Open Networking Conference Japan

Data Intensive Architecture へ
- What’s next for Edge Computing?

15 October 2020

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Abstract

- 前回のONIC2019では、「データ中心アプローチ」とその道筋について議論した[*]。
- コネクション中心、かつポリシーや認証がアクセス手段に密接に結び付けられている方式では、スケール、セキュリティ、効率性の面で限界が見えている。またデータも、遅延やトラフィック最適化のために、できるだけユーザの近くに遍在することが求められる。
- しかし、新たなアーキテクチャ実践はなかなか簡単ではない。
- そこで今回は、「データの偏在性」に関連し、改めてEdge Computingを取り上げる。新たなアーキテクチャ実践は簡単ではないが、このままでは、5G等でどんなにアクセス回線が速くなってもアプリケーションの品質は上がらない。逼迫した問題として、議論を行いたい。

[*] https://onic.jp/_cms/wp-content/uploads/2019/11/ONIC2019_kono.pdf

Agenda

1. *Data Intensive Architectureのおさらい*
2. Edge Computing – What’s next ?
    - 必要性
    - 分類と参照アーキテクチャ
    - 現状の課題とNext Step
    - 今後の展望

Data Intensive Application Systems

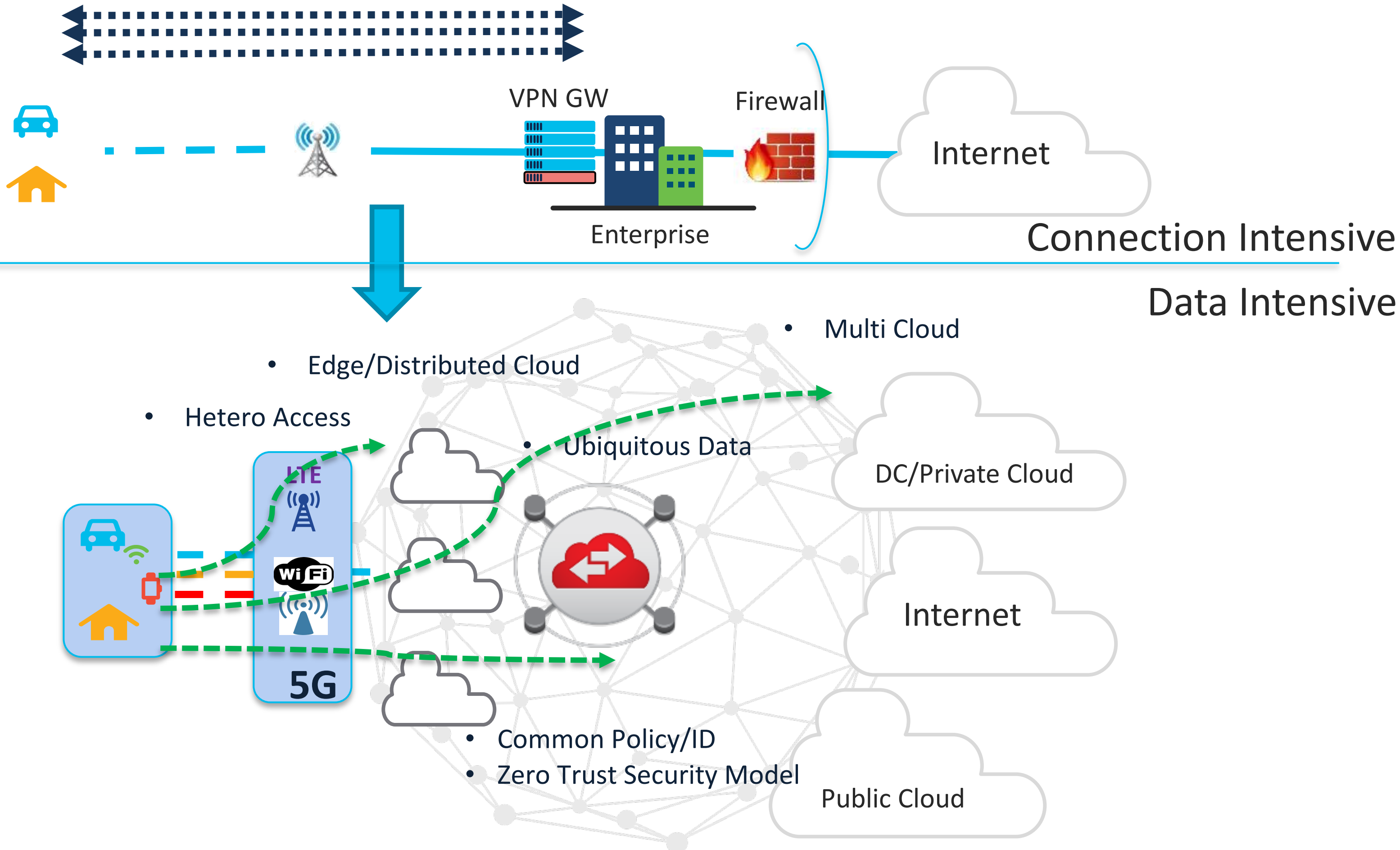
- アプリケーションは、「演算中心(Compute-Intensive)」ではなく「データ中心(Data Intensive)」であることにより、信頼性、スケーラビリティ、保守性を獲得した。[*]

「データシステム」としての抽象化

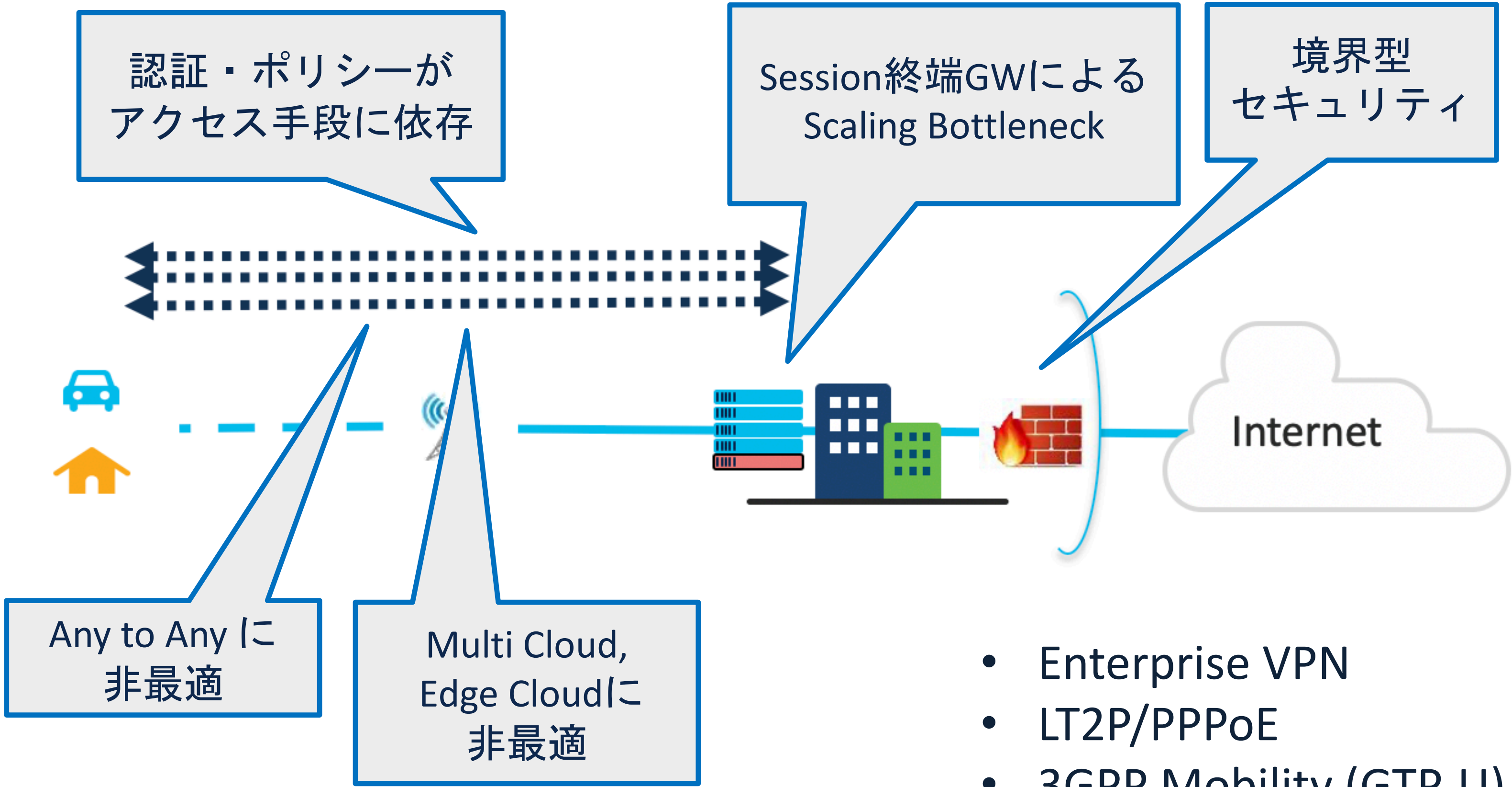
信頼性	スケーラビリティ	保守性
• 何か問題が発生しても正しく動作し続ける • ハードウェア・ソフトウェア・ヒューマンエラーに対する耐障害性	• 負荷とパフォーマンスの計測 • 負荷の増大に対してシステムが対応できる	• 運用性 • シンプル性 • 進化への対応

[*] Martin Kleppmann著、斎藤 太郎監訳「データ指向アプリケーションデザイン」オライリー・ジャパン社

Data Intensive Architecture



Connection Intensive Architecture の限界



- Enterprise VPN
- LT2P/PPPoE
- 3GPP Mobility (GTP-U)

データ中心アーキテクチャへの道筋

マルチクラウド

分散・

エッジクラウド

ヘテロアクセス

ゼロトラスト

セキュリティ

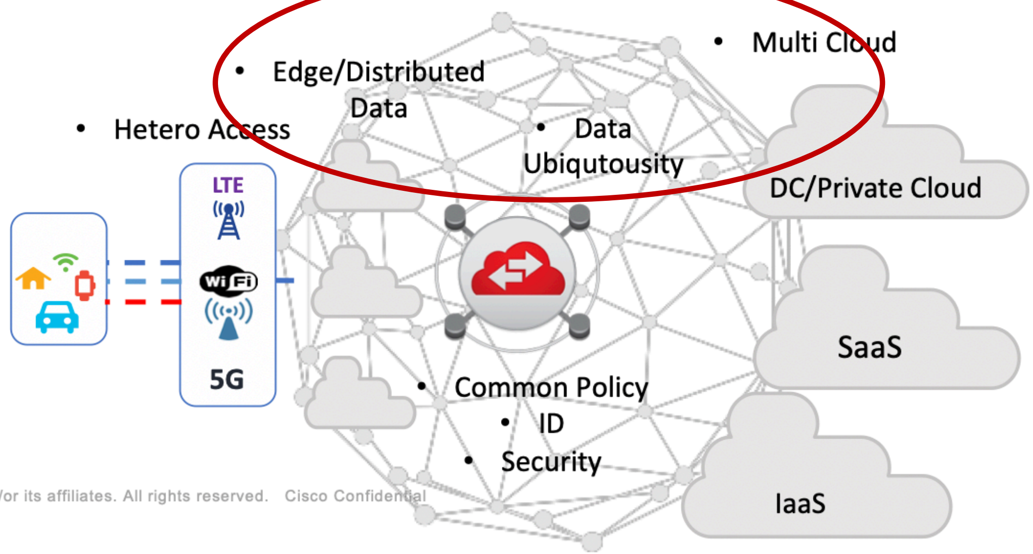
Network as

a Service

より革新的な

データ中心性

データの偏在



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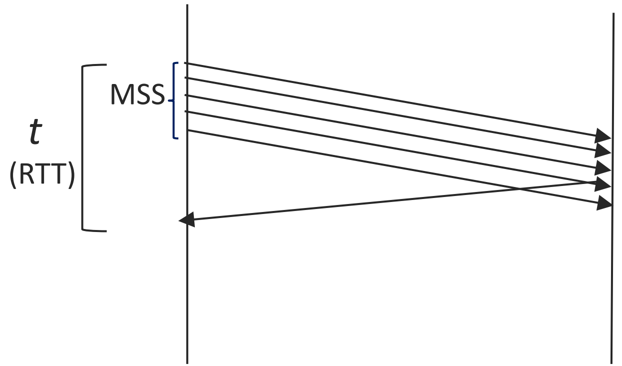
どんなにアクセス速度が速くなっても…

フルリモートワークになり、家のネットワークを高速化した

- PPPoE → IPoE
- VDSL → 光配線方式
- 古い Hub Switch の撤去

しかし、体感はあまり変わらない。
家族からも気付いてもらえない…☹



MSS : Maximum Sebment Size
RTT : Round Trip Time

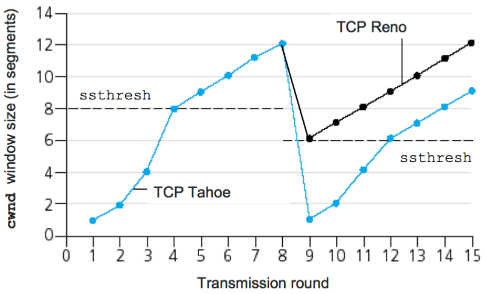
TCP flow control は RTTに依存している

$$Throughput == \frac{MSS}{RTT}$$

RTT が100msあるとすると, スループットは:

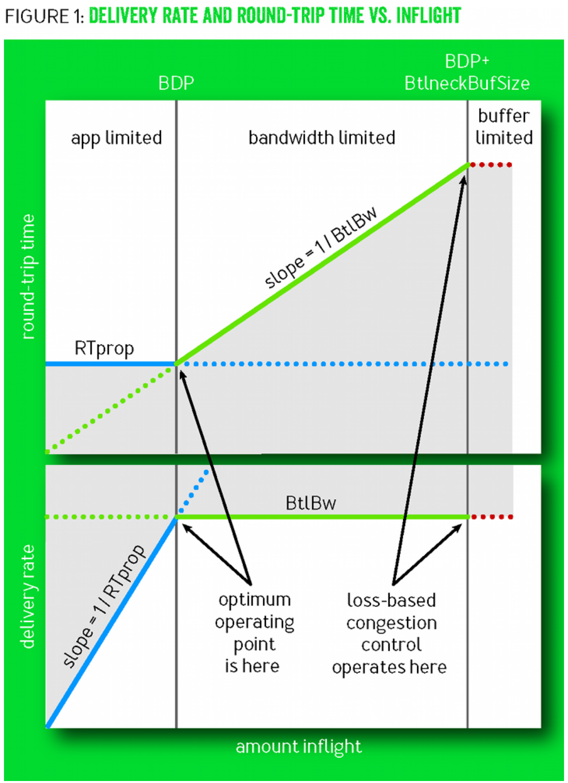
$65{,}536 \times 8\ (bits) / 0.1\ (sec) = \underline{5{,}242{,}880\ (bps)}$!!

