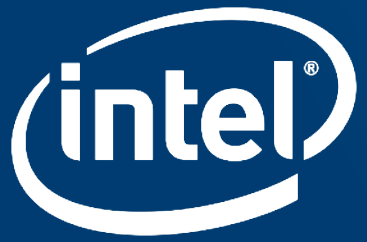

# NFF-GO (YANFF) — YET ANOTHER NETWORK FUNCTION FRAMEWORK LABS

Intel Golang Team

Gregory Shimansky

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Optimization Notice

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# NFF-Go (YANFF - Yet Another Network Function Framework)

Framework for building performant native network functions

- Open-source project
- Higher level abstractions than DPDK
- Go language: productivity, performance, concurrency, safety
- Network functions are application programs and not virtual machines

**Benefits**:

- Easily leverage IA HW capabilities: multi-cores, AES-NI, CAT, QAT, DPDK
- 10x reduction lines of code
- No need to be expert network system programmer
- Similar performance with C
- Take advantage of cloud native deployment: continuous delivery, micro-services, containers

**https://github.com/intel-go/nff-go**

# Technical Motivation

- Developers need framework to shorten development cycle of VNFs
  - Currently VNFs are monolithic - “virtual appliances” instead of network functions
  - Significant part of VNF is about plumbing. Plumbing VNFs to CommSPs network is an art. Should be abstracted from VNFs
- Lack of stable and unified  APIs for VNF control and data plane
- Challenges with access to HW Accelerators in cloud environment.
- Cloud-friendly APIs and designs needed.

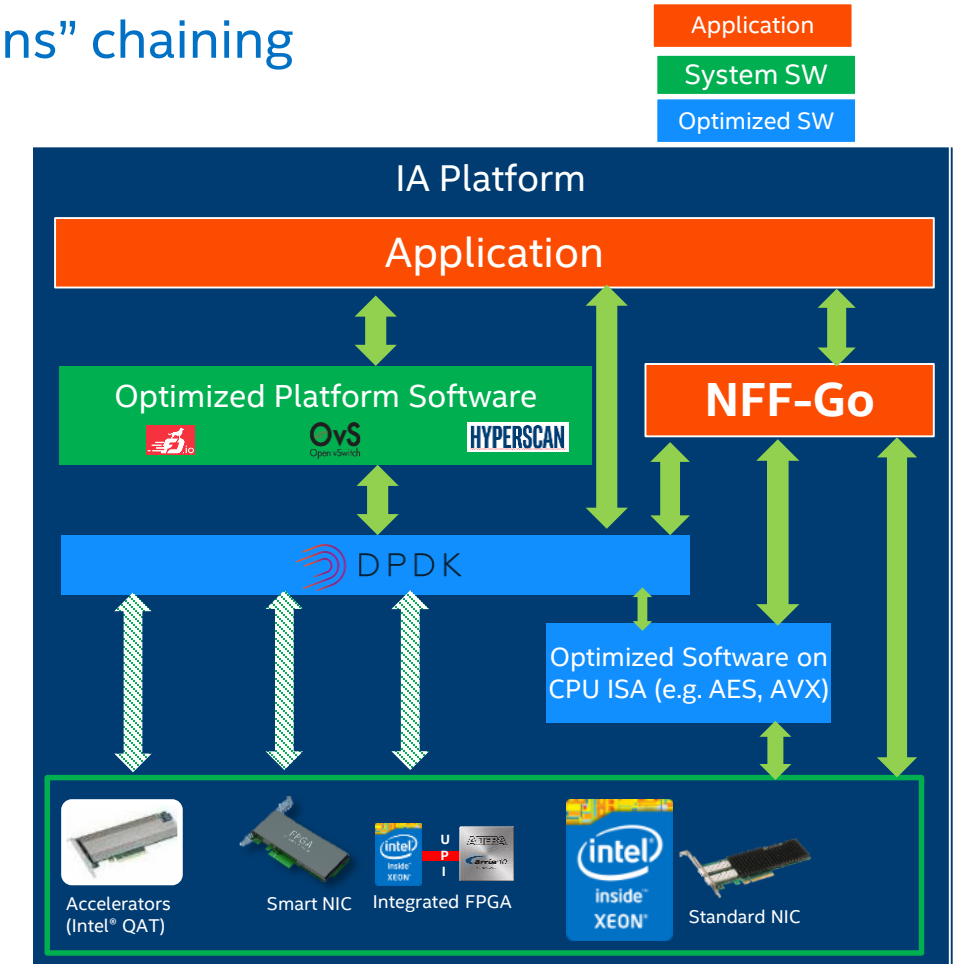
**Accelerating transition to from rule-based networking to *imperative networking***



https://github.com/intel-go/nff-go

# NFF-Go: Network Function Framework

- Simple but powerful abstractions:
  - Flow, Packet
- User builds packet processing graph using “flow functions” chaining
  - SetReceiver -> SetHandler -> SetSender
  - Several predefined possibilities of adding user processing inside packet processing graph
    - Split, Separate, Generate, Handle
- Can leverage predefined functions which parse packets, check ACL rules, etc.
- Run to completion – NFs can be expressed in the flow functions and natural chaining
- Auto-scaling, ease of development
- Zero-copy between NFs
- Flexible incoming flow handling – sources can be anything: network port, memory buffer, remote procedure call, etc.






