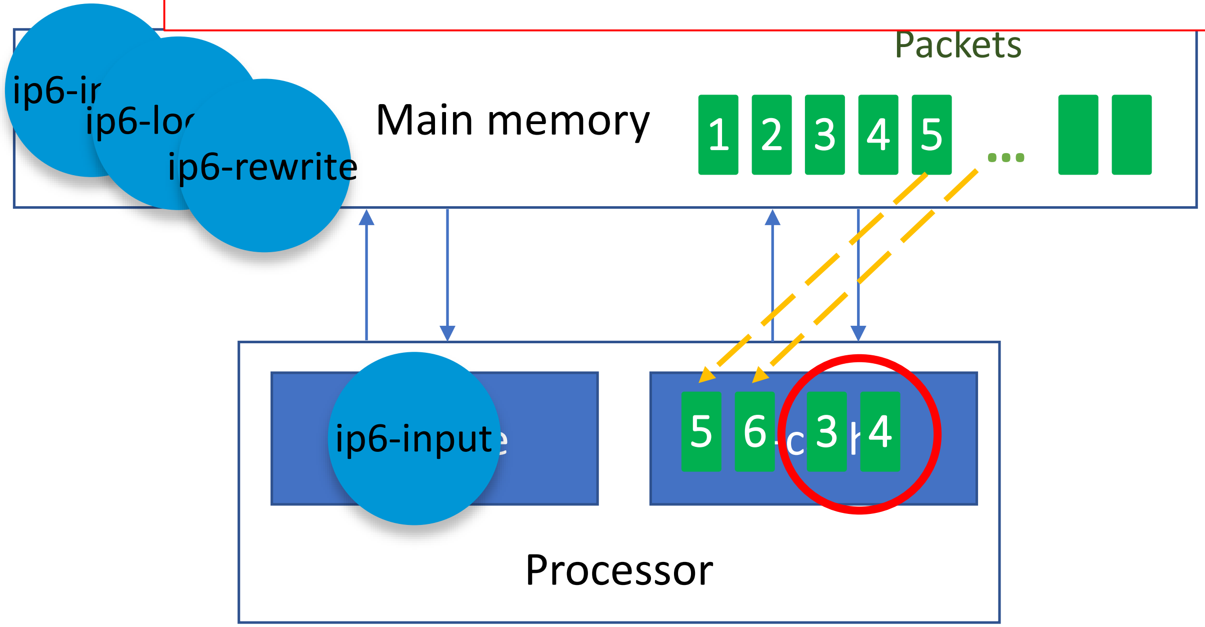
```
while packets in vector
    while 4 or more packets
        PREFETCH #3 and #4
        PROCESS #1 and #2
    while any packets
        <as above but single packet>
```

Reduce cache miss – D-cache

Example: Processing packet 3 & 4

The cost of the first D-cache miss is amortized by the subsequent D-cache hits.

et



```
while 4 or more packets
    PREFETCH #5 and #6
    PROCESS #3 and #4
while any packets
    <as above but single packet>
```

Hands on VPP!

VPP documentation

- Wiki

  https://wiki.fd.io/view/VPP

- Doxygen

  https://docs.fd.io/vpp/17.04/

Download VPP (v17.04)

- Clone the source code from git

```
git clone https://gerrit.fd.io/r/vpp
```

- Or install it from .deb pkg (rpm for Centos available too)

… see wiki

Configure and Start VPP

- VPP configuration file

```
# emacs /etc/vpp/startup.conf
```

- Start vpp

```
# sudo vpp -c /etc/vpp/startup.conf
```

VPP Command Line Interface

- To start a shell:

```
# vppctl
```

- To run one command:

```
# vppctl <command>
```

VPP Command Line Interface

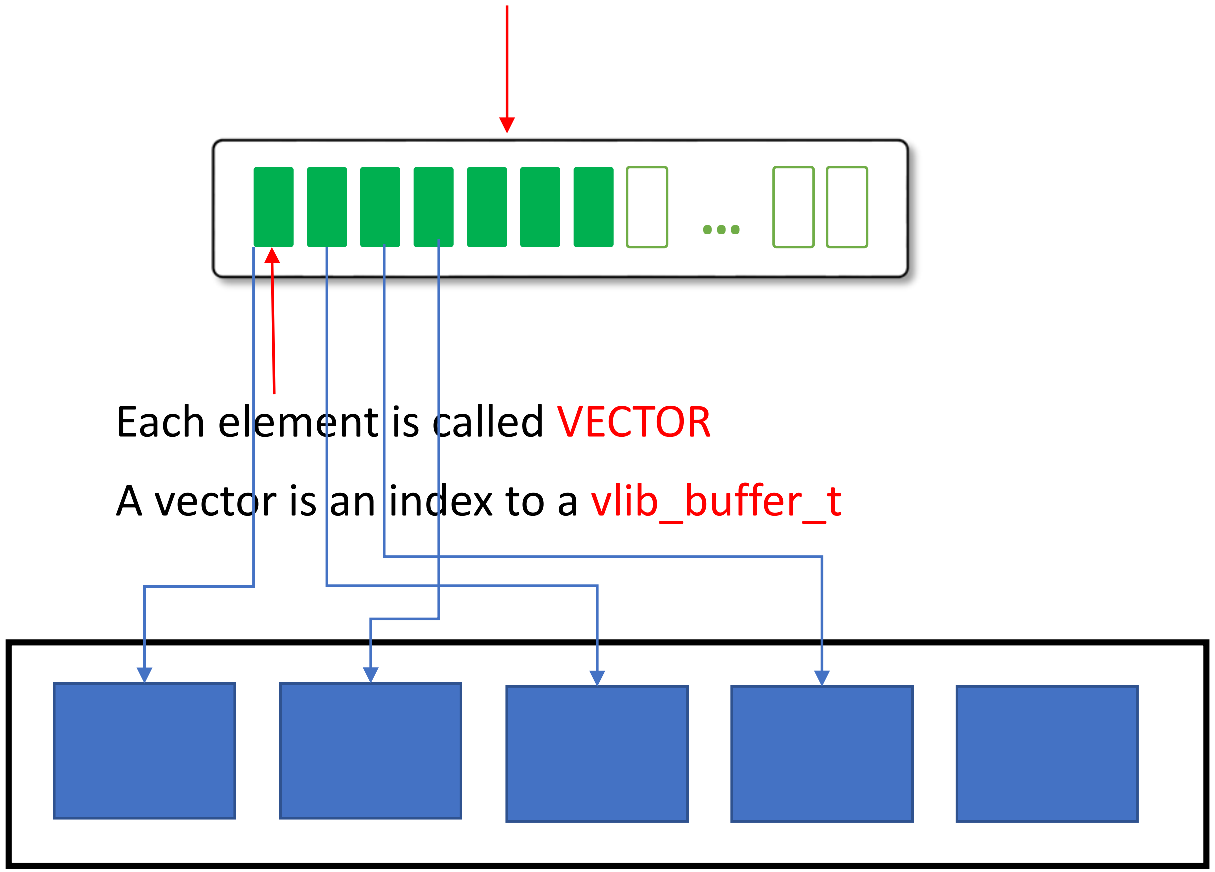
- A bunch of useful commands:
  - ?
  - show
  - set

Create your own plugin

Outline

- VPP structures
- Design & Implement your node(s)
- Insert your node(s) in the vlib_graph
- Compile and install your plugin

VPP structures



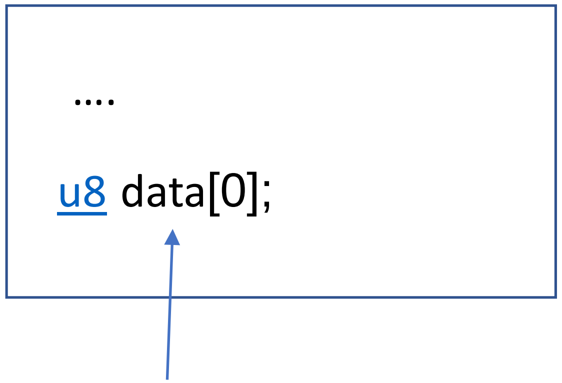
The vector of packets is called FRAME

Each element is called VECTOR

A vector is an index to a vlib_buffer_t

Memory holding vlib_buffer_t objects

vlib_buffer_t



```
....

u8 data[0];
```

Pointer to packet data
(DMA memory)

Outline

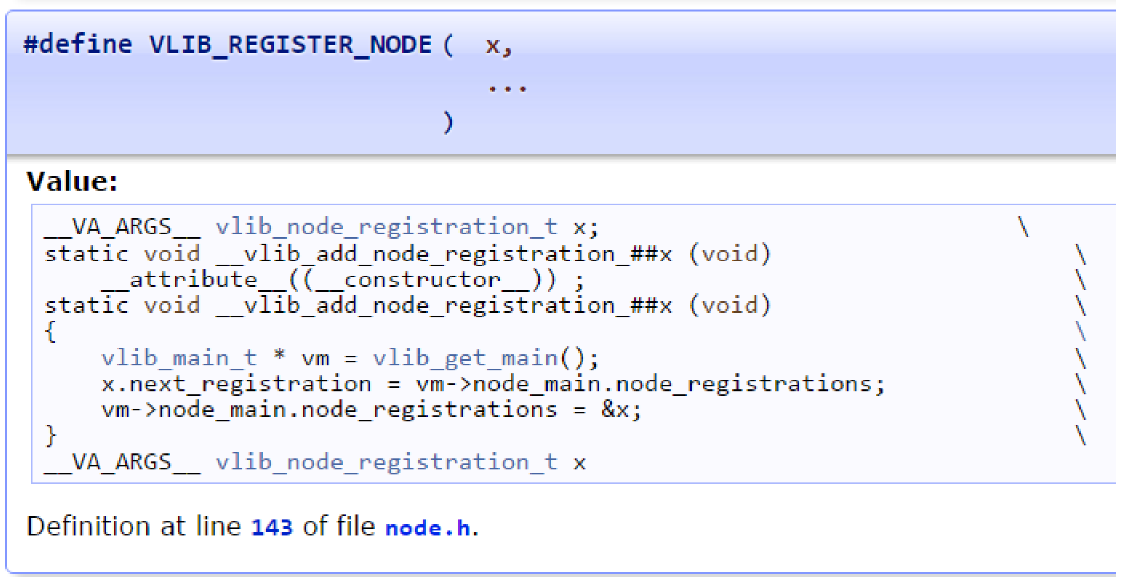
- VPP structures
- Design & Implement your node(s)
- Inserting your node(s) in the vlib_graph
- Compiling and installing your plugin

Design & Implement your node(s)

- Your node should follow VPP style
  - Multi-loop, Branch prediction, Function flattening, Lock-free structures
- A node must implement a processing function that
  - “Moves vectors” from your node’s frame to the next node’s frame
  - Processes packets as YOU want
- Add whatever else you need
  - Supporting Functions, macros, variables, etc.. (C code)

Register your node(s) to VPP

- Each node must be registered to VPP through VLIB_REGISTER_NODE macro

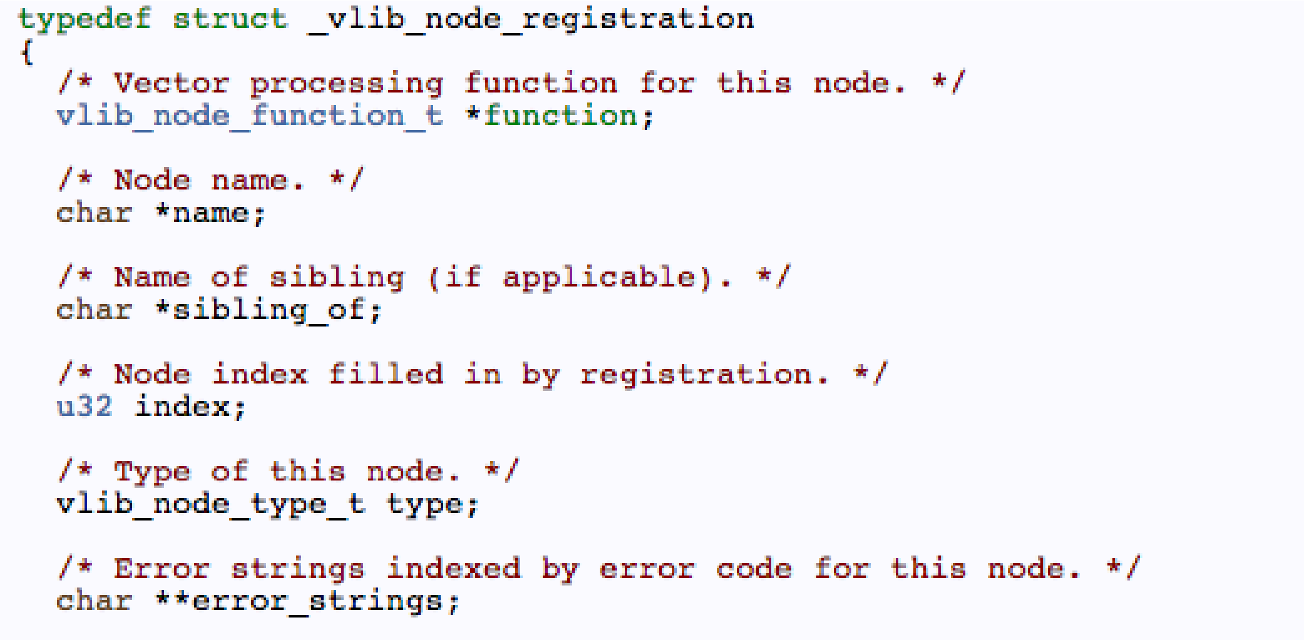


```
#define VLIB_REGISTER_NODE (  x,
                              ...
                           )
```

Value:

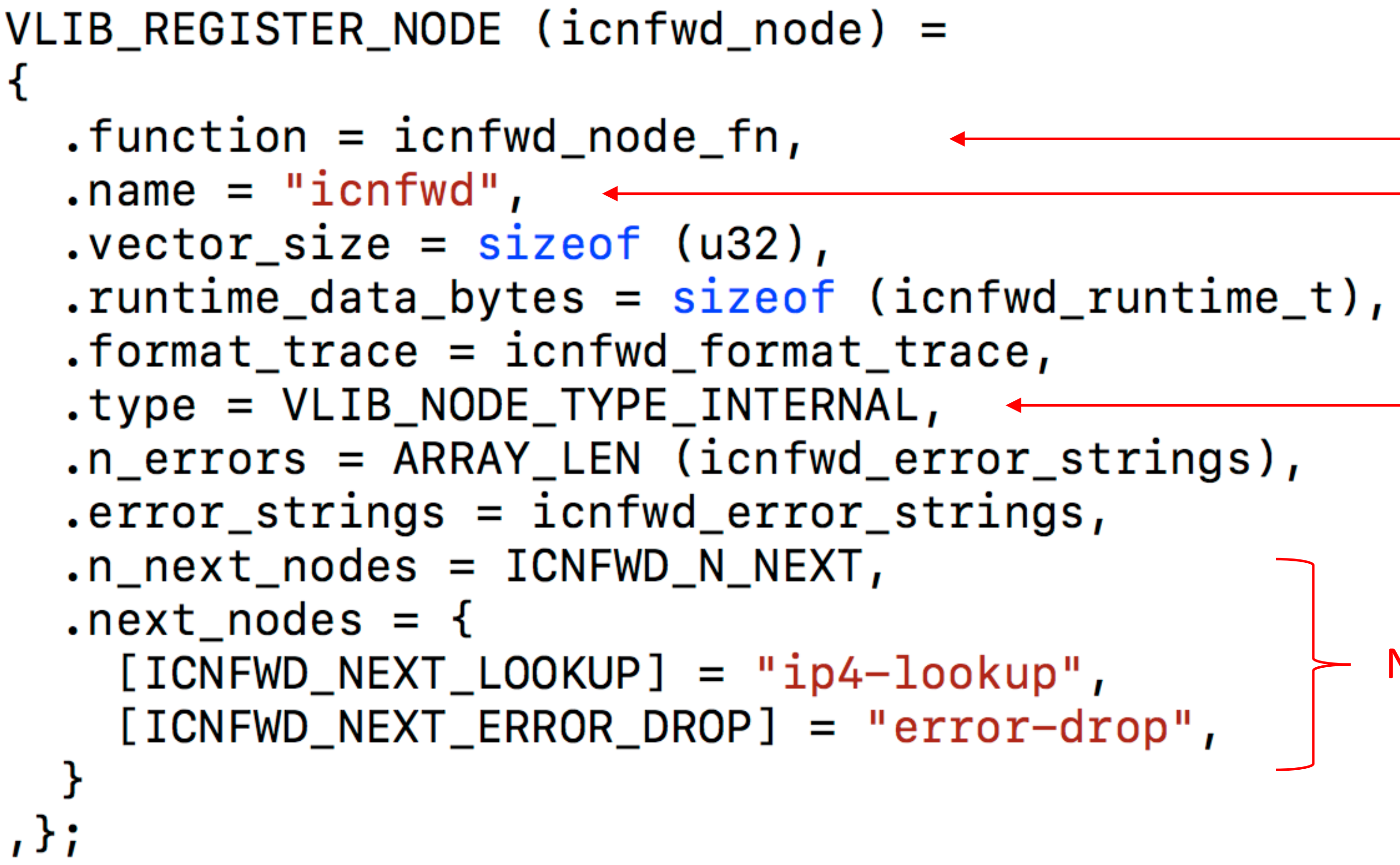
```
__VA_ARGS__ vlib_node_registration_t x;                                  \
static void __vlib_add_node_registration_##x (void)                        \
    __attribute__((__constructor__)) ;                                     \
static void __vlib_add_node_registration_##x (void)                        \
{                                                                          \
    vlib_main_t * vm = vlib_get_main();                                    \
    x.next_registration = vm->node_main.node_registrations;                \
    vm->node_main.node_registrations = &x;                                 \
}                                                                          \
__VA_ARGS__ vlib_node_registration_t x
```

Definition at line 143 of file node.h.



```
typedef struct _vlib_node_registration
{
  /* Vector processing function for this node. */
  vlib_node_function_t *function;

  /* Node name. */
  char *name;

  /* Name of sibling (if applicable). */
  char *sibling_of;

  /* Node index filled in by registration. */
  u32 index;

  /* Type of this node. */
  vlib_node_type_t type;

  /* Error strings indexed by error code for this node. */
  char **error_strings;
```

Example: Cicn plugin



```
VLIB_REGISTER_NODE (icnfwd_node) =
{
  .function = icnfwd_node_fn,
  .name = "icnfwd",
  .vector_size = sizeof (u32),
  .runtime_data_bytes = sizeof (icnfwd_runtime_t),
  .format_trace = icnfwd_format_trace,
  .type = VLIB_NODE_TYPE_INTERNAL,
  .n_errors = ARRAY_LEN (icnfwd_error_strings),
  .error_strings = icnfwd_error_strings,
  .n_next_nodes = ICNFWD_N_NEXT,
  .next_nodes = {
    [ICNFWD_NEXT_LOOKUP] = "ip4-lookup",
    [ICNFWD_NEXT_ERROR_DROP] = "error-drop",
  }
,};
```

