Application-aware Networking (APN)
# Solution Discussions

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Progress summary

- APN Side Meetings @IETF105 & IETF108

- APN Hackathons @IETF108 & IETF109 & IETF110

- APN Demos @INFOCOM2020 & 2021

- APN Mailing List: apn@ietf.org

- APN Wiki: https://datatracker.ietf.org/wg/apn/about/

- The use cases have been discussed extensively in previous IETF meetings
  - SD-WAN, FBB, MBB, etc.

- RTG people would like to start working on the solutions of APN.

Scope & Scenario of APN

- APN works within a service operator's network domain.
  - Typically, an APN domain is defined as a service provider's network domain where MPLS, SR/SRv6, VXLAN and other tunnel technologies are adopted.
  - APN attribute is tagged/removed at the edge of the network domain.
- APN is not about identifying a particular application or user within the network.
- APN is about telling the network what policies to apply to traffic.
- **APN attribute is constructed based on the existing information such as 5-tuple presented in the packet header.**
- According to the APN attribute, various policies can be flexibly applied to the traffic flow on various nodes along the network path, without the need of resolving the 5-tuple at every policy enforcement point in the network.
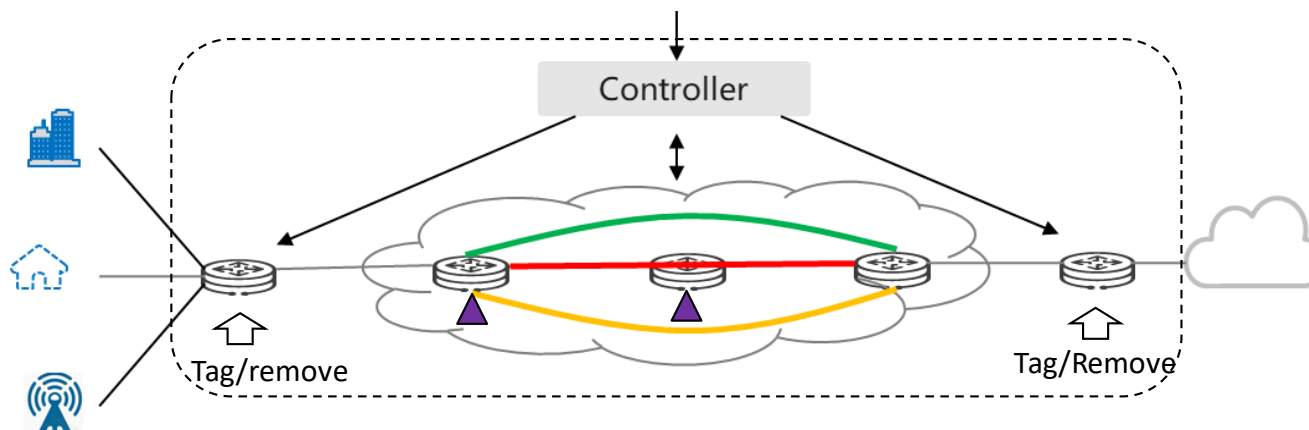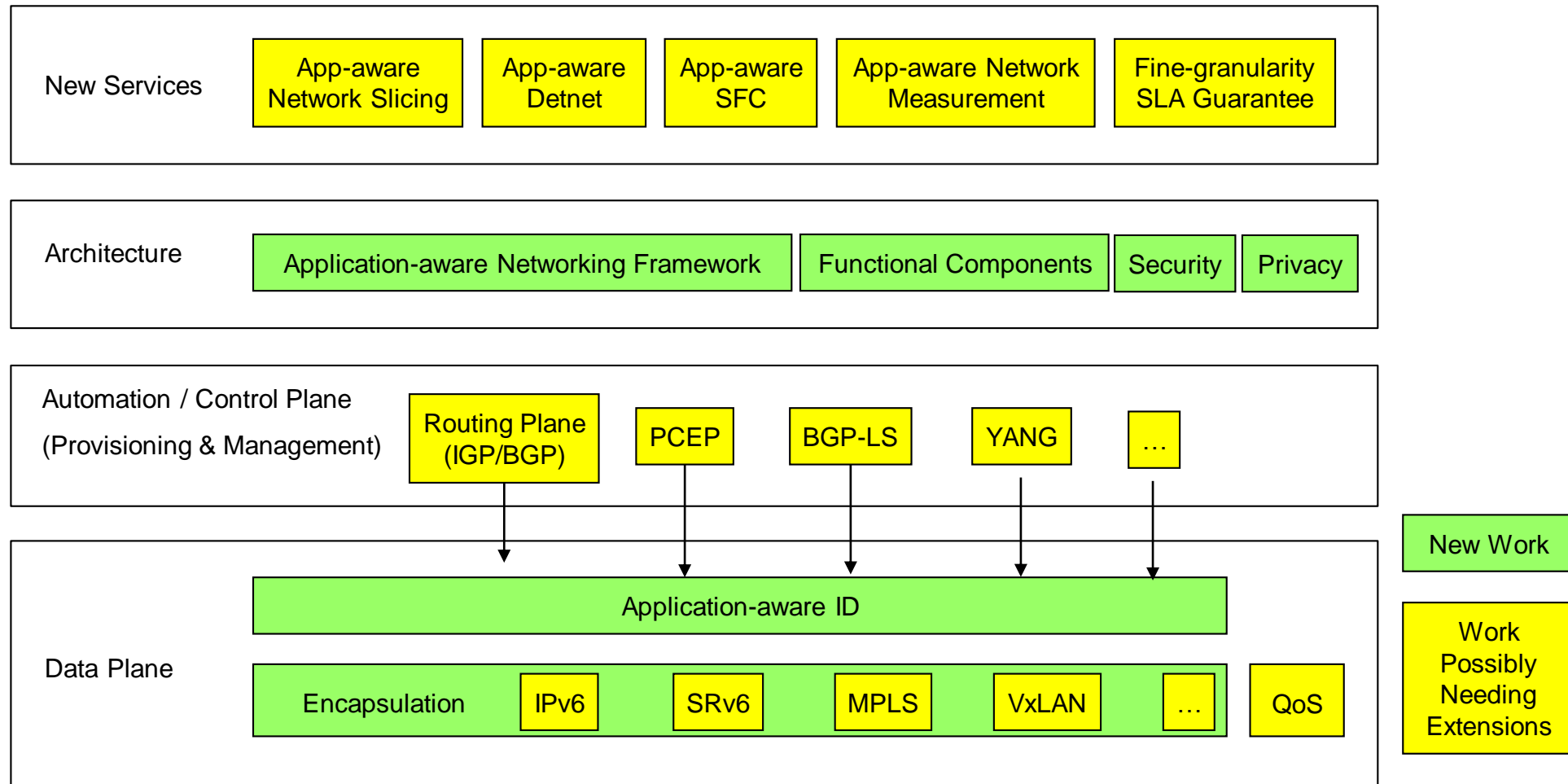
Updates

