IPv6+ Introduction and Innovation
Principle of SRv6 Network Programming

Three Layers of Programming Spaces

<table>
<thead>
<tr>
<th>Version</th>
<th>Traffic Class</th>
<th>Flow Label</th>
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<tbody>
<tr>
<td>Pload Length</td>
<td>Next=43</td>
<td>Hop Linmit</td>
</tr>
<tr>
<td>Source Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next Header</td>
<td>Hdr Ext Len</td>
<td>Routing Type</td>
</tr>
<tr>
<td>Last Entry</td>
<td>Flags</td>
<td>Tag</td>
</tr>
</tbody>
</table>

IPv6 Header

SR Header

IPV6 SRH HEADER

Payload

The “Function” can identify the L2VPN/L3VPN, and other services or APP.

1. Flexible Segments Combination
2. Flexible Fields of Segment
3. Flexible TLVs Combination

Option TLV
L3VPN Over BE Tunnel for SRv6

VPN route: 1.1.1.1
NHP: A2:1::124
VPN Sid: A2:1::B100

My local sid table:
A2:1::B100 END.DT4
IPv4 L3VPN(VRF 100) END.DX4 – per CE per SID, no FRR for CE/PE

Control

BGP Route: A2:1/64
Redistribute to ISIS
ISIS Route: A2:1/64

PE
P
P
PE

Payload
SA:2.2.2.2
DA:1.1.1.1

Payload
SA:2.2.2.2
DA:1.1.1.1

Payload
SA:2.2.2.2
DA:1.1.1.1

Payload
SA:2.2.2.2
DA:1.1.1.1

Payload
SA:2.2.2.2
DA:1.1.1.1

Forwarding

CFG:
1 SR ipv6-srh end-sid A2:1 64
2 ip vpn-instance vpn100
prefix-sid dynamic A2:1 64
3 Interface loopback0
IPv6 address A2:1::124 64
L3VPN Over TE Tunnel for SRv6

SR Policy:{A1:2,A1:3} ENDPOINT:A2:1 explicitly config Steering VPN Traffic into an SR Policy

Payload
SA:2::2 DA:1::1
A2:1::B100
A1:3
A1:2

Payload
SA:2::2 DA:1::1
A2:1::B100
A1:3
A1:2

Payload
SA:2::2 DA:1::1
A2:1::B100
A1:3
A1:2

Payload
SA:2::2 DA:1::1
A2:1::B100
A1:3
A1:2

Payload
SA:2::2 DA:1::1
A2:1::B100
A1:3
A1:2
SA:A1:1::123 DA:A2:1::B100

My local sid table: A2:1::B100 END.DT4 IPv4 L3VPN(VRF 100)

FG: 1 SR ipv6-srh end-sid A2:1 64
2 ip vpn-instance vpn100 prefix-sid dynamic A2:1 64
3 Interface loopback0 Ipv6 address A2:1::124 64
SRv6 Evolution: End-to-end Network Unified Forwarding Process

- Simplicity: Work based on IPv6 reachability, no extra signaling.
- Industry Acceptance: MPLS in DC is not well accepted. SRv6 is based on IP reachability as VXLAN.
- E2E: Unified process to converge different IP network domain. TE and SFC can be deployed incrementally and easily.
- Extensibility: Possibility to be extended from network devices to application devices which support IPv6.
SRv6 pushes the next generation Internet to the IPv6+ Era

IPv4
- TCP/IP Basic Connection
- IP/TCP Framework
- RIP/IGRP/OSPF/ISIS/BGP/IGMP
- Insufficient IPv4 addresses
- V4/v6 transition
- IPv6 basic protocol
- NAT64, 6PE, 6vPE
- RIPng, OSPFv3, BGP
- 4+, ISISv6, ICMPv6, PIM-IPv6, IGMPv3
- Fast forwarding, multi-service bearer and quality of service

IPv6
- Multicast requirement
- Reliability requirements
- IPv6 requirement
- PIM
- PIM-IPv6
- IPv6 base protocol
- IPFRR
- SDN, network cloudification
- SDN, network programmability
- Internet of Everything
- SRv6 technology drives IPv6 protocol into the mainstream

MPLS
- SLA: MPLS TE
- Multiple services: L3/2VPN
- MPLS basic protocols
- EVPN/BGP-LS/BIER/SR/TI-LFA
- SDN, network cloudification
- SDN, network cloudification, Internet of Everything

IETF IAB stated that IPv4 protocol updates are no longer supported

2016

2018

New service, QoS: VPN+/IOAM/BIER6/DETNET/iFIT
IPv6 for Cloud: DC/SFC/SD-WAN/compression/security
App and Network Convergence, network programmability: APN6
SDN/AI: PCEP for SRv6
IPv6+ Research and Standard Planning Recommendations