Node processing function

Name of the node

Runtime structure

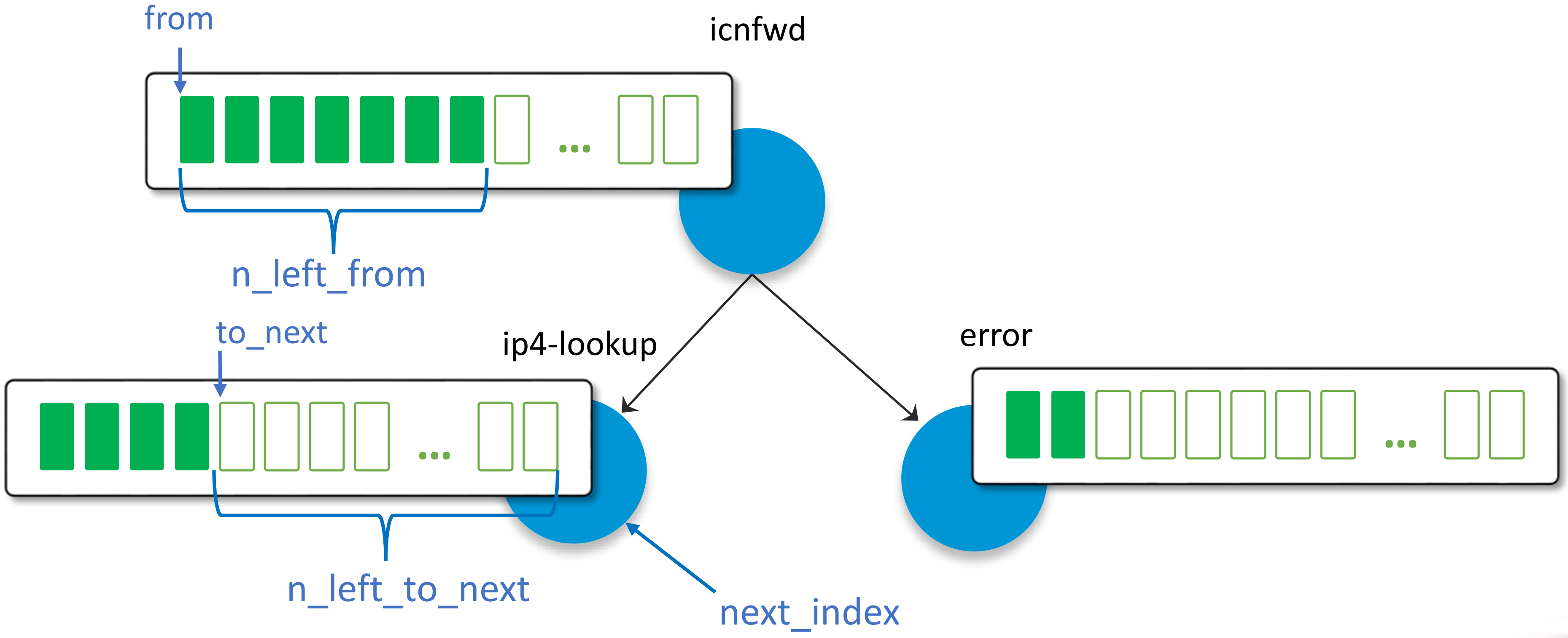
You need to initialize it by yourself

Type of node

Next nodes in the Vpp graph

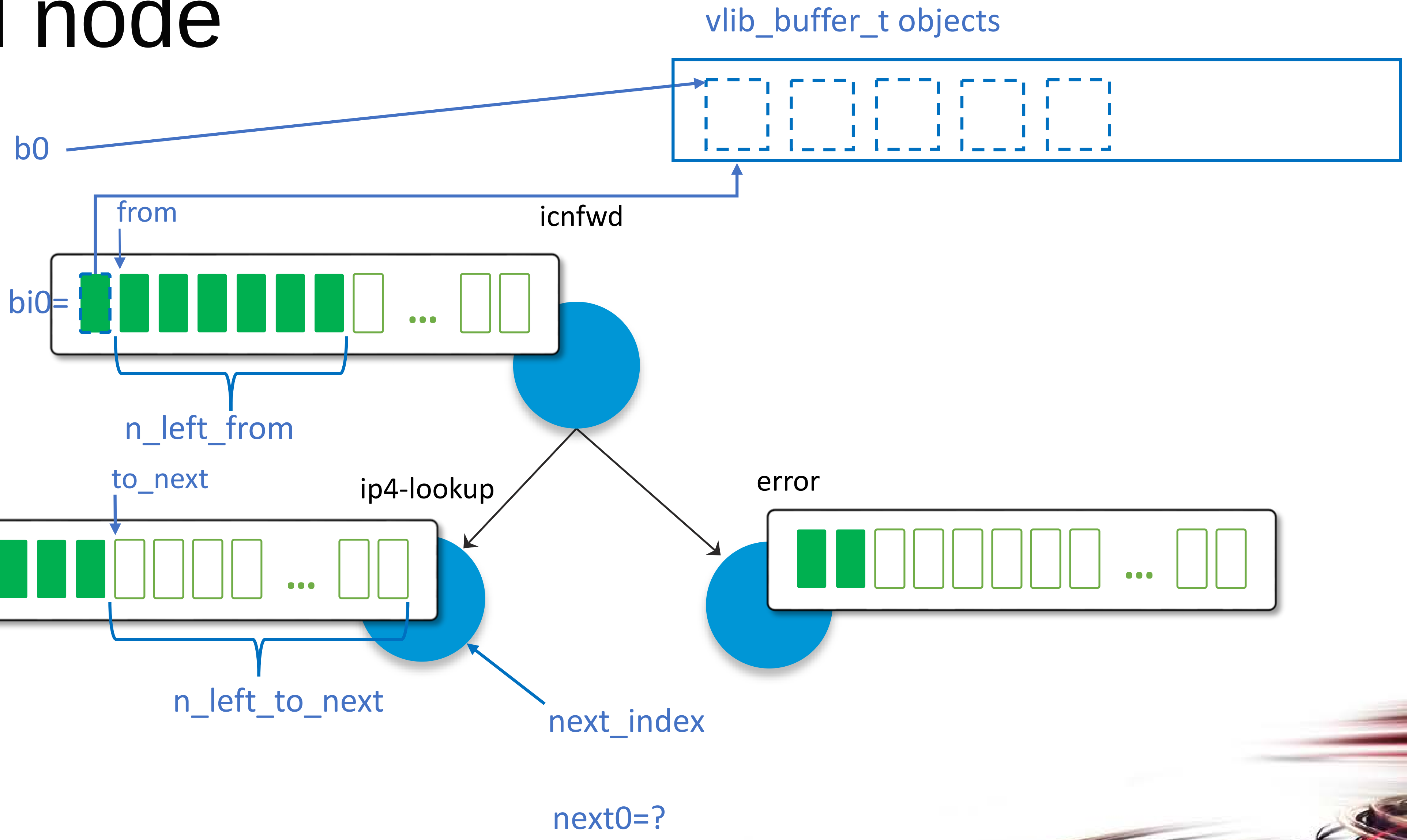
Let’s take a look to icnfwd_node_fn

icnfwd node

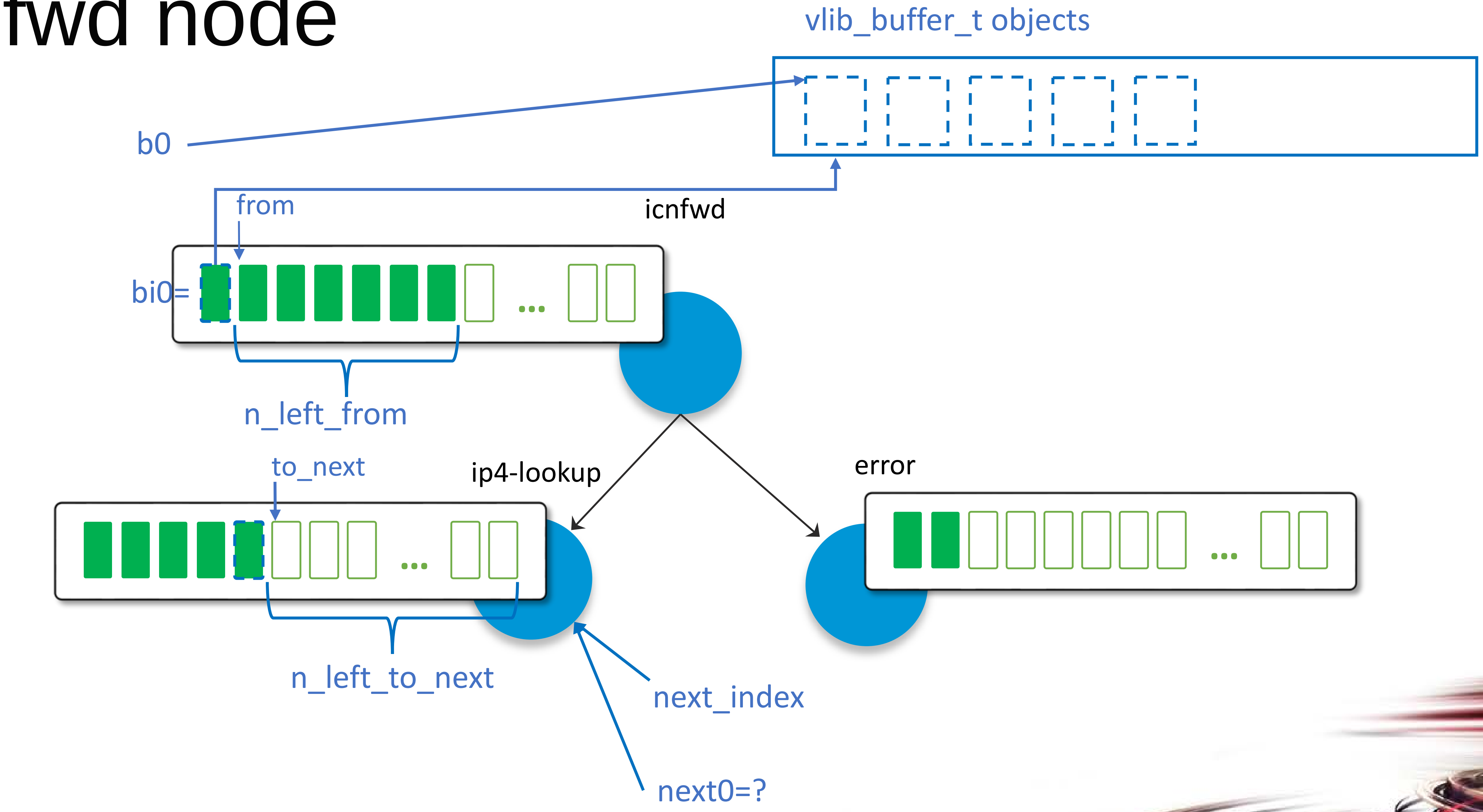


next0=? ← Hold the actual next node id

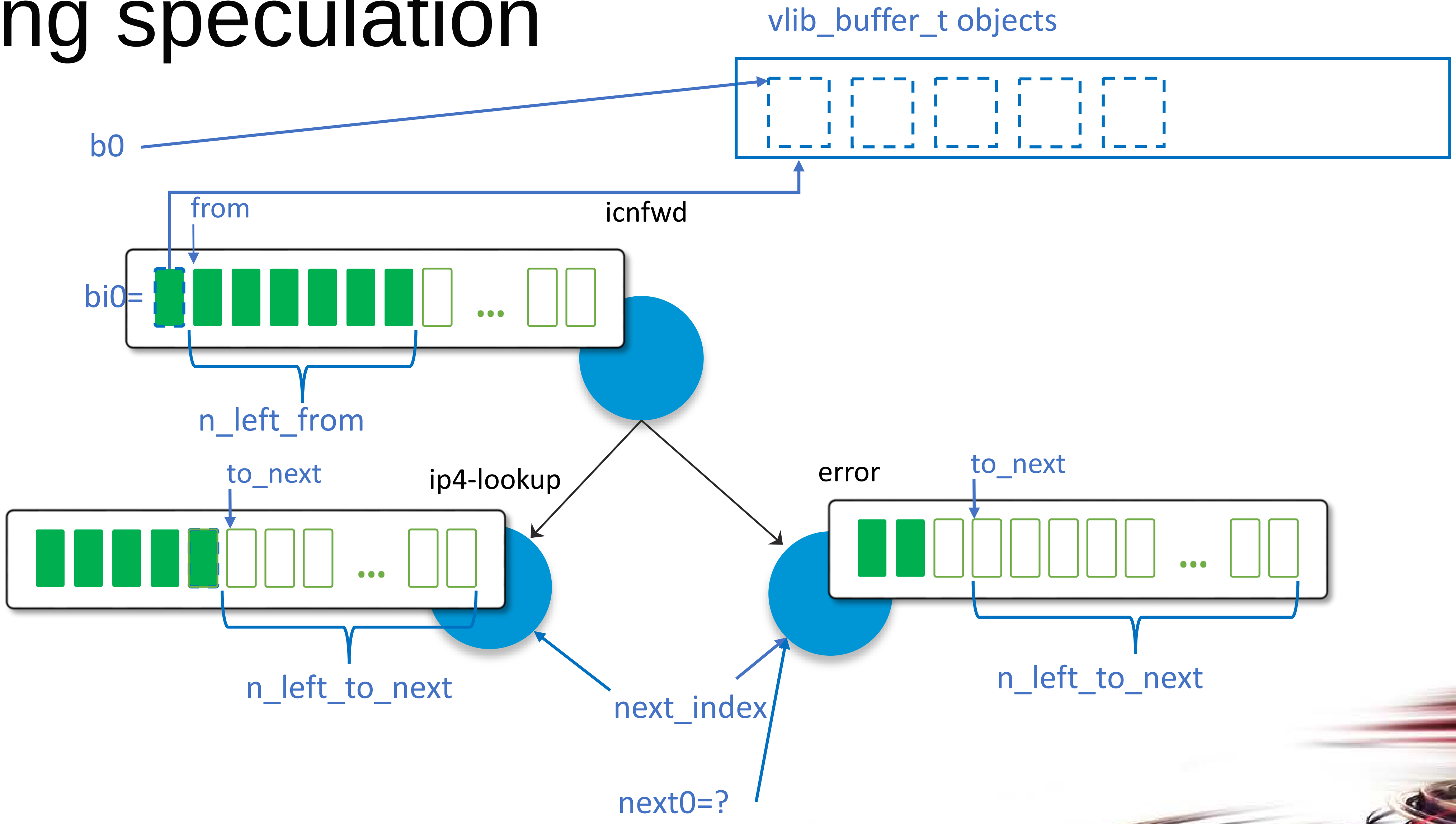
icnfwd node


vlib_buffer_t objects
b0
from
icnfwd
bi0=
...
n_left_from
to_next
ip4-lookup
error
...
...
n_left_to_next
next_index
next0=?

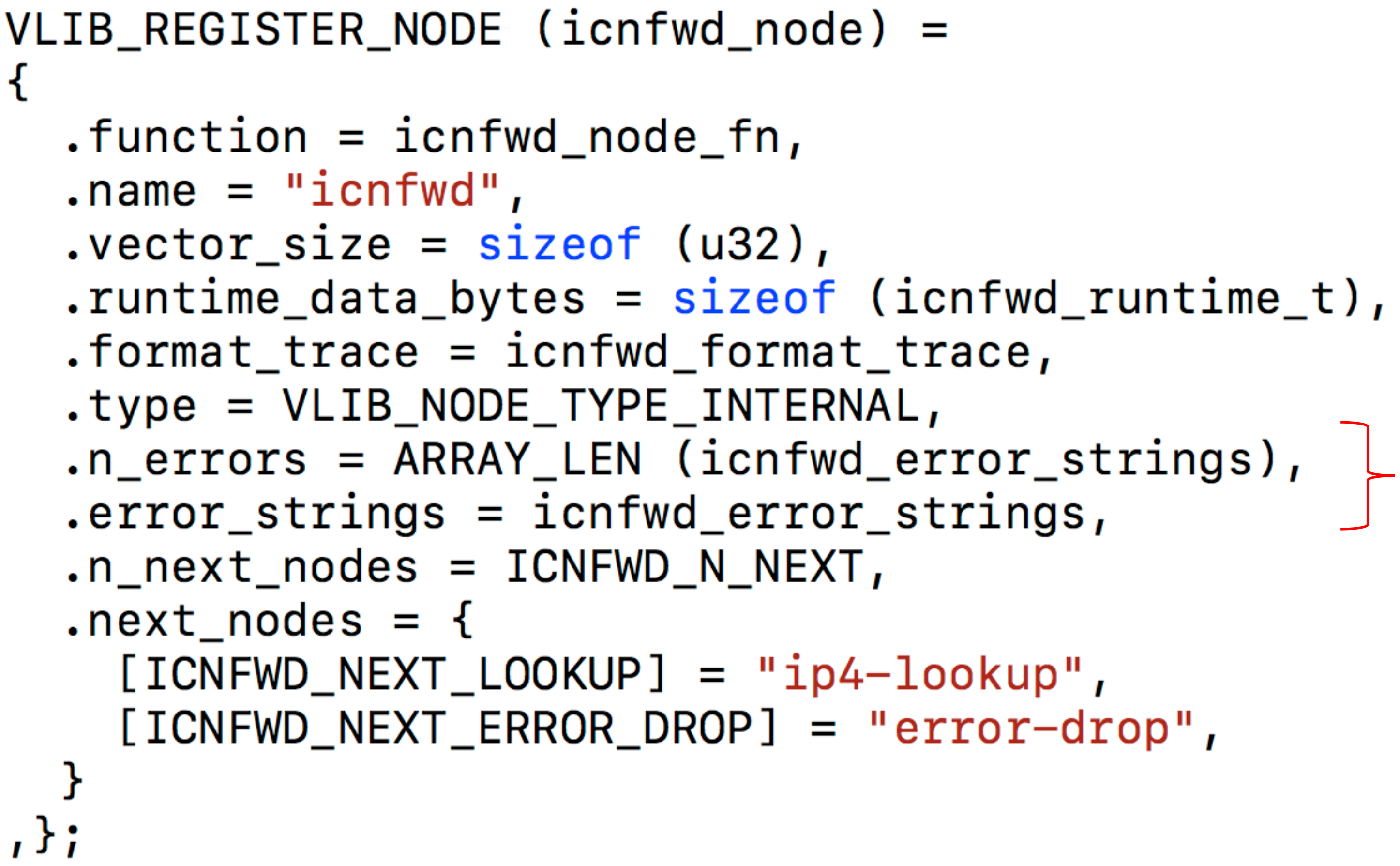
icnfwd node


vlib_buffer_t objects
b0
from
icnfwd
bi0=
...
n_left_from
to_next
ip4-lookup
error
...
...
n_left_to_next
next_index
next0=?