https://github.com/intel-go/nff-go

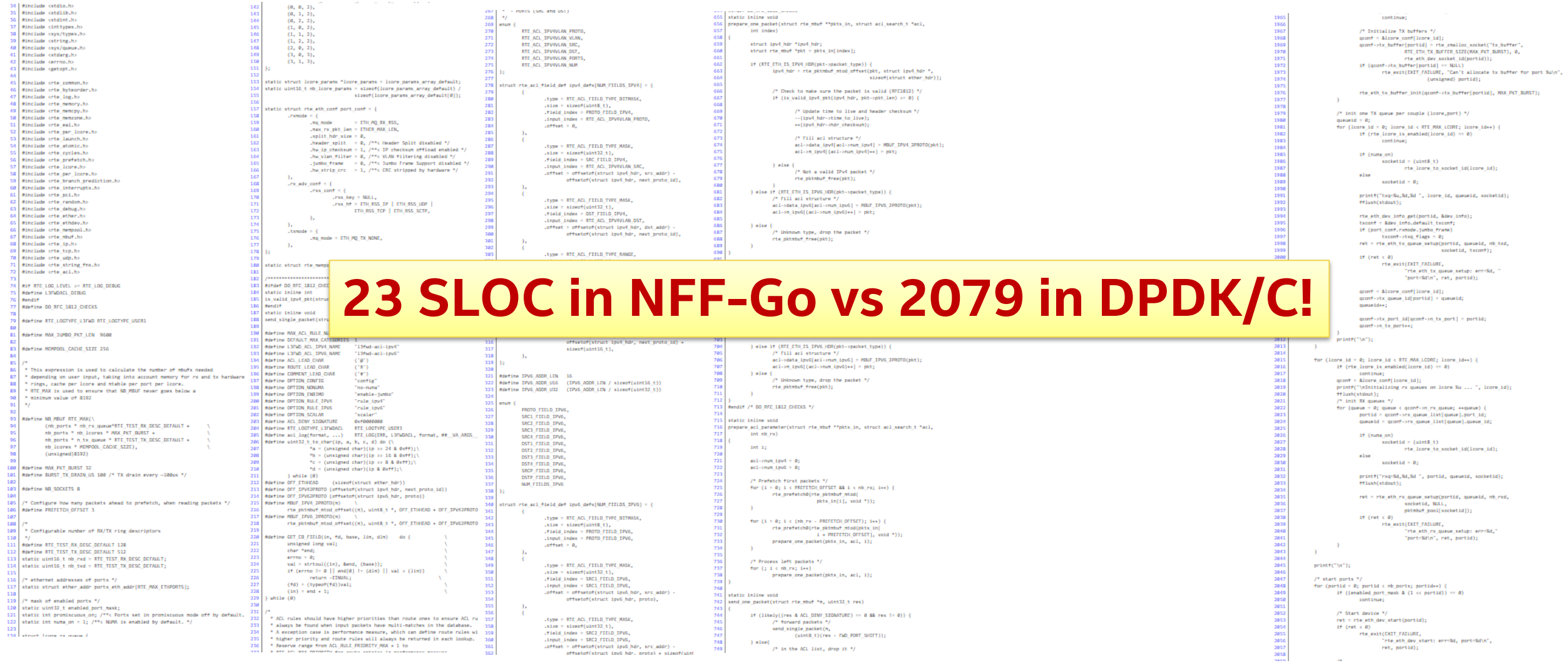
# L3 Simple Forwarding Example

```
var L3Rules *rules.L3Rules

func main() {
     flow.SystemInit(16)
     L3Rules = rules.GetL3RulesFromORIG("Forwarding.conf")
     inputFlow := flow.SetReceiver(0)
     outputFlows := flow.SetSplitter(inputFlow, L3Splitter, uint(3))
     flow.SetStopper(outputFlows[0])
     for i := 1; i < 3; i++ {
          flow.SetSender(outputFlows[i], uint8(i-1))
     }
     flow.SystemStart()
}

// User defined function for splitting packets
func L3Splitter(currentPacket *packet.Packet) uint {
     currentPacket.ParseL4()
     return rules.L3_ACL_port(currentPacket, L3Rules)
}
```

# Configuration file for Forwarding

```
# Source address, Destination address, L4 protocol ID, Source port, Destination port, Output port
  111.2.0.0/31      ANY      tcp      ANY          ANY          1
  111.2.0.2/32      ANY      tcp      ANY          ANY          Reject
  ANY               ANY      udp      3078:3964    56:61020     2
```

# Exactly The Same Example in DPDK/C



**23 SLOC in NFF-Go vs 2079 in DPDK/C!**

# NFF-Go – Main Architectural Concepts

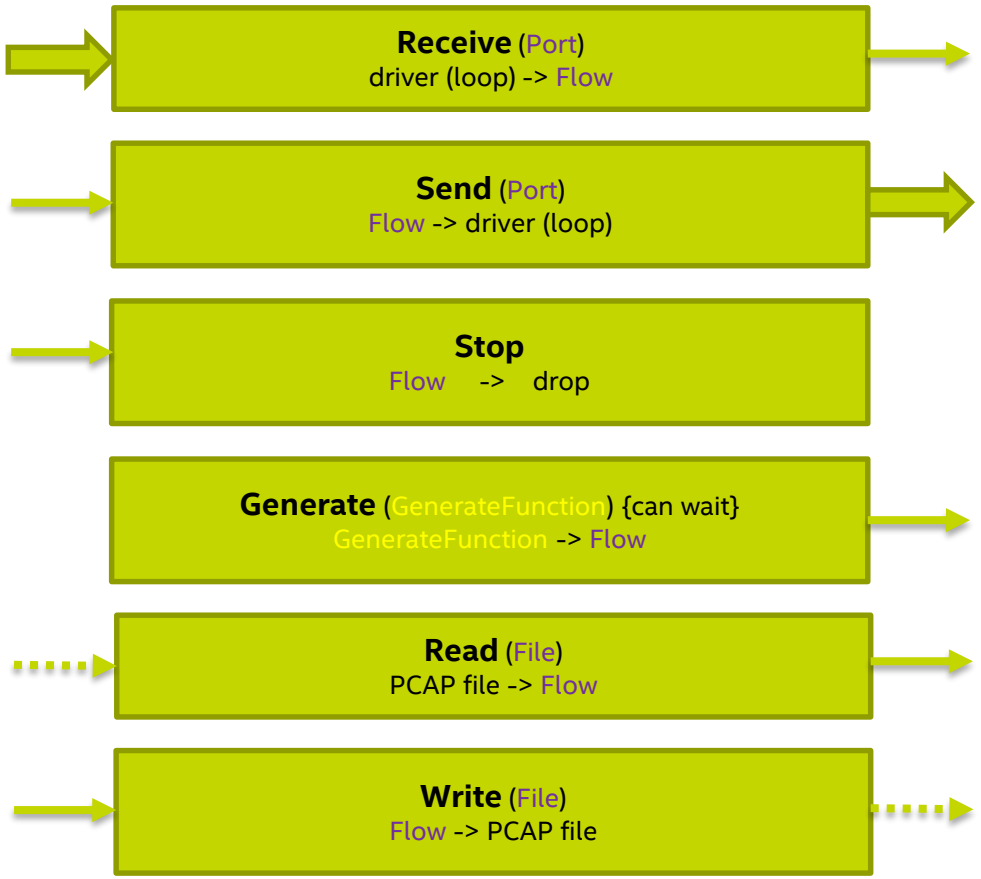
**Flow**
Abstraction without public fields, which is used for pointing connections between Flow functions.
Opened by Receive / Split / Separate / Counter / Generate.
Closed by Send / Merge / Stop.

