gRIBI
gRPC Service for RIB Injection

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Overview

- gRIBI is a gRPC service to inject entries into the RIB
- We will look at
  - Existing approaches for route injection, their challenges and how gRIBI helps overcome them
  - Details about the gRIBI service
  - walk thru simple weighted route injection scenario

Motivation

- **Existing approaches* for route injection include**
  - **Direct programming of forwarding plane entries (P4Runtime, OpenFlow)**
  - **Use existing routing protocols to inject entries**
    - **e.g., BGP SR-TE Policy, BGP-LU for egress peer engineering.**
  - **Device APIs using a vendor SDK**

*** something, something … I2RS**

Motivation (contd.)

- **Direct programming assumes**
  - **Controller(s) have full view of device's forwarding table.**
  - **Controller(s) can modify all hardware tables**
  - **Requires controller to know about resolving routes (usually IGP) and reacting to changes**
  - **adds complexity to overall system**

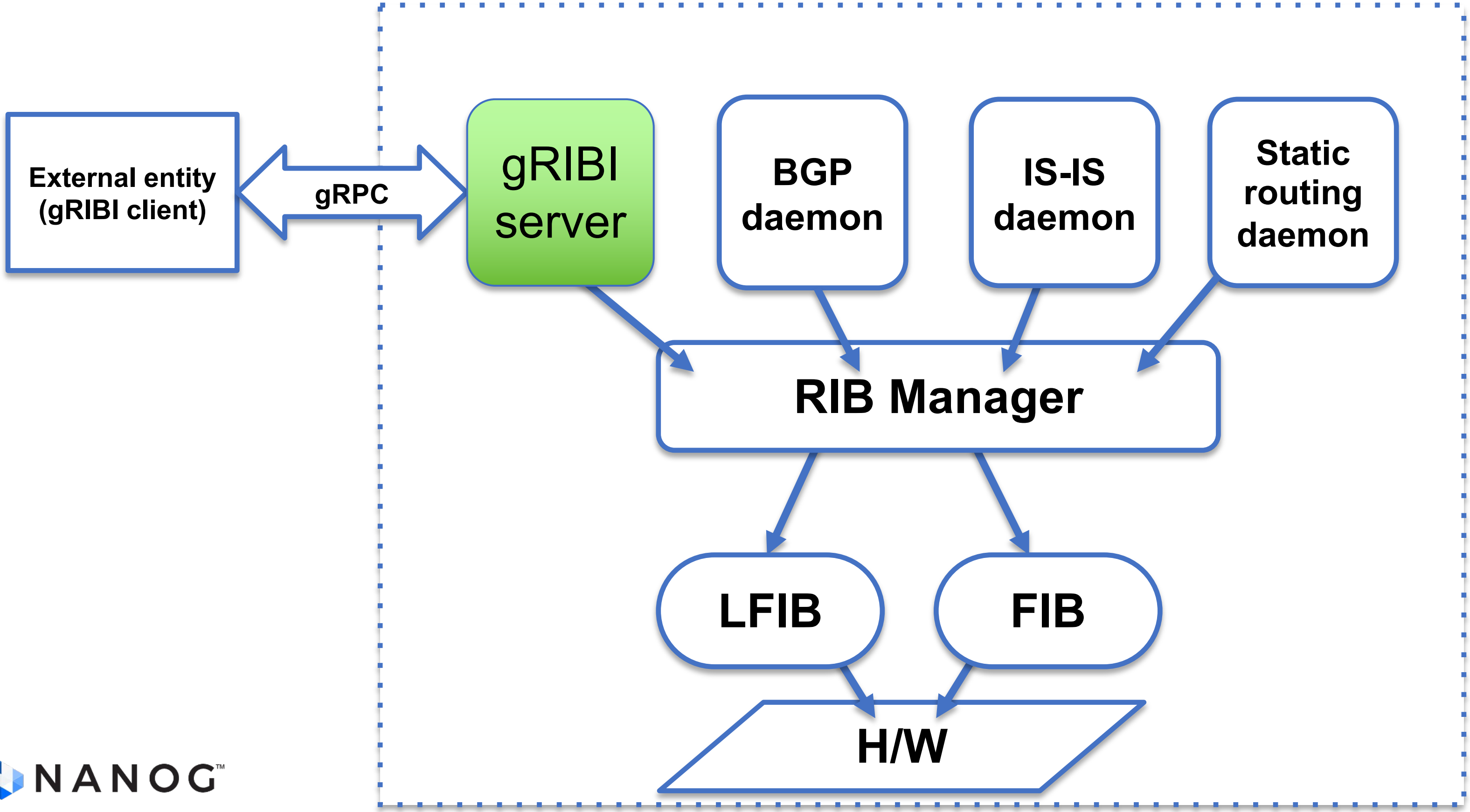
Motivation (contd.)