Wrong speculation



Example: Cicn plugin



```
VLIB_REGISTER_NODE (icnfwd_node) =
{
  .function = icnfwd_node_fn,
  .name = "icnfwd",
  .vector_size = sizeof (u32),
  .runtime_data_bytes = sizeof (icnfwd_runtime_t),
  .format_trace = icnfwd_format_trace,
  .type = VLIB_NODE_TYPE_INTERNAL,
  .n_errors = ARRAY_LEN (icnfwd_error_strings),
  .error_strings = icnfwd_error_strings,
  .n_next_nodes = ICNFWD_N_NEXT,
  .next_nodes = {
    [ICNFWD_NEXT_LOOKUP] = "ip4-lookup",
    [ICNFWD_NEXT_ERROR_DROP] = "error-drop",
  }
,};
```

Errors handling (counters)

Other important macros

- VPP_INIT_FUNCTION
  - Function that is called during VPP initialization

- VPP_REGISTER_PLUGIN
  - Required to guarantee that your plugin is actually a VPP plugin …and not a library copied by mistake in /usr/lib/vpp_plugins

Outline

- VPP structures
- Design & Implement your node(s)
- Insert your node(s) in the vlib_graph
- Compile and install your plugin

Insert your node to VPP graph

1. direct all the packets from one interface
   - vnet_hw_interface_rx_redirect_to_node (vnet_main, hw_if_index, my_graph_node.index /* redirect to my_graph_node */);

2. capture packets with a particular ethertype
   - ethernet_register_input_type (vm, ETHERNET_TYPE_CDP, cdp_input_node.index);

3. for-us packet for new protocol on top of IP
   - ip4_register_protocol (IP_PROTOCOL_GRE, gre_input_node.index);

Insert your node to VPP graph

4. ip-for-us packet sent to a specific UDP port
   - udp_register_dst_port (vm, UDP_DST_PORT_vxlan, vxlan_input_node.index, 1 /* is_ip4 */);

5. direct all packets from one ip prefix
   - Create your own Data Path Object (i.e. result of a FIB lookup)

Outline

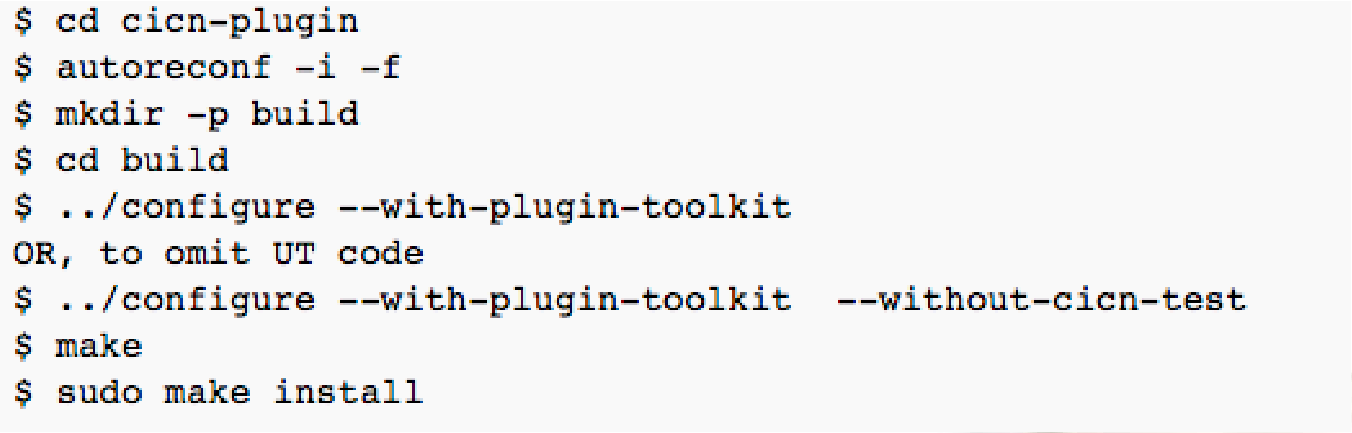
- VPP structures
- Design & Implement your node(s)
- Insert your node(s) in the vlib_graph
- Compile and install your plugin

Compiling your plugin

- VPP provides Automake/Autoconf examples
  - Install vpp-dev and move to /usr/share/doc/vpp/examples

- Adapting Makefile.am and sample.am is trivial

- Compile cicn-plugin:



```
$ cd cicn-plugin
$ autoreconf -i -f
$ mkdir -p build
$ cd build
$ ../configure --with-plugin-toolkit
OR, to omit UT code
$ ../configure --with-plugin-toolkit  --without-cicn-test
$ make
$ sudo make install
```

vICN: configuration, management and control of an virtual ICN network

Marcel Enguehard

ACM ICN Conference – CICN tutorial

September 26th 2017

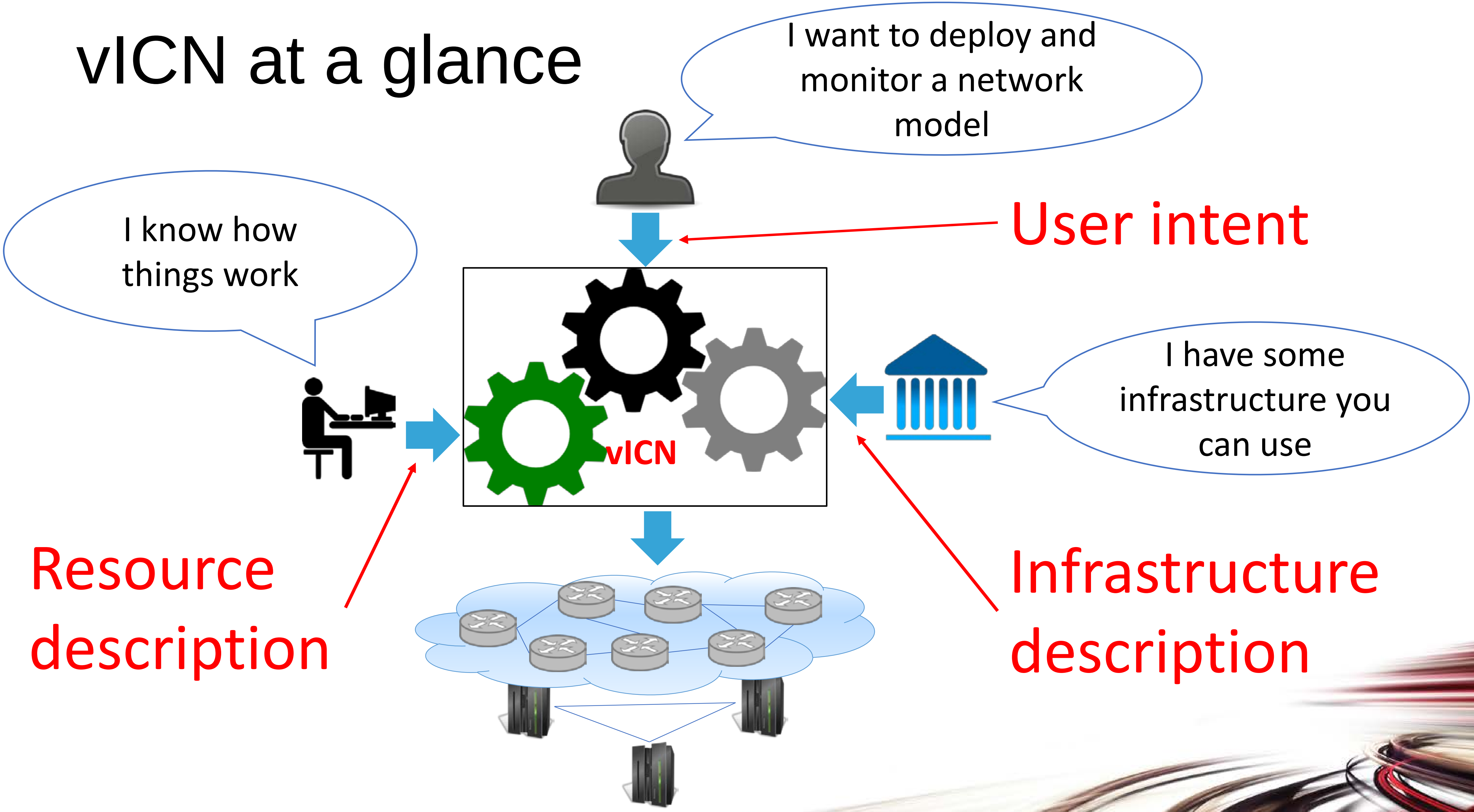
What is vICN

- Unified framework for network deployment, management and monitoring

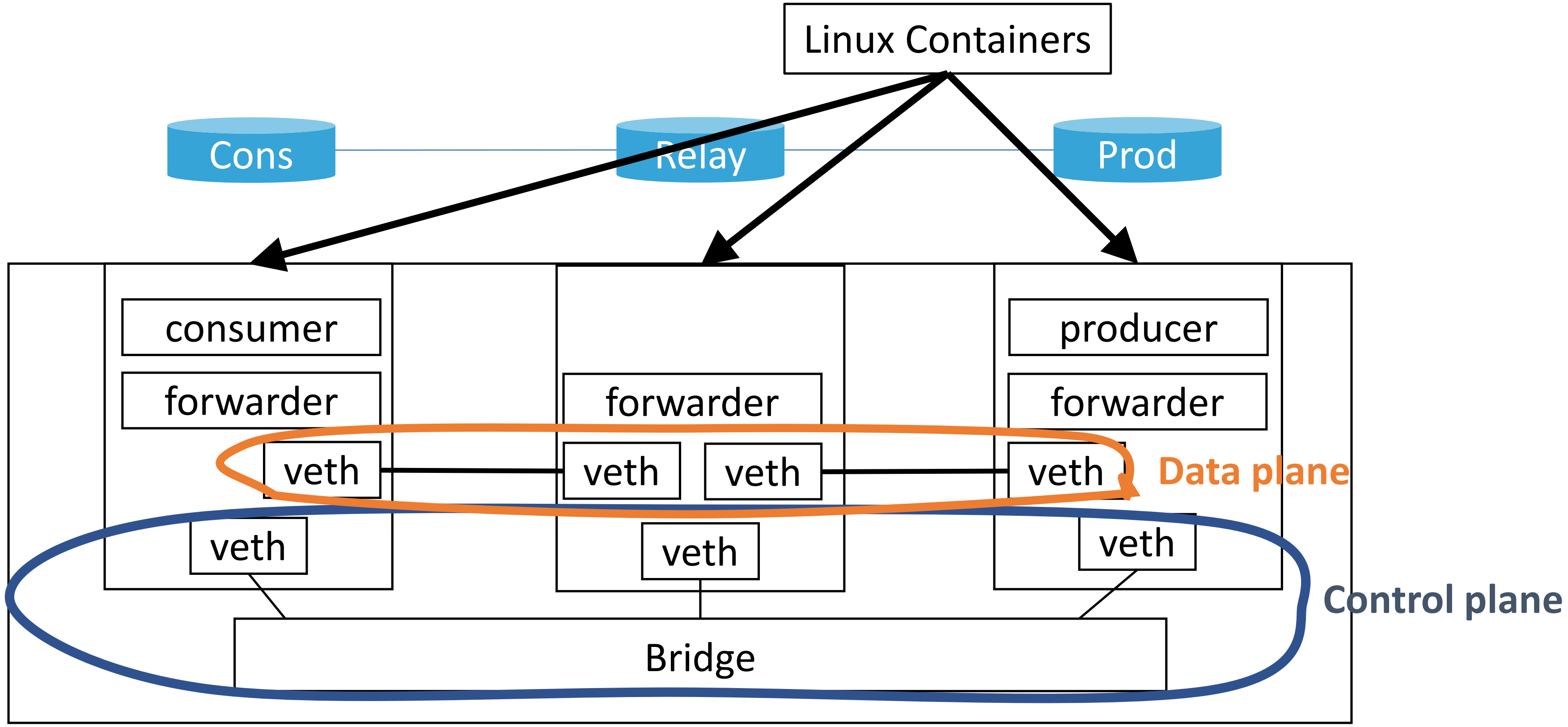
- Integrates all the tools of the CICN fd.io suite

- Provides an API to easily to bootstrap ICN deployments and get meaningful telemetry out of it

vICN at a glance


I want to deploy and monitor a network model
User intent
I know how things work
vICN
I have some infrastructure you can use
Resource description
Infrastructure description

Example vICN topology



vICN resources

Class

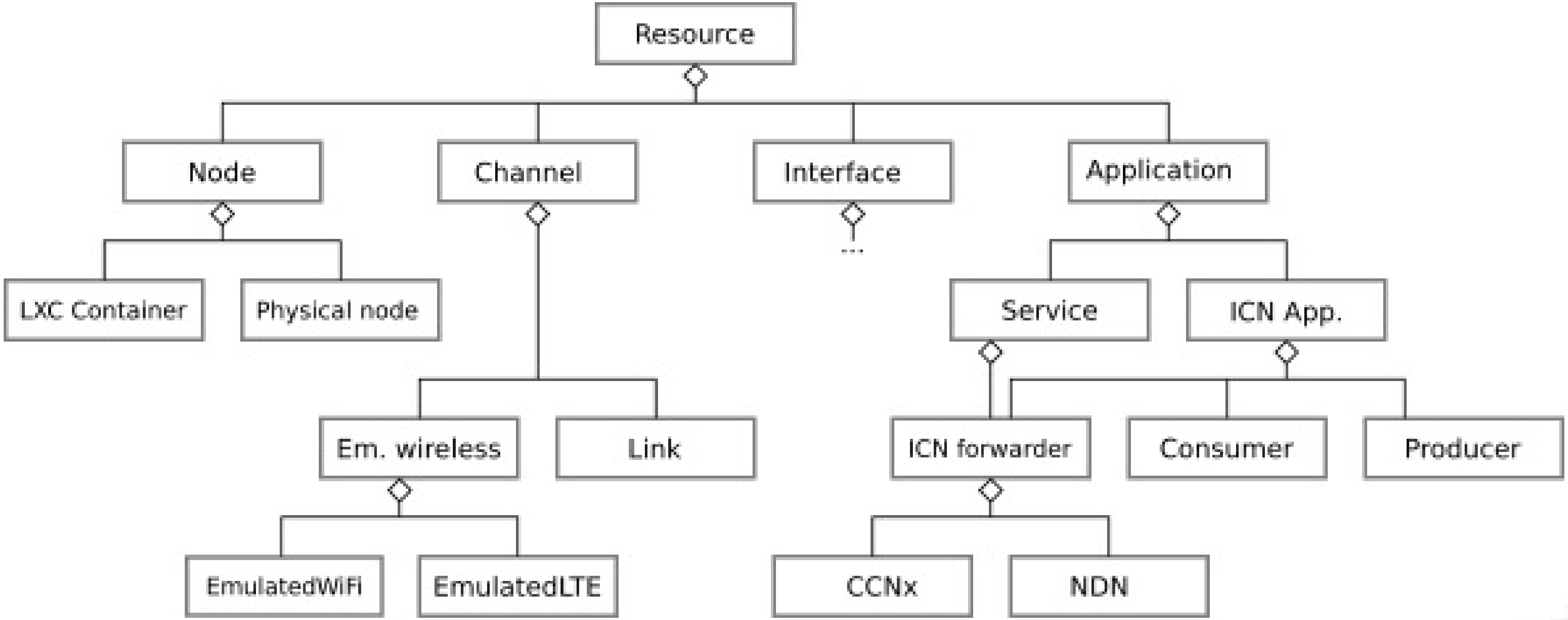
- Virtual representation of deployment element
- Node, forwarder, application, link, etc.
- Described by *attributes*

Members

Example resource: forwarder

- Represents an ICN forwarder
- Attributes:
  - node
  - cache_size
  - cache_policy (e.g., LRU)
  - log_file
  - etc.

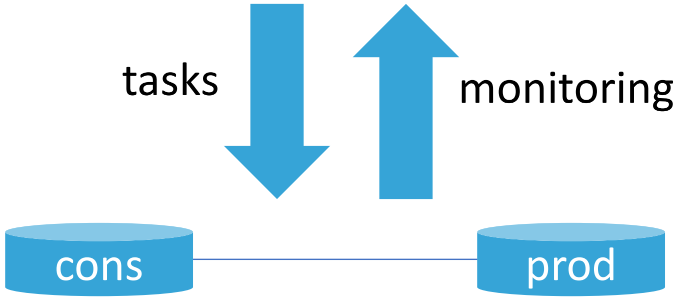
Resource hierarchy



How does it work?

- Intent based-framework
- Object-based model
- State reconciliation between model and deployment

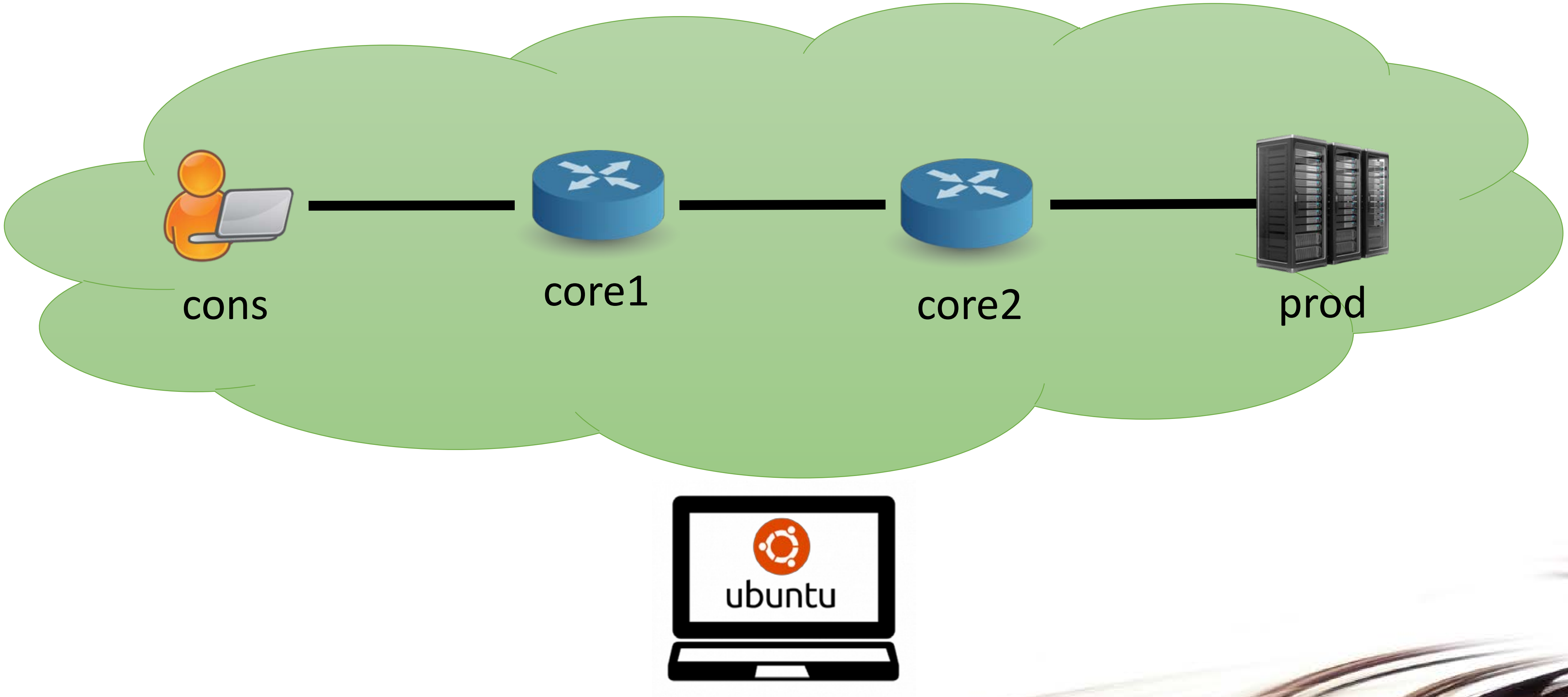
```
cons = LxcContainer()
prod = LxcContainer()
link = Link(src=cons, dst=prod)
```



vICN functionalities

- Multithreaded deployment of network models
- SDN controller for IPv4, IPv6, and ICN
- Wireless links emulation
- Connection of real devices
- Built-in monitoring through Python model