BBRにより改善するが、適用範囲は限定的



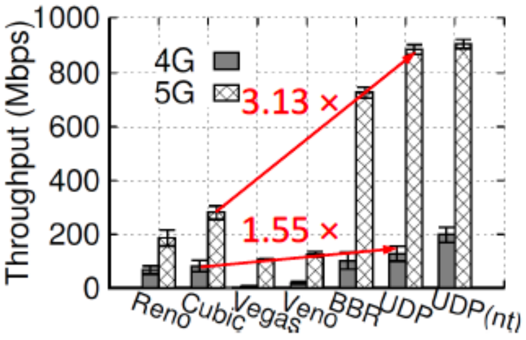
Loss-based Congestion control

https://gkf168.wordpress.com/2012/05/20/tcp-effective-bandwidth-2/



BBR: Congestion-Based Congestion Control: Measuring bottleneck bandwidth and round-trip propagation time

Queue October 2016 https://doi.org/10.1145/3012426.3022184

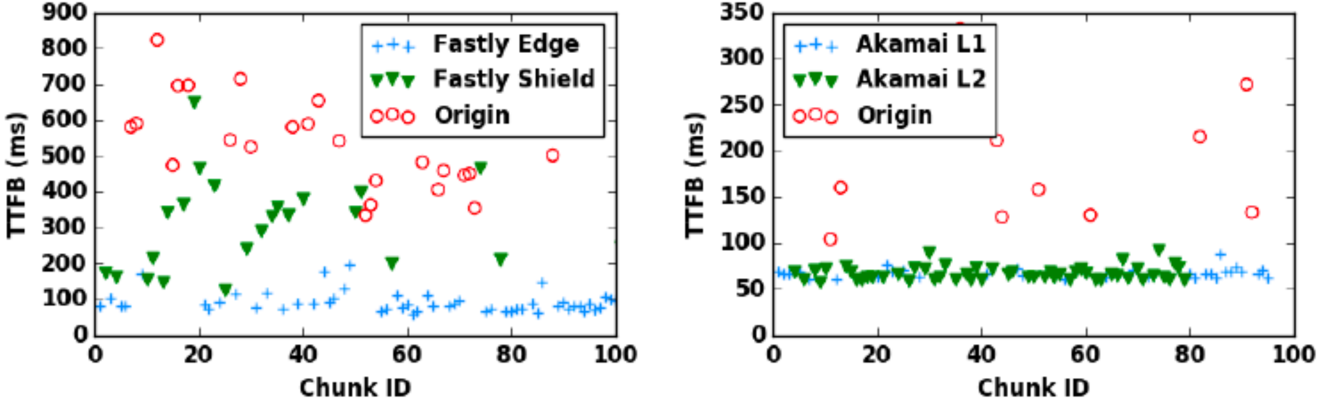


For 5G, BBR achieves reasonably high band- width utilization of 82.5%. However, the traditional loss/delay based TCP algorithms suffer from extremely low bandwidth utilization— only 21.1%, 31.9%, 12.1%, 14.3%, for Reno, Cubic, Vegas, and Veno, respectively.

SIGCOMM '20: Proceedings of the Annual conference of the ACM Special Interest Group on Data Communication on the applications, technologies, architectures, and protocols for computer communication July 2020 Pages 479–494https://doi.org/10.1145/3387514.3405882

CDNによるVideo Throughput向上

Data (Chunk) のロケーションによる、TFTBのばらつき



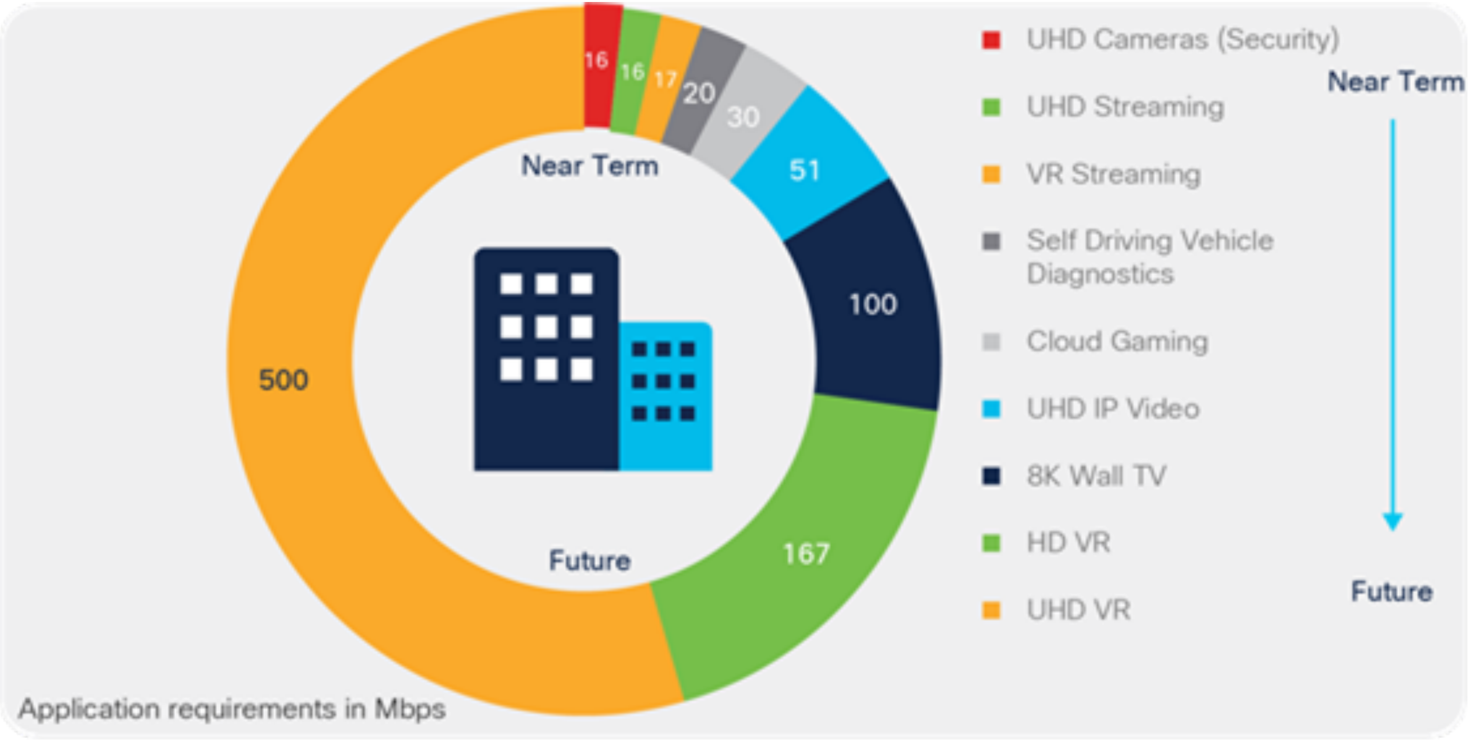
(a) Vimeo Fastly. (b) Vimeo Akamai.

Figure 1: Example video sessions served from origin and different CDN layers

TTFB: Time to First Byte - クライアントがHTTPリクエストをしてからWebサーバーから最初のバイトのデータを受信するまでにかかる時間のこと

“Exploring the interplay between CDN caching and video streaming performance”, Ehab Gahbashneh, Purdue University
https://blogs.cisco.com/sp/cdn-caching-and-video-streaming-performance

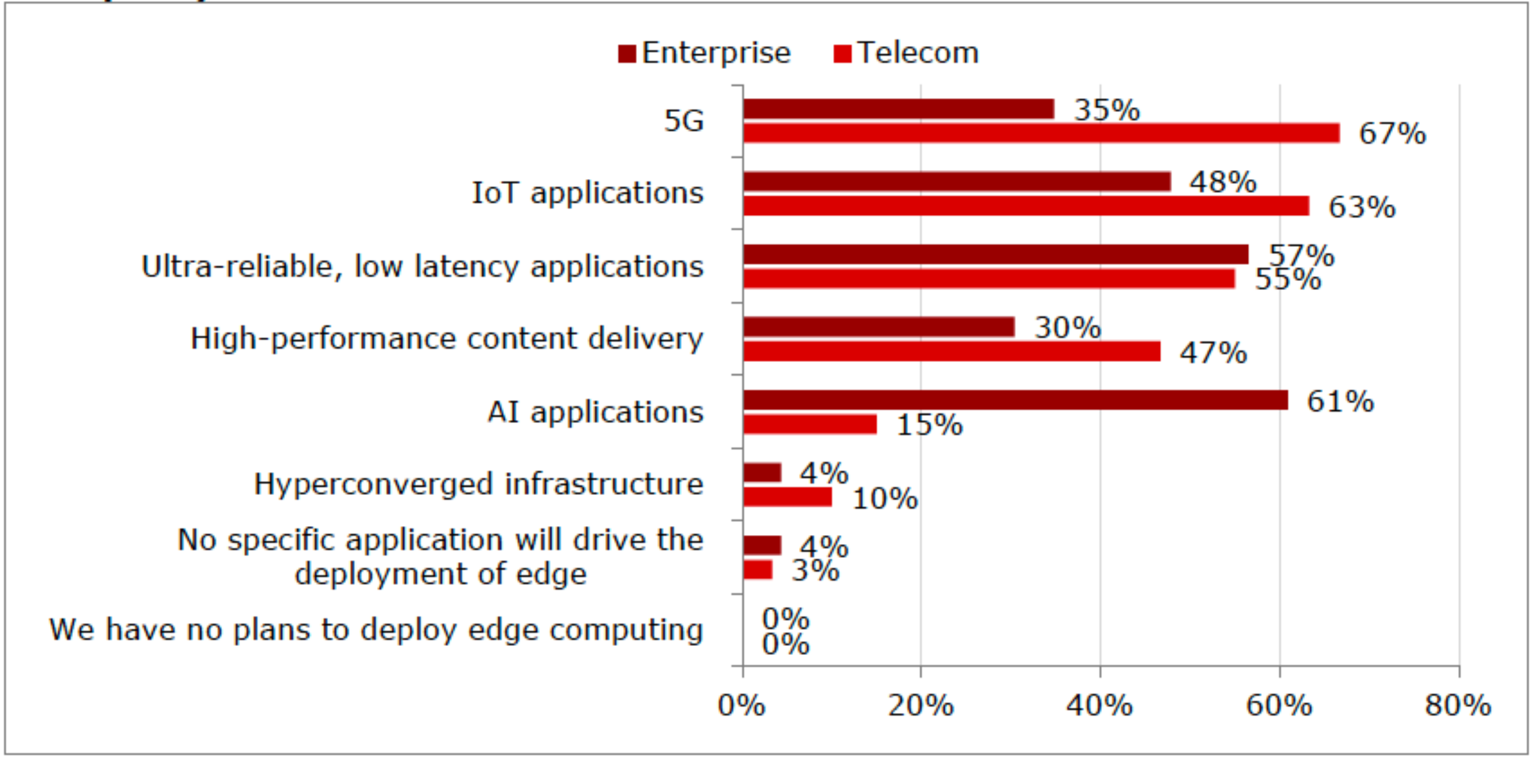
Video applications are demanding more BW



Source: Cisco Annual Internet Report, 2018–2023

Use cases driving Edge deployments

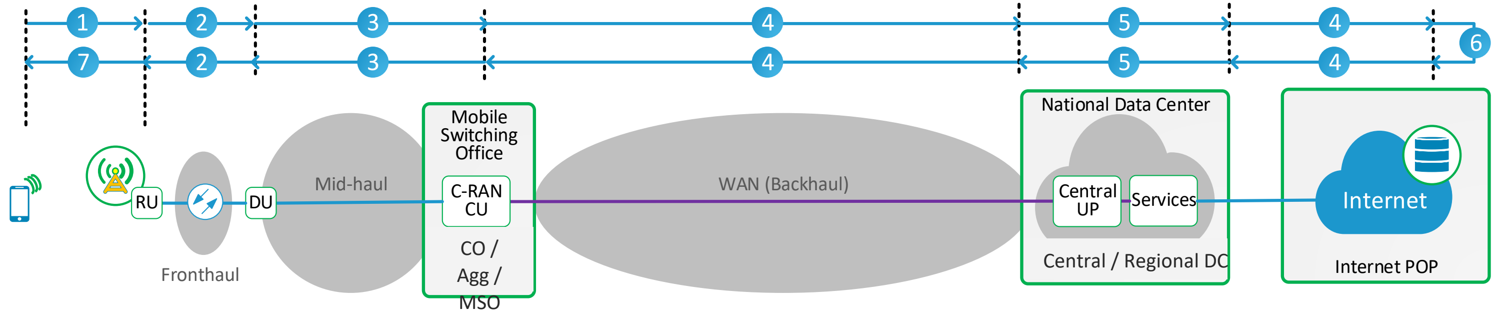
Figure 2: Leading Use Cases/Business Drivers for Edge Compute (Telecom vs. Enterprise)



N=60 telecom, 23 enterprise
Source: Heavy Reading

Strategies for Connecting the Edge : Heavy Reading Survey 2019

遅延の目安



	Delay	Description
1	0.5 ~20 ms	アップリンク遅延（片方向 ）- 約20ms、5Gでは0.5ms -10ms
2	$< 25\ \mu s\ - 100\mu s$	フロントホール 25μs - 100μs (RANベンダーに依存)
3	1 – 10ms	ミッドホール 1- 10ms (RANベンダーに依存) RRC, PDCP, RLC はCU、 MAC scheduling はDU
4	$= 11.2\frac{\mu s}{mi} \times D + T_B$	広域ネットワーク遅延（片方向） - 7 μs/km (= 11.2 μs/mi) + T_B (queuing delay)
5	~2 ms	Packet Core遅延（片方向）- 約2ms
6	$\rightarrow 0$	サーバ処理時間（無視できる）
7	0.5 ~ 15 ms	ダウンリンク遅延（片方向 ）- 約15ms、5Gでは0.5ms -10ms