- Changes we have made to the drafts according to feedback received from the presentations @IETF110
  - Removed the application-side solution, only keep the network-side solution
  - The APN attribute is acquired based on the existing information in the packet header such as 5-tuple and QinQ (S-VLAN and C-VLAN) at the edge devices of the APN domain, added to the data packets along with the tunnel encapsulation.
  - When the packets leave the APN domain, the attribute will be removed together with the tunnel encapsulation header.
  - APN aims to apply various policies in different nodes along a network path onto a traffic flow altogether, for example, at the headend to steer into corresponding path, at the midpoint to collect corresponding performance measurement data, and at the service function to execute particular policies.

- Drafts have been updated accordingly to reflect the presented contents and concepts
  - Framework
    - ✓ https://tools.ietf.org/html/draft-li-apn-framework
  - Problem Statement
    - ✓ https://tools.ietf.org/html/draft-li-apn-problem-statement-usecases
  - Scope & Gap analysis
    - ✓ https://tools.ietf.org/html/draft-peng-apn-scope-gap-analysis
  - Security & Privacy consideration
    - ✓ https://tools.ietf.org/html/draft-peng-apn-security-privacy-consideration

Supporters would like to form a working group

- The potential work items as below,

New Services	App-aware Network Slicing	App-aware Detnet	App-aware SFC	App-aware Network Measurement	Fine-granularity SLA Guarantee

Architecture

Application-aware Networking Framework | Functional Components | Security | Privacy

Automation / Control Plane

(Provisioning & Management)