Our example deployment



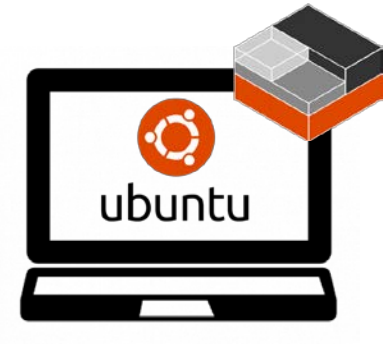
Network model deployment

Network model declaration

- JSON file containing list of resources
- Resources complemented with “key” attributes
- Intent-based declaration: descriptive approach (not imperative)

Physical resources

```
{
   "type": "Physical",
   "name": "server",
   "hostname": "localhost"
},
{
   "type": "LxcImage",
   "name": "cicn-image",
   "node": "server",
   "image": "ubuntu1604-cicnsuite-rc3"
}
```



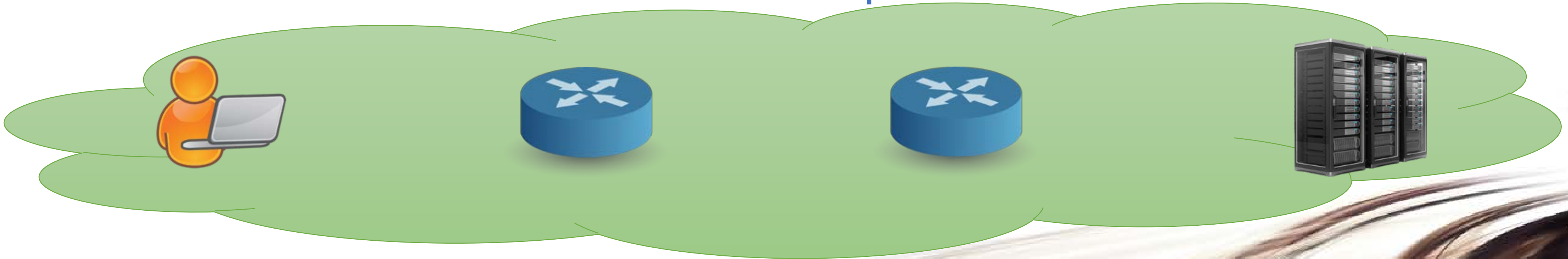
Nodes

Virtual topology

Refer to previous resources

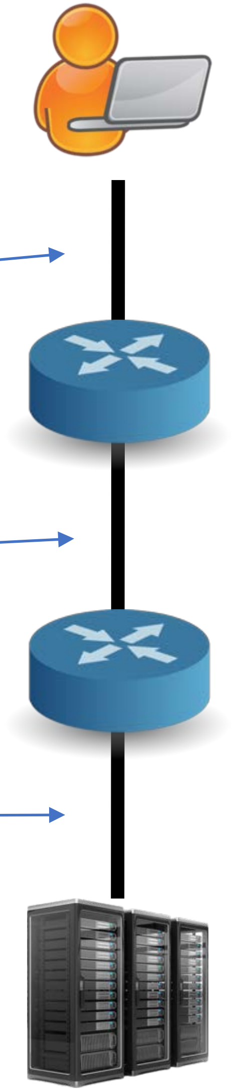
```
{
        "type" : "LxcContainer",
        "image": "cicn-image",
        "name" : "cons",
        "groups": [ "virtual" ],
        "node" : "server"
},
{
        "type" : "LxcContainer",
        "image": "cicn-image",
        "name" : "prod",
        "groups": [ "virtual" ],
        "node" : "server"
},
```

```
{
        "type" : "LxcContainer",
        "image": "cicn-image",
        "name" :  "core1",
        "groups": [ "virtual" ],
        "node" : "server"
},
{
        "type" : "LxcContainer",
        "image": "cicn-image",
        "name" : "core2",
        "groups": [ "virtual" ],
        "node" : "server"
},
```



Links

```
{
    "type": "Link",
    "src_node": "cons",
    "dst_node": "core1",
    "groups": [ "virtual" ]
},
{
    "type": "Link",
    "src_node": "core1",
    "dst_node": "core2",
    "groups": [ "virtual" ]
},
{
    "type": "Link",
    "src_node": "core2",
    "dst_node": "prod",
    "groups": [ "virtual" ]
},
```



IP networking on topology

```
{
        "type": "CentralIP",
        "ip4_data_prefix": "192.168.19.0/24",
        "ip6_data_prefix": "9001::/16",
        "ip_routing_strategy": "spt",
        "groups": [
                "virtual"
         ]
}
```

IPv6 addresses are attributed by /64

Defines objects on which to act

`CentralIP` is similar to an SDN controller that assigns addresses and sets up the routing in the network:

`CentralIP = (Ipv4Assignment | Ipv6Assignment) > IPRoutes`

ICN forwarders

```
{
        "type": "MetisForwarder",
        "cache_size": 0,
        "node": "cons"
},
{
        "type": "MetisForwarder",
        "cache_size": 2000,
        "node": "core1"
},
{
        "type": "MetisForwarder",
        "cache_size": 0,
        "node": "core2"
},
{
        "type": "MetisForwarder",
        "cache_size": 0,
        "node": "prod"
},
```

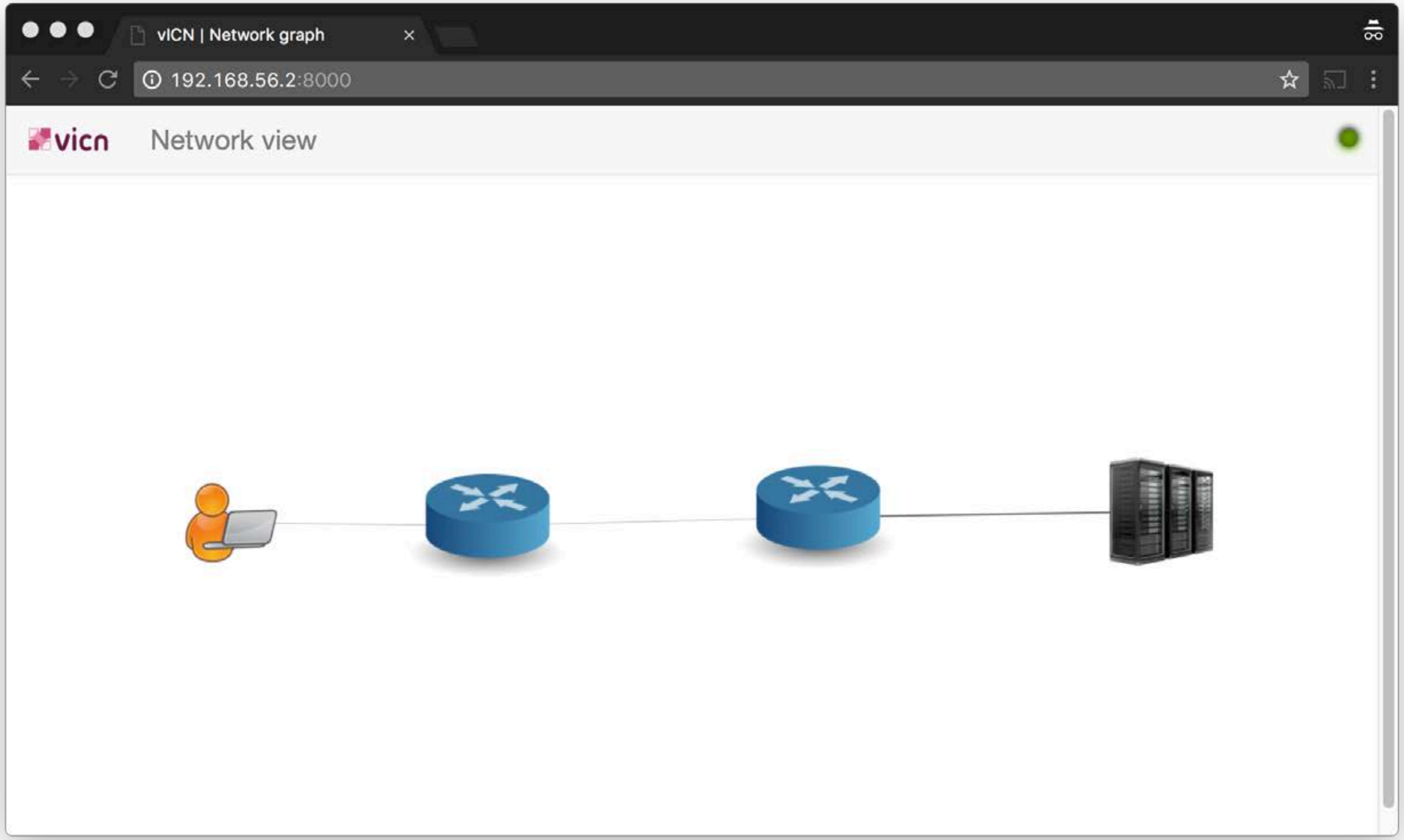
```
{
        "type": "WebServer",
        "prefixes": [
                "/webserver"
        ],
        "node": "prod"
},
{
        "type": "CentralICN",
        "groups": [ "virtual" ],
        "face_protocol": "udp4"
}
```

Like CentralIP

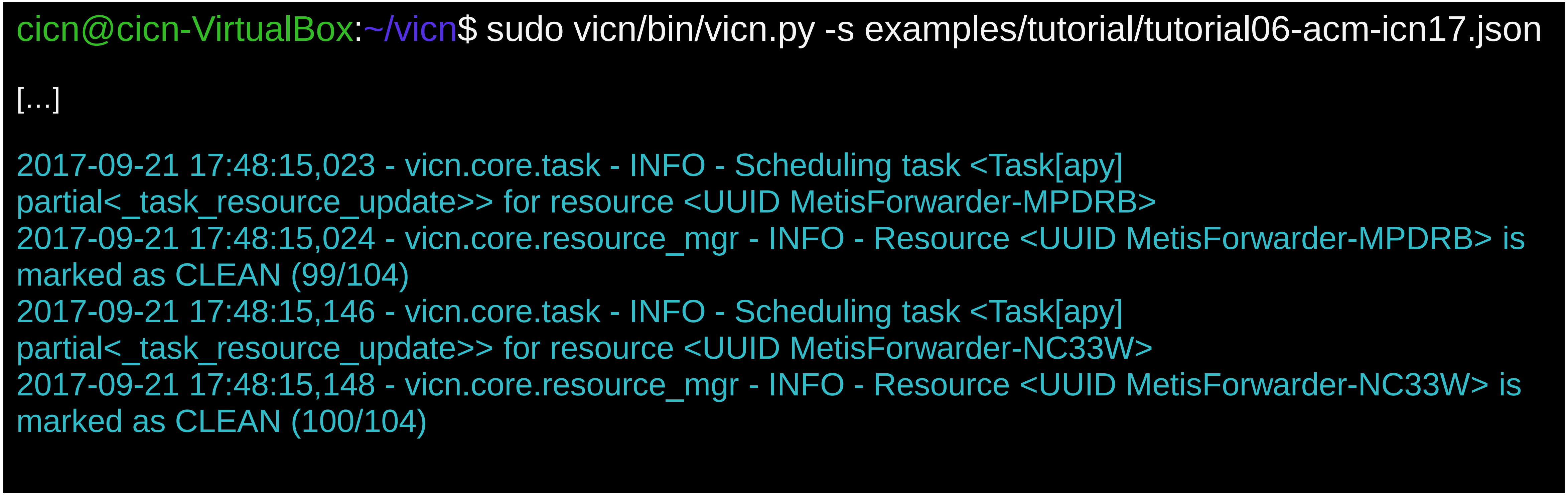
ether, udp4, udp6, tcp4, tcp6

GUI

```
{
        "type": "GUI",
        "groups": ["virtual"]
},
```



Launching vicn



```
cicn@cicn-VirtualBox:~/vicn$ sudo vicn/bin/vicn.py -s examples/tutorial/tutorial06-acm-icn17.json

[...]

2017-09-21 17:48:15,023 - vicn.core.task - INFO - Scheduling task <Task[apy]
partial<_task_resource_update>> for resource <UUID MetisForwarder-MPDRB>
2017-09-21 17:48:15,024 - vicn.core.resource_mgr - INFO - Resource <UUID MetisForwarder-MPDRB> is
marked as CLEAN (99/104)
2017-09-21 17:48:15,146 - vicn.core.task - INFO - Scheduling task <Task[apy]
partial<_task_resource_update>> for resource <UUID MetisForwarder-NC33W>
2017-09-21 17:48:15,148 - vicn.core.resource_mgr - INFO - Resource <UUID MetisForwarder-NC33W> is
marked as CLEAN (100/104)
```

Traffic creation

Producer setup:

- producer-test

```
producer-test -D ccnx:/webserver
```

- Webserver

```
http-server -p $server_folder -l
http://webserver
```

Consumer setup

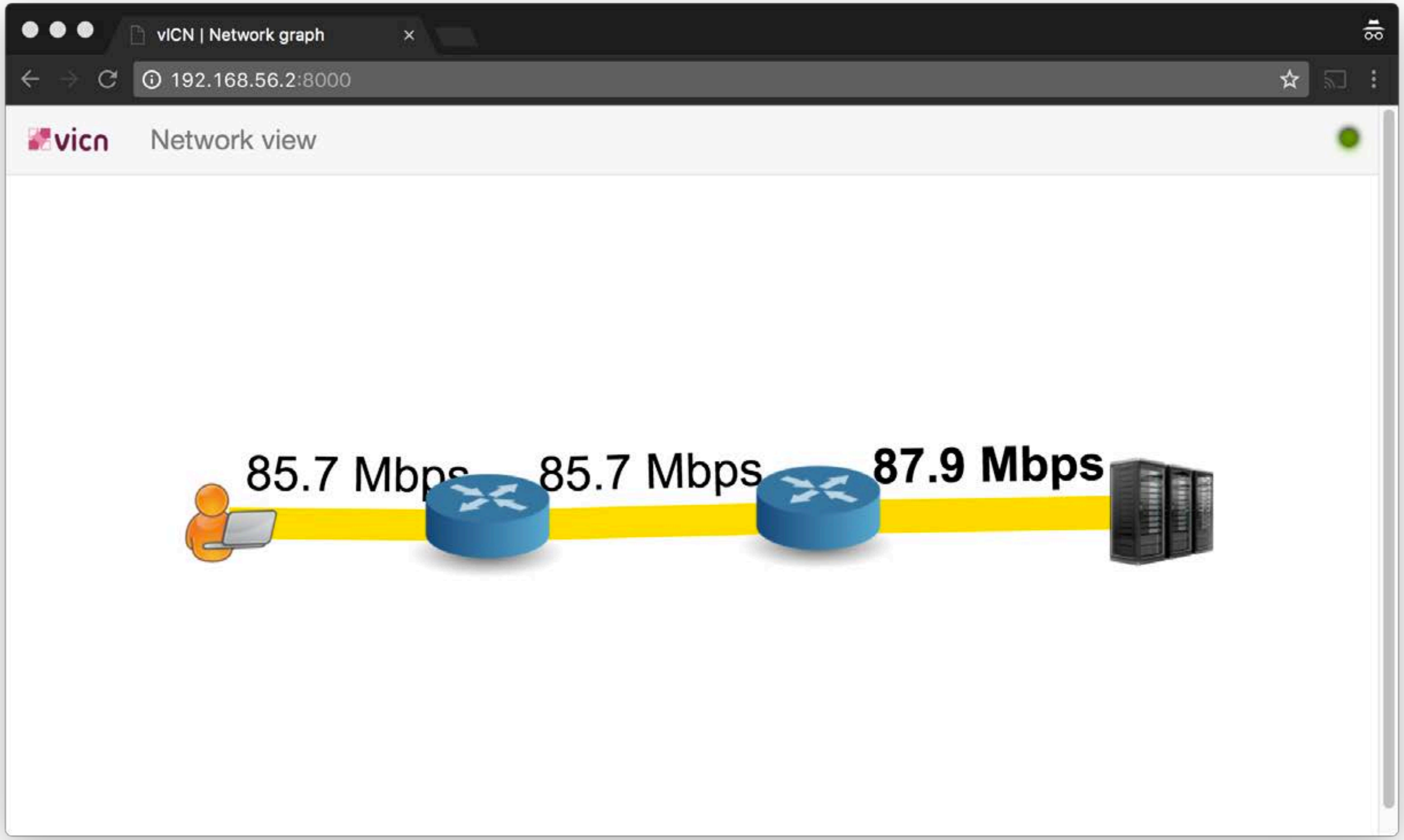
- consumer-test

```
consumer-test -D ccnx:/webserver
```

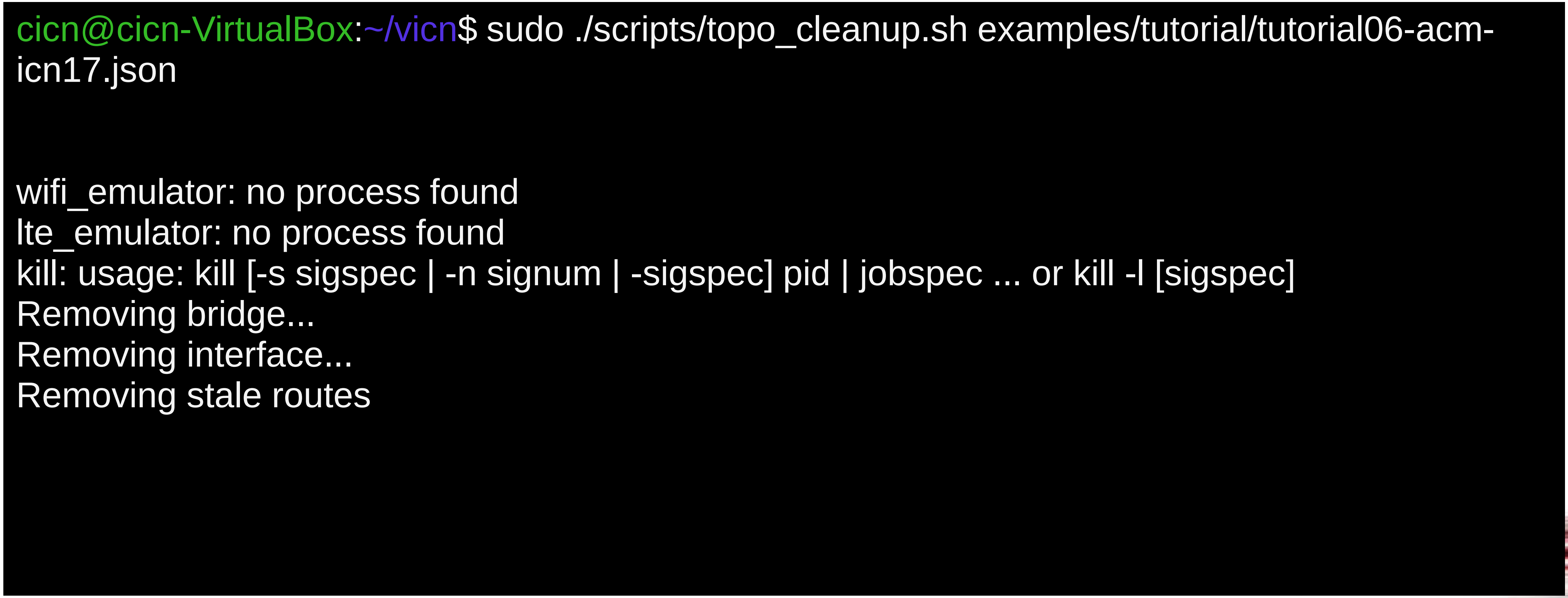
- iget

```
iget http://webserver/$filename
```