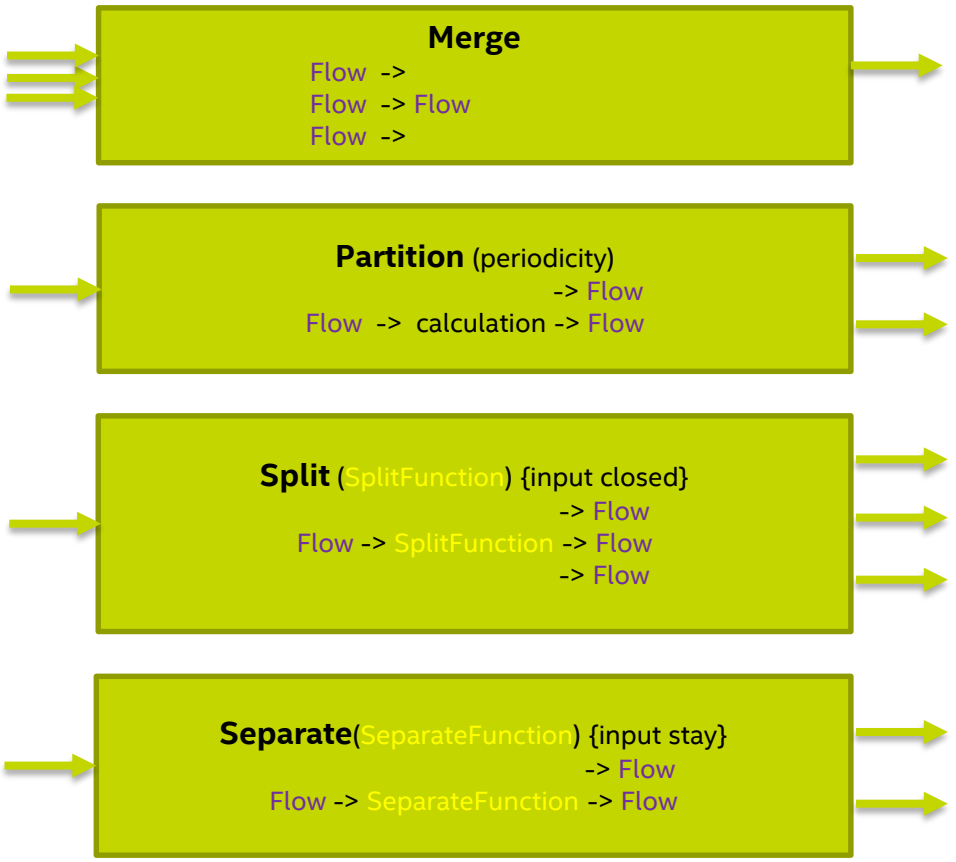
**Packet**
High-level representation of network packet. Private field is *mbuf, public fields are mac / ip / data /etc: pointers to mbuf with offsets (zero copy).
Is extracted before any User defined function. Can be filled after user request by Packet functions. Can be checked by Rule functions.

**Port**
Network door, used in Receive, Send.

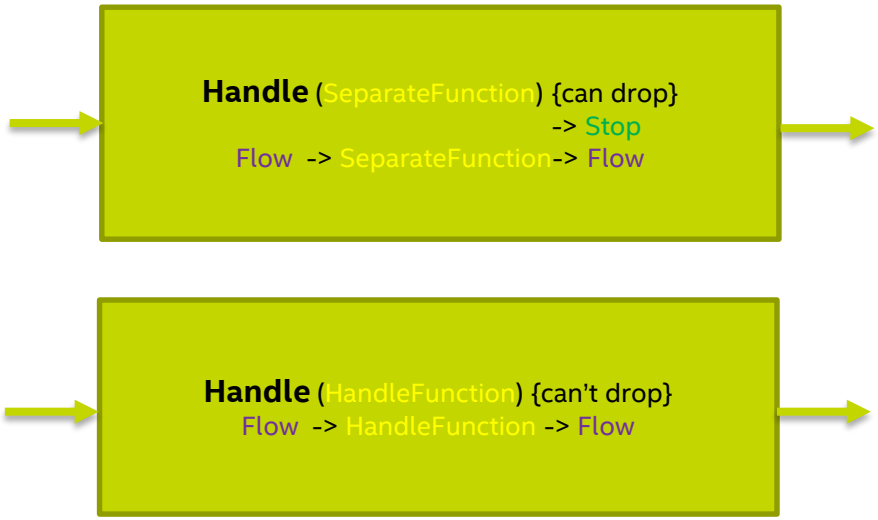
**Rule**
Set of checking rules, used in User defined functions.

# Building Processing Graph



# Packet modification functions




## Packet functions

**Parsing packet fields**
Parse L2 or/and L3 or/and L4 levels

**Initializing packet fields**
Initialize L2 or/and L3 or/and L4 levels

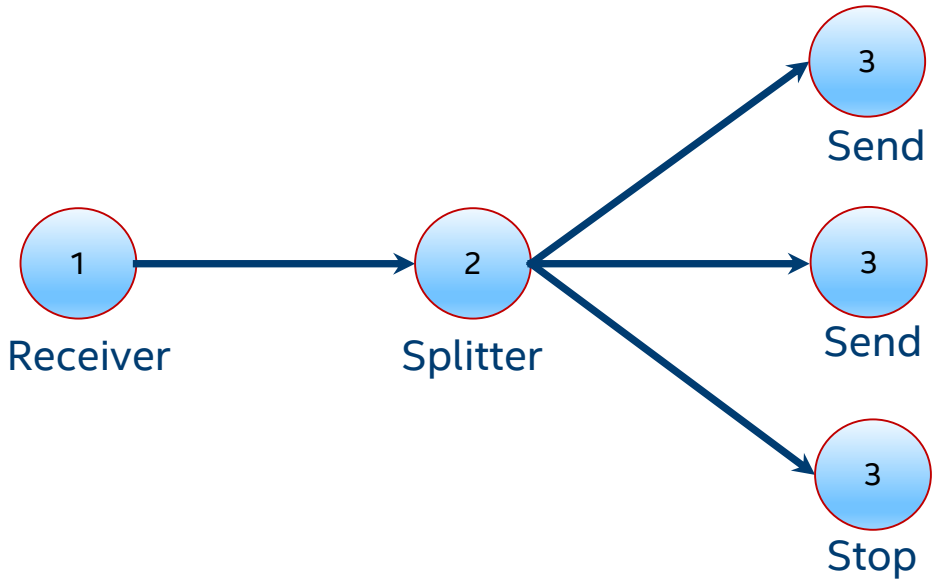
**Encapsulate / Decapsulate**

## Rule functions

**Create rule**
Create checking rule from json / config

**Checking packet fields by rule**
Check L2 or/and L3 or/and L4 levels

# Flow Graph Example - Forwarding



# Let’s build some functions!

# Create test VMs

1. Create and provision two test VMs:

```
$ cd nff-go/vagrant
$ vagrant up
```

2. Open two terminal windows
3. cd to vagrant directory below
4. run "vagrant ssh nff-go-"***VM_number"*** to connect to pktgen VM and target VM, e.g.

```
$ vagrant ssh nff-go-1      # NFF-Go test program host
nff-go-1$ bindports         # if ports not bound yet

$ vagrant ssh nff-go-0      # pktgen host
nff-go-0$ bindports         # if ports not bound yet
```

