

IETF に見る ネットワークと ソフトウェアの関係

東京大学 情報基盤センター
関谷 勇司

IETF とは (1)

- Internet Engineering Task Force
 - 精神 : We believe in rough consensus and running code.
- 主にネットワークのプロトコルに関する標準化を行う
 - 議論は分科会 (WG) 単位で行う
 - 誰でも WG に参加でき誰でも提案できる
 - 誰でも提案を発表し、議論を行うことができる
- 年に3回開催され、近年は 北米、EU、アジア地区 のローテーションが多い

IETF とは (2)

■ 問題点も

- 標準 (RFC) として発行されるまでの時間が長くなりがち
- 複数対案が出た場合の決定が難しい

■ WG は Area に属しており、Area 毎に Area Director が存在する

IETF Meeting

100th IETF

November 11-17, 2017, Singapore; Hosted by Cisco
1018 onsite attendees
468 remote attendees
[Proceedings](#)

99th IETF

July 16-21, 2017, Prague, Czech Republic; Sponsored by CZ.NIC, Comcast, NBC Universal
1230 onsite attendees
506 remote attendees
[Proceedings](#)

98th IETF

March 26-31; Chicago, IL, USA; Sponsored by Ericsson
1127 onsite attendees
315 remote attendees
[Proceedings](#)

97th IETF

November 13-18, 2016; Seoul, South Korea; Sponsored by Huawei
1018 onsite attendees
367 remote attendees
[Proceedings](#)

96th IETF

July 17-22, 2016; Berlin, Germany; Sponsored by Juniper Networks
1424 onsite attendees
368 remote attendees
[Proceedings](#)

IETF 101

March 18-23, 2018
Hosts: Google and ICANN
Location: London, UK - Hilton London Metropole

IETF 102

July 14-20, 2018
Host: Juniper Networks
Location: Montreal, Canada - Fairmont Queen Elizabeth Montreal

IETF 103

November 3-9, 2018
Host: Please contact iad@ietf.org for hosting opportunities.
Location: Bangkok, Thailand - Marriott Marquis Queen's Park

IETF 104

March 23-29, 2019
Host: Please contact iad@ietf.org for hosting opportunities.
Location: Prague, Czech Republic - Hilton Prague

IETF 105

July 20-26, 2019
Host: Please contact iad@ietf.org for hosting opportunities.
Location: Montreal, Canada - Fairmont Queen Elizabeth Montreal

WGs

int active WGs

Group	Responsible AD	Name	Chairs
6lo	Suresh	IPv6 over Networks of Resource-constrained Nodes	Samita Chakrabarti , Gabriel Montenegro
6man	Suresh	IPv6 Maintenance	Robert Hinden , Ole Troan
6tisch	Suresh	IPv6 over the TSCH mode of IEEE 802.15.4e	Pascal Thubert , Thomas Watteyne
dhc	Suresh	Dynamic Host Configuration	Tomek Mrugalski , Bernie Volz
dmm	Suresh	Distributed Mobility Management	Sri Gundavelli , Dapeng Liu
dnssd	Terry	Extensions for Scalable DNS Service Discovery	Tim Chown , David Schinazi
dprive	Terry	DNS PRIVate Exchange	Brian Haberman , Tim Wicinski
hip	Terry	Host Identity Protocol	Gonzalo Camarillo
homenet	Terry	Home Networking	Ray Bellis , Stephen Farrell , Barbara Stark
intarea	Suresh	Internet Area Working Group	Wassim Haddad , Juan-Carlos Zúñiga
ipwave	Suresh	IP Wireless Access in Vehicular Environments	Carlos Bernardos , Russ Housley
lpwan	Suresh	IPv6 over Low Power Wide-Area Networks	Alexander Pelov , Pascal Thubert
lwig	Suresh	Light-Weight Implementation Guidance	Zhen Cao , Mohit Sethi
ntp	Suresh	Network Time Protocol	Karen O'Donoghue , Dieter Sibold
savi	Suresh	Source Address Validation Improvements	Jean-Michel Combes
softwire	Terry	Softwires	Yong Cui , Ian Farrer
sunset4	Terry	Sunsetting IPv4	Marc Blanchet , Wesley George
tictoc	Suresh	Timing over IP Connection and Transfer of Clock	Karen O'Donoghue , Yaakov Stein