- Using a routing protocol involves:
  - Force fitting data model and routes to constraints of protocol (for example BGP NLRI uniqueness and affecting BGP best path Algo in the context of BGP SR-TE Policy)
  - No notion of transactional semantics
  - No acknowledgments of programming
- Using a device/vendor-specific API isn't open and portable

gRIBI

- gRPC service to inject (and query) routing table entries into a network device's RIB from an external entity (say a controller)
- From device's PoV, control plane service where injected entries are just another source to device's RIB(s)

gRIBI as a control plane service



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gRIBI Data model

Table entries data model is the existing OpenConfig Abstract Forwarding Table (AFT) converted to protobuf

afts	container
ipv4-unicast	container
ipv4-entry[prefix]	list
prefix	leaf
state	container
prefix	leaf
counters	container
entry-metadata	leaf
origin-protocol	leaf
decapsulate-header	leaf
oc-aftni:next-hop-group	leaf
oc-aftni:next-hop-group-network-instance	leaf
oc-aftni:origin-network-instance	leaf

Transactional semantics for programming operation

- **Every programming operation request from the external entity has an (unique) “id”**
- **Device responds with programming response for every request using the “id” which allows the external entity to tie back to a specific operation**

Support for FIB programming ACK

Acknowledgement from the device can separately indicate the status of the programming in the device's software RIB and hardware FIB

- **enables the controller to do something intelligent based on the response from the device**

Other features

- Includes support for redundant clients
  - i.e., active/standby and active/active
- Persistence of programmed entries
  - Entries programed by client persist in RIB and FIB on client disconnect and gRIBI daemon restart
- Leverages support for gRPC transport security (mTLS/TLS/SPIFFE-ID) to provide secure connections from external entity to device

Example Applications

- Inject route entries into a VRF for scrubbing traffic for DDoS mitigation
  - gRIBI injected entry is another route with its own type and preference
  - Next hops are recursively resolved in the RIB like for any other route from a routing protocol
- Injecting a Labeled FIB entry that points to a WECMP set of label stacks akin to BSID steering in SR Policy
- Variations on these themes for selective tunnel-based traffic engineering