Routing Plane (IGP/BGP)   PCEP   BGP-LS   YANG   …

Data Plane

Application-aware ID

Encapsulation   IPv6   SRv6   MPLS   VxLAN   …   QoS

New Work

Work Possibly Needing Extensions

APN: Application-aware Networking

Solutions that need to look into

1. Design of the APN attribute

2. Encapsulation of the APN attribute on the various data planes

3. Delivery of the APN attribute through the control plane protocols

4. Management of the APN attribute via NETCONF/YANG

Design of the APN attribute

- Do we need a dedicated header for APN?
- What should be the structure of the APN attribute?
- Shall the APN attribute include
  - SLA (Mandatory/Optional?)
    - ✓ The SLA level of the service requirements
  - APP Group ID (Mandatory/Optional?)
    - ✓ The identifier of the application type/group
  - USER Group ID (Mandatory/Optional?)
    - ✓ The identifier of the user type/group
  - Session/FLOW ID (Mandatory/Optional?)
    - ✓ The identifier of the key session/flow of the traffic flow
  - Requirement parameters?
    - ✓ Bandwidth, Latency, Jitter, Packet loss?
- Total Length
  - Flexible/Fixed?
- Length of each field
  - Flexible/Fixed?

Example of the APN attribute structure

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   SLA Level   |    APP ID    |   User ID   |   Flow ID   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

        Figure 4. Application-aware ID Structure I


+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SLA Level|  APP ID  |  User ID  |  Flow ID   |  Arguments  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

        Figure 5. Application-aware ID Structure II
```

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Length    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   RESERVED    |                Delay                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

              Figure 9. Delay Sub-TLV
```

https://tools.ietf.org/html/draft-li-6man-app-aware-ipv6-network-03
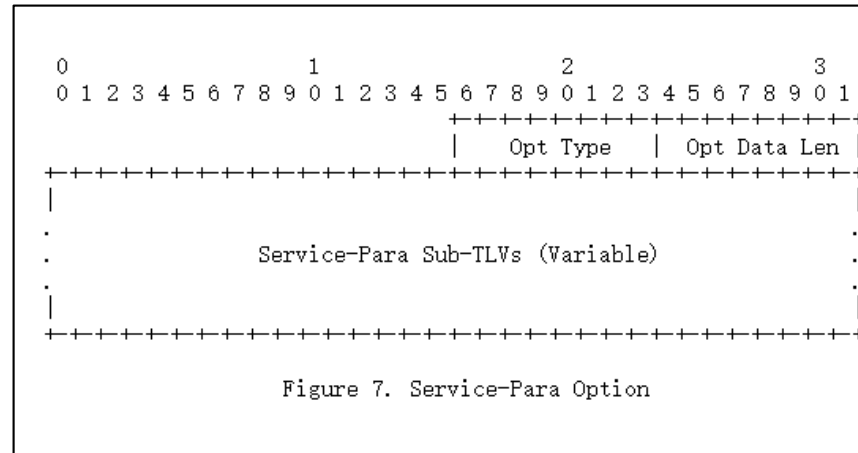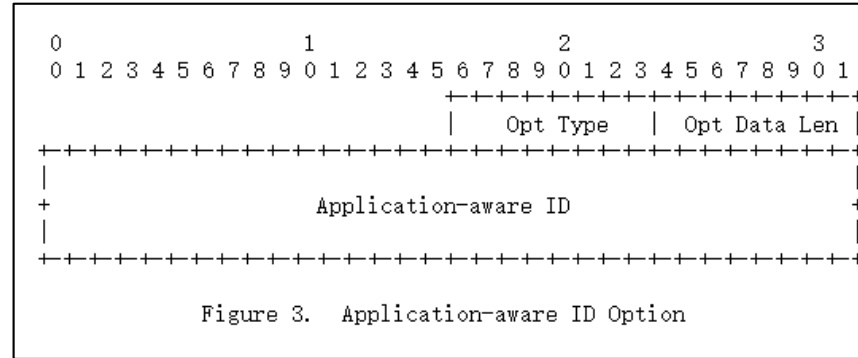
Encapsulation of the APN attribute on the various data planes

- MPLS

- IPv6

- SRv6

- VxLAN

- GRE

- ?