Traffic visualization on the GUI



Network teardown

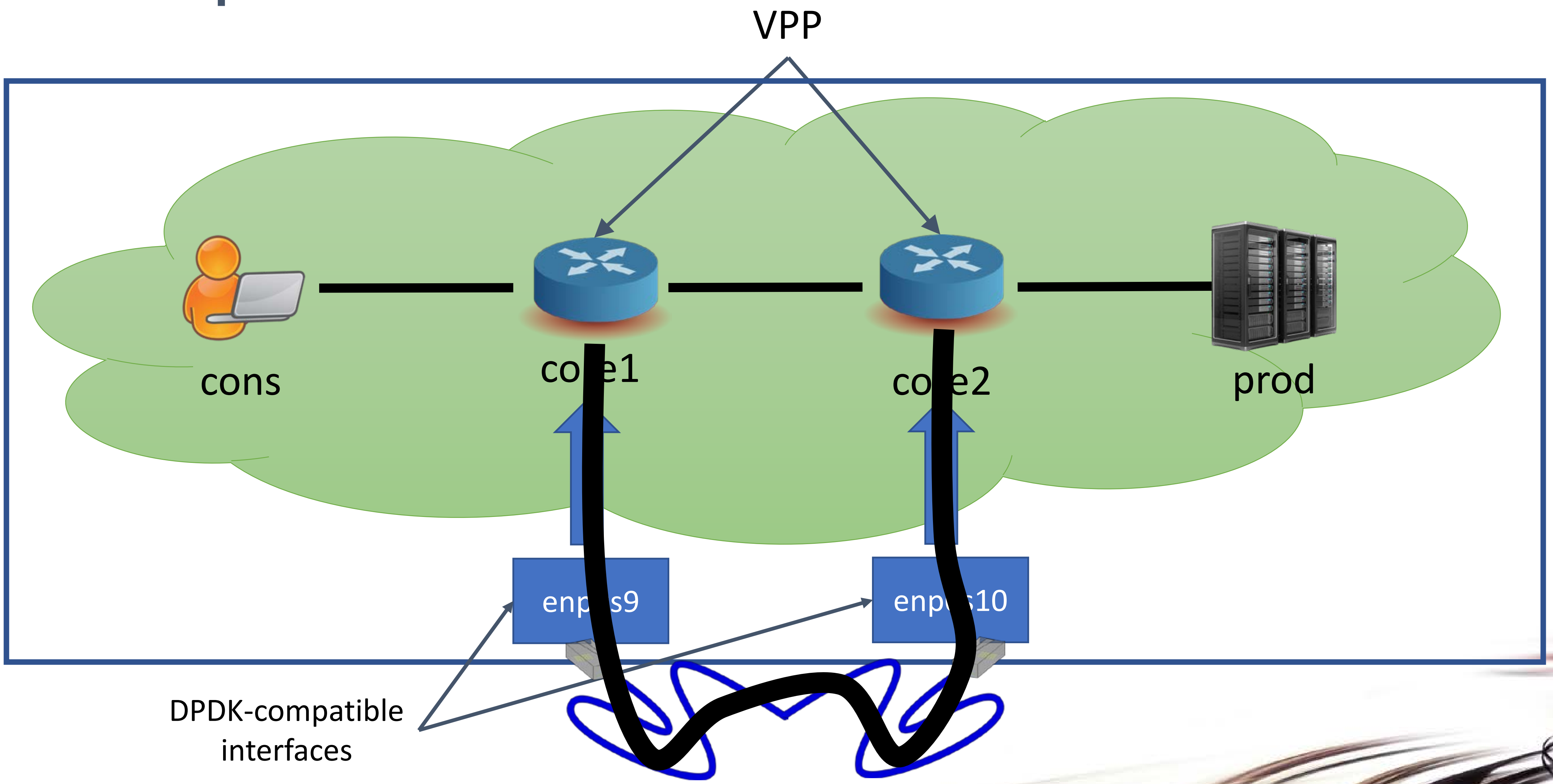


```
cicn@cicn-VirtualBox:~/vicn$ sudo ./scripts/topo_cleanup.sh examples/tutorial/tutorial06-acm-icn17.json



wifi_emulator: no process found
lte_emulator: no process found
kill: usage: kill [-s sigspec | -n signum | -sigspec] pid | jobspec ... or kill -l [sigspec]
Removing bridge...
Removing interface...
Removing stale routes
```

VPP in vICN

- Objective: learn to setup vICN to use your Intel interfaces
- VPP running in container
- Uses DPDK and ZC-forwarding

Setup

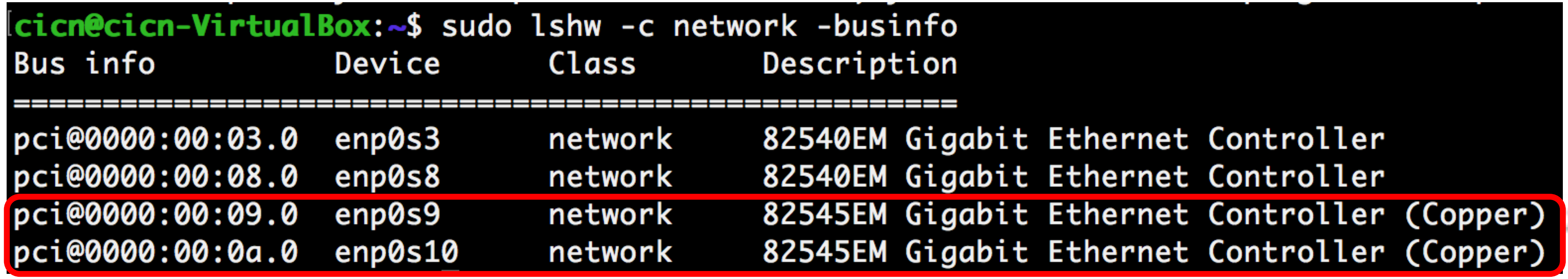

VPP
cons
core1
core2
prod
enp s9
enp s10
DPDK-compatible interfaces

Identifying the DPDK interfaces

Compare:

```
sudo lshw -c network -businfo
```

with http://dpdk.org/doc/nics

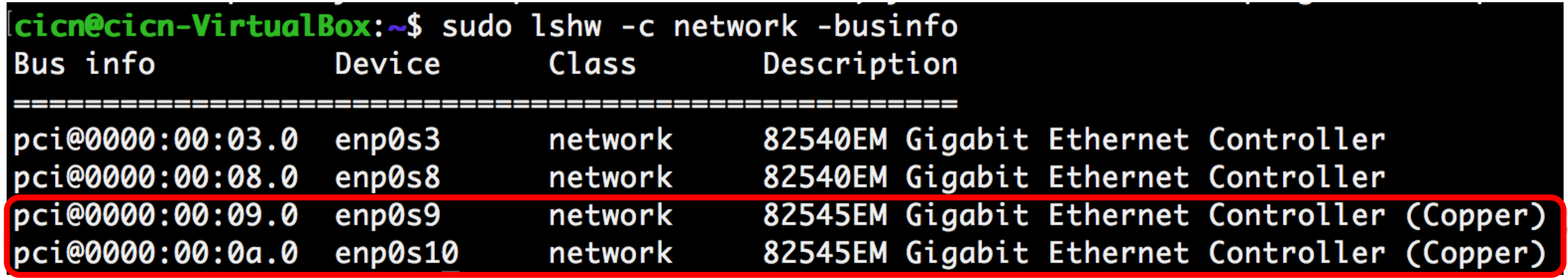


```
cicn@cicn-VirtualBox:~$ sudo lshw -c network -businfo
Bus info          Device      Class      Description
=====================================================
pci@0000:00:03.0  enp0s3      network    82540EM Gigabit Ethernet Controller
pci@0000:00:08.0  enp0s8      network    82540EM Gigabit Ethernet Controller
pci@0000:00:09.0  enp0s9      network    82545EM Gigabit Ethernet Controller (Copper)
pci@0000:00:0a.0  enp0s10     network    82545EM Gigabit Ethernet Controller (Copper)
```

Declaring the DPDK Interfaces

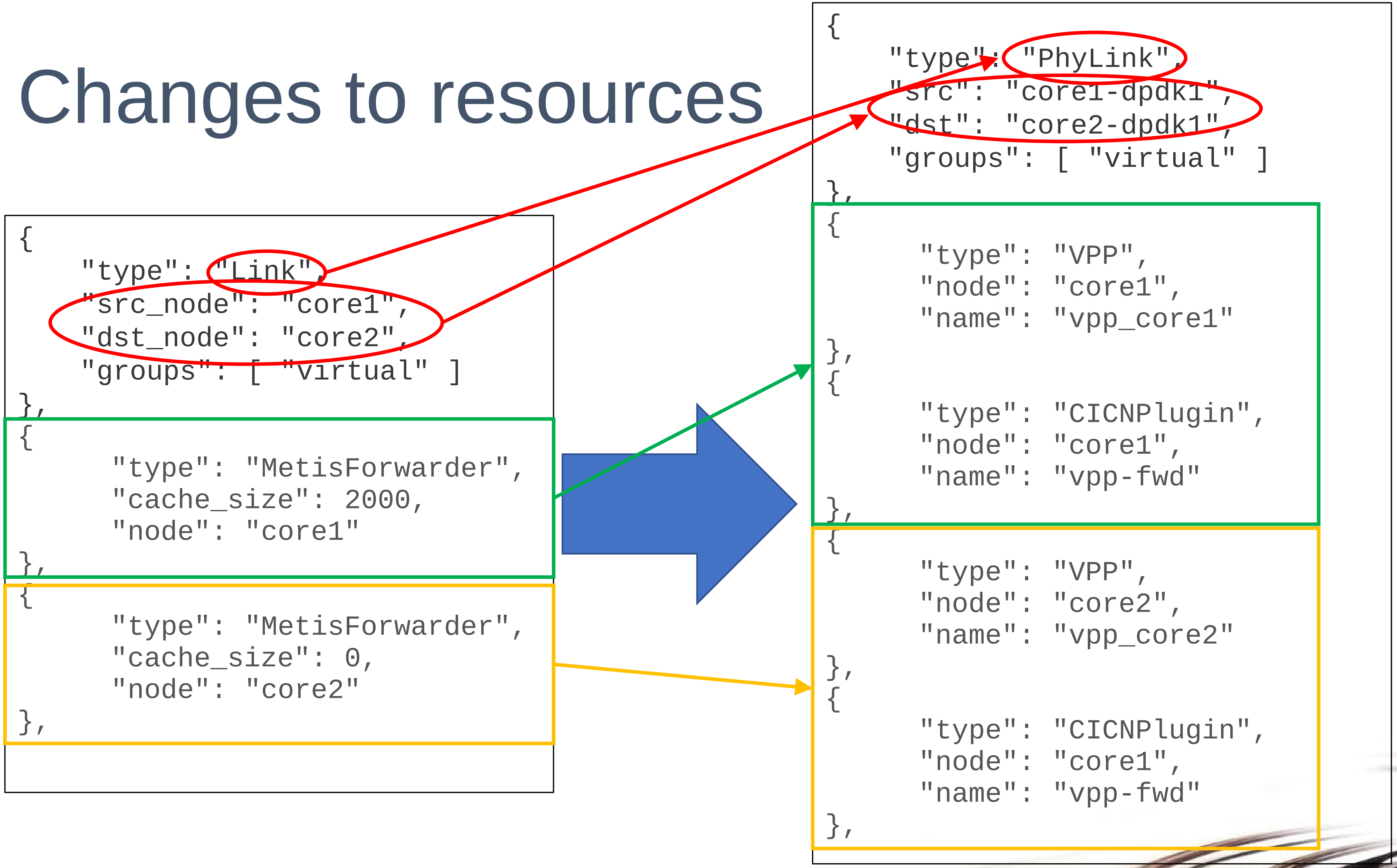
```
{
        "type": "DpdkDevice",
        "name": "core1-dpdk1",
        "mac_address": "08:00:27:44:9a:38",
        "node": "core1",
        "device_name": "enp0s9",
        "pci_address": "0000:00:09.0"
},
```

```
{
        "type": "DpdkDevice",
        "name": "core2-dpdk1",
        "mac_address": "08:00:27:18:42:f2",
        "node": "core2",
        "device_name": "enp0s10",
        "pci_address": "0000:00:0a.0"
},
```



```
cicn@cicn-VirtualBox:~$ sudo lshw -c network -businfo
Bus info          Device      Class      Description
=====================================================
pci@0000:00:03.0  enp0s3      network    82540EM Gigabit Ethernet Controller
pci@0000:00:08.0  enp0s8      network    82540EM Gigabit Ethernet Controller
pci@0000:00:09.0  enp0s9      network    82545EM Gigabit Ethernet Controller (Copper)
pci@0000:00:0a.0  enp0s10     network    82545EM Gigabit Ethernet Controller (Copper)
```

Changes to resources



```
{
    "type": "Link",
    "src_node": "core1",
    "dst_node": "core2",
    "groups": [ "virtual" ]
},
{
      "type": "MetisForwarder",
      "cache_size": 2000,
      "node": "core1"
},
{
      "type": "MetisForwarder",
      "cache_size": 0,
      "node": "core2"
},
```

```
{
    "type": "PhyLink",
    "src": "core1-dpdk1",
    "dst": "core2-dpdk1",
    "groups": [ "virtual" ]
},
{

      "type": "VPP",
      "node": "core1",
      "name": "vpp_core1"

},
{

      "type": "CICNPlugin",
      "node": "core1",
      "name": "vpp-fwd"
},
{

      "type": "VPP",
      "node": "core2",
      "name": "vpp_core2"
},
{

      "type": "CICNPlugin",
      "node": "core1",
      "name": "vpp-fwd"
},
```

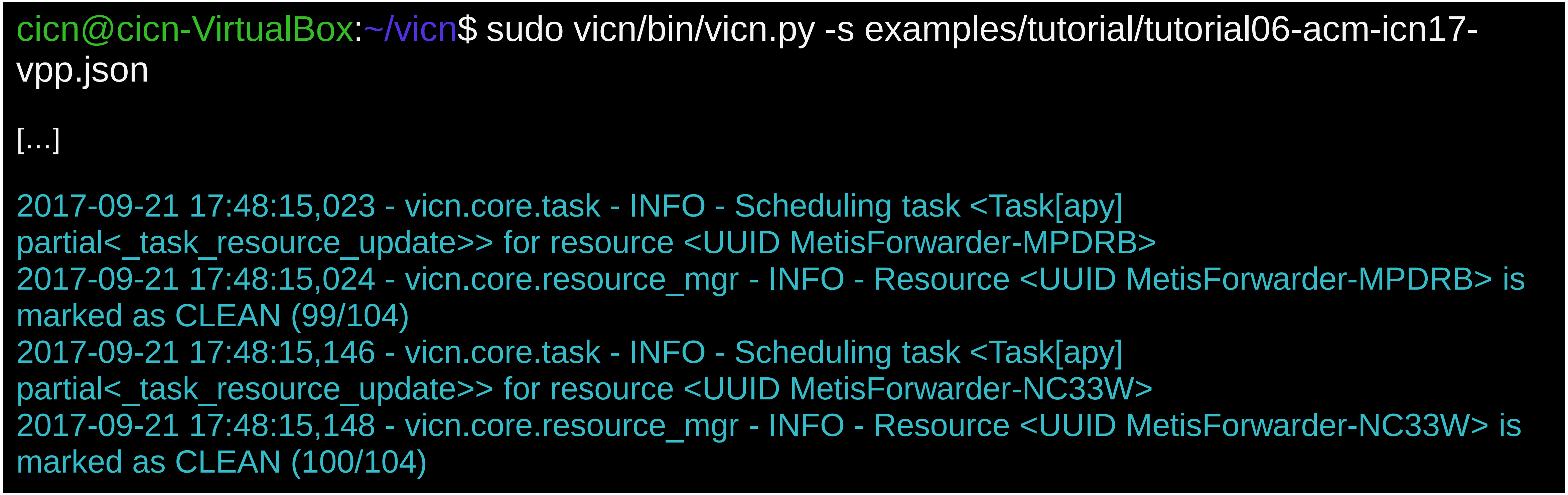
What is vICN actually doing?

- VPP-ready host
  - Install (if necessary) the DPDK driver and load it in the host kernel
  - Change driver for DPDK-compatible devices
  - Change number of hugepages for VPP
- VPP-ready container
  - Create a privileged container by changing its apparmor profile
  - Add DPDK-enabled interfaces to the container

What is vICN actually doing? (cont’d)

- Start VPP on the container
  - Create configuration file for VPP in the container
  - Start VPP
  - Set up IP forwarding
- Start CICN plugin in VPP
  - Enable CICN plugin
  - Set up ICN faces and routes

Launching vicn



```
cicn@cicn-VirtualBox:~/vicn$ sudo vicn/bin/vicn.py -s examples/tutorial/tutorial06-acm-icn17-
vpp.json

[…]

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```

Traffic creation

Producer setup:

- producer-test

```
producer-test -D ccnx:/webserver
```

- Webserver

```
http-server -p $server_folder -l
http://webserver
```

Consumer setup

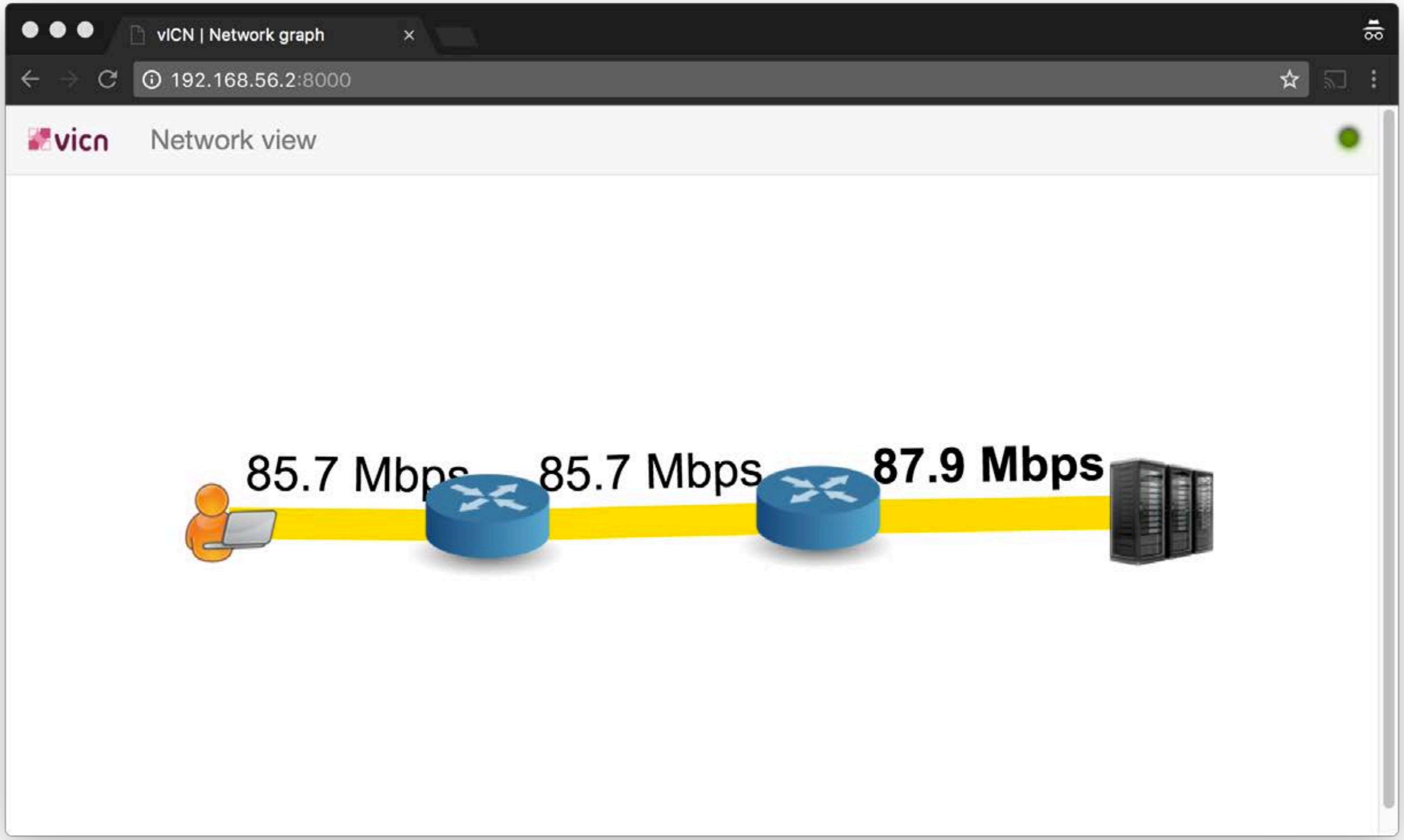
- consumer-test