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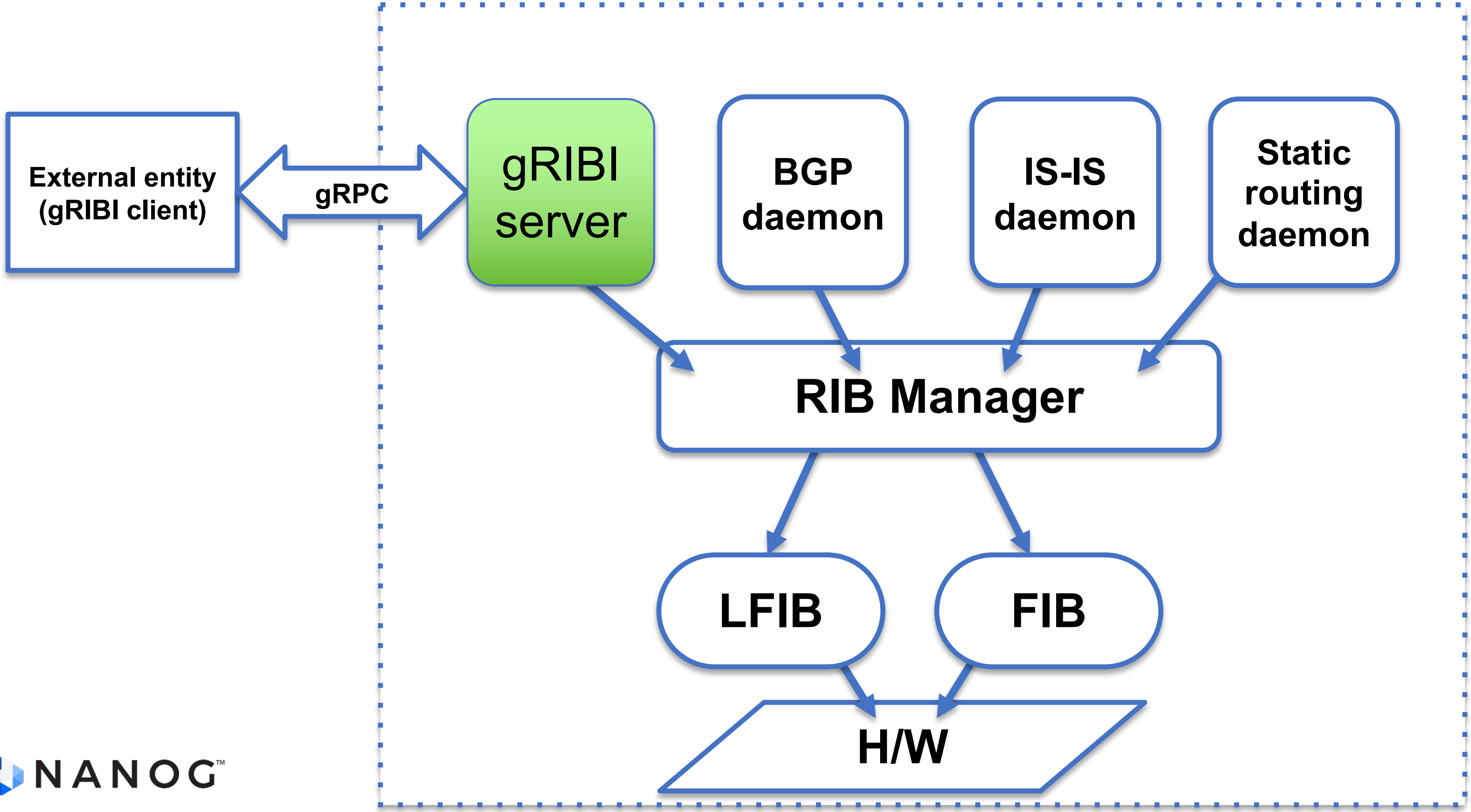
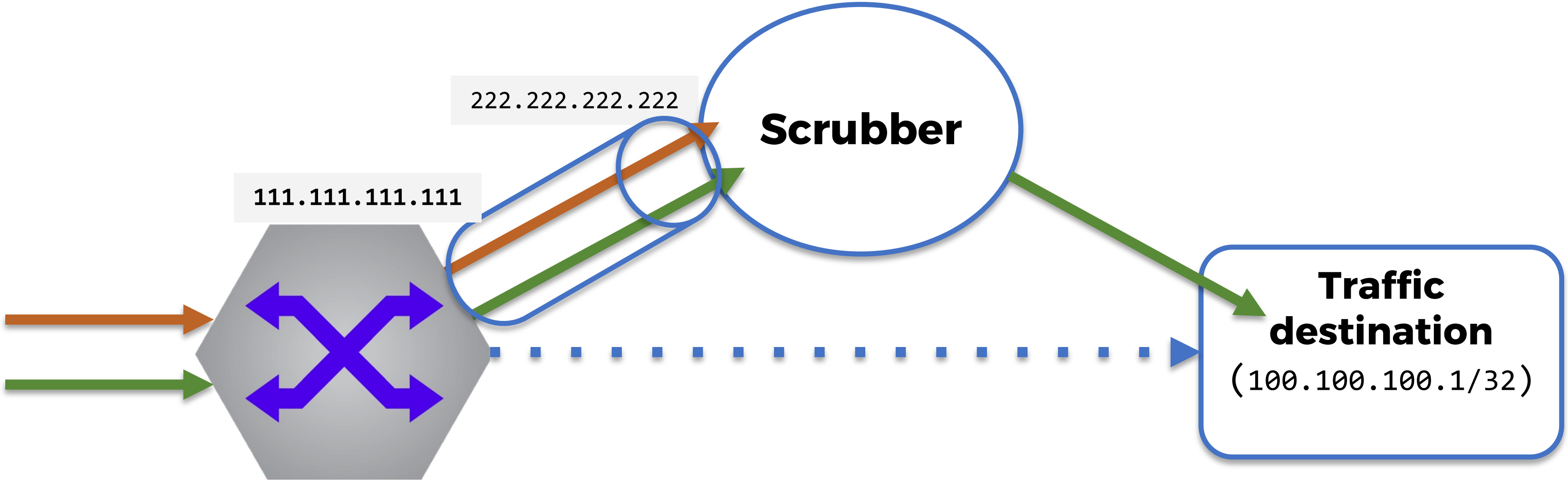
Route injection, *not* config