Example of the encapsulation of the APN
attribute on the IPv6 data plane

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                |   Opt Type    | Opt Data Len  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                        Application-aware ID                   +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

          Figure 3.  Application-aware ID Option
```

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                |   Opt Type    | Opt Data Len  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
.                                                               .
.                   Service-Para Sub-TLVs (Variable)            .
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

          Figure 7. Service-Para Option
```

https://tools.ietf.org/html/draft-li-6man-app-aware-ipv6-network-03

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Delivery of the APN attribute through the control plane protocols

- BGP
  - Between PE

  - Between the Controller and the PE

- PCEP
  - Between the Controller and the PE

- IGP?
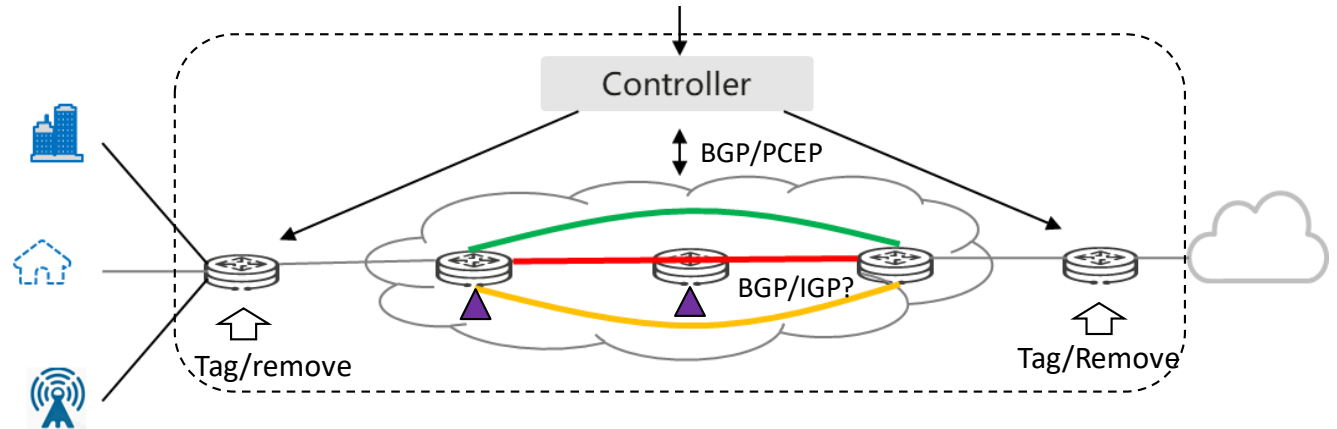
Management of the APN attribute via NETCONF/YANG

- YANG model for the NBI of the controller

- YANG model for the SBI of the controller

```
+--rw application* [app-id]
|  +--rw app-id     svc-id
|  +--rw ac* [name]  =application criteria
|     +--rw name                          string
|     +--rw (match-type)?
|        +--:(match-flow)
|        |  +--rw match-flow
|        |     +--rw ethertype?         uint16
|        |     +--rw cvlan?             uint8
|        |     +--rw ipv4-src-prefix?   inet:ipv4-prefix
|        |     +--rw ipv4-dst-prefix?   inet:ipv4-prefix
|        |     +--rw l4-src-port?       inet:port-number
|        |     +--rw l4-dst-port?       inet:port-number
|        |     +--rw ipv6-src-prefix?   inet:ipv6-prefix
|        |     +--rw ipv6-dst-prefix?   inet:ipv6-prefix
|        |     +--rw protocol-field?    union
|        +--:(match-application)
|           +--rw match-application?    identityref
+--rw application-group* [app-group-id]
|  +--rw app-group-id   svc-id
|  +--rw app-id*              -> ../../application/app-id
+--rw policy* [policy-id]
|  +--rw policy-id          svc-id
|  +--rw policy-package
|     +--rw encryption?        enumeration
|     +--rw public-private?    enumeration
|     +--rw local-breakout?    boolean
|     +--rw billing-method?    enumeration
|     +--rw backup-path?       enumeration
|     +--rw bandwidth
|        +--rw commit?    uint32
|        +--rw max?       uint32
+--rw endpoints* [endpoint-id]
   +--rw endpoint-id              svc-id
   +--rw site-role?               identityref
   +--rw site-attachment
   |  +--rw site-id?   -> /sdwan-svc/sites/site/site-id
   +--rw endpoint-policy-map
      +--rw app-group-policy* [app-group-id]
      |  +--rw app-group-id   leafref
      |  +--rw policy-id?     leafref
      +--rw app-policy* [app-id]
         +--rw app-id         leafref
         +--rw policy-id?     leafref
```