# Let's try (01 of 11)

Flow graph:



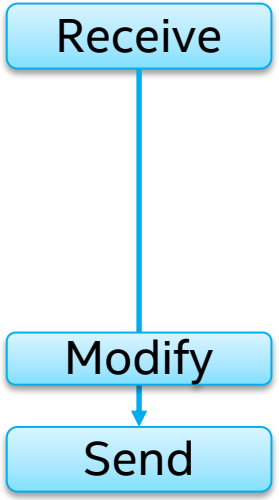
```
package main
import "github.com/intel-go/nff-go/flow"

func main() {
    // Init NFF-Go system
    config := flow.Config{}
    checkFatal(flow.SystemInit(&config))

    initCommonState()

    checkFatal(flow.SystemStart())
}
```

```
nff-go-1$ cd $NFF_GO/examples/tutorial
nff-go-1$ sudo ./step01
```

```
nff-go-0$ cd $NFF_GO/examples/tutorial
nff-go-0$ ./genscripts
nff-go-0$ ./runpktgen.sh

Pktgen:/> start 0
……
Pktgen:/> quit
```

# Let's try (02 of 11)

Flow graph:



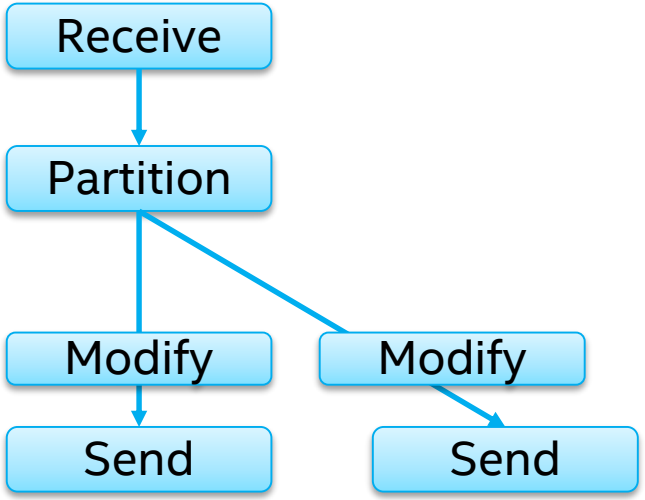

```
package main

import "github.com/intel-go/nff-go/flow"

func main() {
    config := flow.Config{}
    checkFatal(flow.SystemInit(&config))

    initCommonState()

    firstFlow, err := flow.SetReceiver(0)
    checkFatal(err)
    checkFatal(flow.SetHandler(firstFlow, modifyPacket[0], nil))
    checkFatal(flow.SetSender(firstFlow, 0))

    checkFatal(flow.SystemStart())
}
```

```
nff-go-1$ sudo ./step02
```

```
nff-go-0$ ./runpktgen.sh
Pktgen:/> load step02.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

# Let's try (03 of 11)

Flow graph:

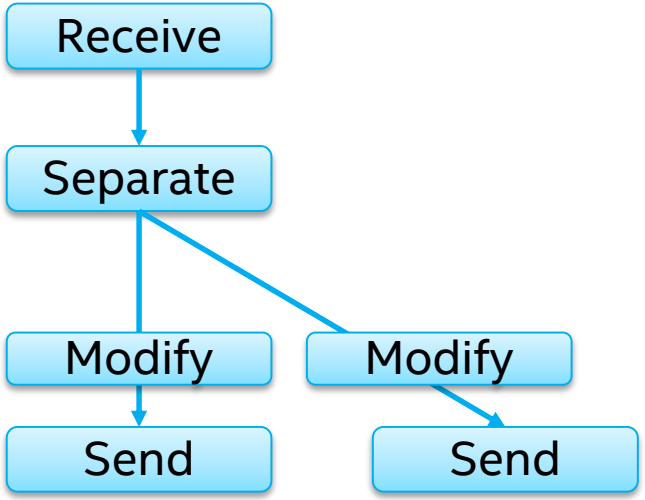



```
nff-go-1$ sudo ./step03

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step03.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

```
package main
import "github.com/intel-go/nff-go/flow"

func main() {
    config := flow.Config{}
    checkFatal(flow.SystemInit(&config))

    initCommonState()

    firstFlow, err := flow.SetReceiver(0)
    checkFatal(err)
    secondFlow, err := flow.SetPartitioner(firstFlow, 300, 300)
    checkFatal(err)
    checkFatal(flow.SetHandler(firstFlow, modifyPacket[0], nil))
    checkFatal(flow.SetHandler(secondFlow, modifyPacket[1], nil))
    checkFatal(flow.SetSender(firstFlow, 0))
    checkFatal(flow.SetSender(secondFlow, 1))

    checkFatal(flow.SystemStart())
}
```

# Let's try (04 of 11)

Flow graph:

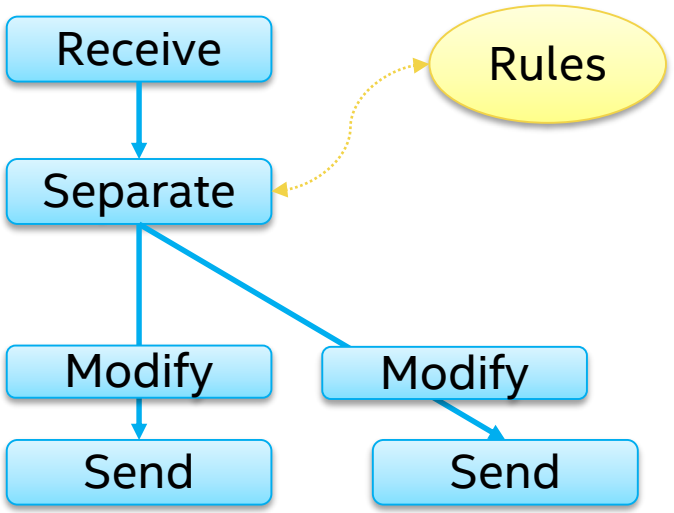



```
nff-go-1$ sudo ./step04

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step04.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