IPv6+ 1.0: SRv6 basic features
- SRv6 VPN
- SRv6 TE
- SRv6 FRR

IPv6+ 2.0: 5G/cloud based application
- VPN+
- IFIT
- SFC

IPv6+ 3.0: APN6 – App-aware network architecture
- Forwarding plane: App information conveying via IPv6 extension header
- Protocol control plane: exchange information through protocol
IFIT (Insitu Flow Information Telemetry) Research Plan

<table>
<thead>
<tr>
<th>Solution</th>
<th>IPRAN SLA</th>
<th>Private Line SLA</th>
<th>Microburst Analysis</th>
<th>Cloud VR Optimization</th>
<th>Active Probe</th>
</tr>
</thead>
</table>

- **Architecture**
  - IFIT Framework: enable the closed loop interactive telemetry

- **Automation**
  - (Control and Management)
    - IGP
    - BGP
    - PCEP
    - ICMP
    - IPFIX
    - YANG

- **Data Plane**
  - Method
    - Passport
    - Postcard
    - Alternate Marking: RFC8321
  - Header Format
    - IFA
    - INT
    - IOAM
    - IOAM-DEX
    - IFIT-Lite
    - Multicast IFIT
  - Encapsulation
    - IPv6, SRv6, MPLS, UDP, VxLAN, BIER …

- **Ready**
- **Standardizing**
- **Studying**
## IFIT Drafts and Award

<table>
<thead>
<tr>
<th>Area</th>
<th>Topic</th>
<th>Drafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework</td>
<td>In-situ Flow Information Telemetry Framework</td>
<td>draft-song-ifit-framework</td>
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<tr>
<td>Basic Encapsulation</td>
<td>Data Fields for In-situ OAM</td>
<td>draft-ietf-ippm-ioam-data</td>
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<td>Export User Flow Telemetry Data by Postcard Packets</td>
<td>draft-song-ippm-postcard-based-telemetry</td>
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<td>In-situ OAM Direct Exporting</td>
<td>draft-ietf-ippm-ioam-direct-export</td>
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<td>Enhanced Alternate Marking Method</td>
<td>draft-zhou-ippm-enhanced-alternate-marking</td>
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<tr>
<td>Encapsulation Types</td>
<td>IPv6 Encapsulation for SFC and IFIT</td>
<td>draft-li-6man-ipv6-sfc-ifit</td>
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<td>IPv6 Application of the Alternate Marking</td>
<td>draft-fz-6man-ipv6-alt-mark</td>
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<td>In-situ OAM Processing in Tunnels</td>
<td>draft-song-ippm-ioam-tunnel-mode</td>
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<tr>
<td>YANG Models</td>
<td>A YANG Data Model for In-Situ OAM</td>
<td>draft-zhou-ippm-ioam-yang</td>
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</tbody>
</table>

IFIT Data Plane has progressed fast and WG adopted

IFIT got awarded at Interop 2019
VPN+ Architecture: Enables Transport Network Slicing

End-to-End Network Slice Manager

RAN Slice Manager

TN Slice Manager

Core Slice Manager

Network Slice Management
- Dynamic/automatic network slice life-cycle management
- Creation, monitoring, adjustment, deletion
- Deploy services in network slices

Network Slice Instantiation
- Customize network slice topology and associated attributes
- Integration between overlay connectivity and underlay resource

Network Resource Partitioning
- Physical Interface
- Flexible Ethernet (FlexE)
- Logical sub-interface
- Dedicated queues
- Time Sensitive Networking (TSN)

YANG Models

SR/SRv6 Extensions

Underlay Innovations

## VPN+ Drafts in IETF

<table>
<thead>
<tr>
<th>Area</th>
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<th>Content</th>
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<tbody>
<tr>
<td>Framework</td>
<td>VPN+ Framework</td>
<td>draft-ietf-teas-enhanced-vpn</td>
<td>Describe the architecture of VPN+ and the candidate technologies in different layers. <strong>Network slicing is one use case of VPN+.</strong></td>
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<tr>
<td></td>
<td>VPN+ Scalability Considerations</td>
<td>draft-dong-teas-enhanced-vpn-vtn-scalability</td>
<td>Analyze the control plane and data plane scalability of VPN+ and possible optimizations</td>
</tr>
<tr>
<td>Data Plane</td>
<td>SR based VPN+</td>
<td>draft-dong-spring-sr-for-enhanced-vpn</td>
<td>Define SR data plane extensions for VPN+, resource semantics are added to SR SIDs.</td>
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<tr>
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<td>Carrying VTN ID in IPv6 Extension Headers</td>
<td>draft-dong-6man-enhanced-vpn-vtn-id</td>
<td>Define IPv6 data plane extensions for identifying the underlay of VPN+</td>
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<td>Control Plane</td>
<td>IGP extensions for SR based VPN+</td>
<td>draft-dong-lsr-sr-enhanced-vpn</td>
<td>Define the IGP extensions for SR based VPN+</td>
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<td>BGP-LS Extensions for SR based VPN+</td>
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<td>Define the BGP-LS extensions for SR based VPN+</td>
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Challenges by the decoupled Applications and Network