```
consumer-test -D ccnx:/webserver
```

- iget

```
iget http://webserver/$filename
```

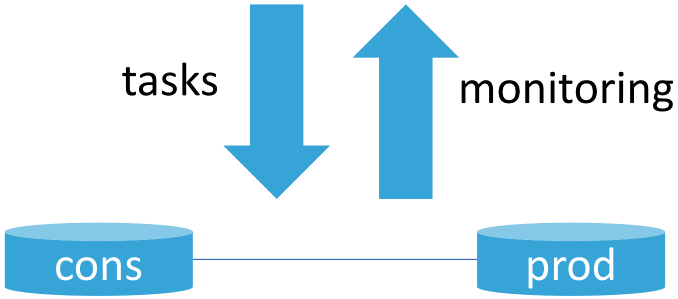
Traffic visualization on the GUI



Toward a new Python API

Use python objects instead of static JSON file

```
cons = LxcContainer()
prod = LxcContainer()
link = Link(src=cons, dst=prod)
```



More on vICN

- Demonstration session: new dynamic python API
- Thursday 10:50am: vICN paper presentation

Available tutorials

In `examples/tutorial/`:

- `tutorial01.json` → Simple topology
- `tutorial02-dumbell` → VPP
- `tutorial03-hetnets.json` → Wireless emulators
- `tutorial06-acm-icn17*` → Today's tutorial (soon)

https://wiki.fd.io/view/Vicn#Tutorials_overview

References

vICN wiki: https://wiki.fd.io/View/Vicn

vICN paper: http://conferences.sigcomm.org/acm-icn/2017/proceedings/icn17-26.pdf

vICN code: git clone -b vicn/master https://gerrit.fd.io/r/cicn vicn

Libicnet: transport layer library for ICN

Mauro Sardara

Tutorial at ACM SIGCOMM ICN, Berlin, Germany
26th of September 2017

What is Libicnet?

- Library implementing a transport layer and exposing **socket API** to applications willing to communicate through an ICN protocol stack

- Relieves applications from the task of managing layer 4 problems, such as **segmentation and congestion control**

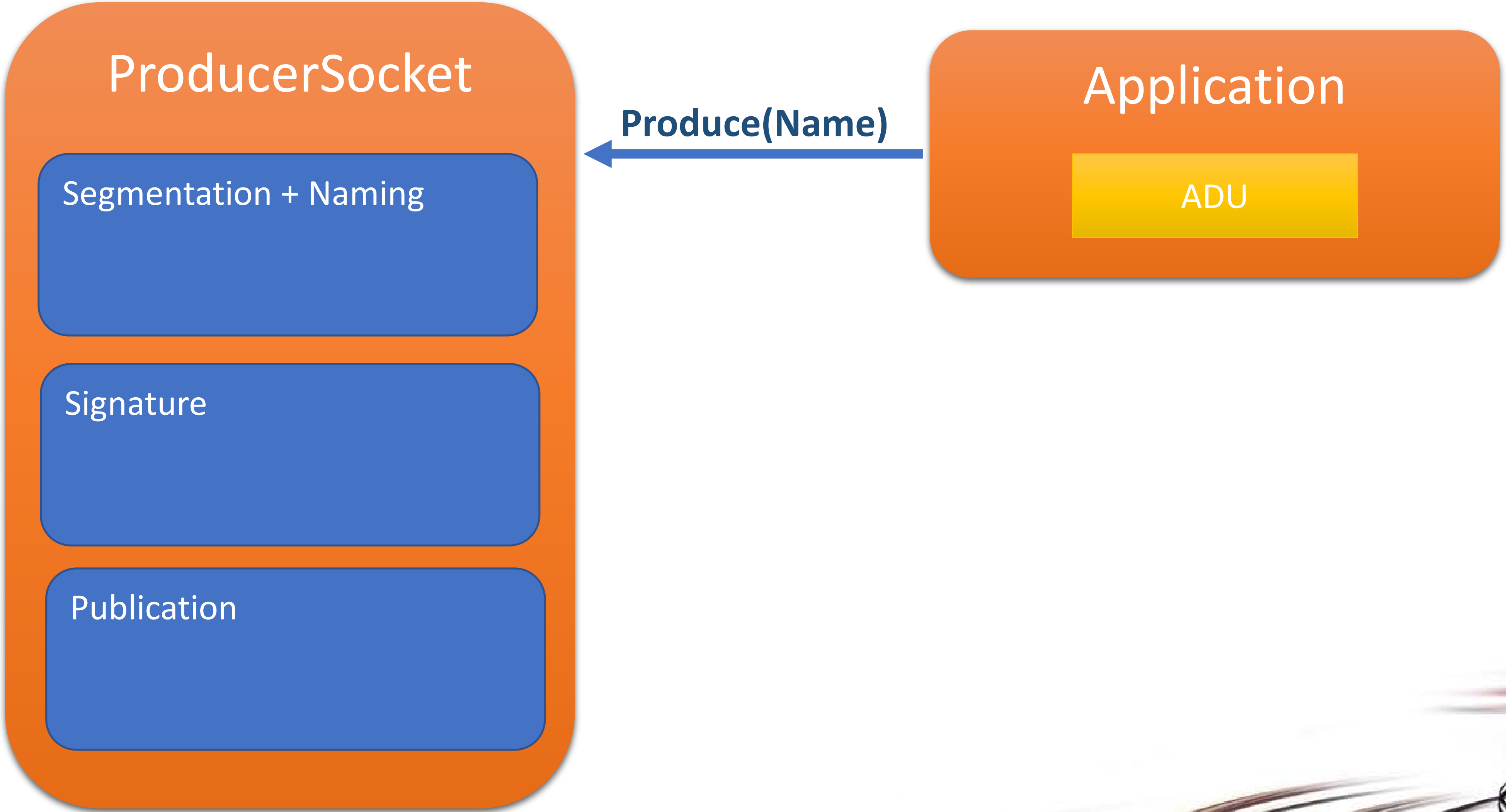
- Enhances the **separation** between Application Data Unit (ADU) and Protocol Data Unit (PDU) processing

Core Elements

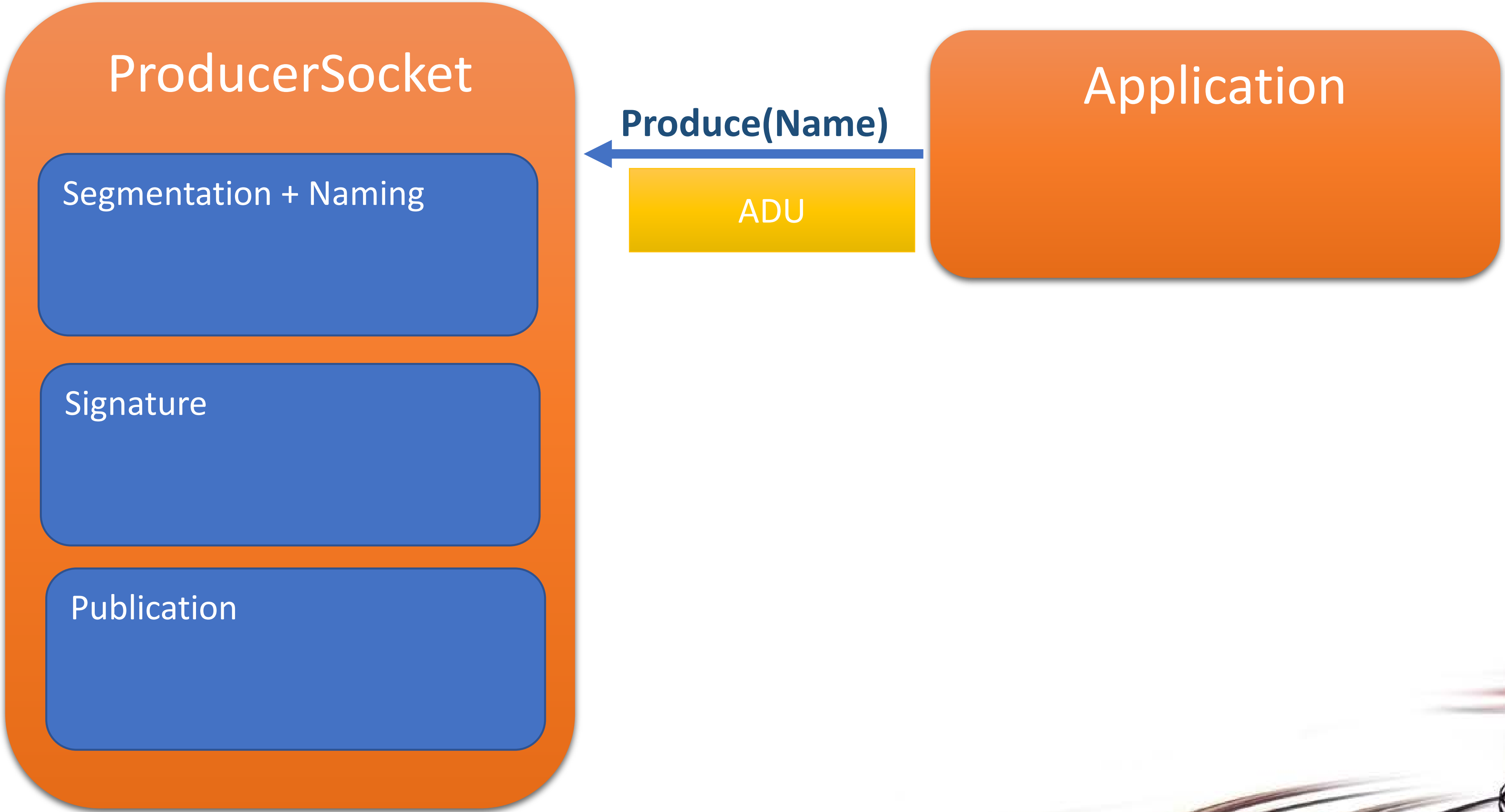
- ProducerSocket
  - ADU Segmentation and Naming → Layer 4 PDU (ICN Content Object)
  - L4 PDU Signature
  - L4 PDU Publication

- ConsumerSocket
  - Congestion control
  - L4 PDU Fetching
  - Signature verification
  - L4 PDU reassembly → ADU

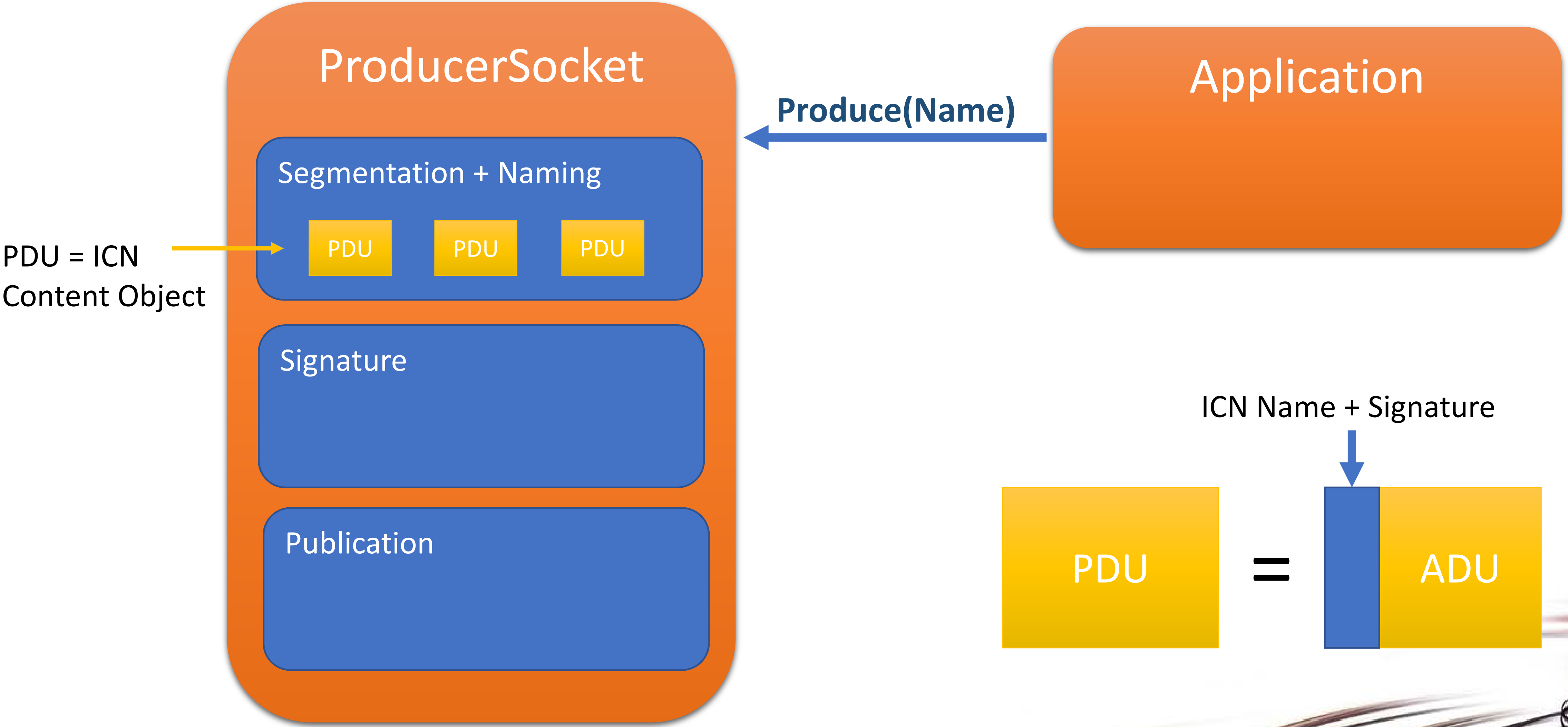
ProducerSocket