ops active WGs

Group ↕	Responsible AD ↕	Name	Chairs ↕
anima	✉ Benoit	Autonomic Networking Integrated Model and Approach	✉ Toerless Eckert , ✉ Sheng Jiang
bmwg	✉ Warren	Benchmarking Methodology	✉ Sarah Banks , ✉ Al Morton
dime	✉ Ben	Diameter Maintenance and Extensions	✉ Jouni Korhonen , ✉ Lionel Morand (Assigned AD: ✉ Ben Campbell)
dnsop	✉ Warren	Domain Name System Operations	✉ Tim Wicinski , ✉ Suzanne Woolf
grow	✉ Warren	Global Routing Operations	✉ Christopher Morrow , ✉ Peter Schoenmaker
l2sm	✉ Benoit	L2VPN Service Model	✉ Adrian Farrel , ✉ Qin Wu
lime	✉ Benoit	Layer Independent OAM Management in the Multi-Layer Environment	✉ Ron Bonica , ✉ Carlos Pignataro
lmap	✉ Benoit	Large-Scale Measurement of Broadband Performance	✉ Dan Romascanu , ✉ Jason Weil
mboned	✉ Warren	MBONE Deployment	✉ Leonard Giuliano , ✉ Greg Shepherd
netconf	✉ Benoit	Network Configuration	✉ Mahesh Jethanandani , ✉ Kent Watsen
netmod	✉ Benoit	Network Modeling	✉ Lou Berger , ✉ Joel Jaeggli , ✉ Kent Watsen
opshawg	✉ Warren	Operations and Management Area Working Group	✉ Ignas Bagdonas , ✉ Joe Clarke , ✉ Tianran Zhou
opsec	✉ Warren	Operational Security Capabilities for IP Network Infrastructure	✉ Gunter Van de Velde , ✉ Éric Vyncke
radext	✉ Kathleen	RADIUS EXTensions	✉ Lionel Morand , ✉ Stefan Winter (Assigned AD: ✉ Kathleen Moriarty)
sidrops	✉ Warren	SIDR Operations	✉ Chris Morrow , ✉ Keyur Patel
v6ops	✉ Warren	IPv6 Operations	✉ Fred Baker , ✉ Ron Bonica , ✉ Lee Howard

rtg active WGs

Group	Responsible AD	Name	Chairs
babel	✉ Alia	Babel routing protocol	Donald Eastlake ✉, Russ White ✉
bess	✉ Alvaro	BGP Enabled ServiceS	Stephane Litkowski ✉, Martin Vigoureux ✉
bfd	✉ Alvaro	Bidirectional Forwarding Detection	Jeffrey Haas ✉, Reshad Rahman ✉
bier	✉ Alia	Bit Indexed Explicit Replication	Tony Przygienda ✉, Greg Shepherd ✉
ccamp	✉ Deborah	Common Control and Measurement Plane	Daniele Ceccarelli ✉, Fatai Zhang ✉
detnet	✉ Deborah	Deterministic Networking	Lou Berger ✉, Janos Farkas ✉, Patricia Thaler ✉
i2rs	✉ Alia	Interface to the Routing System	Susan Hares ✉, Russ White ✉
idr	✉ Alvaro	Inter-Domain Routing	Susan Hares ✉, John Scudder ✉
isis	✉ Alia	IS-IS for IP Internets	Hannes Gredler ✉, Christian Hopps ✉
l2tpext	✉ Deborah	Layer Two Tunneling Protocol Extensions	Ignacio Goyret ✉, Carlos Pignataro ✉
lisp	✉ Deborah	Locator/ID Separation Protocol	Joel Halpern ✉, Luigi Iannone ✉
manet	✉ Alvaro	Mobile Ad-hoc Networks	Justin Dean ✉, Stan Ratliff ✉
mpls	✉ Deborah	Multiprotocol Label Switching	Loa Andersson ✉, Nicolai Leymann ✉, George Swallow ✉
nvo3	✉ Alia	Network Virtualization Overlays	Sam Aldrin ✉, Matthew Bocci ✉
ospf	✉ Alia	Open Shortest Path First IGP	Acee Lindem ✉, Abhay Roy ✉
pals	✉ Deborah	Pseudowire And LDP-enabled Services	Stewart Bryant ✉, Andrew Malis ✉
pce	✉ Deborah	Path Computation Element	Jonathan Hardwick ✉, Julien Meuric ✉
pim	✉ Alvaro	Protocols for IP Multicast	Mike McBride ✉, Stig Venaas ✉
roll	✉ Alvaro	Routing Over Low power and Lossy networks	Ines Robles ✉, Peter Van der Stok ✉
rtgwg	✉ Alia	Routing Area Working Group	Chris Bowers ✉, Jeff Tantsura ✉
sfc	✉ Alia	Service Function Chaining	Jim Guichard ✉, Joel Halpern ✉
sidr	✉ Alvaro	Secure Inter-Domain Routing	Chris Morrow ✉, Sandra Murphy ✉
spring	✉ Alvaro	Source Packet Routing in Networking	Bruno Decraene ✉, Martin Vigoureux ✉
teas	✉ Deborah	Traffic Engineering Architecture and Signaling	Vishnu Beeram ✉, Lou Berger ✉
trill	✉ Alia	Transparent Interconnection of Lots of Links	Susan Hares ✉, Jon Hudson ✉