Traffic scrubbing for DDoS mitigation



Example: prefix forwarding into IPinIP tunnel

```
AFTOperation {
  network_instance: default
  Ipv6 route AFT entry {
    Prefix: 100.100.100.1/32
    Next hop group: 1
 }
}
```

```
AFTOperation {
  network_instance: default
  next hop group AFT entry{
    Id: 1
    Next hops, wt: [(1000, 1)]
  }
}
```

```
AFTOperation {
 network_instance: default
 next hop AFT entry: {
    Id: 1000
    IpInIp {
      src_ip: 111.111.111.111
      Dst_ip: 222.222.222.222
   }
}
```

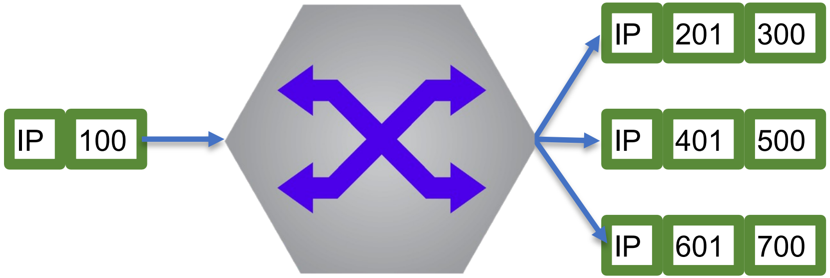
Example: MPLS traffic to LSPs

```
AFTOperation {
  network_instance: default
  MPLS AFT entry {
    Label: 100
    Next hop group: 1
 }
}
```

```
AFTOperation {
 network_instance: default
 next hop group AFT {
  Id: 1
  Next hops, wt: [(1000, 1), (2000,2), (3000, 5)]
 }
}
```

```
AFTOperation {
 network_instance: default
 next hop AFT:
    Id: 1000
    Pushed MPLS label: 201
    Pushed MPLS label: 300
   }
}

{ … Id: 2000}
{ … Id: 3000}
```



* not all WECMP legs are shown

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RPCs

- **Modify**
  - **Inject entries, client parameters.**
- **Get**
  - **Retrieve entries with RIB/FIB installation state**
- **Flush**
  - **OOB delete all entries**