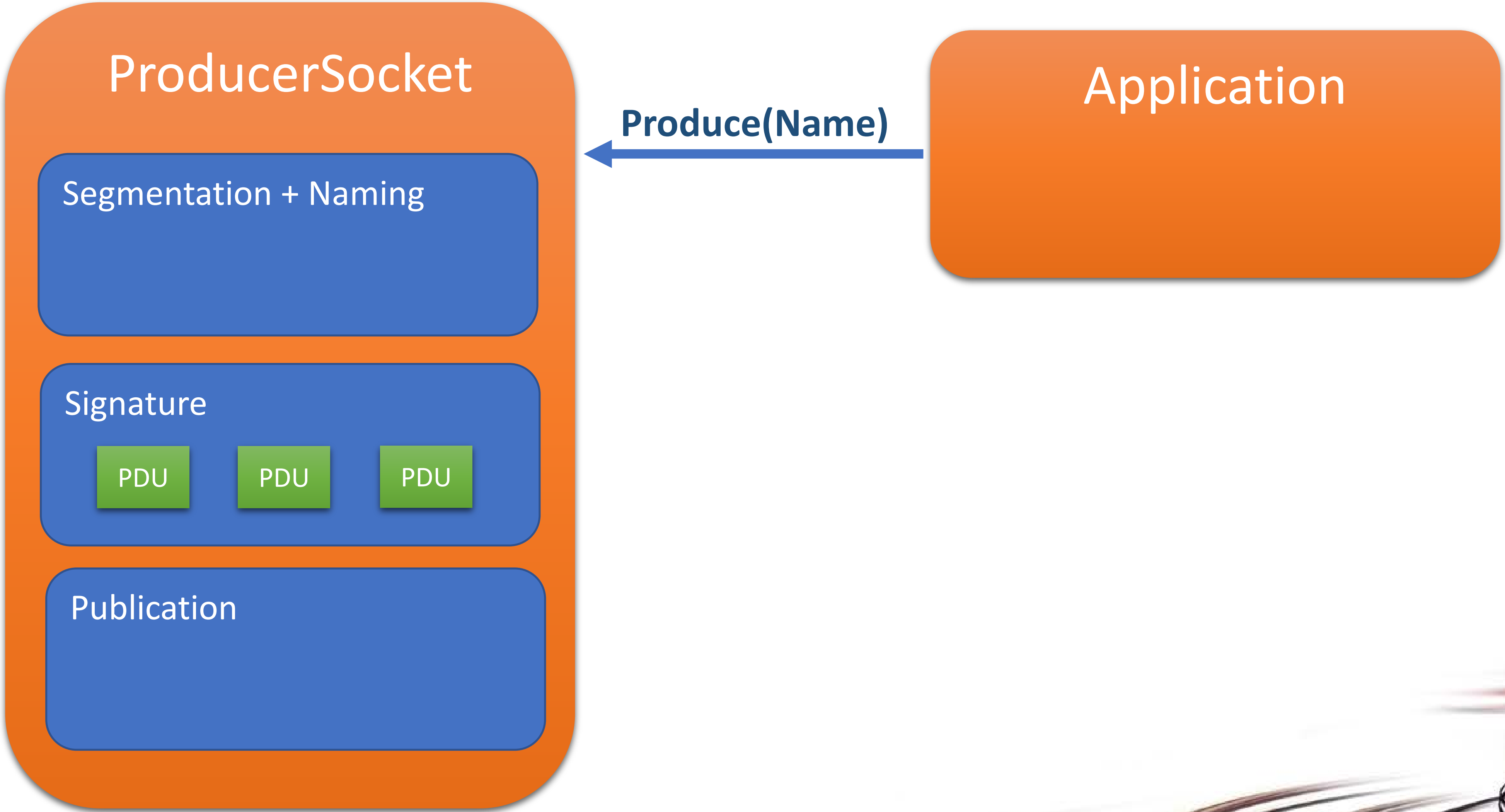
ProducerSocket



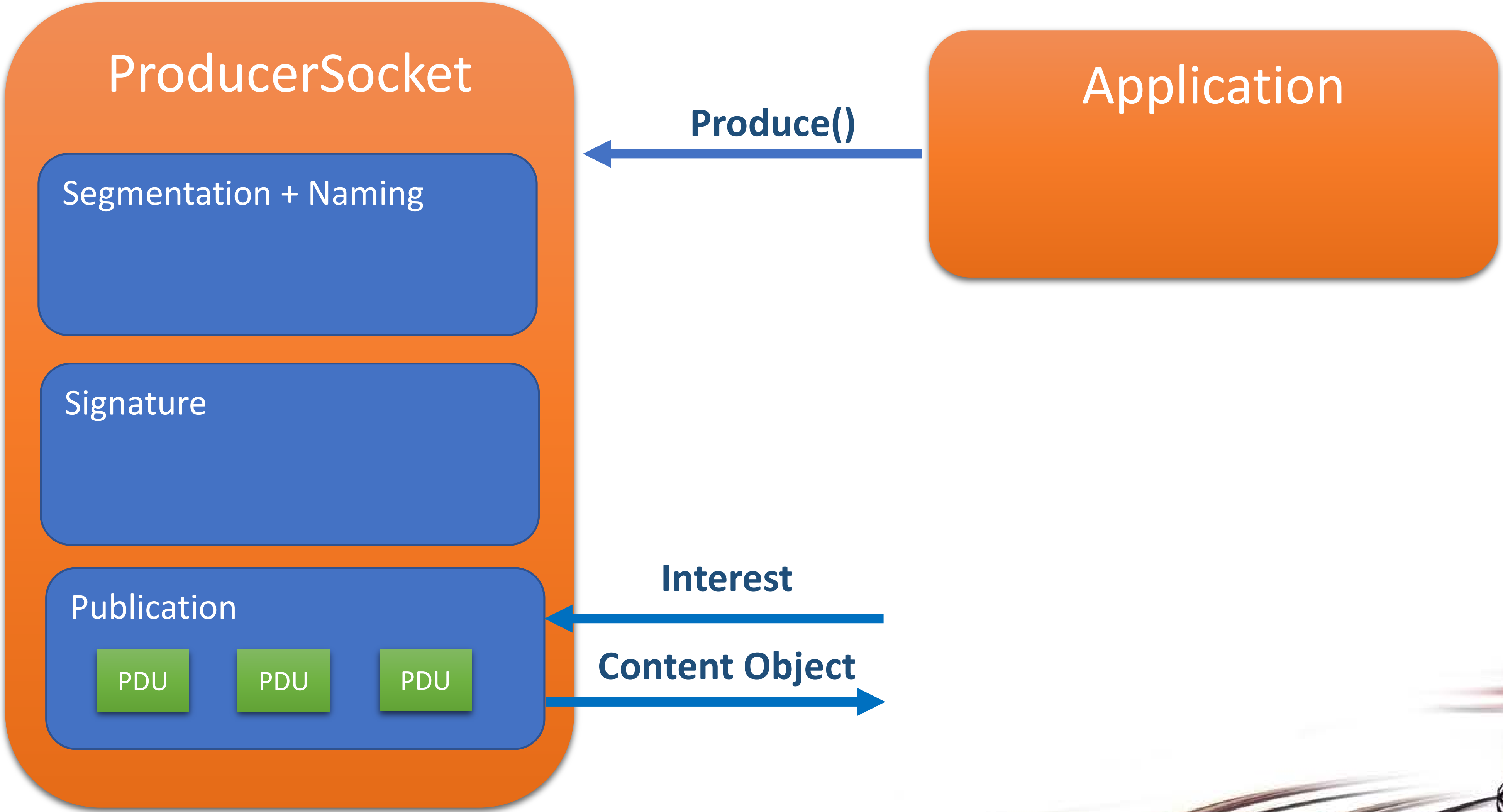
ProducerSocket



ProducerSocket

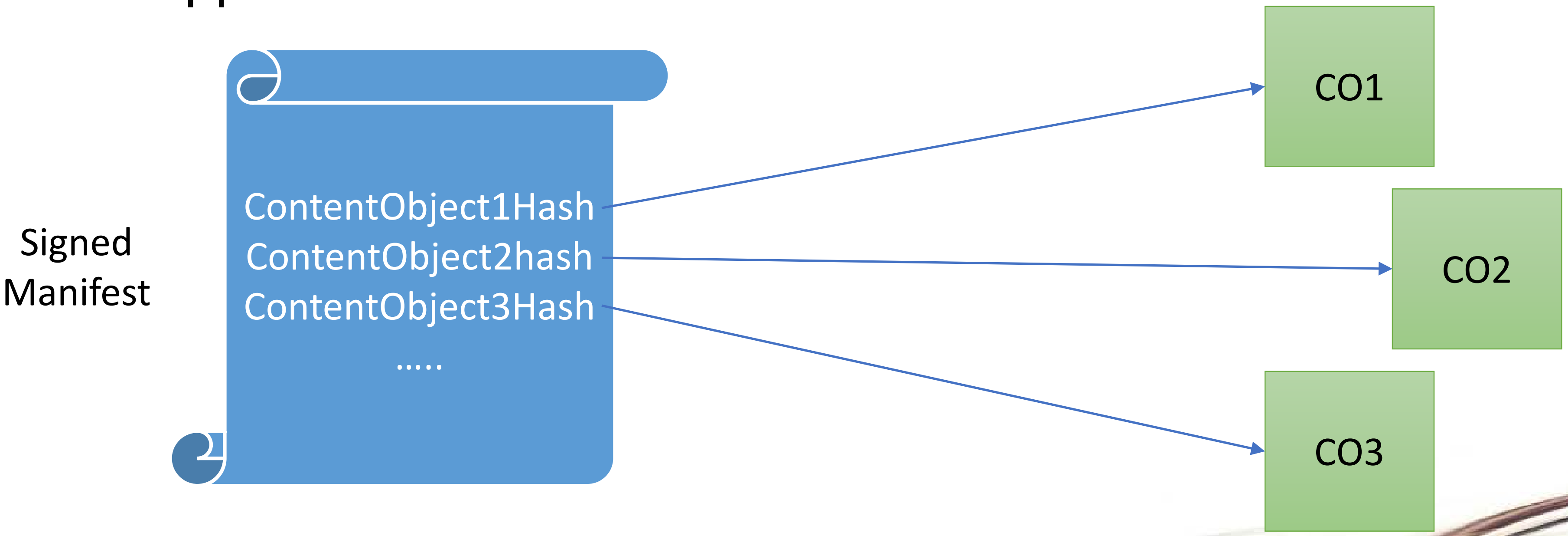


ProducerSocket

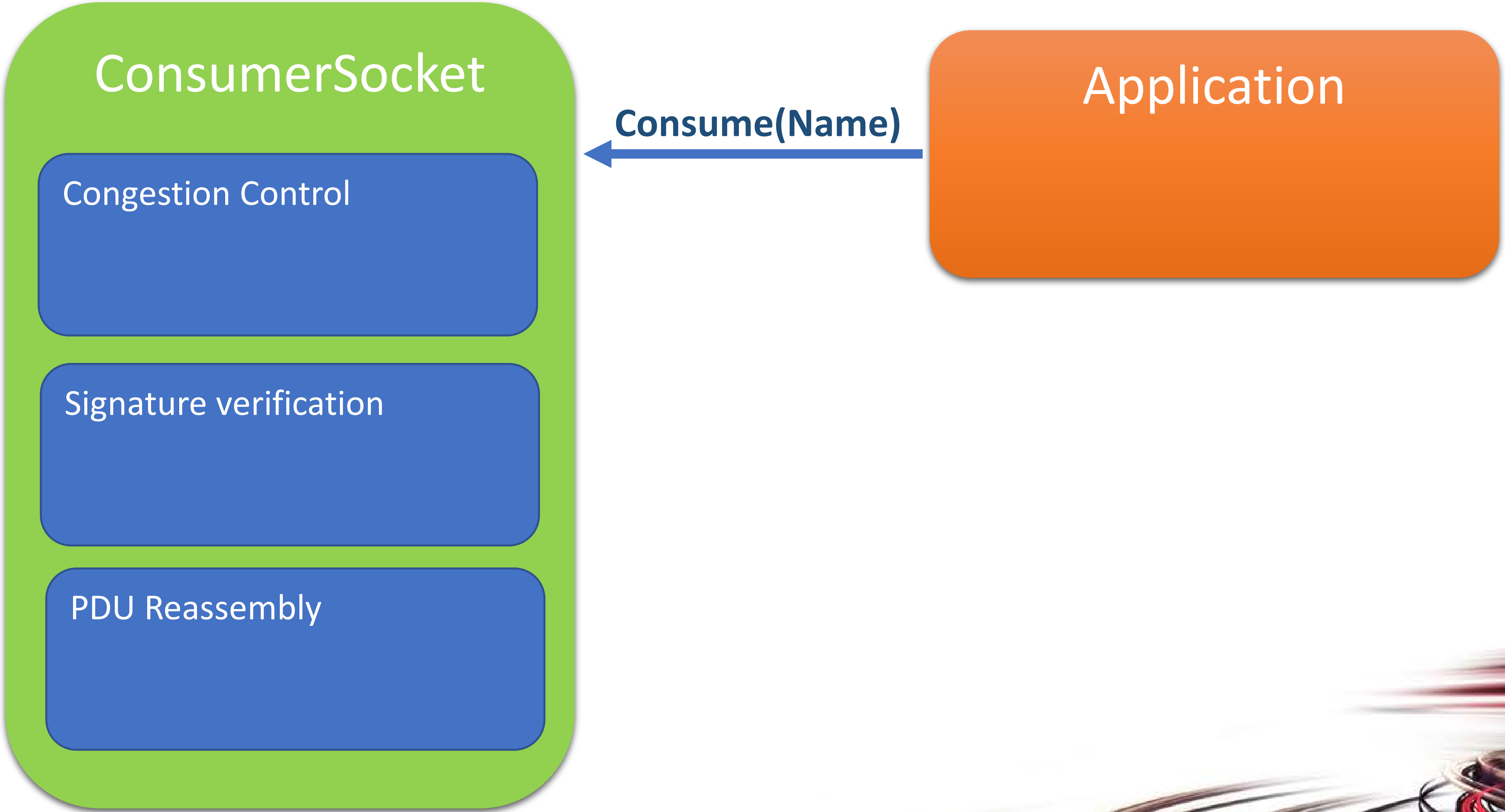


ProducerSocket

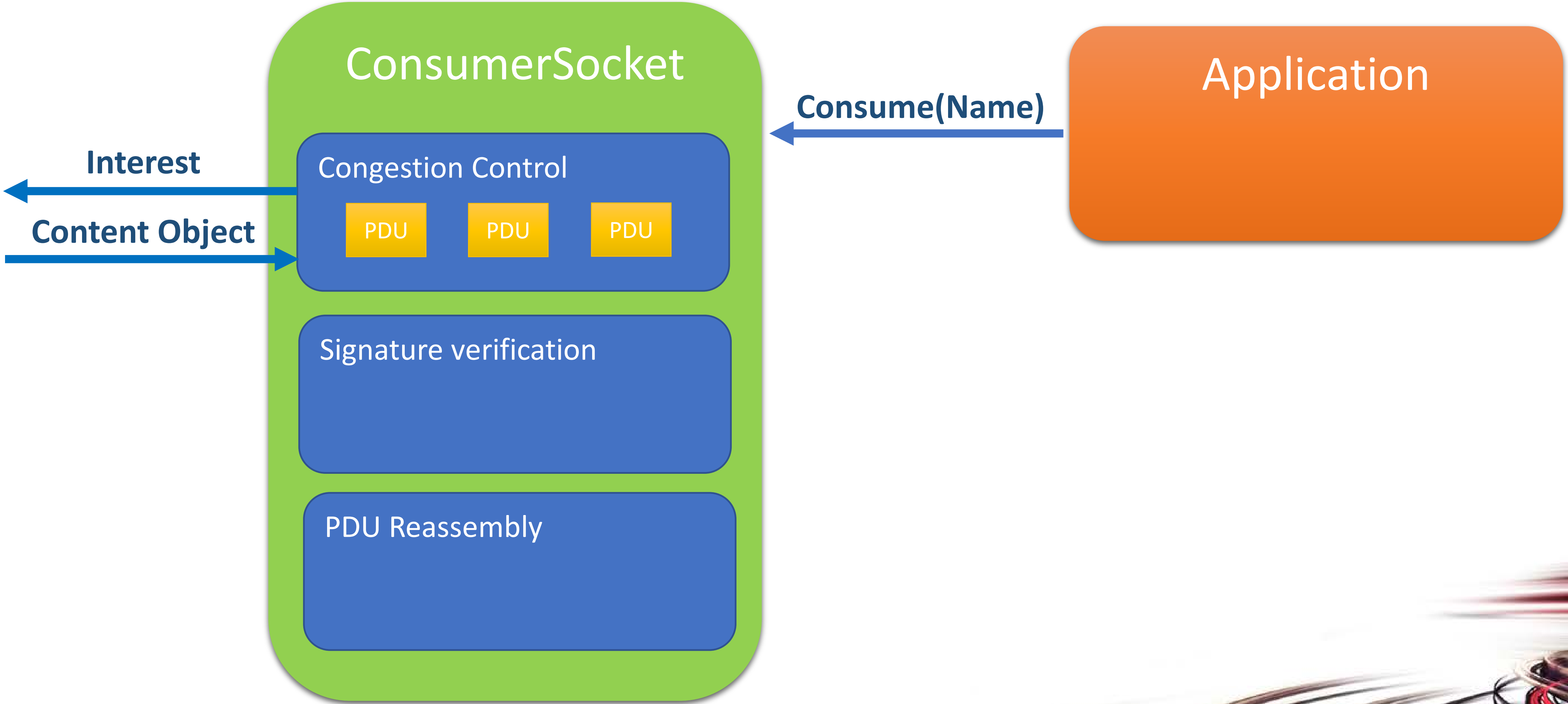
- Signature
  - The application has to provide the library with the information for signing the content objects
  - Signing every content object is computationally expensive: we provide support for manifest



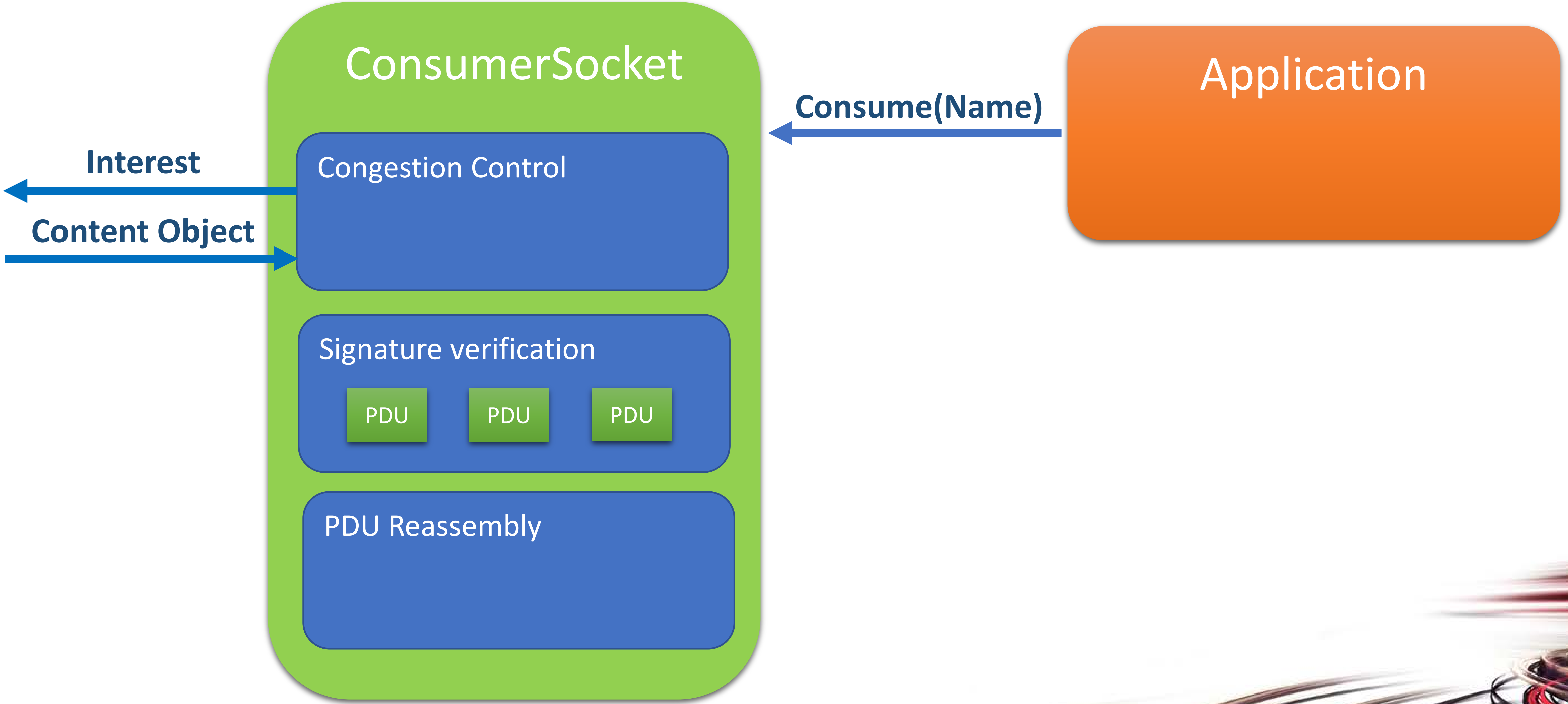
ConsumerSocket



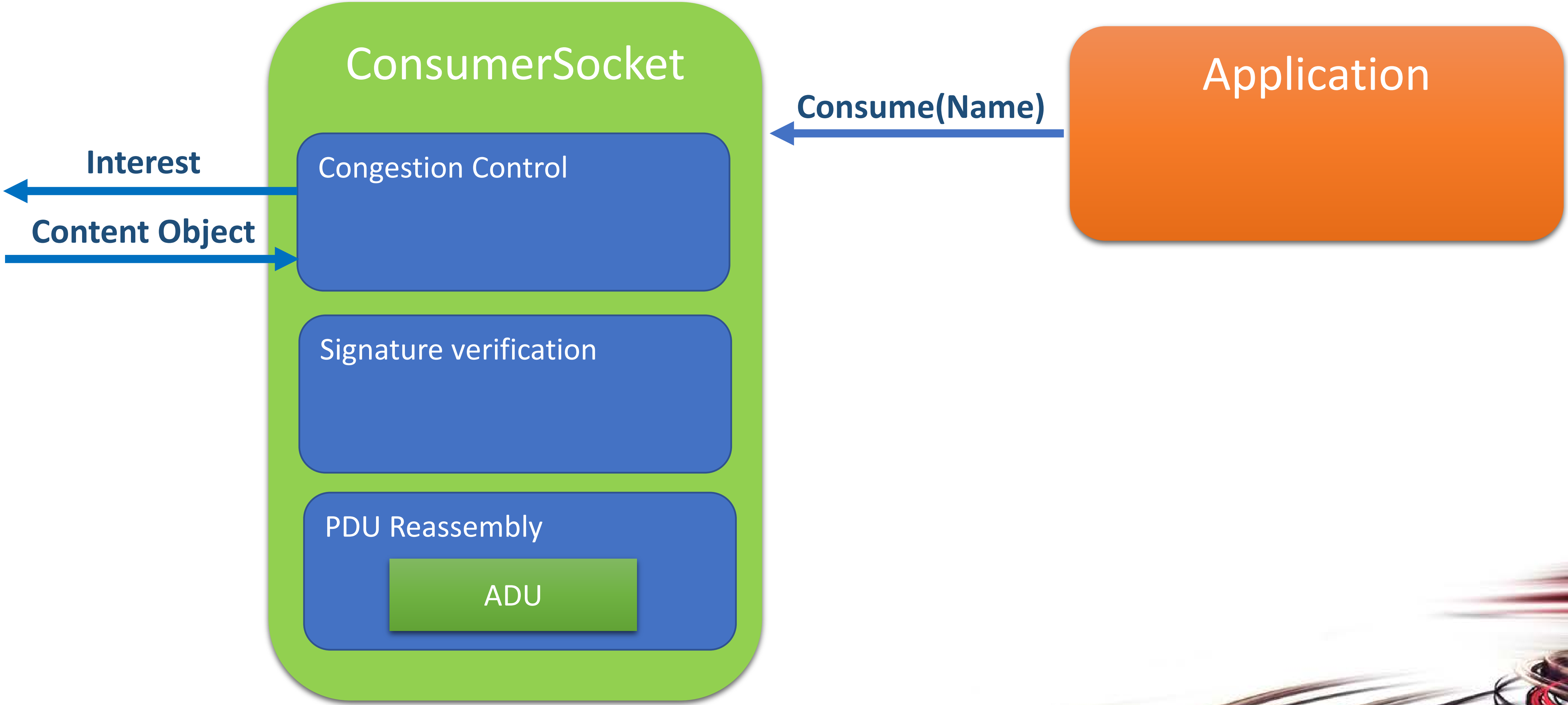
ConsumerSocket



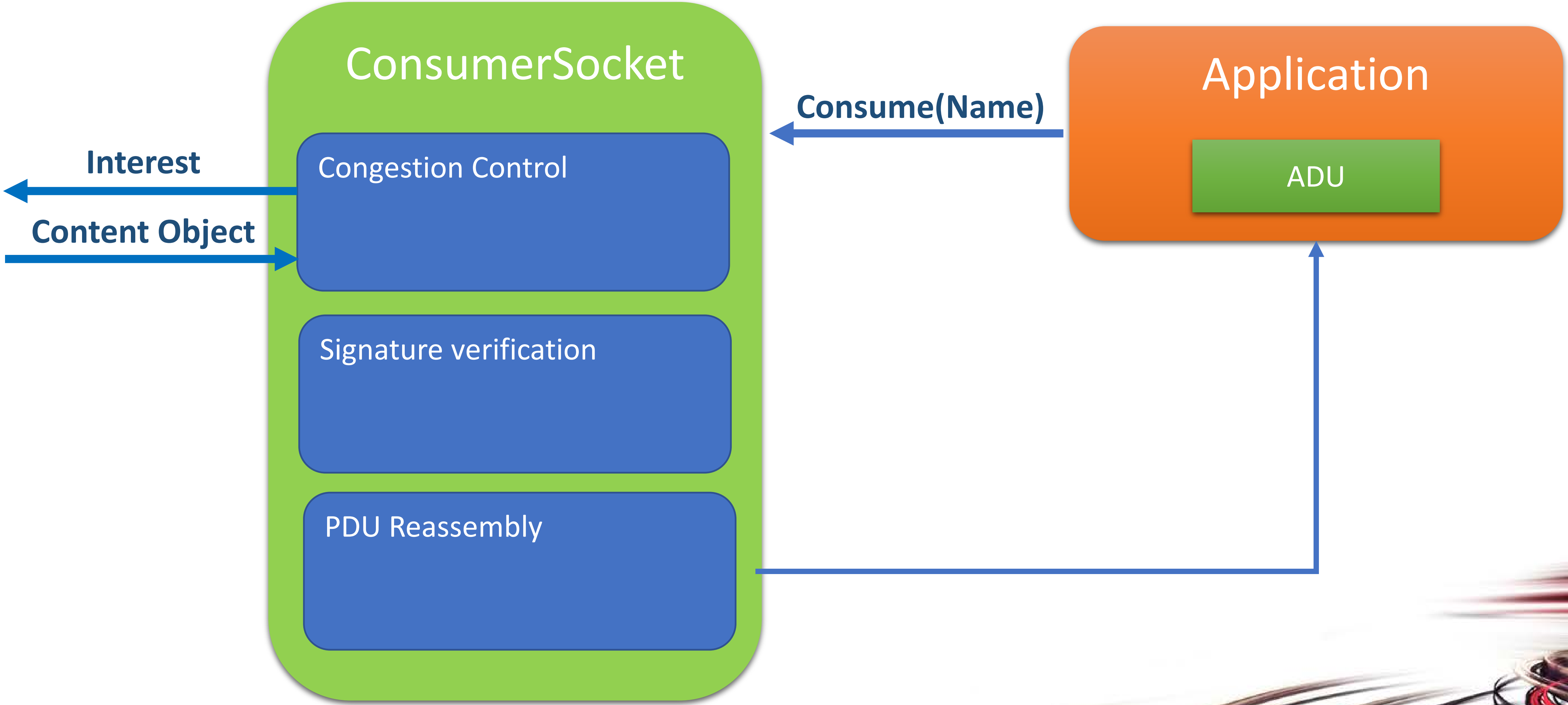
ConsumerSocket



ConsumerSocket



ConsumerSocket



ConsumerSocket

- Congestion Control
  - Application can choose among a set of algorithms: VEGAS, RAAQM[1], FIXED_WINDOW
  - Extension with new algorithms possible
- Signature
  - The application has to provide the library with the information for verifying the signature of the received content objects
  - As the producer case, verifying every content object is expensive: we verify just the manifest signature

[1] G. Carofiglio et al. "Multipath congestion control in content-centric networks,"
2013 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)

Hands on Libicnet!

Where to find Libicnet?

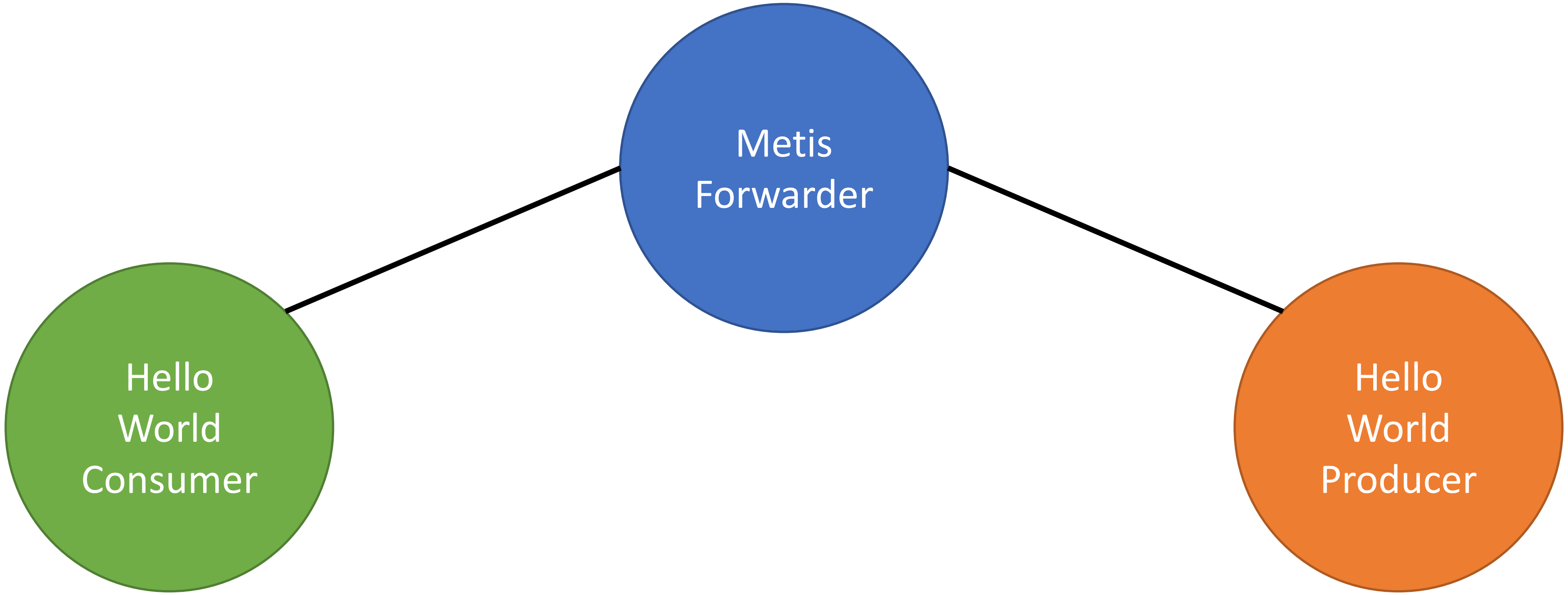
- Wiki page
  - https://wiki.fd.io/view/Libicnet

- Code
  - https://git.fd.io/cicn/log/?h=libicnet/master

Hello World Applications

- **We will see how building two trivial applications against Libicnet:**
  - Hello world Producer
    - It will produce a content of a certain size
  - Hello world Consumer
    - It will pull the content published by the producer

Topology



Metis
Forwarder

Hello
World
Consumer

Hello
World
Producer

Hello World Producer