```
package main
import "github.com/intel-go/nff-go/flow“
import "github.com/intel-go/nff-go/packet“

func main() {
	config := flow.Config{}
	checkFatal(flow.SystemInit(&config))
	initCommonState()

	firstFlow, err := flow.SetReceiver(0)
	checkFatal(err)
	secondFlow, err := flow.SetSeparator(firstFlow, mySeparator, nil)
	checkFatal(err)
	checkFatal(flow.SetHandler(firstFlow, modifyPacket[0], nil))
	checkFatal(flow.SetHandler(secondFlow, modifyPacket[1], nil))
	checkFatal(flow.SetSender(firstFlow, 0))
	checkFatal(flow.SetSender(secondFlow, 1))

	checkFatal(flow.SystemStart())
}

func mySeparator(cur *packet.Packet, ctx flow.UserContext) bool {
	cur.ParseL3()
	if cur.GetIPv4() != nil {
		cur.ParseL4ForIPv4()
		if cur.GetTCPForIPv4() != nil &&
packet.SwapBytesUint16(cur.GetTCPForIPv4().DstPort) == 53 {
			return false
		}
	}
	return true
}
```

# Let's try (05 of 11)

Flow graph:

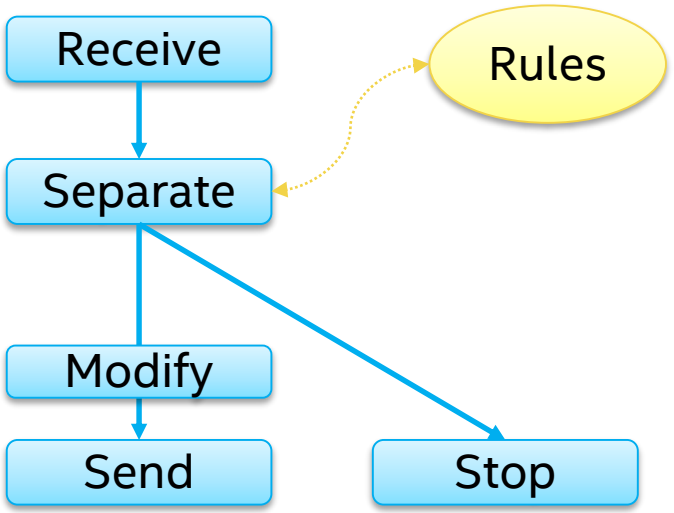



```
nff-go-1$ sudo ./step05

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step05.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

```
… … …
import "github.com/intel-go/nff-go/rules“
var L3Rules *rules.L3Rules

func main( ) {
     var err error
     config := flow.Config{}
     checkFatal(flow.SystemInit(&config))
     initCommonState( )

     l3Rules, err = packet.GetL3ACLFromORIG("rules1.conf")
     checkFatal(err)

     firstFlow, err := flow.SetReceiver(0)
     checkFatal(err)
     secondFlow, err := flow.SetSeparator(firstFlow, mySeparator, nil)
     checkFatal(err)
     checkFatal(flow.SetHandler(firstFlow, modifyPacket[0], nil))
     checkFatal(flow.SetHandler(secondFlow, modifyPacket[1], nil))
     checkFatal(flow.SetSender(firstFlow, 0))
     checkFatal(flow.SetSender(secondFlow, 1))
     checkFatal(flow.SystemStart())
}

func MySeparator(cur *packet.Packet, ctx flow.UserContext) bool {
     return cur.L3ACLPermit(l3Rules)
}
```

# Let's try (06 of 11)

Flow graph:

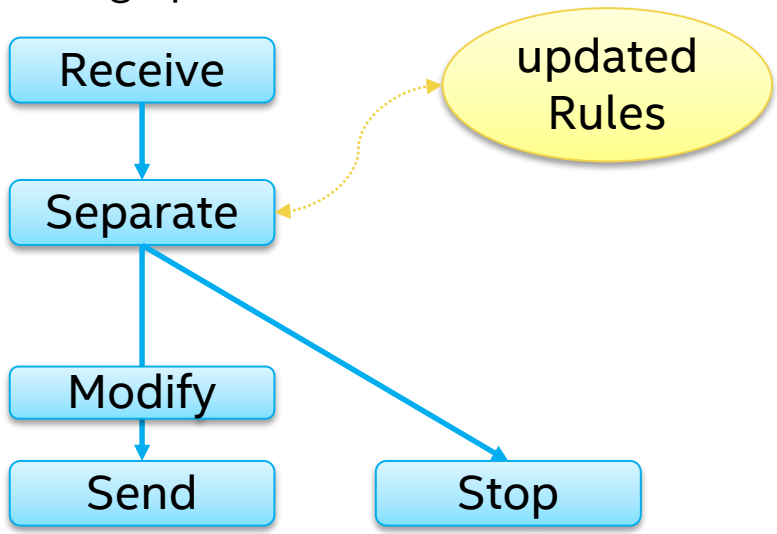



```
nff-go-1$ sudo ./step06

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step06.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

```
… … …
func main() {
    var err error
    config := flow.Config{}
    checkFatal(flow.SystemInit(&config))
    L3Rules = rules.GetL3RulesFromORIG("rules1.conf")
    checkFatal(err)
    firstFlow, err := flow.SetReceiver(0)
    checkFatal(err)
    secondFlow, err := flow.SetSeparator(firstFlow, mySeparator, nil)
    checkFatal(err)
    checkFatal(flow.SetHandler(firstFlow, modifyPacket[0], nil))
    checkFatal(flow.SetSender(firstFlow, 0))
    checkFatal(flow.SetStopper(secondFlow))
    checkFatal(flow.SystemStart())
}