sec active WGs

Group ↕	Responsible AD ↕	Name	↕ Chairs	↕
ace	✉ Kathleen	Authentication and Authorization for Constrained Environments	Benjamin Kaduk ✉, Jim Schaad ✉	
acme	✉ Kathleen	Automated Certificate Management Environment	Yoav Nir ✉, Rich Salz ✉	
curdle	✉ Eric	CURves, Deprecating and a Little more Encryption	Daniel Migault ✉, Rich Salz ✉	
dots	✉ Kathleen	DDoS Open Threat Signaling	Roman Danyliw ✉, Tobias Gondrom ✉	
i2nsf	✉ Kathleen	Interface to Network Security Functions	Linda Dunbar ✉, Yoav Nir ✉	
ipsecme	✉ Eric	IP Security Maintenance and Extensions	Tero Kivinen ✉, David Waltermire ✉	
kitten	✉ Eric	Common Authentication Technology Next Generation	Benjamin Kaduk ✉, Matthew Miller ✉	
lamps	✉ Eric	Limited Additional Mechanisms for PKIX and SMIME	Russ Housley ✉	
mile	✉ Kathleen	Managed Incident Lightweight Exchange	Nancy Cam-Winget ✉, Takeshi Takahashi ✉	
oauth	✉ Eric	Web Authorization Protocol	Rifaat Shekh-Yusef ✉, Hannes Tschofenig ✉	
sacm	✉ Kathleen	Security Automation and Continuous Monitoring	Christopher Inacio ✉, Adam Montville ✉, Karen O'Donoghue ✉	
secevent	✉ Kathleen	Security Events	Dick Hardt ✉, Yaron Sheffer ✉	
suit	✉ Kathleen	Software Updates for Internet of Things	Russ Housley ✉, Dave Thaler ✉, David Waltermire ✉	
tls	✉ Kathleen	Transport Layer Security	Joseph Salowey ✉, Sean Turner ✉	
tokbind	✉ Eric	Token Binding	John Bradley ✉, Leif Johansson ✉	
trans	✉ Eric	Public Notary Transparency	Melinda Shore ✉, Paul Wouters ✉	

tsv active WGs

Group	Responsible AD	Name	Chairs
alto	✉ Mirja	Application-Layer Traffic Optimization	Vijay Gurbani ✉ , Jan Seedorf ✉
dtm	✉ Spencer	Delay/Disruption Tolerant Networking	Marc Blanchet ✉ , Rick Taylor ✉
ippm	✉ Spencer	IP Performance Measurement	Bill Cervený ✉ , Brian Trammell ✉
mptcp	✉ Mirja	Multipath TCP	Philip Eardley ✉ , Yoshifumi Nishida ✉
nfsv4	✉ Spencer	Network File System Version 4	Brian Pawlowski ✉ , Spencer Shepler ✉
quic	✉ Spencer	QUIC	Lars Eggert ✉ , Mark Nottingham ✉
rmcat	✉ Mirja	RTP Media Congestion Avoidance Techniques	Anna Brunstrom ✉ , Colin Perkins ✉ , Martin Stiernerling ✉
taps	✉ Spencer	Transport Services	Aaron Falk ✉ , Zaheduzzaman Sarker ✉
tcpinc	✉ Mirja	TCP Increased Security	David Black ✉ , Kyle Rose ✉
tcpm	✉ Mirja	TCP Maintenance and Minor Extensions	Yoshifumi Nishida ✉ , Michael Scharf ✉ , Michael Tüxen ✉
tram	✉ Spencer	TURN Revised and Modernized	Gonzalo Camarillo ✉ , Simon Perreault ✉
tsvwg	✉ Spencer	Transport Area Working Group	David Black ✉ , Wesley Eddy ✉ , Gorry Fairhurst ✉