```
#include <icnet/icnet_transport_socket_producer.h>
…
Name n("ccnx://helloworld");

ProducerSocket p_(n);


std::string content(10000, 'A');


p_.produce(n, (uint8_t *)content.data(), content.size());

p_.attach();

p_.serveForever();
```

Routable prefix

Naming, Segmentation, Signature, Publication

Local face forwarder-producer establishment

Hello World Consumer

```
#include <icnet/icnet_transport_socket_consumer.h>
…
Consumer c_(Name(), TransportProtocolAlgorithms::RAAQM);
c_.setSocketOption(GeneralTransportOptions::INTEREST_LIFETIME, 1001);
c_.setSocketOption(GeneralTransportOptions::MAX_INTEREST_RETX, 25);


c_.setSocketOption(ConsumerCallbacksOptions::CONTENT_RETRIEVED,
                (ConsumerContentCallback) std::bind(&processContent,
                                              std::placeholders::_1,
                                              std::placeholders::_2));
Name name("ccnx://helloworld");

c_.consume(name);
```

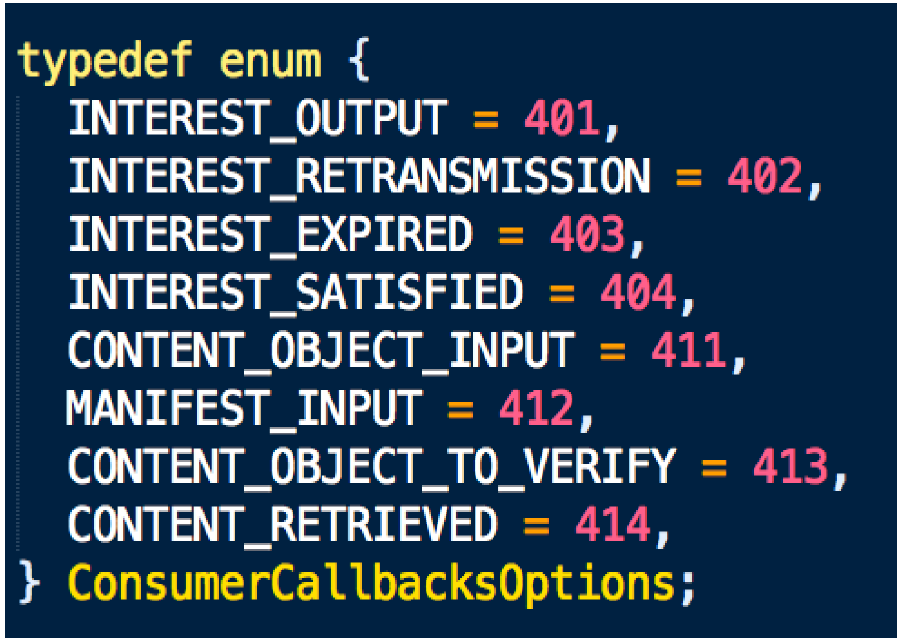
Congestion control algorithm

Callback called after
whole ADU will be pulled
and reassembled

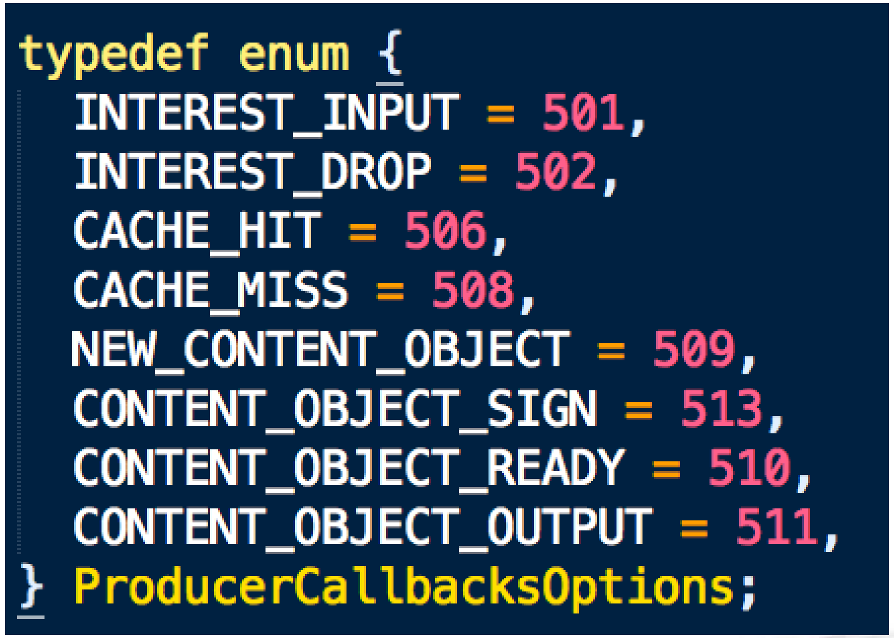
Content Pull +
Signature Verification +
Reassembly

Callbacks

- The application can register into the library a set of callback allowing to directly handle events during the download/publication.

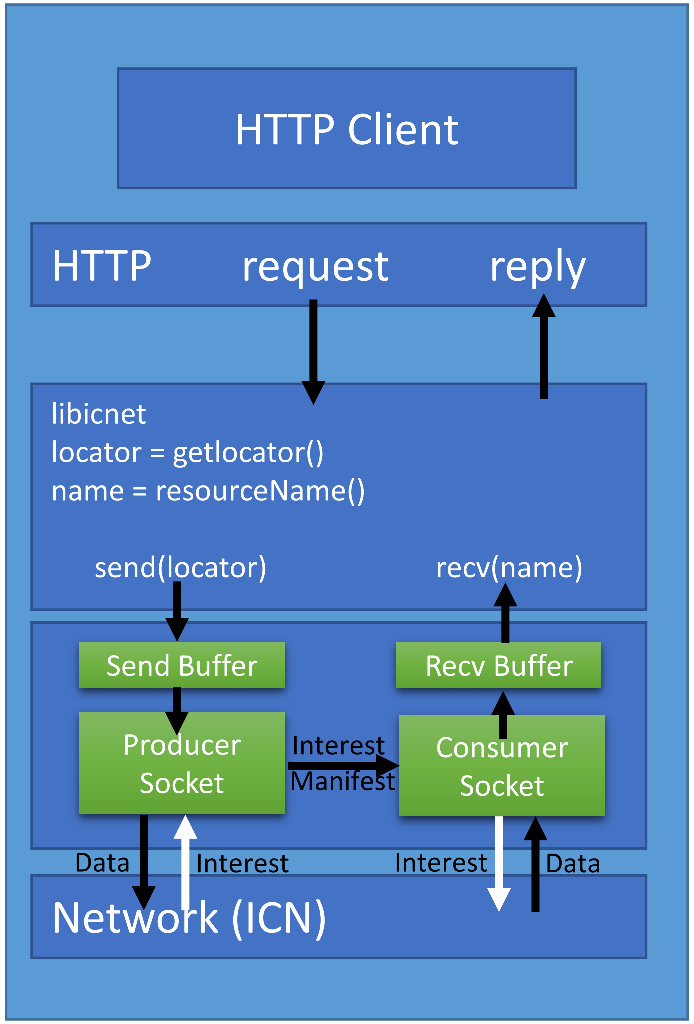


```
typedef enum {
  INTEREST_OUTPUT = 401,
  INTEREST_RETRANSMISSION = 402,
  INTEREST_EXPIRED = 403,
  INTEREST_SATISFIED = 404,
  CONTENT_OBJECT_INPUT = 411,
  MANIFEST_INPUT = 412,
  CONTENT_OBJECT_TO_VERIFY = 413,
  CONTENT_RETRIEVED = 414,
} ConsumerCallbacksOptions;
```



```
typedef enum {
  INTEREST_INPUT = 501,
  INTEREST_DROP = 502,
  CACHE_HIT = 506,
  CACHE_MISS = 508,
  NEW_CONTENT_OBJECT = 509,
  CONTENT_OBJECT_SIGN = 513,
  CONTENT_OBJECT_READY = 510,
  CONTENT_OBJECT_OUTPUT = 511,
} ProducerCallbacksOptions;
```

Advanced Example: HTTP support



HTTP Client

HTTP request reply

libicnet
locator = getlocator()
name = resourceName()

send(locator) recv(name)

Send Buffer

Recv Buffer

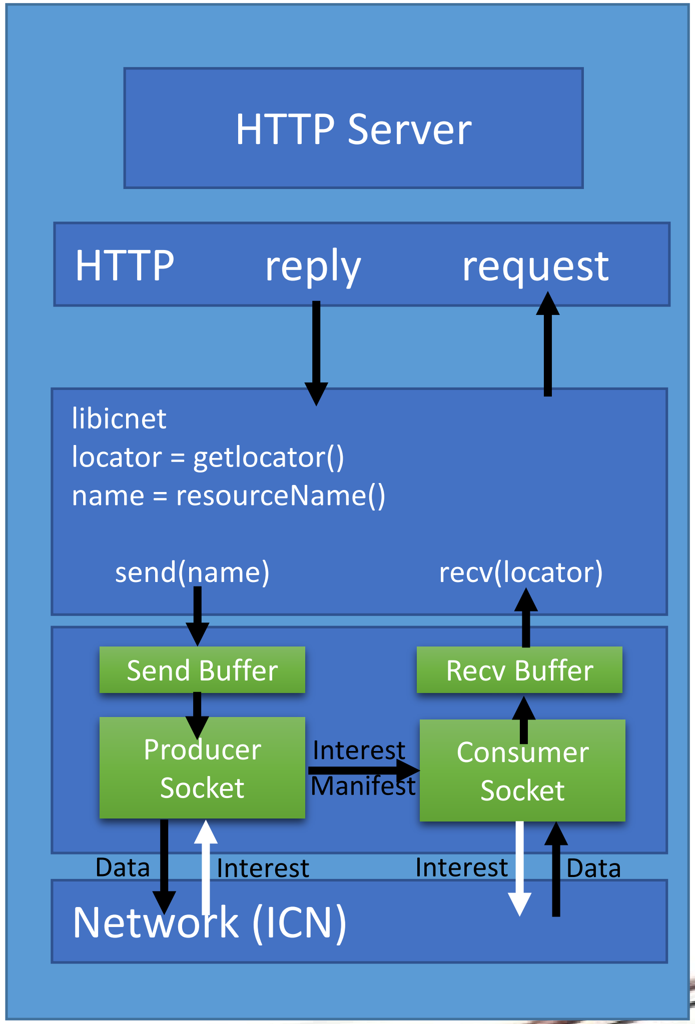
Producer Socket

Interest
Manifest

Consumer Socket

Data Interest Interest Data

Network (ICN)



HTTP Server

HTTP reply request

libicnet
locator = getlocator()
name = resourceName()

send(name) recv(locator)

Send Buffer

Recv Buffer

Producer Socket

Interest
Manifest

Consumer Socket

Data Interest Interest Data

Network (ICN)

Thank You!