- The challenges faced by Operators
  - Large but dumb pipeline, not able to obtain corresponding revenue increase
  - Not aware of the applications, only coarse-granularity SLA, resource waste and cost increase
- The problems caused by the current app-aware network services
  - ACL/PBR based on 5 tuples
    - Indirect application information which requires mapping and converting
    - Impacted forwarding performance
    - Bad scalability limited by the hardware resources
  - DPI (Deep Packet Inspection)
    - Challenges by network neutrality and security
    - Impacted forwarding performance
  - Application-awareness based on the orchestrator/controller
    - Long control and management loop, hard to have quick response
    - Multiple interfaces, hard to standardize, difficult to interwork
**App-aware IPv6 Networking (APN6) Framework**

- Make use of IPv6 extensions header to convey the service requirements along with the packet to the network.
- To facilitate the service deployment and network resource adjustment to guarantee SLA for applications.

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**IPv6/SRv6 (Host-side Solution)**

**IPv6/SRv6 (Network-side Solution)**

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https://tools.ietf.org/html/draft-li-6man-app-aware-ipv6-network-00 @IETF105
Three Elements of APN6

1. Open Application info carrying
   - APP-ID
     - SLA Level
     - App ID
     - User ID
     - Flow ID
   - APP Parameter Info
     - Bandwidth
     - Latency
     - Loss rate

2. Rich network services
   - DiffServ
   - H-QoS
   - Network slicing
   - DetNet
   - SFC
   - BIER6

3. Accurate Network Measurement
   - Finer-granularity
     - per packet vs. per flow, per node vs. E2E, individual vs. statistics, etc.
   - Comprehensive measurements
     - per packet with per flow, per node with E2E, individual with statistics, in-band with out-band, passive with active, etc.
## APN6 Side Meeting @ IETF105
- Thursday Morning @Notre Dame
- Attendee: 50+

### Agenda
1. Admin (Chairs) [5 : 5/75]
2. Problem Statement and Requirements (Zhenbin Li) [10 : 15/75]
3. Application-aware Information Conveying
   a) Framework of App-aware IPv6 Networking (Shuping Peng) [10 : 25/75]
   b) Firewall and Service Tickets (Tom Herbert) [10 : 35/75]
   c) SRH Metadata for Simplified Firewall (Jim Guichard) [5 : 40/75]
4. App-aware Services
   a) IPv6-based DetNet (Yongqing Zhu) [5 : 45/75]
   b) SV6 Path Segment (Fengwei Qin) [5 : 50/75]
   c) IPv6-based IFIT (In-situ Flow Information Telemetry) (Haoyu Song) [5 : 55/75]
5. Shaping Our Discussion (Chairs and Room) [15 : 70/75]
6. Wrap Up (Chairs) [5 : 75/75]

### Next Step:
- Setup Mailing list to continue discussions
- [https://github.com/shupingpeng/IETF105-Side-Meeting-APN6](https://github.com/shupingpeng/IETF105-Side-Meeting-APN6)

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<tr>
<td>APN6</td>
<td>Problem statement and use cases</td>
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<td>Application-aware IPv6 Networking</td>
<td>draft-li-apn6-app-aware-ipv6-network</td>
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<table>
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<tr>
<th>Chinese Gov.</th>
<th>Operators</th>
<th>Vendors</th>
<th>Operators &amp; Verticals</th>
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<tbody>
<tr>
<td>CAICT 中国信通院</td>
<td>Bell</td>
<td>Deutsche Telekom</td>
<td>SoftBank</td>
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<td>KDDI</td>
<td>VMware</td>
<td>TOYOTA</td>
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<table>
<thead>
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<td>NOKIA</td>
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<tr>
<td>Cisco MDE</td>
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<td>Loughborough University</td>
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<td>Google</td>
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<tbody>
<tr>
<td>TOYOTA</td>
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<td>CERN</td>
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Chinese IPv6+ Technology Innovation Working Group

**Technology Innovation WG Goals:**
Relying on the achievements of IPv6 large-scale deployment in China, **strengthen the architectural innovation** based on IPv6 next-generation Internet technology, **integrate the IPv6 related technology ECO-system.**

The direction is to actively carry out **new IPv6+ network technologies**, test verification and demonstration of **new applications**, continuously improve the **IPv6 technical standard** system, and significantly improve China’s **international competitiveness in the IPv6 field.**

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**Industry-University-Research-Application, Multi-dimensional Integration**

- CAICT
- HUAWEI
- Peking University
- China Telecom
- China Mobile
- China Unicom
- Alibaba Group
- Tencent
- CBN
- ChinaCache
- State Grid
- TopSec
- FIEC
- NGIunion
- HUAWEI
- SINOPEC
- China Petroleum
- China Oil
Thank you