art active WGs

Group	Responsible AD	Name	Chairs
avtcore	Ben	Audio/Video Transport Core Maintenance	Rachel Huang, Jonathan Lennox
bfcpbis	Adam	Binary Floor Control Protocol Bis	Keith Drage, Charles Eckel
calext	Alexey	Calendaring Extensions	Donald Eastlake, Philipp Kewisch, Daniel Migault
capport	Adam	Captive Portal Interaction	Erik Kline, Martin Thomson
cbor	Alexey	Concise Binary Object Representation Maintenance and Extensions	Joe Hildebrand, Francesca Palombini
cdni	Alexey	Content Delivery Networks Interconnection	Francois Le Faucheur, Kevin Ma, Phil Sorber
cellar	Ben	Codec Encoding for LossLess Archiving and Realtime transmission	Tessa Fallon, Tim Terriberry
clue	Adam	ControlLing mUltiple streams for tElepresence	Roni Even, Paul Kyzivat
codec	Ben	Internet Wideband Audio Codec	Tim Terriberry, Mo Zanaty
core	Alexey	Constrained RESTful Environments	Carsten Bormann, Jaime Jimenez
dcrup	Alexey	DKIM Crypto Update	Murray Kucherawy, Rich Salz
dispatch	Ben	Dispatch	Mary Barnes, Cullen Jennings, Murray Kucherawy
dmARC	Alexey	Domain-based Message Authentication, Reporting & Conformance	Tim Draegen, Ned Freed, Barry Leiba
doh	Adam	DNS Over HTTPS	David Lawrence, Benjamin Schwartz
ecrit	Adam	Emergency Context Resolution with Internet Technologies	Allison Mankin, Roger Marshall
extra	Alexey	Email mailstore and eXtensions To Revise or Amend	Bron Gondwana, Jiankang Yao
httpbis	Alexey	Hypertext Transfer Protocol	Patrick McManus, Mark Nottingham
ice	Ben	Interactive Connectivity Establishment	Ari Keränen, Peter Thatcher
insipid	Ben	INtermediary-safe SIP session ID	Keith Drage, Gonzalo Salgueiro
jmap	Alexey	JSON Mail Access Protocol	Bron Gondwana, Barry Leiba
mmusic	Ben	Multiparty Multimedia Session Control	Flemming Andreassen, Bo Burman
modern	Adam	Managing, Ordering, Distributing, Exposing, & Registering telephone Numbers	Steve Donovan, Tom McGarry
netvc	Adam	Internet Video Codec	Natasha Rooney, Mo Zanaty
payload	Ben	Audio/Video Transport Payloads	Ali Begen, Roni Even
perc	Ben	Privacy Enhanced RTP Conferencing	Suhas Nandakumar, Nils Ohlmeier
regext	Adam	Registration Protocols Extensions	James Galvin, Antoin Verschuren
rtcweb	Adam	Real-Time Communication in WEB-browsers	Ted Hardie, Cullen Jennings, Sean Turner
sipbrandy	Ben	SIP Best-practice Recommendations Against Network Dangers to privacy	Gonzalo Camarillo, Gonzalo Salgueiro
sipcore	Ben	Session Initiation Protocol Core	Jean Mahoney, Brian Rosen
slim	Alexey	Selection of Language for Internet Media	Bernard Aboba
stir	Adam	Secure Telephone Identity Revisited	Russ Housley, Robert Sparks
uta	Alexey	Using TLS in Applications	Leif Johansson, Valery Smyslov
xrblock	Ben	Metric Blocks for use with RTCP's Extended Report Framework	Dan Romascanu, Shida Schubert

IRTF (Internet Research Task Force)