Match

Policy

Policy

```
+--rw flowspec-cfg
   +--rw flowspec-policy* [policy-name]
      +--rw policy-name        string
      +--rw vrf-name?          string
      +--rw address-family?    identityref
      +--rw flowspec-rule* [rule-name]
         +--rw rule-name             string
         +--rw flowspec-component* [component-type]
            +--rw component-type          component-enum
            +--rw (component)?
               +--:(destination-prefix)
               |  +--rw destination-prefix?   inet:ip-address
               +--:(source-prefix)
               |  +--rw source-prefix?        inet:ip-address
               +--:(ip-protocol)
               |  +--rw ip-protocol* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    uint16
               +--:(port)
               |  +--rw port* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    uint16
               +--:(destination-port)
               |  +--rw destination-port* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    uint16
               +--:(source-port)
               |  +--rw source-port* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    uint16
               +--:(icmp-type)
               |  +--rw icmp-type* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    uint8
               +--:(icmp-code)
               |  +--rw icmp-code* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    uint8
               +--:(tcp-flags)
               |  +--rw tcp-flag* [op value]
               |     +--rw op       bitmask-operator
               |     +--rw value    uint16
               +--:(packet-length)
               |  +--rw packet-length* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    uint16
               +--:(dscp)
               |  +--rw dscp* [op value]
               |     +--rw op       numeric-operator
               |     +--rw value    dscp-type
               +--:(fragment)
                  +--rw fragment* [op value]
                     +--rw op       numeric-operator
                     +--rw value    fragment-type
      +--rw flowspec-action* [action-type]
         +--rw action-type     action-type
         +--rw (action)?
            +--:(traffic-rate)
            |  +--rw rate?            float
            +--:(redirect)
            |  +--rw route-target?    string
            +--:(traffic-marking)
               +--rw remark-dscp?     dscp-type
```
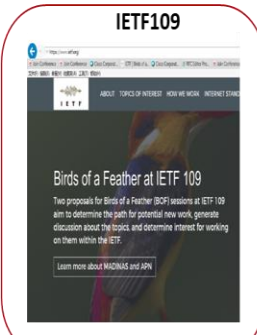
Match

Action

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Next step

- Work on the Charter of the APN working group, who wants to get involved?

- Work on the drafts on solutions, who wants to get involved?

Thank you!

APN Activities

- **Side Meetings** @IETF105 & IETF108
- **Hackathons** @IETF108 & IETF109 & IETF110
- **Demos** @INFOCOM2020 & 2021
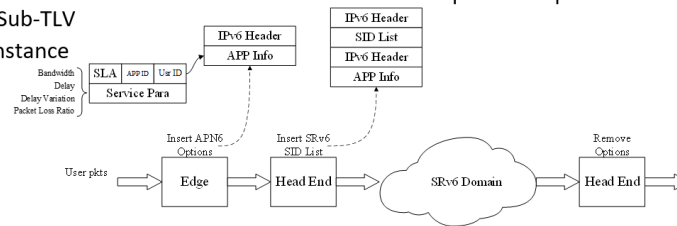- **APN Mailing List** Discussions - apn@ietf.org

IETF105

IETF108

IETF109

IETF110

https://github.com/APN-Community

https://www.ietf.org/blog/ietf109-bofs/
https://www.ietf.org/blog/ietf110-bofs/

https://ieeexplore.ieee.org/abstract/document/9162934
https://www.youtube.com/watch?v=ONqwxKVmPp0

Application-aware G-SRv6 network

- Champions
  - Jianwei Mao (maojianwei@...)
  - Cheng Li (c.l@...)
  - Shuping Peng (pengshuping@...)
- Projects
  - Develop functions of Generalized SRv6 (G-SRv6)
  - Combine G-SRv6 with APN6, to achieve Applica...
- Specifications
  - ➡draft-lc-6man-generalized-srh
  - ➡draft-cl-spring-generalized-srv6-np
  - ➡draft-cl-spring-generalized-srv6-for-cmpr
  - ➡draft-li-6man-app-aware-ipv6-network
  - ➡draft-li-apn-framework