サービスによる遅延許容特性

Use Case	Latency	Notes
モバイルビデオ	~75ms (片方向)	~25ms のバッファリングを含む。無線区間におけるPacket Loss Ratioに依存。
モバイル拡張現実(AR)	10ms (片方向)	エアインタフェースバジェット($30\ ms$) が、許容遅延($20\ ms$)よりも大きいため、LTEでのモバイルARは困難。5Gにおいても、RANノードの隣接にComputingを置く必要があるだろう
モバイルVR, Interactive Gaming	20ms (片方向), 50ms (片方向)	VRの場合、$40\ ms$ RTT が必要なので、LTE で $< 5\ ms$ 5Gで$< 10\ ms$が求められる
VoIP	200ms (片方向)	Voice, IMSは集中配置で問題ない。
特に低遅延が求められる将来Use Cases		
Factory Automation	$0.25 - 10\ ms$	生産ラインの機器とシステムのリアルタイム制御
Intelligent Transportation	$0 - 100\ ms$	自律運転、道路混雑の最適化
Robotics and telepresence	$10 - 100\ ms$	視覚と触覚フィードバック同期による遠隔制御
Health care	$1 - 10\ ms$	バイオテレメトリー、遠隔診断、遠隔手術
Smart Grid	$100\ ms$	需要変動を補償するための電源のオン/オフ

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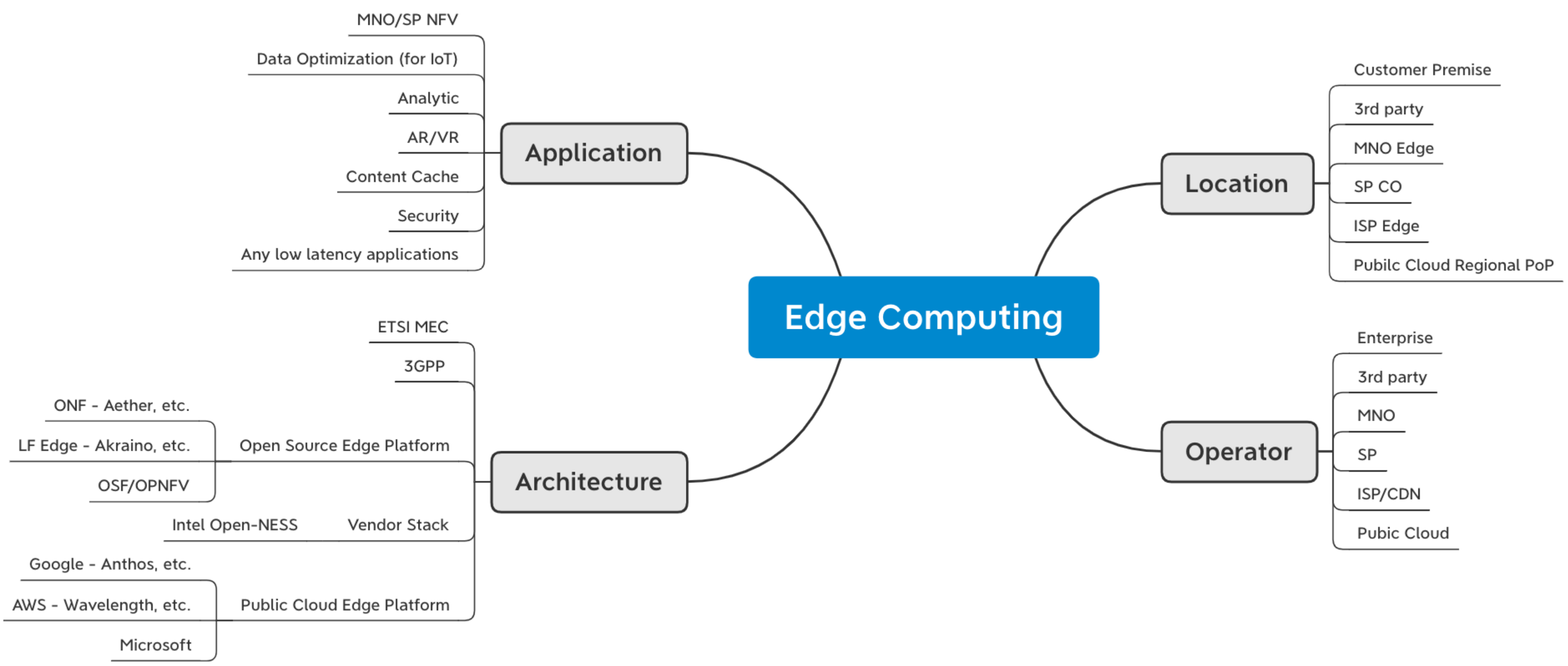
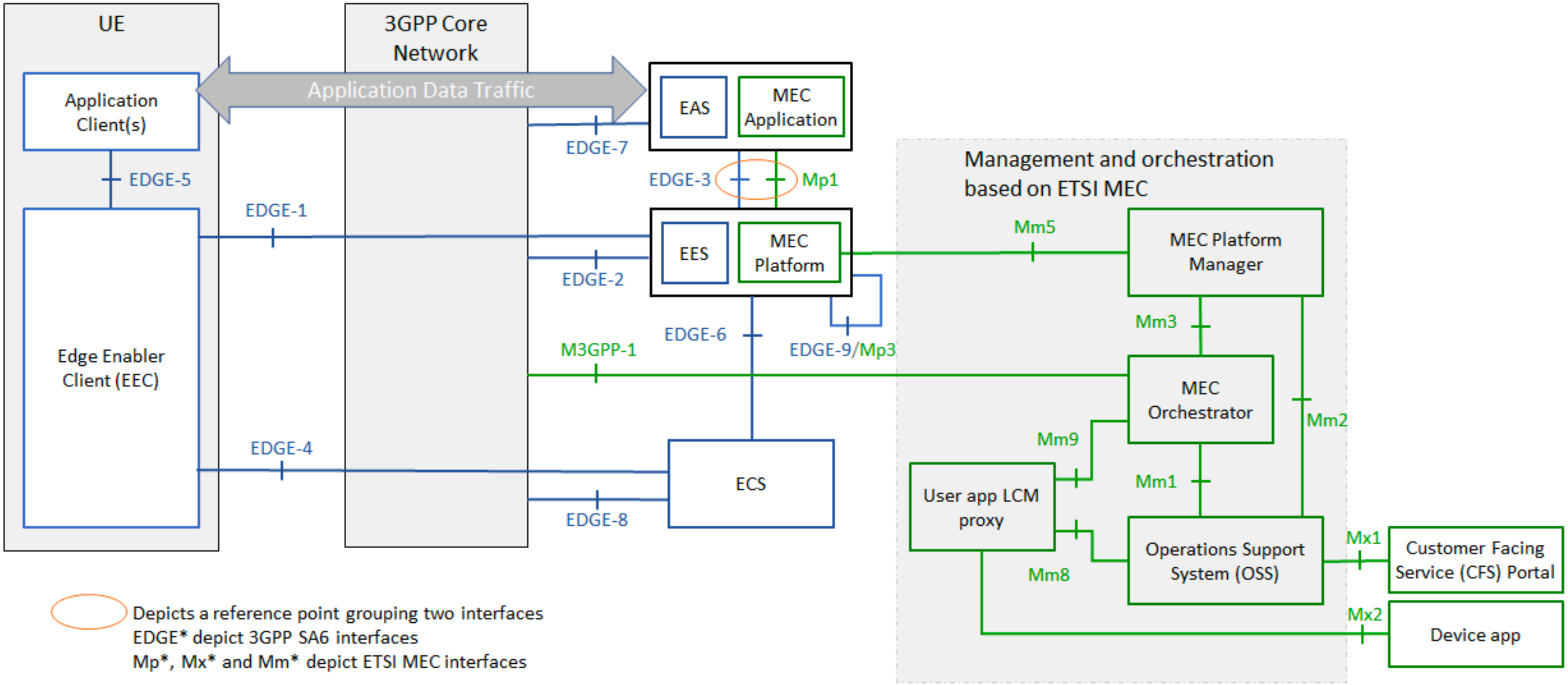
Taxonomy of Edge Computing



ETSI MEC

Complements with 3GPP to harmonize mobile architecture



https://www.etsi.org/technologies/multi-access-edge-computing

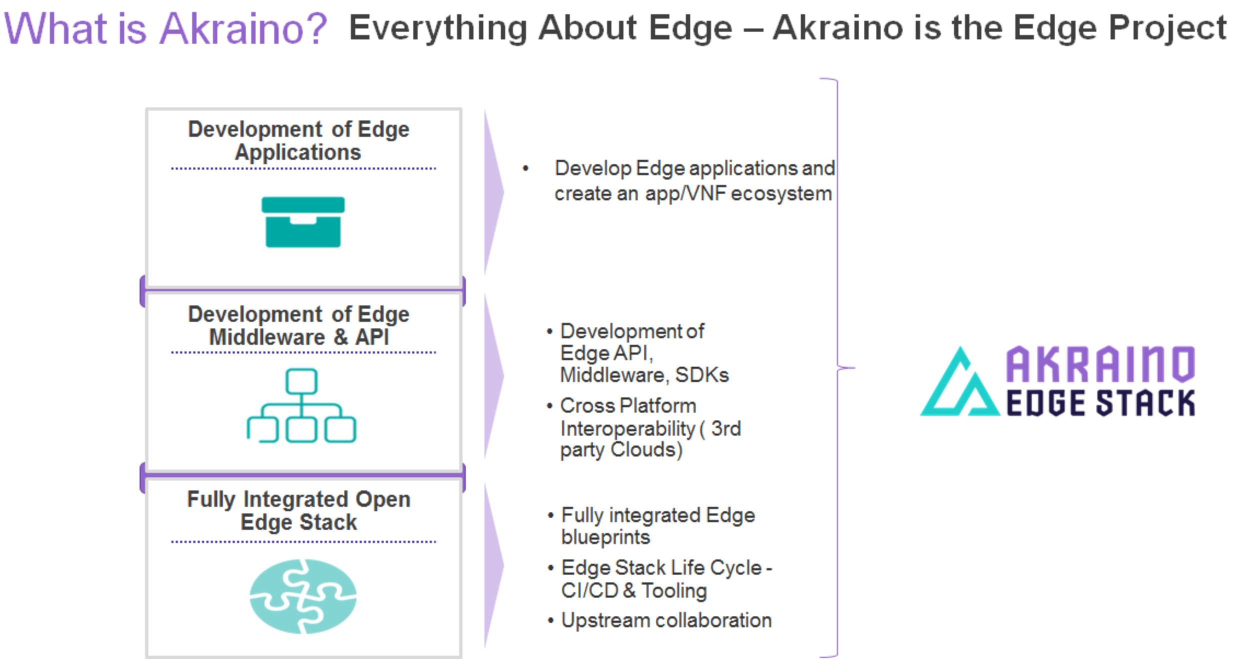
3GPP

Edge computing can be supported by one or a combination of the following enablers:

- User plane (re)selection: the 5G Core Network (re)selects UPF to route the user traffic to the local Data Network as described in clause 6.3.3;
- Local Routing and Traffic Steering: the 5G Core Network selects the traffic to be routed to the applications in the local Data Network;
    - this includes the use of a single PDU Session with multiple PDU Session Anchor(s) (UL CL / IP v6 multi-homing) as described in clause 5.6.4.
- Session and service continuity to enable UE and application mobility as described in clause 5.6.9;
- An Application Function may influence UPF (re)selection and traffic routing via PCF or NEF as described in clause 5.6.7;
- Network capability exposure: 5G Core Network and Application Function to provide information to each other via NEF as described in clause 5.20 or directly as described in TS 23.502 [3] clause 4.15;
- QoS and Charging: PCF provides rules for QoS Control and Charging for the traffic routed to the local Data Network;
- Support of Local Area Data Network: 5G Core Network provides support to connect to the LADN in a certain area where the applications are deployed as described in clause 5.6.5.

5.13 “Support for Edge Computing”, 3GPP TS 23.501 V16.6.0 (2020-09)