Active research groups		
Status ReportsChair Photos		
Group	Name	Chairs
cfrg	Crypto Forum	Alexey Melnikov , Kenny Paterson
dinrg	Decentralized Internet Infrastructure Proposed RG	Dirk Kutscher , Melinda Shore
gaia	Global Access to the Internet for All	Jane Coffin , Arjuna Sathaseelan
hrpc	Human Rights Protocol Considerations	Avri Doria , Niels ten Oever
iccrgr	Internet Congestion Control	Janardhan Iyengar
icnrg	Information-Centric Networking	Dirk Kutscher , Borje Ohlman , David Oran
maprg	Measurement and Analysis for Protocols	Mirja Kühlewind , Dave Plonka
nfvrg	Network Function Virtualization	Ram Krishnan , Diego Lopez
nmrg	Network Management	Laurent Ciavaglia , Lisandro Granville
nwcrg	Coding for efficient NetWork Communications Research Group	Marie-Jose Montpetit , Vincent Roca
panrg	Path Aware Networking Proposed RG	Jen Linkova , Brian Trammell
t2trg	Thing-to-Thing	Carsten Bormann , Ari Keränen

Network Softwarization

- ソフトウェアを有効活用し、カスタマイズ可能なネットワーク仕様を実現する
- 5G におけるスライシングやファンクション仮想化をサポートする要素技術になる
- SD-WAN 等のオーバレイネットワークを実現する要素技術になる
- ソフトウェアを用いて運用管理モデルをより自動化するための要素技術となる

Network Softwarizationに関する WG (1)

- cndi (Content Delivery Networks Interconnection)
- clue (ControLling mUltiple streams for tElepresence)
- rtcweb (Real-Time Communication in WEB-browsers)
- softwire (Softwires)
- anima (Autonomic Networking Integrated Model and Approach)
- netconf (Network Configuration)
- netmod (Network Modeling)

Network Softwarization(に関連する WG (2)

- bess (BGP Enabled ServiceS)
- i2rs (Interface to the Routing System)
- lisp (Locator/ID Separation Protocol)
- nvo3 (Network Virtualization Overlays)
- pce (Path Computation Element)
- sfc (Service Function Chaining)
- dots (DDoS Open Threat Signaling)

Network Softwarization(に関連する WG (3)

- i2nsf (Interface to Network Security Functions)
- mptcp (Multipath TCP)
- quic (QUIC)
- dinrg (Decentralized Internet Infrastructure Proposed RG)
- gaia (Global Access to the Internet for All)
- nfvrg (Network Function Virtualization)
- nmrg (Networking Management)
- Panrg (Path Aware Networking Proposed RG)

オーバーレイネットワーク系

- nvo3
 - データセンター内外のオーバーレイネットワークに関するモデリングとプロトコル
 - VXLAN や Geneva 等の *encap* プロトコルを用いたオーバーレイ化
- lisp
 - *Locator / ID* の分割を利用した可搬型ネットワークモデルの提案と実現
 - より使いやすいオーバーレイプロトコルとしての道を
- bess
 - BGP を利用した情報交換を定義する
 - オーバーレイ上でのノード情報交換などに用いられる

ネットワークマネージメント系

■ anima

- ネットワーク運用の一連のワークフローを自動化するためのモデルと手法
- 初期段階の *autoconf* も含め継続自動化

■ nmrg

- ネットワーク運用への AI 技術の適用

■ netconf / netmod

- ネットワーク機能のモデル化 (YANG) とそのモデル化された機器への設定手法の提案

NFV 技術系

- i2rs /i2ns
 - ルーティング機能、セキュリティ機能へのインタフェース定義
- nfvrg
 - NFV に関連する技術全般に関する RG
 - オープンソースに関連する話題も
- dinrg
 - まだ発足したばかりだが、遠隔地にあるリソース同士を結びつけてサービスを構築する手法を議論