Modify

- rpc Modify(stream ModifyRequest) returns (stream ModifyResponse)
- Each ModifyRequest AFTOperation has
  - id
  - Network instance (VRF)
  - Operation (add/replace/delete)
  - Entry
- Response has
  - id
  - RIB, FIB Status
  - Timestamp

Modify - Session Parameters

- **When a client connects it sends session parameters in a ModifyRequest to specify the type of connections and behaviors that are desired**
  - **Client redundancy - active/active, active/standby**
  - **AFT persistence - persist or delete**
  - **ACK type - RIB ACK or RIB+FIB ACK**

Modify - Election ID

- Used by device to determine active client
- When a client connects, it sends its election ID
- Device responds with highest election ID it knows about
- Each AFT Operation also has the election ID and the gRIBI server only processes operations from the client with the highest election ID

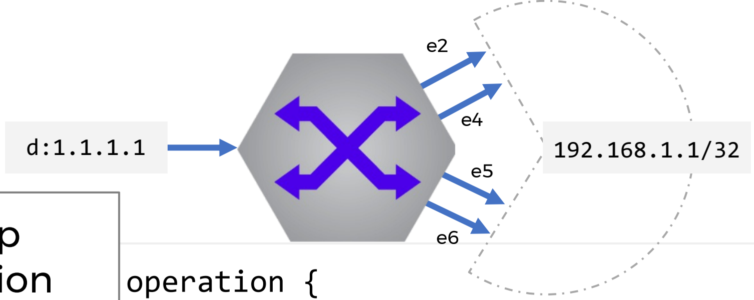
Get - fetch device state

- rpc Get(GetRequest) returns (stream GetResponse):
  - GetRequest from client can request all AFT entries from all VRFs or filter on VRF and/or AFT type
  - Device streams entries along with last RIB and FIB acknowledgement status

Flush - clear one or all VRFs

- rpc Flush(FlushRequest) returns (FlushResponse);
- FlushRequest contains
  - Election ID (or an override to ignore election ID)
  - A VRF name or all VRFs
- FlushResponse contains a result and timestamp.
- Meant to be used by external entity during controller malfunction.

Example



connection params

```
params {
  redundancy:
SINGLE_PRIMARY
  persistence: PRESERVE
}

election_id {
  low: 1
}

{...}
```

next-hop construction

```
operation {
  id: 3
  network_instance: "default"
  op: ADD
  next_hop {
    index: 3
    next_hop {
      ip_address {
        value: "192.168.1.1"
      }
      interface_ref {
        interface {
          value: "Ethernet5"
        }
      }
    }
  }
  election_id {
    low: 1
  }
}
```

```
operation {
  id: 4
  network_instance: "default"
  op: ADD
  next_hop {
    index: 4
    next_hop {
      ip_address {
        value: "192.168.1.1"
      }
      interface_ref {
        interface {
          value: "Ethernet2"
        }
      }
    }
  }
  election_id {
    low: 1
  }
}
```

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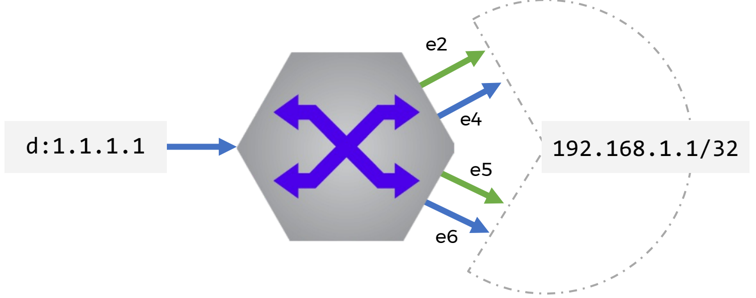
Example

```
{ ... }

operation {
  id: 8
  network_instance: "default"
  op: ADD
  next_hop_group {
    id: 2
    next_hop_group {
      next_hop {
        index: 3
        next_hop {
          weight {
            value: 1
          }
        }
      }
```

next-hop group construction

```
      next_hop {
        index: 4
        next_hop {
          weight {
            value: 3
          }
        }
      }
    }
  }
  election_id {
    low: 1
  }
}
```