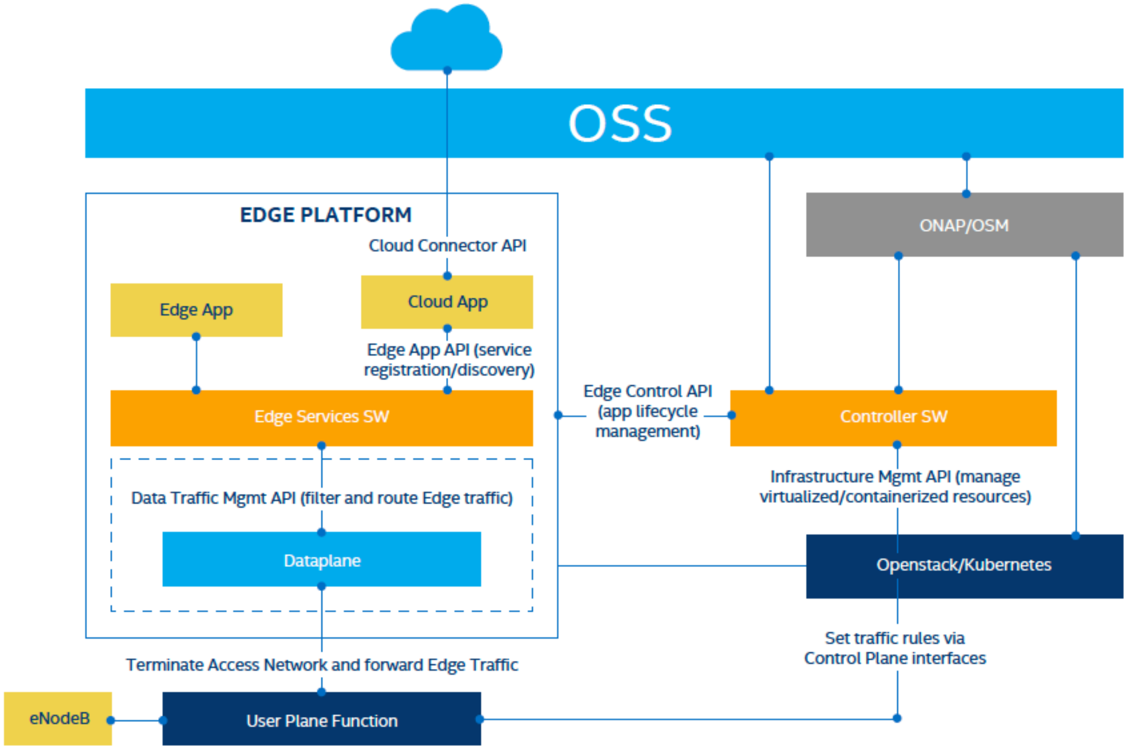
LF Edge – Akraino Edge Stack



https://wiki.akraino.org/display/AK/Akraino+Edge+Stack+Goal+and+Key+Principles

NTT has joined Akraino : https://www.ntt.co.jp/topics/akraino/index.html

Intel - OpneNESS

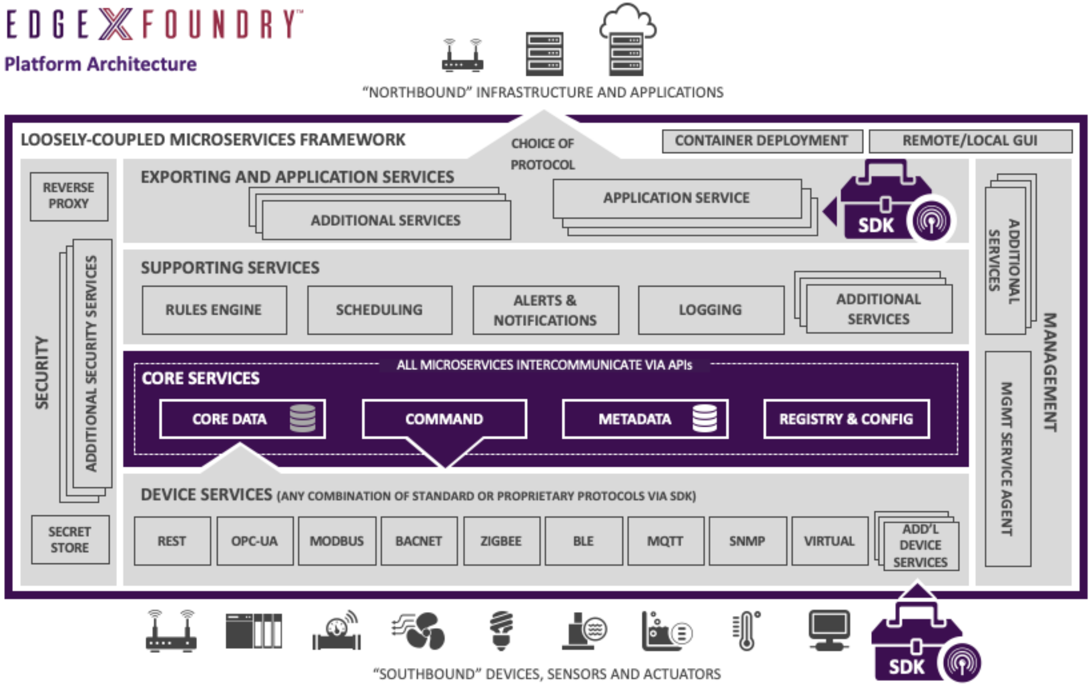


https://www.openness.org/templates/openness/images/the-network-and-onpremise-edge-new.pdf

Robin.io announced the adoption of OpenNESS :

https://www.globenewswire.com/news-release/2020/03/03/1994436/0/en/Robin-io-Adopts-Open-Network-Edge-Services-Software-OpenNESS-to-Advance-Innovations-in-5G-Networks.html

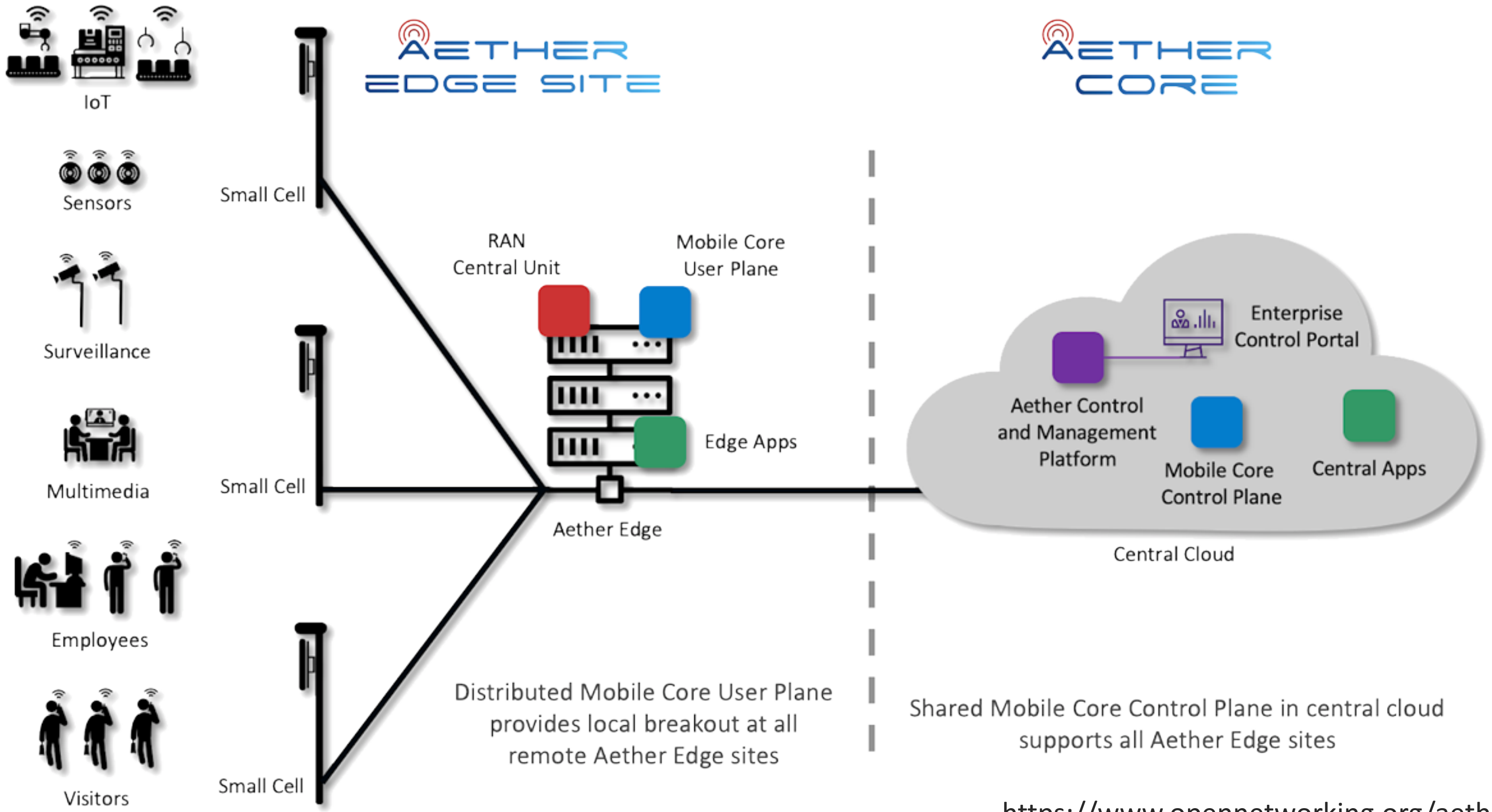
LF Edge – EdgeX Foundry



https://www.lfedge.org/projects/edgexfoundry/

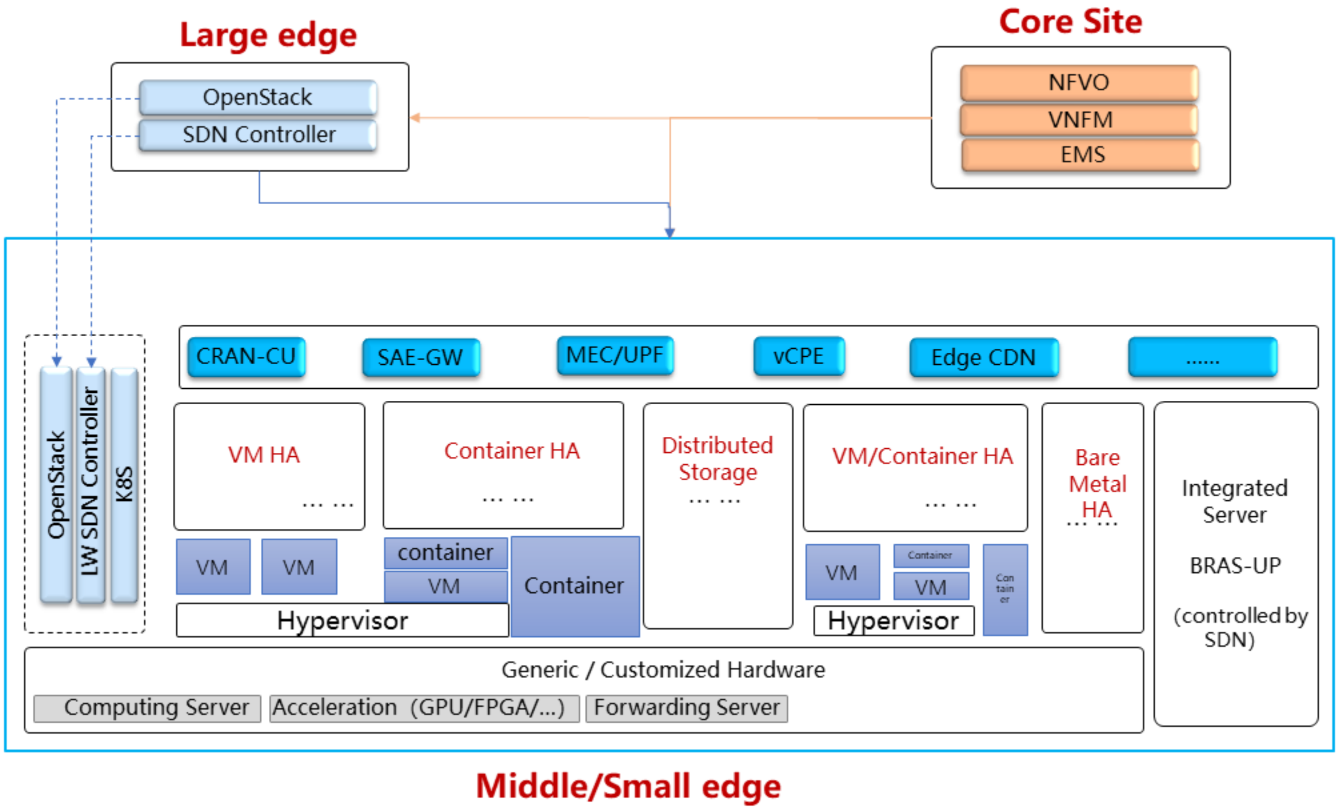
NEC endorses EdgeX Foundry : https://thinkit.co.jp/article/17501

ONF – AETHER



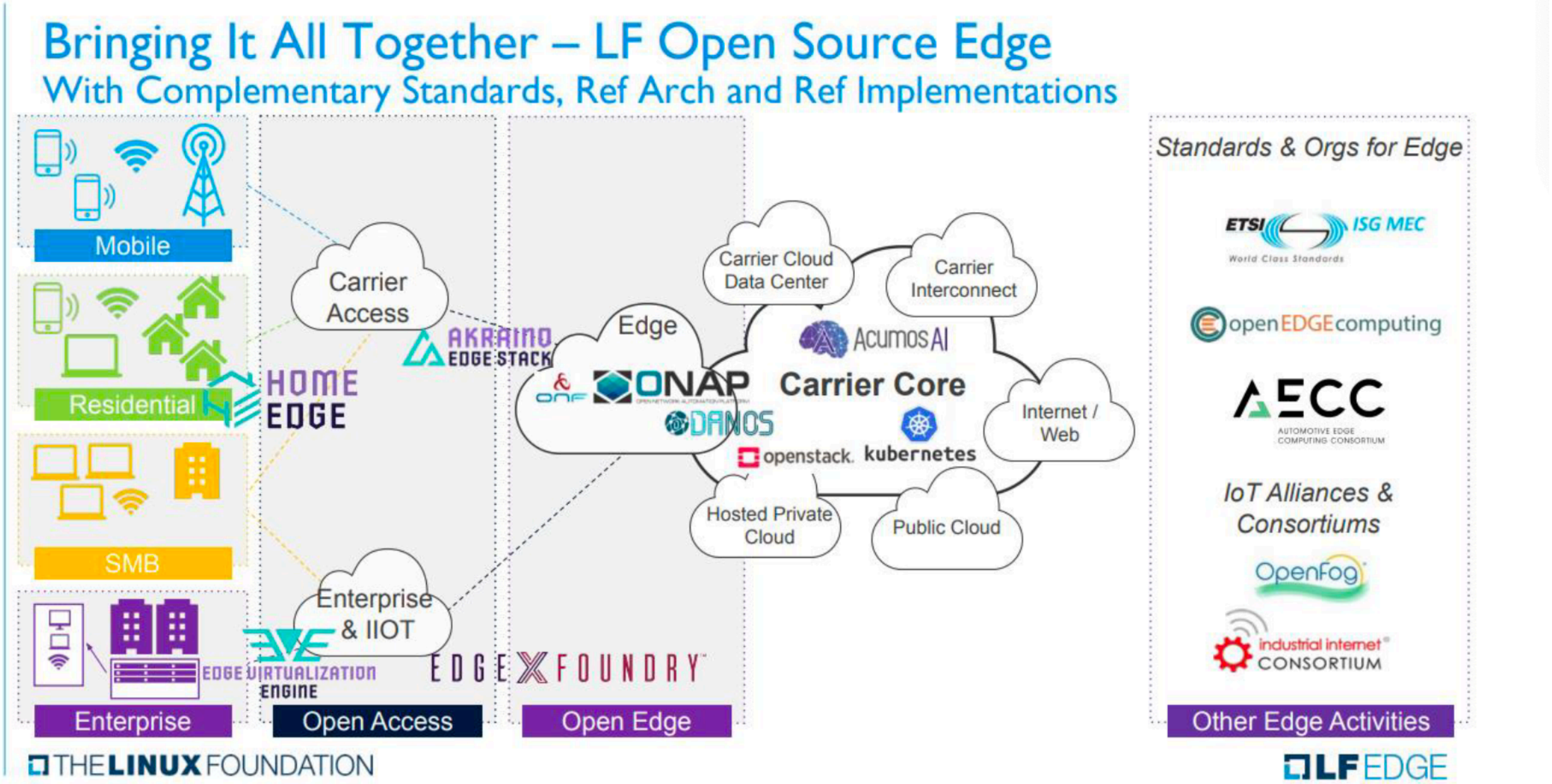
https://www.opennetworking.org/aether/

OPNFV – Edge Cloud Structure



https://opnfv-edgecloud.readthedocs.io/en/latest/development/requirements/requirements.html

Open Reference Architecture



"5G at the Edge", 5G Americas Whitepaper, Oct 2019

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現状の課題 (1/2)

- 従来のMobile Architecture に Edge Computing を適用するのはそんなに簡単ではない
  - Bump in the Wire
  - SIPTO (Selective IP Traffic Offload)
  - SSC mode
  - Remote CUPS + distributed UPF
  - ・・・
- Application Architecture と Mobile Architecture のネイティヴな連携の欠如
  - DNS や UE Client による discovery 程度 (?)