柔軟なパス制御系

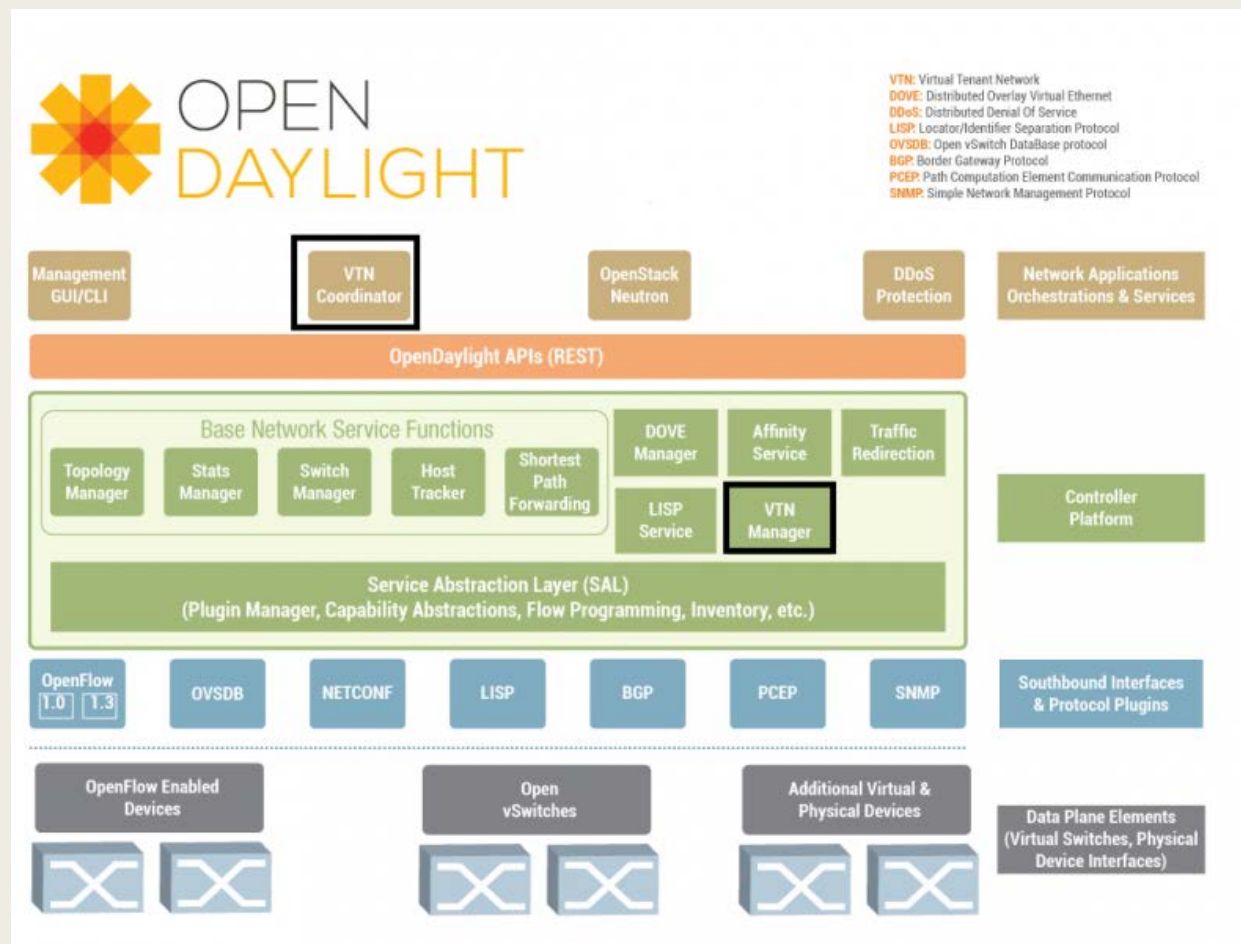
- sfc
 - サービスを連結させるパスを構成するための手法とプロトコルの提案
- pce
 - アプリケーションに応じたネットワークパス制御を行うための手法とプロトコルの提案
- dots
 - DDoS 攻撃を防ぐためのシグナリング手法の提案
- panrg
 - パス形成情報を広域に活かすための手法の提案

Running Code としての Open Source 一例

- Network Controller / Orchestration
 - *Open Daylight (Linux Foundation)*
 - *ONAP (Linux Foundation)*
 - *ONOS (ONF)*
 - *OpenCORD (ONF)*
- NFV Infrastructure
 - *OPNFV (Linux Foundation)*
 - *OpenStack (OpenStack Project)*
- Automation
 - *Ansible (RedHat)*

Open Daylight

- Java 言語で書かれており、様々なプロトコルを Southbound API として利用可能なプラグイン形態を実現
- Northbound API として、ネットワーク機器の集中制御やセグメントルーティングといった、実際の用途に即したプラグインを提供



まとめ

- IETF は直接ソフトウェアそのものや API の議論を扱う場ではないため、プロトコルやモデルとしてのソフトウェア化要素技術が見受けられる
- API やユースケース標準化は OPNFV や MEF, ONF といった業界団体に見られる
- Running Code として各事業者が工夫している部分が多く見受けられる