func MySeparator(cur *packet.Packet, ctx flow.UserContext) bool {
    return cur.L3ACLPermit(l3Rules)
}
```

# Let's try (07 of 11)

Flow graph:



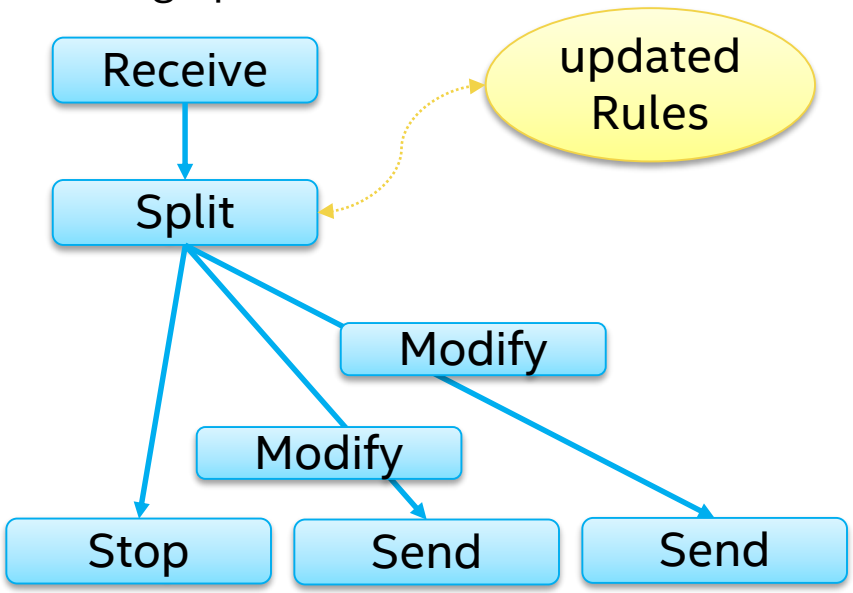

```
nff-go-1$ sudo ./step07

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step07.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

```
… … …
import "time"
var rulesp unsafe.Pointer
… … …
    l3Rules, err := packet.GetL3ACLFromORIG("rules1.conf")
    checkFatal(err)
    rulesp = unsafe.Pointer(&l3Rules)
    go updateSeparateRules()
… … …

func MySeparator(cur *packet.Packet, ctx flow.UserContext) bool {
    localL3Rules := (*packet.L3Rules)(atomic.LoadPointer(&rulesp))
    return cur.L3ACLPermit(localL3Rules)
}

func updateSeparateRules() {
    for {
        time.Sleep(time.Second * 5)
        locall3Rules, err := packet.GetL3ACLFromORIG("rules1.conf")
        checkFatal(err)
        atomic.StorePointer(&rulesp, unsafe.Pointer(locall3Rules))
    }
}
```

*To make changes in rules1.conf file it is necessary to connect to target VM in another window or run NFF-Go executable in screen terminal multiplexer.*

# Let's try (08 of 11)

Flow graph:



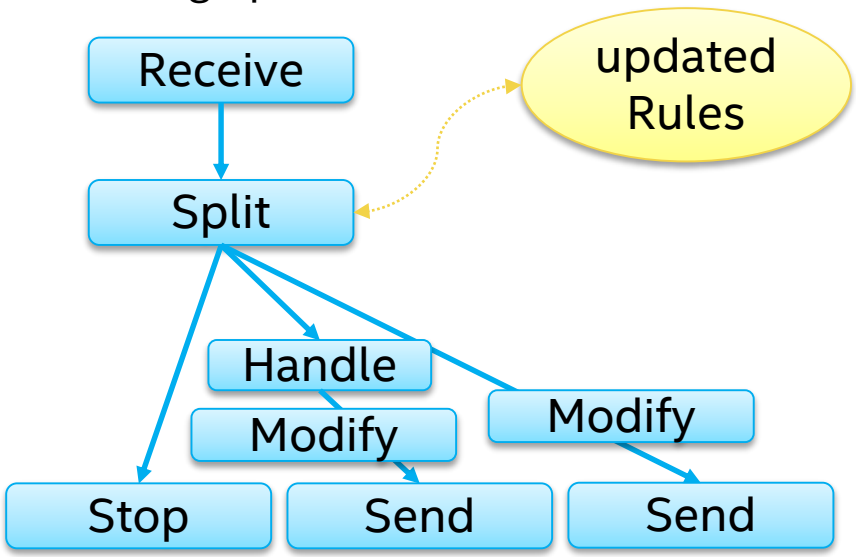

```
nff-go-1$ sudo ./step08

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step08.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

```
… … …
const flowN = 3
… … …
      firstFlow, err := flow.SetReceiver(0)
      checkFatal(err)
      outputFlows, err := flow.SetSplitter(firstFlow, mySplitter, flowN, nil)
      checkFatal(err)
      checkFatal(flow.SetStopper(outputFlows[0]))
      for i := uint8(1); i < flowN; i++ {
            checkFatal(flow.SetHandler(outputFlows[i], modifyPacket[i-1], nil))
            checkFatal(flow.SetSender(outputFlows[i], i-1))
      }
… … …

func mySplitter(cur *packet.Packet, ctx flow.UserContext) uint {
      localL3Rules := L3Rules
      return cur.L3ACLPort(localL3Rules)
}
… … …
```

*To make changes in rules2.conf file it is necessary to connect to target VM in another window or run NFF-Go executable in screen terminal multiplexer.*

# Let's try (09 of 11)

Flow graph:




```
nff-go-1$ sudo ./step09
```

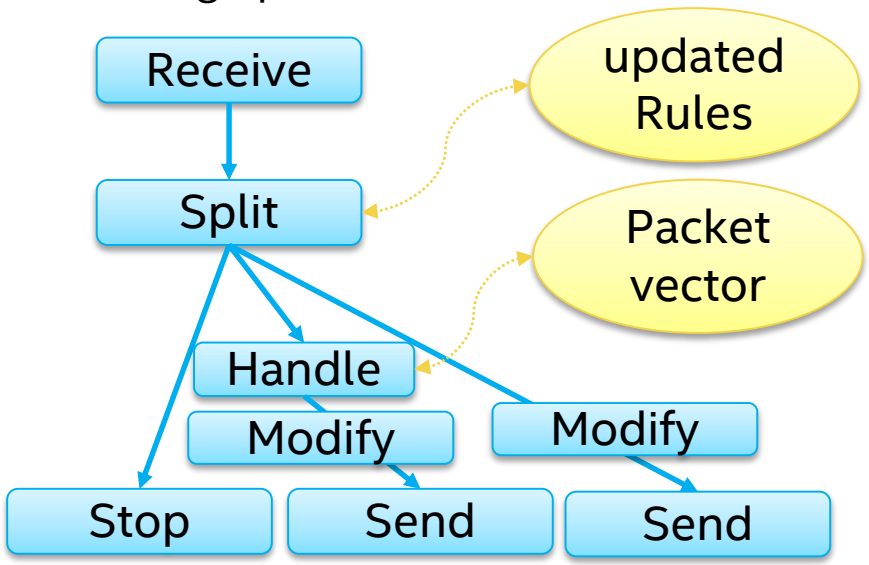
```
nff-go-0$ ./runpktgen.sh
Pktgen:/> load step09.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

```
… … …
import "github.com/intel-go/nff-go/common“
… … …
      firstFlow, err := flow.SetReceiver(0)
      checkFatal(err)
      outputFlows, err := flow.SetSplitter(firstFlow, mySplitter, flowN, nil)
      checkFatal(err)
      checkFatal(flow.SetStopper(outputFlows[0]))
      checkFatal(flow.SetHandler(outputFlows[1], myHandler, nil))
      for i := uint8(1); i < flowN; i++ {
            checkFatal(flow.SetHandler(outputFlows[i], modifyPacket[i-1], nil))
            checkFatal(flow.SetSender(outputFlows[i], i-1))
      }
… … …
func myHandler(cur *packet.Packet, ctx flow.UserContext) {
      cur.EncapsulateHead(common.EtherLen, common.IPv4MinLen)
      cur.ParseL3()
      cur.GetIPv4NoCheck().SrcAddr = packet.BytesToIPv4(111, 22, 3, 0)
      cur.GetIPv4NoCheck().DstAddr = packet.BytesToIPv4(3, 22, 111, 0)
      cur.GetIPv4NoCheck().VersionIhl = 0x45
      cur.GetIPv4NoCheck().NextProtoID = 0x04
}
```