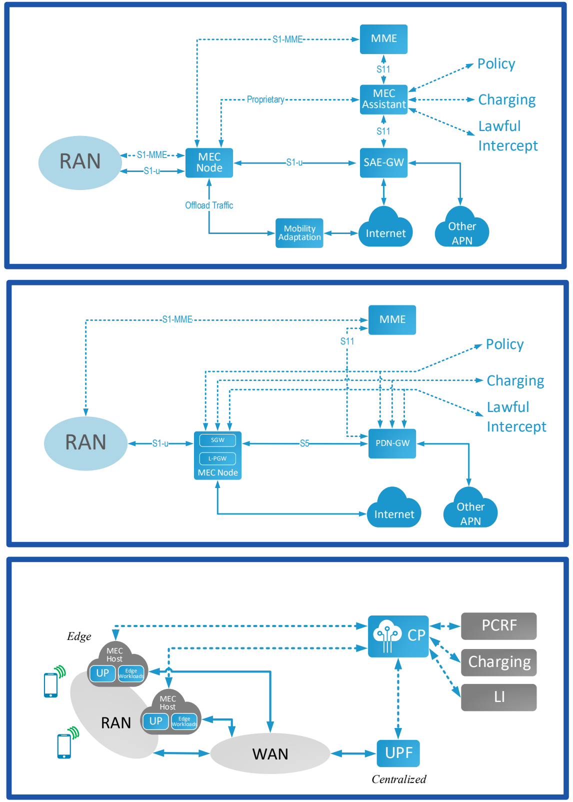


Figure: From Humberto La Roche

現状の課題 (2/2)

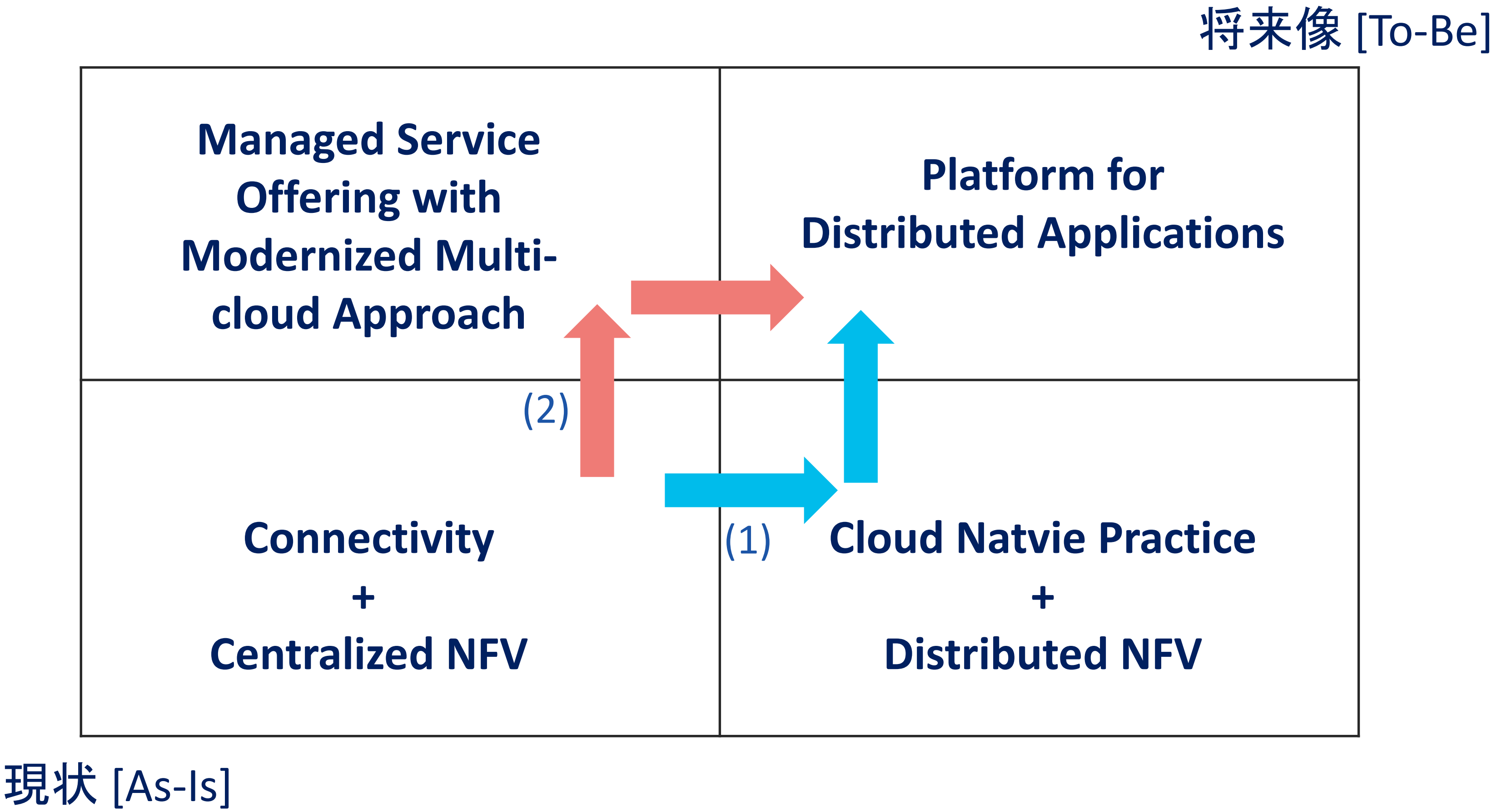
- Opensource/Open Community は エコシステム醸成には至っていない
  - コンポーネントが多く複雑
- AWS, Google Cloud, Azure 三強か
  - Application Architecture との 連携、Programming Framework が充実
  - Infra Agnostic
  - Mobility Agnostic

Fang Liu et. al "A Survey on Edge Computing Systems and Tools"

Aspect	EdgeX Foundry	Azure IoT Edge	Apache Edgent	CORD	Akraino Edge Stack
User access interface	Restful API or EdgeX UI	Web service, Command-line	API	API or XOS-GUI	N/A
OS support	Various OS	Various OS	Various OS	Ubuntu	Linux
Programming framework	Not provided	Java, .NET, C, Python, etc.	Java	Shell script, Python	N/A
Main purpose	Provide with Interoperability for IoT edge	Support hybrid cloud-edge analytics	Accelerate the development process of data analysis	Transform edge of the operator network into agile service delivery platforms	Support edge clouds with an open source software stack
Application area	IoT	Unrestricted	IoT	Unrestricted	Unrestricted
Deployment	Dynamic	Dynamic	Static	Dynamic	Dynamic
Target user	General users	General users	General users	Network operators	Network operators
Virtualization technology	Container	Container	JVM	Virtual Machine and Container	Virtual Machine and Container
System characteristics	A common API for device management	Powerful Azure services	APIs for data analytics	Widespread edge clouds	Widespread edge clouds
Limitation	Lack of programable interface	Azure Services is chargeable	Limited to data analytics	Unable to be offline	Unable to be offline
Scalability	Scalable	Scalable	Not scalable	Scalable	Scalable
Mobility	Not support	Not support	Not support	Support	Support

https://arxiv.org/pdf/1911.02794.pdf

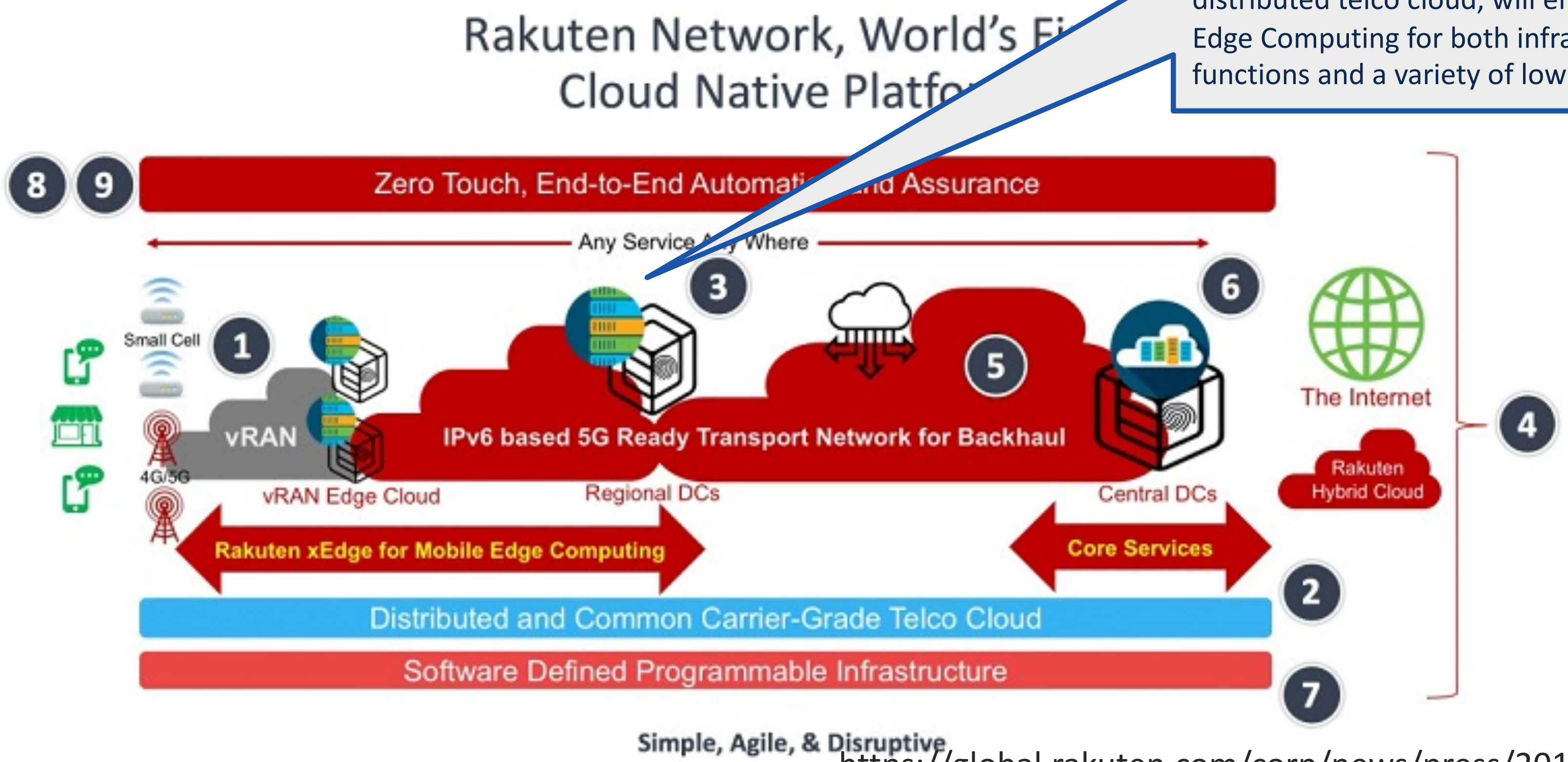
Nest Step？（通信事業者・SP視点）



Rakuten

(1) Cloud Native Platform for Distributed NFV as a start point

3. Mobile Edge Computing – Putting server-like devices closer to the computing need - Rakuten Mobile Network's innovative xEdge architecture, leveraging vRAN, Control & User Plane Separated (CUPS) packet core and distributed telco cloud, will enable Mobile Edge Computing for both infrastructure functions and a variety of low latency services.