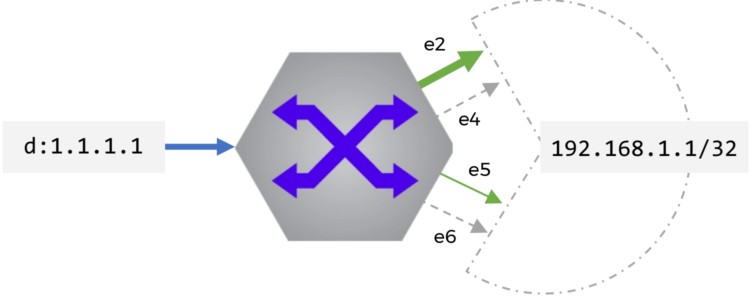


route association

```
{ ... }

operation {
  id: 12
  network_instance: "default"
  op: ADD
  ipv4 {
    prefix: "1.1.1.1/32"
    ipv4_entry {
      next_hop_group_network_instance {
        value: "default"
      }
      next_hop_group {
        value: 2
      }
    }
  }
  election_id {
    low: 1
  }
}
```

Example



network-instance

```
aip1#show ip route
show ip route
VRF: default
WARNING: Some of the routes are not programmed in
kernel, and they are marked with '%'.
Codes: C - connected, S - static, K - kernel,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type2, B - Other BGP Routes,
       B I - iBGP, B E - eBGP, R - RIP, I L1 - IS-IS level 1,
       I L2 - IS-IS level 2, O3 - OSPFv3, A B - BGP Aggregate,
       A O - OSPF Summary, NG - Nexthop Group Static Route,
       V - VXLAN Control Service, M - Martian,
       DH - DHCP client installed default route,
       DP - Dynamic Policy Route, L - VRF Leaked,
       G  - gRIBI, RC - Route Cache Route

Gateway of last resort is not set

 G%       1.1.1.1/32 [5/0] via 192.168.1.1, Ethernet2, weight 3/4
                           via 192.168.1.1, Ethernet5, weight 1/4
 G%       2.2.2.2/32 [5/0] via 192.168.1.1, Ethernet4, weight 3/4
                           via 192.168.1.1, Ethernet6, weight 1/4
 C        3.3.3.0/24 is directly connected, Ethernet5
 C        4.4.4.0/24 is directly connected, Ethernet2
 C        5.5.5.0/24 is directly connected, Ethernet6
 C        6.6.6.0/24 is directly connected, Ethernet4
 C        10.30.1.0/24 is directly connected, Ethernet1
 C        10.40.1.0/24 is directly connected, Ethernet3
 S        192.168.1.1/32 [1/0] is directly connected, Ethernet2
                               is directly connected, Ethernet4
                               is directly connected, Ethernet5
                               is directly connected, Ethernet6
 C        192.168.201.4/30 is directly connected, Ethernet4
```

dynamically programmed entries for 1.1.1.1/32

dynamically programmed next-hop weights

static routes for 192.168.1.1 recursive resolution

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References

- gRIBI - Github repository
  - Motivation document
  - Specification
  - Protobuf definitions
- gRIBIGo Reference implementation

Conclusions

- **gRIBI provides a new and *open* mechanism for programming network device RIB state**
- **Supports a range of forwarding paradigms**
  - **IP tunnels, surgical routing, VRF population, etc.**
  - **not constrained to classic traffic engineering technologies (RSVP)**
- **multiple implementations do exist**
- **reaching a point where operators can start to utilize modern tools and software engineering techniques to interact with the RIB and customize forwarding behaviors**

Thank you

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