*To make changes in rules2.conf file it is necessary to connect to target VM in another window or run NFF-Go executable in screen terminal multiplexer.*

# Let's try (10 of 11)

Flow graph:




… … …

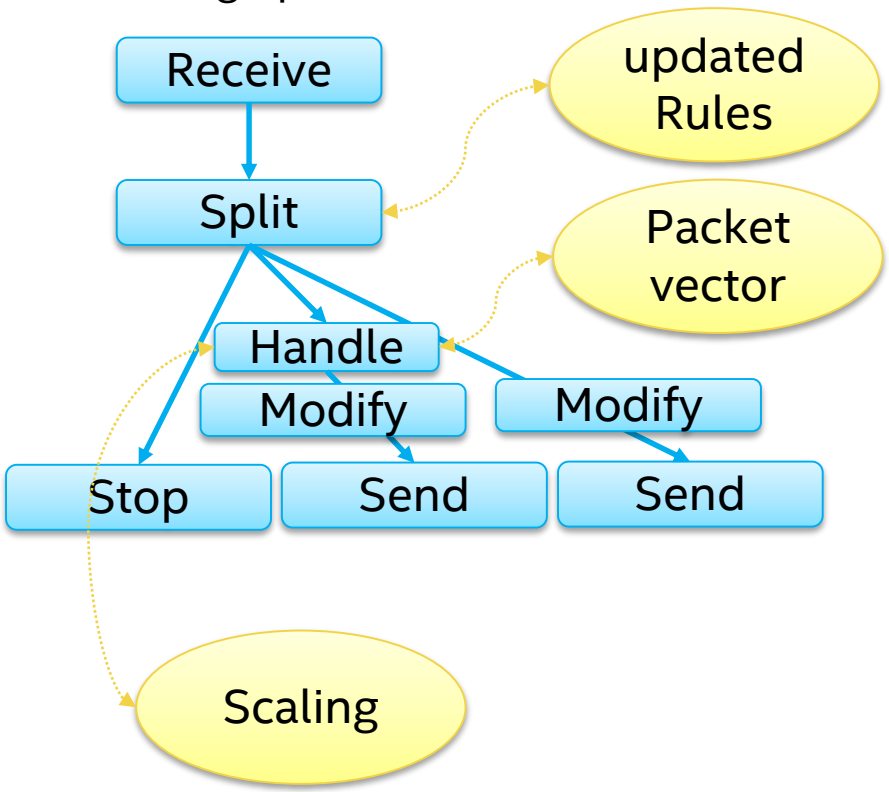
```
func myHandler(curV []*packet.Packet, num uint, ctx flow.UserContext) {
    for i := uint(0); i < num; i++ {
        cur := curV[i]
        cur.EncapsulateHead(common.EtherLen, common.IPv4MinLen)
        cur.ParseL3()
        cur.GetIPv4NoCheck().SrcAddr = packet.BytesToIPv4(111, 22, 3, 0)
        cur.GetIPv4NoCheck().DstAddr = packet.BytesToIPv4(3, 22, 111, 0)
        cur.GetIPv4NoCheck().VersionIhl = 0x45
        cur.GetIPv4NoCheck().NextProtoID = 0x04
    }
}
```

```
nff-go-1$ sudo ./step10

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step10.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

*To make changes in rules2.conf file it is necessary to connect to target VM in another window or run NFF-Go executable in screen terminal multiplexer.*

# Let's try (11 of 11)

Flow graph:




```
… … …

func myHandler(curV []*packet.Packet, num uint, ctx flow.UserContext) {
     for i := uint(0); i < num; i++ {
          cur := curV[i]
          cur.EncapsulateHead(common.EtherLen, common.IPv4MinLen)
          cur.ParseL3()
          cur.GetIPv4NoCheck().SrcAddr = packet.BytesToIPv4(111, 22, 3, 0)
          cur.GetIPv4NoCheck().DstAddr = packet.BytesToIPv4(3, 22, 111, 0)
          cur.GetIPv4NoCheck().VersionIhl = 0x45
          cur.GetIPv4NoCheck().NextProtoID = 0x04
     }
     // Some heavy computational code
     heavyCode()
}
```

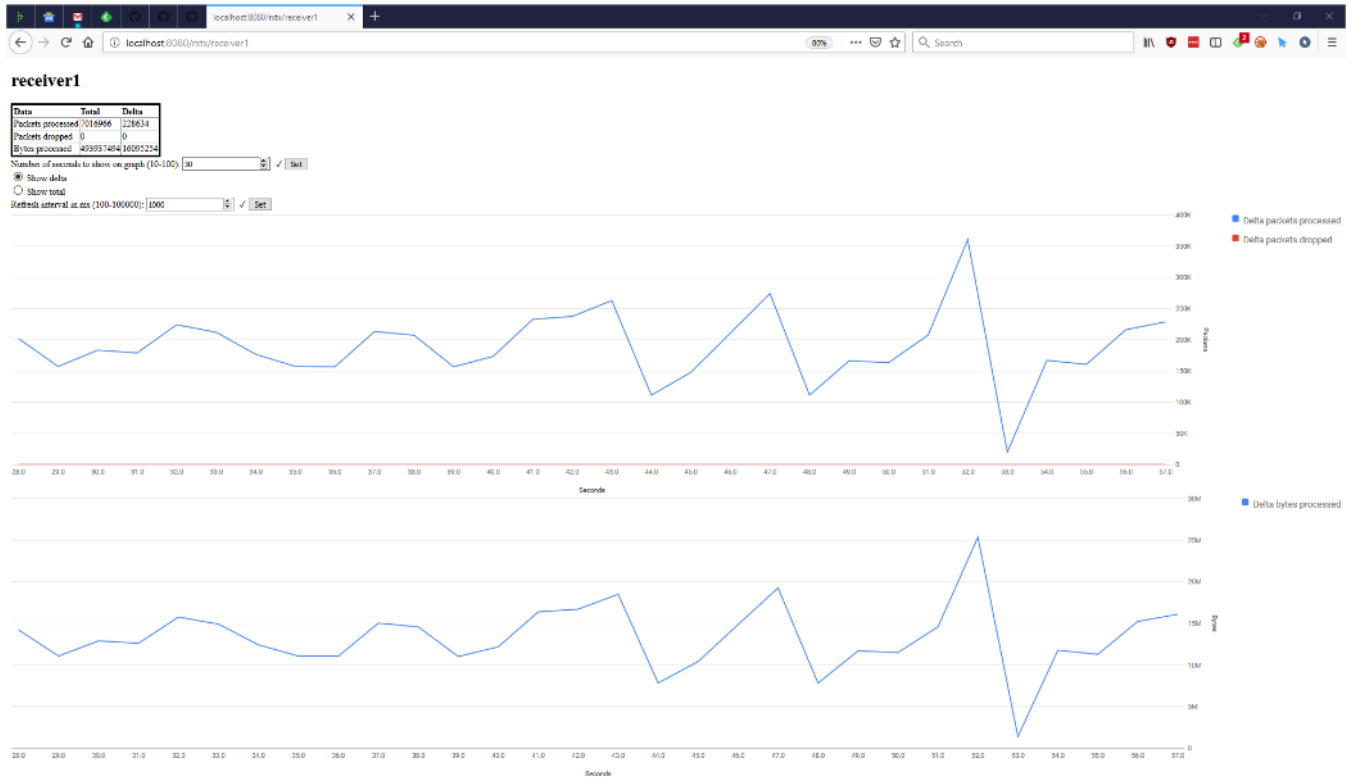
*To make changes in rules2.conf file it is necessary to connect to target VM in another window or run NFF-Go executable in screen terminal multiplexer.*

```
nff-go-1$ sudo ./step11

nff-go-0$ ./runpktgen.sh
Pktgen:/> load step11.pg
Pktgen:/> start 0
…
Pktgen:/> quit
```

# Alternative network packet IO

- KNI interfaces (examples/kni.go)
- Linux raw sockets (examples/OSforwarding.go)
- PCAP files (examples/clonablePcapDumper.go)
- Linux XDP (coming soon)

# Statistic counters




… … …

```
// Set up address for stats web server
statsServerAddres = &net.TCPAddr{
      Port: 8080,
}

config := flow.Config{
      StatsHTTPAddress: statsServerAddres,
}
```

… … …



Optimization Notice

# Finally: NAT

```
nff-go-1$ ./genscripts -pktgen direct
nff-go-1$ sudo ../nat/main/nat -config nat.json
```

```
nff-go-0$ ./runpktgen.sh
Pktgen:/> load nat.pg
Pktgen:/> start 0
Pktgen:/> start 1
…
Pktgen:/> quit
```

# Q & A ?

# Optimization Notice

**Optimization Notice**

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2®, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Notice revision #20110804

# Basic components

## Flow functions

**Receive** (Port)
driver (loop) -> Flow

**Send** (Port)
Flow -> driver (loop)

**Stop**
Flow -> free

**Merge** {slow}
Flow ->
Flow -> Flow

**Partition** (periodicity)
-> Flow
Flow -> calculation -> Flow

**Split** (SplitFunction) {input closed}
-> Flow
Flow -> SplitFunction -> Flow
-> Flow

**Separate**(SeparateFunction) {input stay}
-> Flow
Flow -> SeparateFunction -> Flow

**Handle** (SeparateFunction) {can drop}
-> Stop
Flow -> SeparateFunction-> Flow

**Handle** (HandleFunction) {can't drop}
Flow -> HandleFunction -> Flow

**Generate** (GenerateFunction) {can wait}
GenerateFunction -> Flow

## Instances (new types)

**Flow**
Abstraction without public fields, which is used for pointing connections between Flow functions. Opened by Receive / Split / Separate / Counter / Generate. Closed by Send / Merge / Stop.

**Packet**
High-level representation of network packet. Private field is *mbuf, public fields are mac / ip / data /etc: pointers to mbuf with offsets (zero copy). Is extracted before any User defined function. Can be filled after user request by Packet functions. Can be checked by Rule functions.

**Port**
Network door, used in Receive, Send.

**Rule**
Set of checking rules, used in User defined functions.

## Packet functions

**Parsing packet fields**
Parse L2 or/and L3 or/and L4 levels

**Initializing packet fields**
Initialize L2 or/and L3 or/and L4 levels

**Encapsulate / Decapsulate**

## Rule functions

**Create rule**
Create checking rule from json / config

**Checking packet fields by rule**
Check L2 or/and L3 or/and L4 levels

## User defined functions

**Split Function**
-> Packet -> № of Flow -> uint

**Separate Function ***
-> Packet -> Boolean value -> bool

**Handle Function ***
-> Packet ->

**Generate Function ***
Packet ->

All functions take packet and handling context

* Can process vector of packets at one time

All functions at separate cores and can be cloned

## Connections

- External (bytes inside network)
- Flow (*mbufs inside rings)
- Packets (as function arguments)

## Library External Components

- Flow: type "Flow" Init, Starting, Checking, Flow functions
- Packet: type "Packet", parsing / initializing packet functions
- Rules: type "Rule", parsing rules / checking Packet functions
- User package: user defined functions

## Library Internal Components

- Scheduler: Cloning of user defined flow functions
- Asm: assembler functions added to GO
- Common: technical functions shared by other components
- Low: connections with DPDK C implementation

# Lab configuration


Jump host: , Login: gashiman, Password:

# Finally (2 of 2): ipsec

- Showing ipsec example