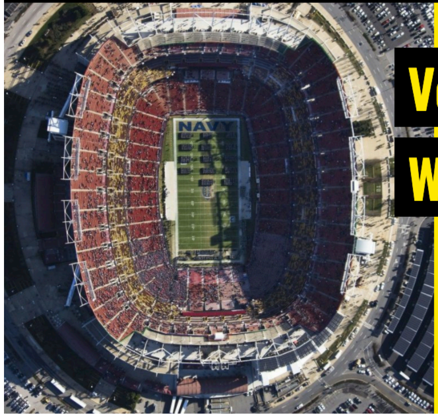
https://global.rakuten.com/corp/news/press/2019/0212_06.html

Verizon

(2) Managed Service Offering - Local 5G + Edge Computing

telecompetitor

Topics



Verizon 5G Stadium Service Will Put Mm Wave 5G + Edge Computing to the Test

Posted on October 7, 2020 by Joan Engebretson Share

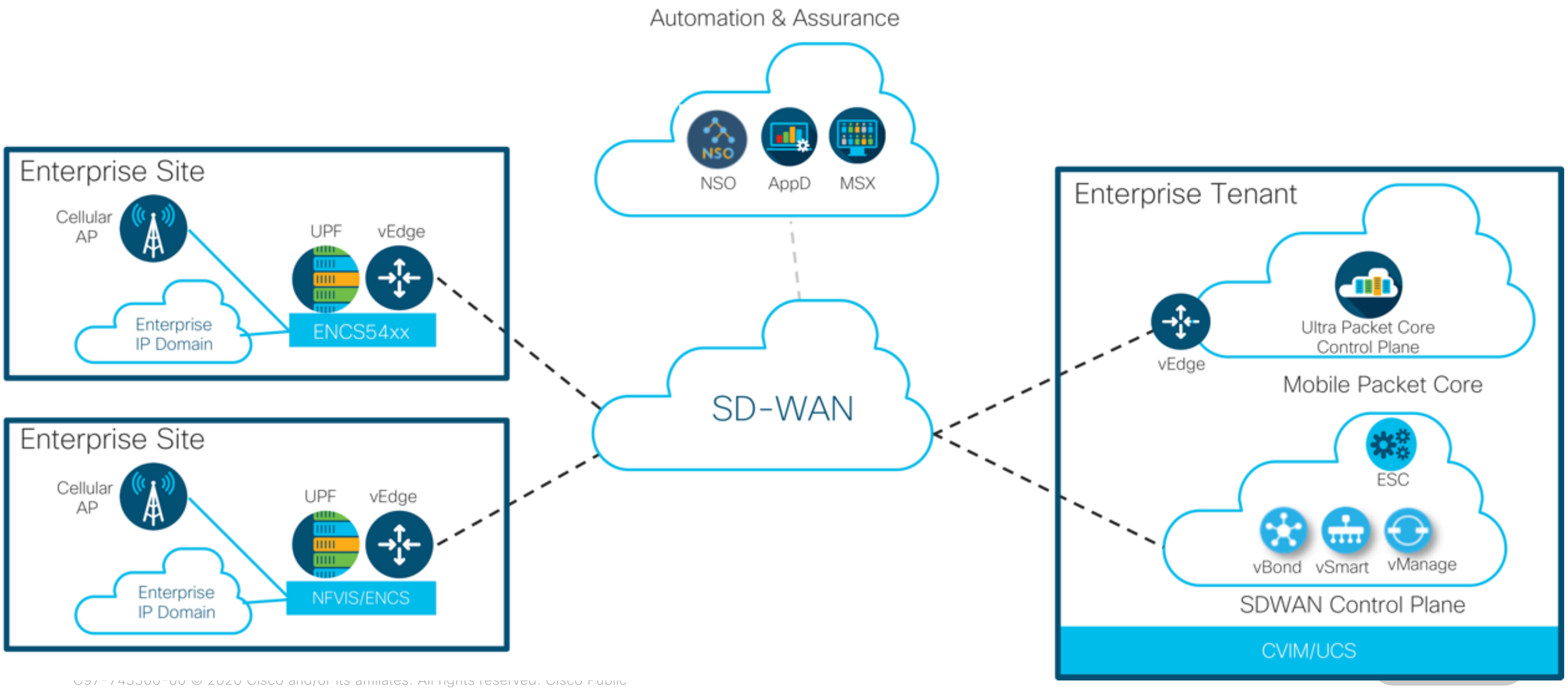
5G Edge Computing Verizon

Home » Verizon 5G Stadium Service Will Put Mm Wave 5G + Edge Computing to the Test

A new Verizon 5G stadium offer intends to target sports and entertainment venues with a potentially "safer in-person experience" – and hopefully a more fun one. The offering relies on a combination of two technologies that Verizon

https://www.telecompetitor.com/verizon-5g-stadium-service-will-put-mm-wave-5g-edge-computing-to-the-test/

(参考) SP Managed Private Cellular 例



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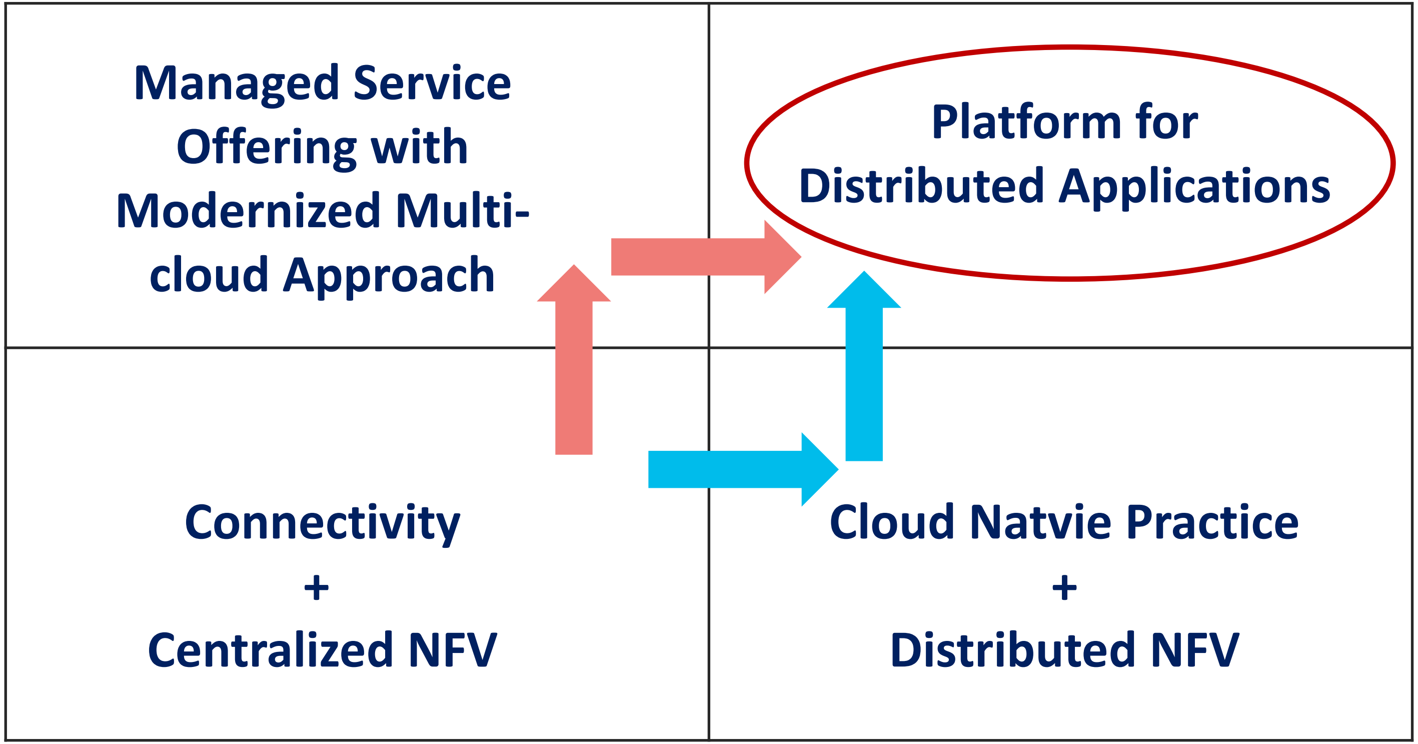
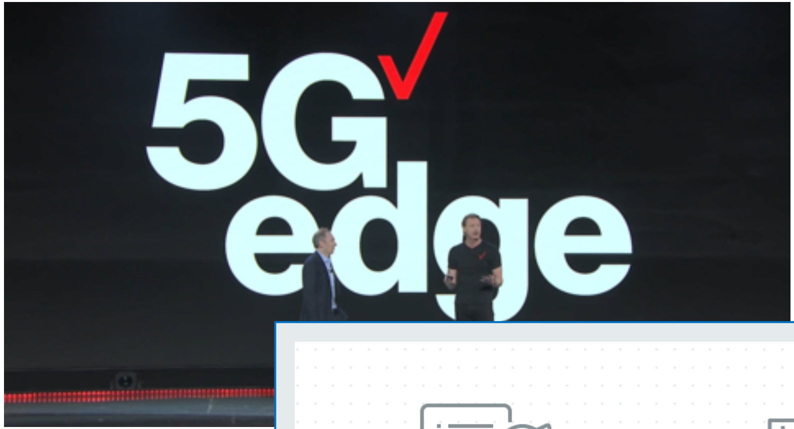
今後の展望 – Platform for Distributed Applicationをどう作るか

将来像 [To-Be]



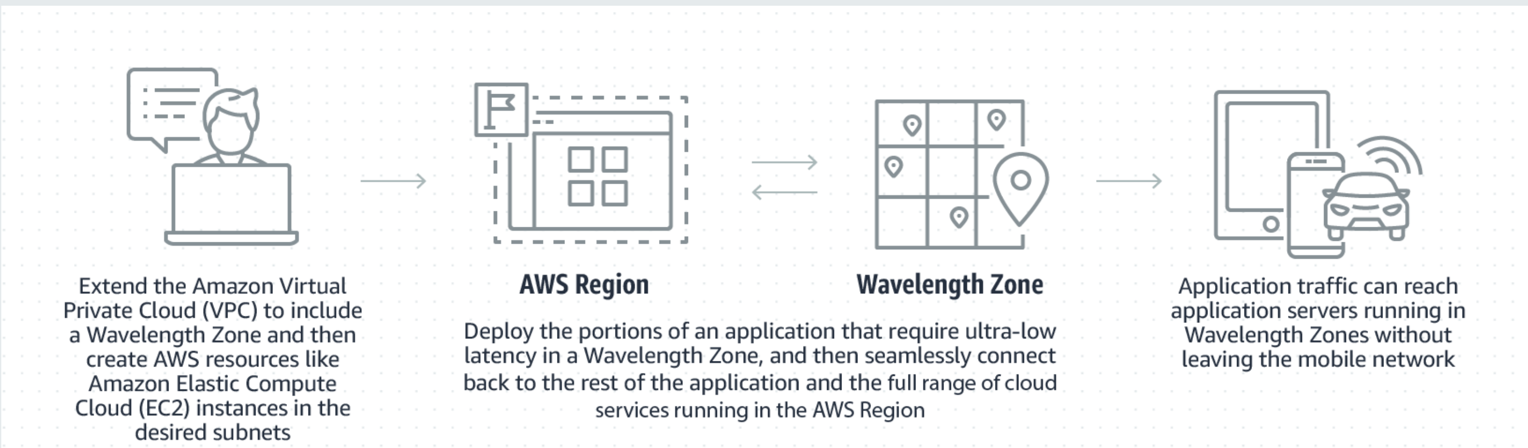
現状 [As-Is]

今後の展望 – “Platform for Distributed Application”をどう作るか



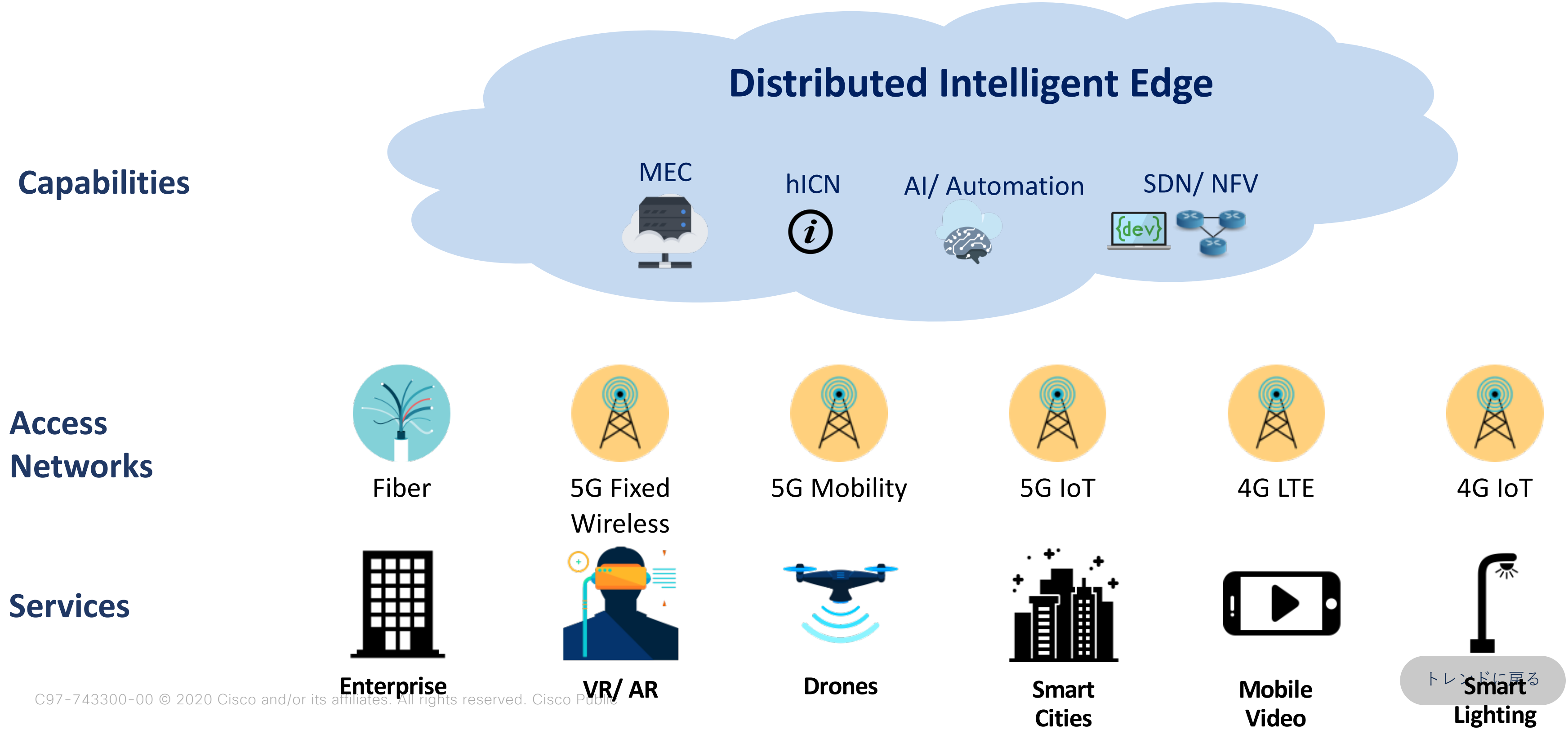
- Public Cloud + SP
  - Infra Integration ?
  - Mobile Integration ?

https://www.fiercewireless.com/5g/verizon-partners-aws-to-bring-more-power-to-its-5g-edge