- Application-aware traffic control.
  - Make use of the IPv6 extensions header to convey the service requirements, in the form of APN6 options and optional Sub-TLV.
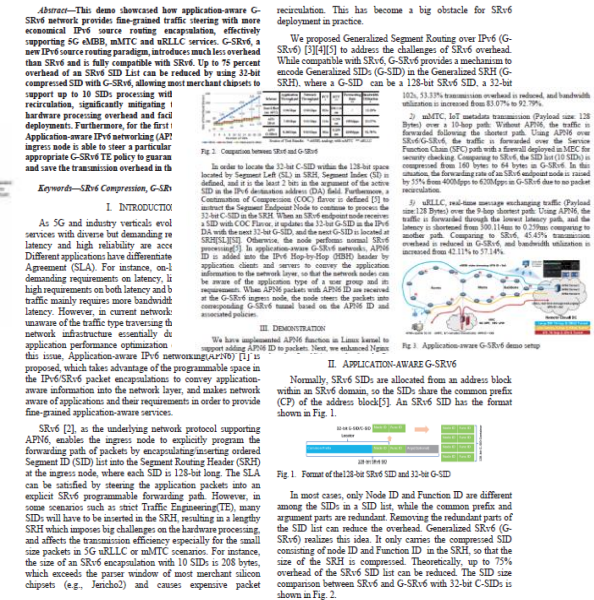 - Determine the SRv6 SID List based on the encapsulated options and Sub-TLV
- An Instance

https://trac.ietf.org/trac/ietf/meeting/wiki/110hackathon
https://trac.ietf.org/trac/ietf/meeting/wiki/109hackathon
https://trac.ietf.org/trac/ietf/meeting/wiki/108hackathon

Implemented Functions

- We've implemented the demo based on *P4*, and conducted some simulations based on *BMv2*.
- Functions in Demo
  - APN6:
    1. The encapsulation of APN6 Options and Serice-Para Sub-TLV, support 2 types of APN6 Options and 4 types of Sub-TLV
    2. The encapsulation of the SRv6 SID List according to IPv6 DA and APN6 options
    3. Basic SRv6 END SID processing

- **Result**
  - Send 50,000 packets in each experiment.
  - The interval between 2 packets is 1ms.
  - All results are in nanoseconds
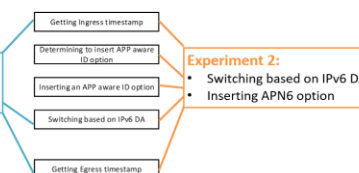
Performance Evaluation

- **Processing Latency**

Experiment 1:
- Switching based on IPv6 DA
- Without processing of APN6

Experiment 2:
- Switching based on IPv6 DA
- Inserting APN6 option

Experiment	Mean	STDEV	MAX	MIN	Range
1 (IPv6)	364.07436	0.56514087	366	363	3
2 (IPv6 & APN6)	370.63256	0.611774343	373	369	4
DIFF	6.5582	0.046633473	7	6	

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References – Drafts have been updated

Please find the APN BoF proposal in the IETF wiki for more information.

- https://trac.tools.ietf.org/bof/trac/wiki/WikiStart

The archived discussions in this APN mailing list can be found here.

- https://mailarchive.ietf.org/arch/browse/apn/

To subscribe the APN Mailing list,

- https://www.ietf.org/mailman/listinfo/apn

Here are some relevant drafts and materials for your reference.
Scope & Gap analysis

- https://tools.ietf.org/html/draft-peng-apn-scope-gap-analysis

Problem statement & Use cases

- https://tools.ietf.org/html/draft-li-apn-problem-statement-usecases
- https://tools.ietf.org/html/draft-liu-apn-edge-usecase
- https://tools.ietf.org/html/draft-zhang-apn-acceleration-usecase
- https://tools.ietf.org/html/draft-yang-apn-sd-wan-usecase

Framework

- https://datatracker.ietf.org/doc/draft-li-apn-framework/

Security & Privacy

- https://datatracker.ietf.org/doc/draft-peng-apn-security-privacy-consideration

APN Community

- https://github.com/APN-Community

APN: Application-aware Networking