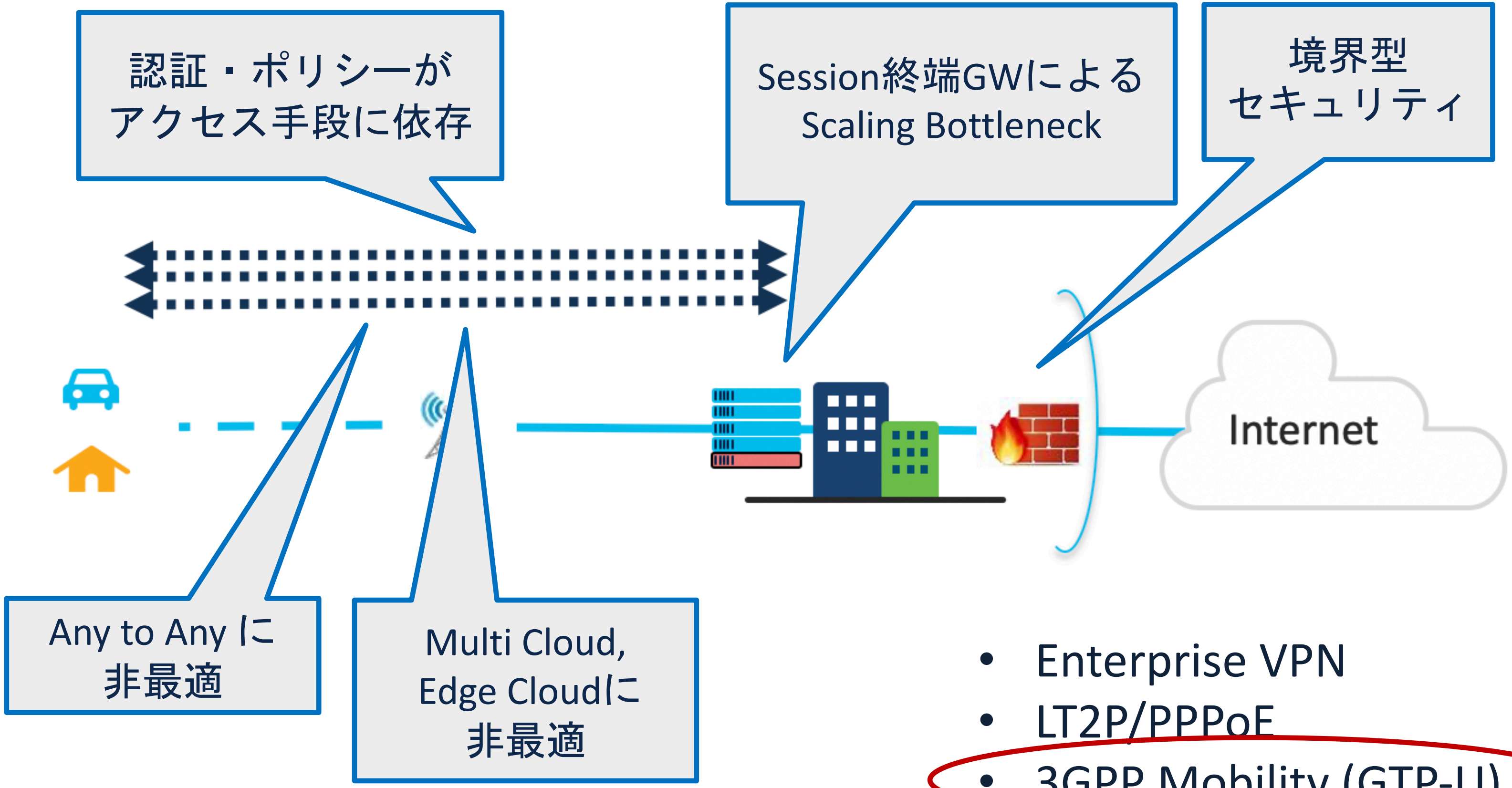
https://aws.amazon.com/wavelength/

Next Architecture
- Intelligent Edge + Diverse Access Networks



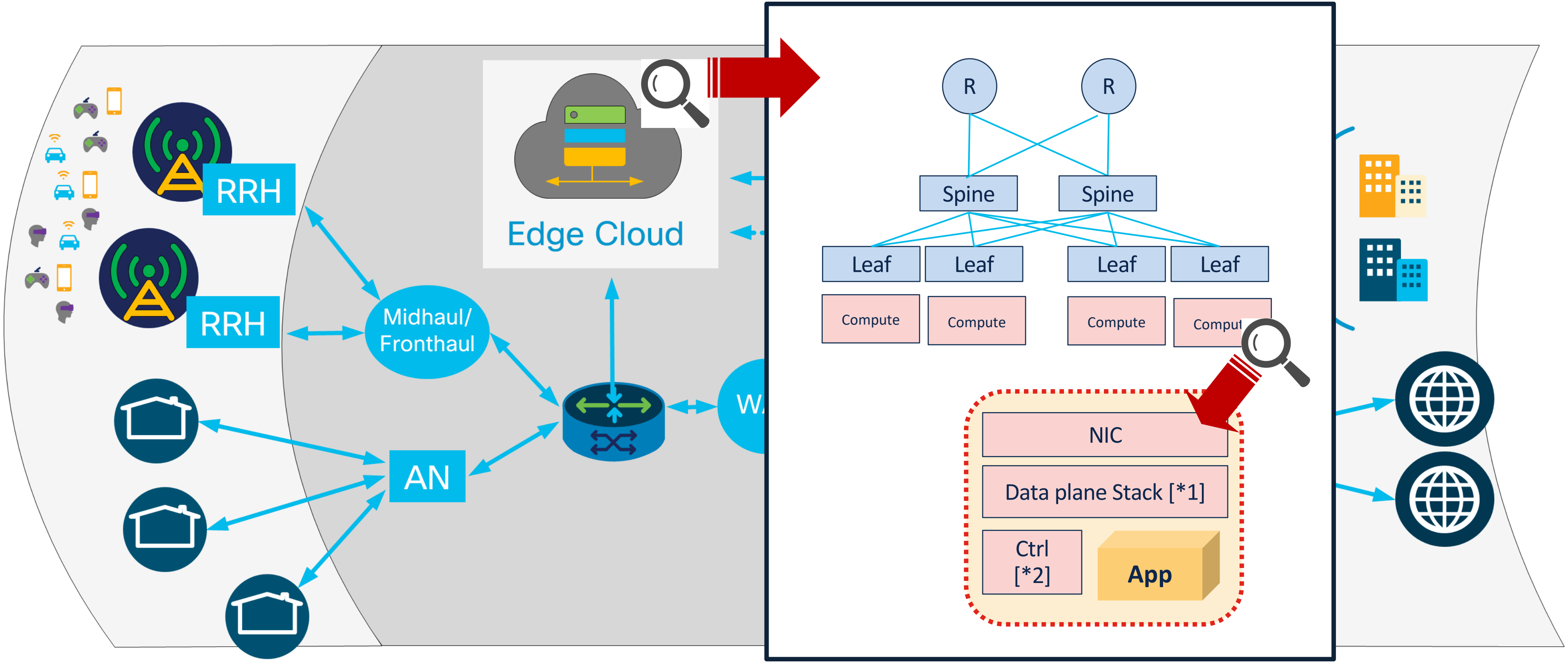
トレンドに戻る

Connection Intensive Architecture の限界 (再掲)



- Enterprise VPN
- LT2P/PPPoE
- 3GPP Mobility (GTP-U)

Application との連携



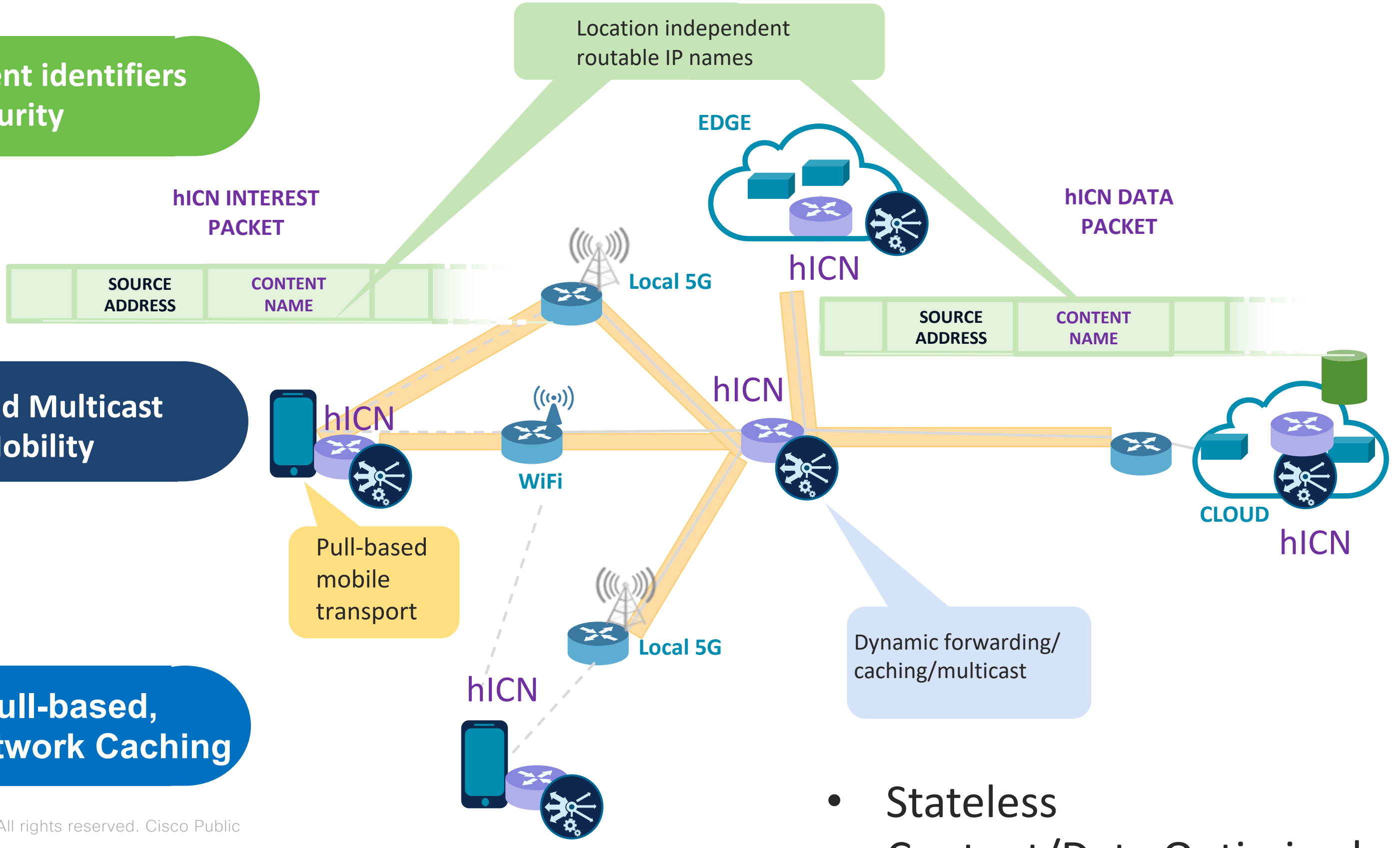
[*1] Data plane stack : VPP, OVS, Linux Kernel (xDP), etc. [*2] Control plane or Agent for Controller, etc.

Dataplane が hICN だったら

Secure Named Data — Location-independent identifiers / Data-centric security

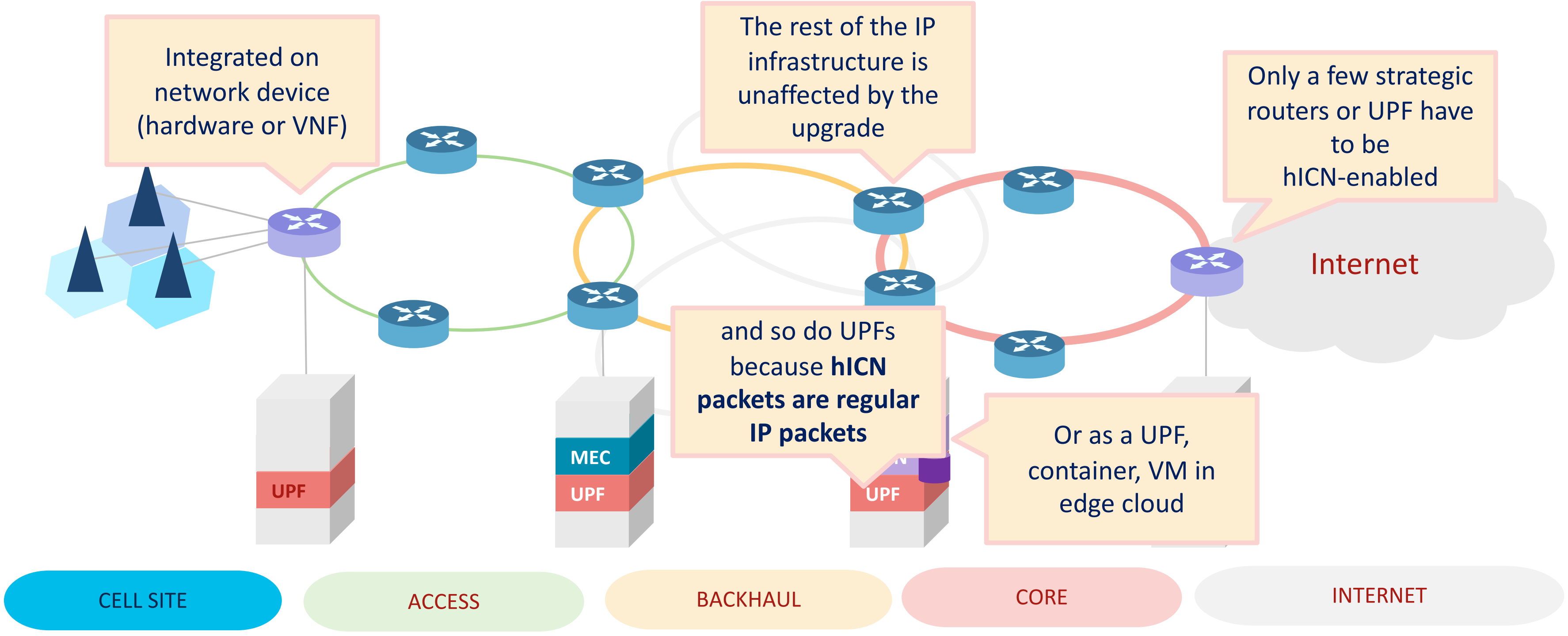
Smart Forwarding — Dynamic Multipath and Multicast / Anchorless Mobility

Connection less transport — Connectionless, Pull-based, / Multi-source, In-network Caching



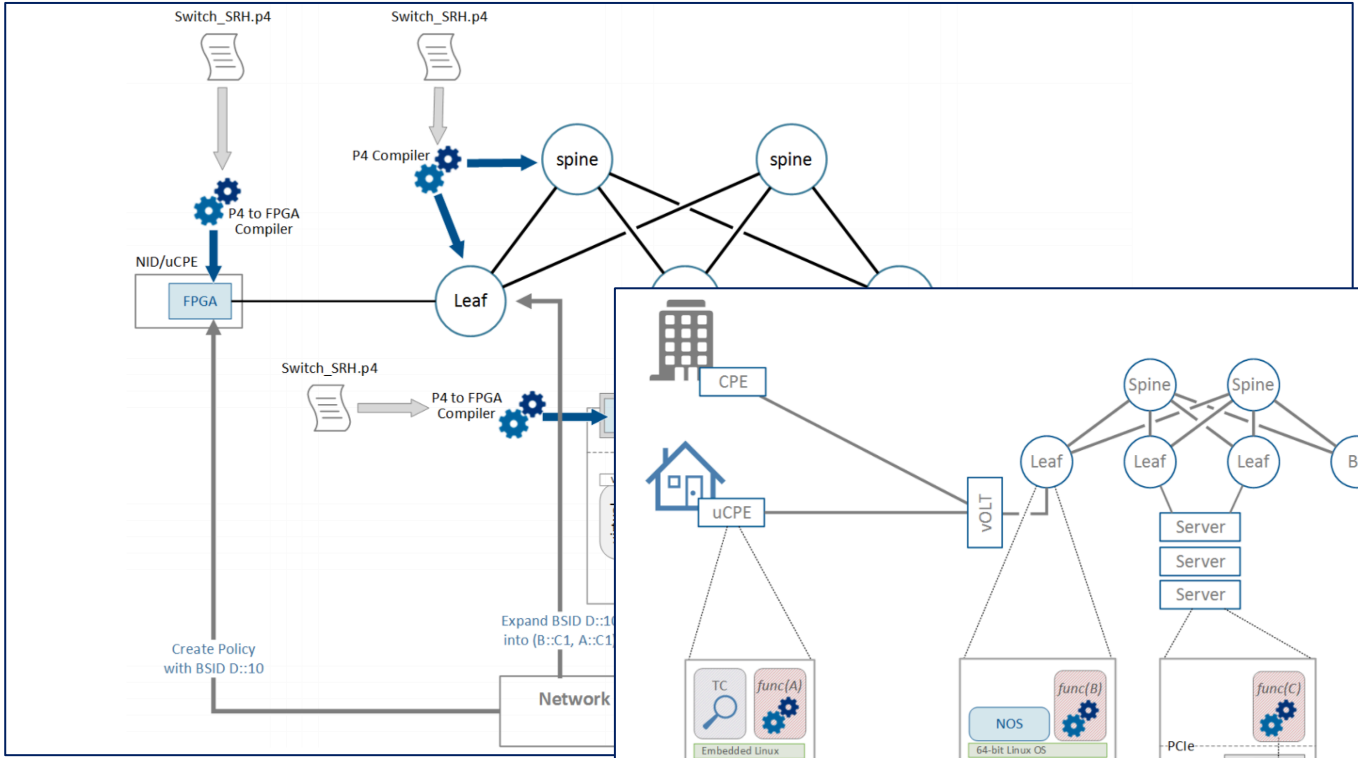
- Stateless
- Content/Data Optimized

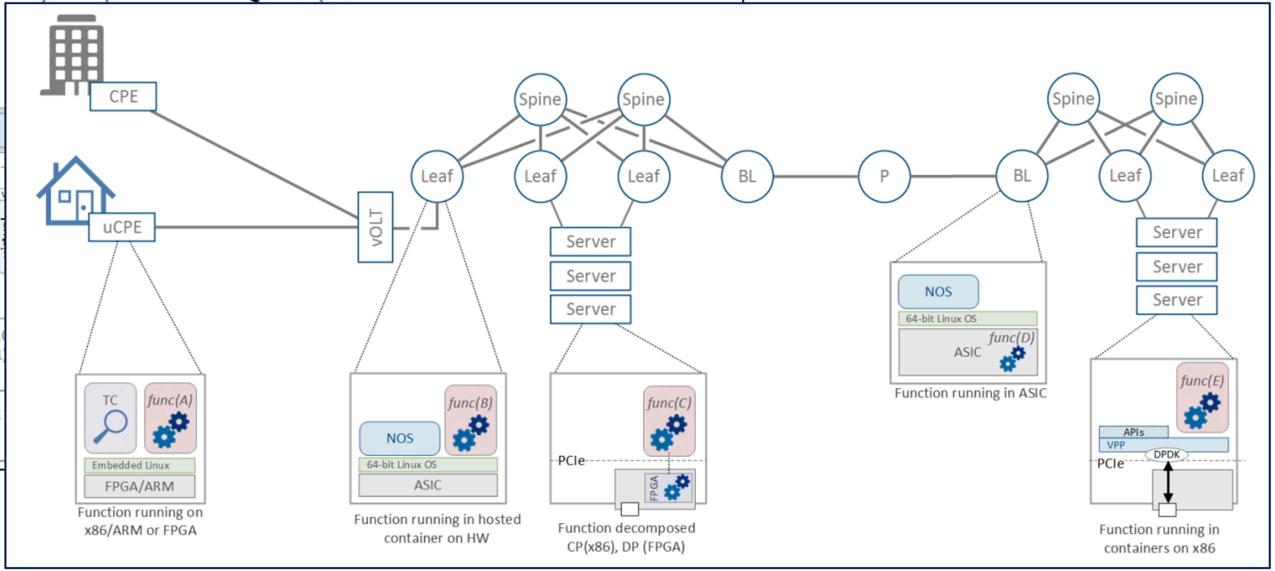
hICN insertion in mobile network



Dataplane が SRv6 だったら

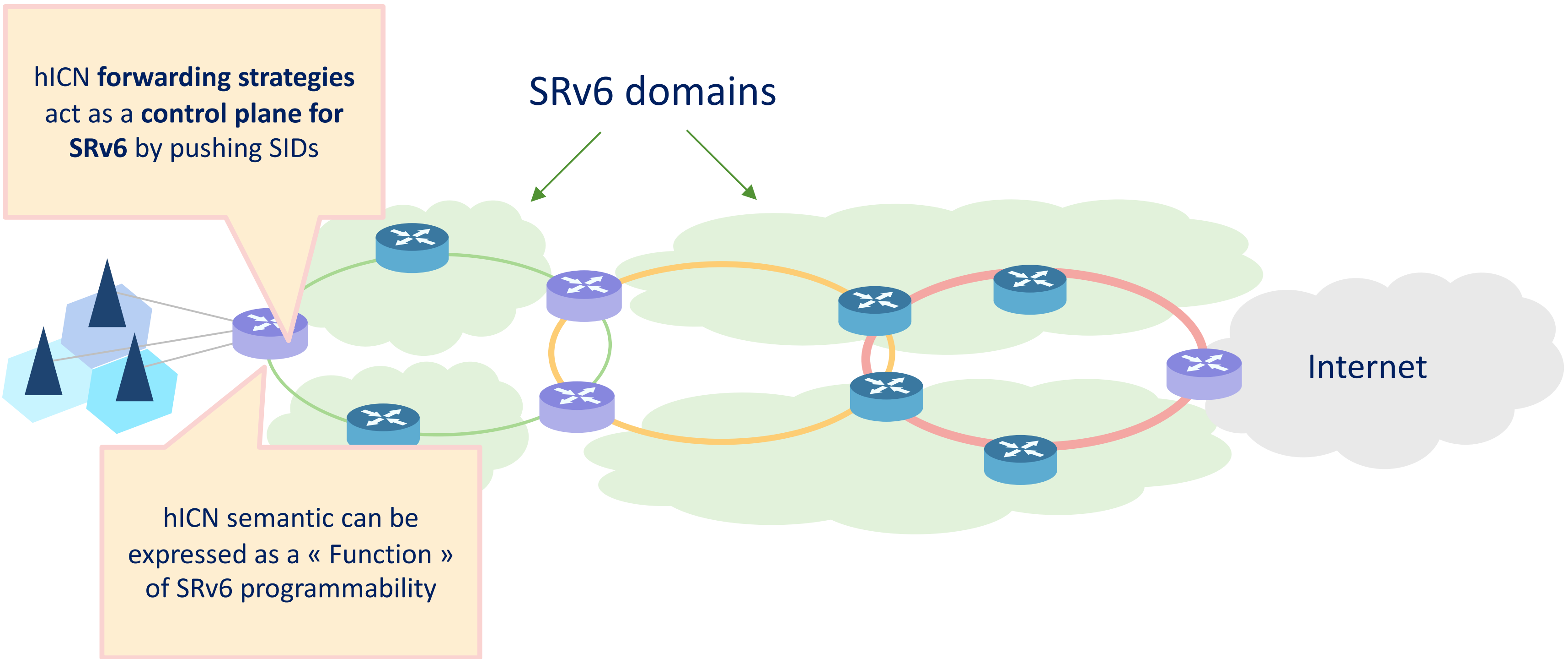
- Stateless
- Flexible Traffic steering
- Programmability





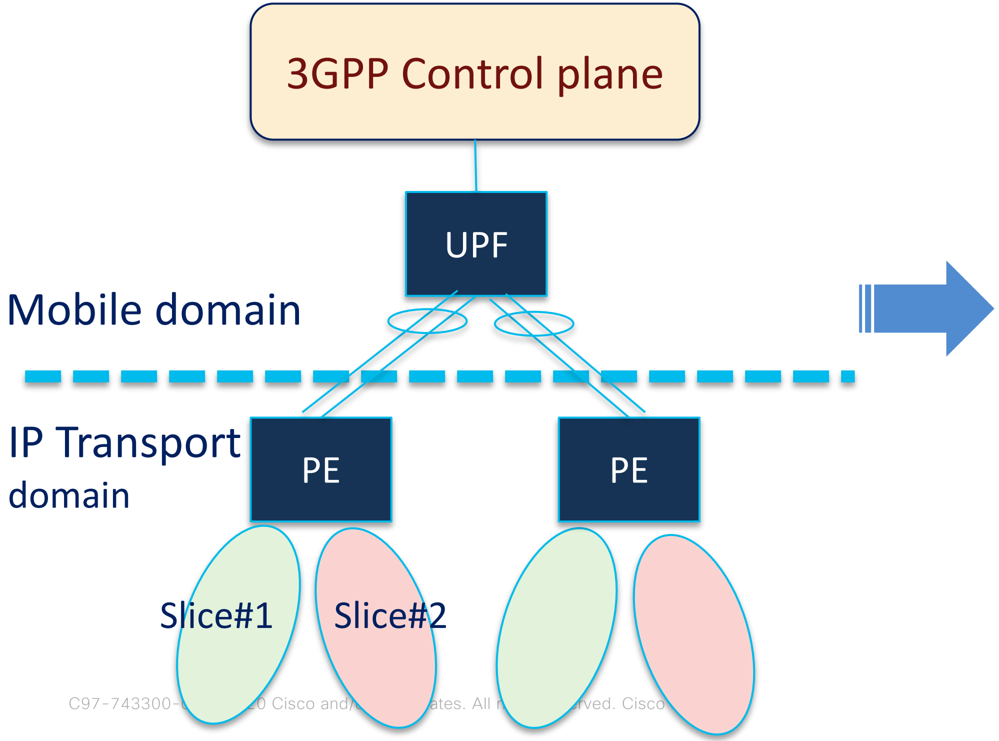
https://www.segment-routing.net/images/20170517-bell-barefoot-cisco-P4%20Workshop%202017%20v2.pdf

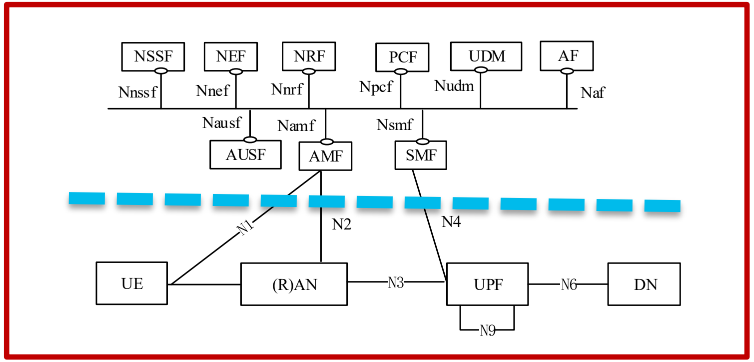
hICN / SRv6 coexistence



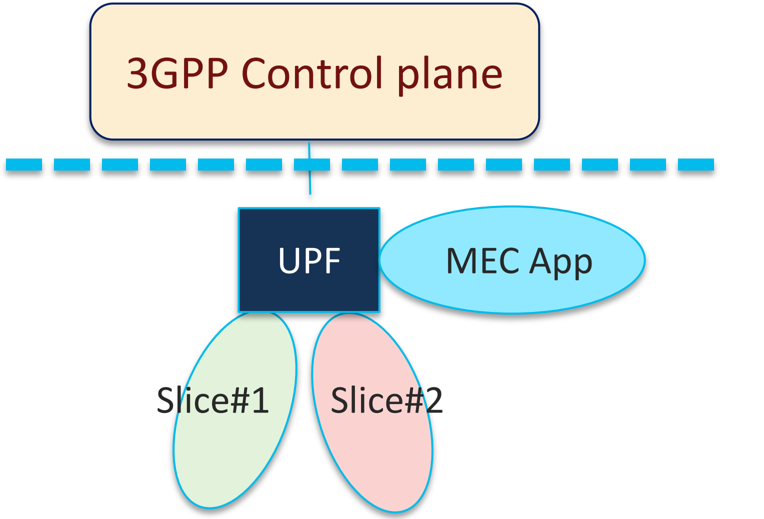
要アーキテクチャ再考！

アプリケーションと連携し易く、
柔軟でステートレスなデータプレーンへ





3GPP TS23.501



draft-kohno-dmm-srv6mob-arch

まとめ

1. Data Intensive Architectureのおさらい
2. Edge Computing – What’s next ?
   - 必要性
   - 分類と参照アーキテクチャ
   - 現状の課題とNext Step
   - 今後の展望

Disrupt, or be disrupted !!
コミュニティの力でアーキテクチャを変遷しよう