5G 時代におけるネットワーク・エッジの変革に向けた
市場動向とシスコの取り組み

Rev.1.0

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Feb 28, 2019
Terminology for Service Edge

Terminology from a Services Edge or Applications Placement Perspective

<table>
<thead>
<tr>
<th>Cisco’s Terminology</th>
<th>Far Edge</th>
<th>Edge</th>
<th>Regional DC</th>
<th>Central DC</th>
<th>Public Cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Terminology</td>
<td>EMEA APJ</td>
<td>Frontend Data Center</td>
<td>Backend Data Center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>Cloud Platform – Deep Edge</td>
<td>Cloud Platform – Far Edge</td>
<td>Cloud Platform - Edge</td>
<td>Cloud Platform - Core</td>
<td></td>
</tr>
</tbody>
</table>
5G’s coming

- **2017**: VZW FWA trial
- **2018**: Orange FWA trial, VZW FWA launch, VF Qatar 5G NSA Launch
- **2019**: 3GPP R16, TMO US 5G SA launch
- **2020**: Orange 5G Cities (SA trial), Handsets in volume
- **2021**: 3GPP R15

**Timeline**:
- **First handsets**
- **5G FWA CPE**
5G - 超高速・多数接続・超低遅延を実現するテクノロジとそれらに基づく次世代の新サービス

総務省 電波政策2020懇談会 報告書より (2016.7)

ITU-R M.2083-0 (2015.9)
Consumer ARPUs are Declining or Flat

B2B or B2B2x Market Has Future Growth

Low Latency for better QOE and to Enable New Applications, Customer Experience Transformation
5G ではネットワークアーキテクチャに大きな変革
エッジはインフラとして必須 かつ 新規ビジネスへの活用のチャンスに
# Use Case / Function

<table>
<thead>
<tr>
<th>Use Case / Function</th>
<th>Latency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>vRAN with Option 7 Split</td>
<td>~250us</td>
<td>End-to-end latency, Including RU symbol buffering, for transport typically 100us delay budget is ok</td>
</tr>
<tr>
<td>Mobile Video</td>
<td>~75ms (One way Delay), will depend on PLR</td>
<td>Including ~25ms of buffering. This recommendation is derived from considering typical PLR in radio and its impact to the performance of TCP congestion control. It implies maximum OWD between streaming server and RAN node must be &lt; 35 ms for LTE and &lt; 40 ms for 5G.</td>
</tr>
<tr>
<td>Mobile Augmented Reality</td>
<td>10ms (One Way Delay)</td>
<td>Network-based inference will not result in viable mobile AR in LTE since the air interface budget (30 ms) exhausts the smallest possible lag (20 ms). In 5G, the AR inference capability likely requires an edge host adjacent to the RAN node.</td>
</tr>
<tr>
<td>Mobile Virtual Reality, Interactive Gaming</td>
<td>20ms (One Way), 50ms (One Way)</td>
<td>For VR, Based on a 40 ms RTT requirement for maximum lag, we see the maximum One Way Delay between the VR server and the RAN node must be &lt; 5 ms for LTE and &lt; 10 ms for 5G.</td>
</tr>
<tr>
<td>VoIP</td>
<td>200ms (One Way Delay)</td>
<td>Note that the number implies VoIP can be supported over longer distances with no measurable impact on delay. This suggests IMS APN should remain centralized</td>
</tr>
</tbody>
</table>

## Other Low Latency / uRLLC Use Cases (More likely to be deployed in later phases)

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Latency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory Automation</td>
<td>0.25 – 10 ms</td>
<td>Real-time control of machines and systems in production lines</td>
</tr>
<tr>
<td>Intelligent Transport</td>
<td>0 – 100 ms</td>
<td>Autonomous driving and optimization of road traffic (platooning and overtaking)</td>
</tr>
<tr>
<td>Robotics and Telepresence</td>
<td>10 – 100 ms</td>
<td>Remote control with synchronous visual–haptic feedback</td>
</tr>
<tr>
<td>Health care</td>
<td>1 – 10 ms</td>
<td>Medial Bio–Telemetry, Tele-diagnosis, tele–surgery</td>
</tr>
<tr>
<td>Smart Grid</td>
<td>100 ms</td>
<td>Switching on/off electrical sources to compensate for demand fluctuations</td>
</tr>
</tbody>
</table>
考慮点2: エッジでのインフラ構築には多くの制約と課題

場所, 現状, 所有者, 諸所の制約事項

Public Cloud Provider

Internet

Branch / Venues

Cell Site / Access
10000’s

C-RAN Hub / Pre-Agg.
1000’s

CO / Agg / MSO / HE
100’s

Regional DC
10’s

Central DC
<10

Peering

Highly Constrained.
Leased by SP in many case (tower companies)

Constrainted location.
SP Owned in most cases (co-lo in some cases)

Constraints varies by SP to SP.
SP Owned in most cases (co-lo in some cases)

Typically proper DC facilities.
SP Owned in most cases
A CO is not a data center

- Some operators have very specific requirements on DC equipage
- Power is ~48 VDC in the CO and grid voltage in the DC
- COs typically have concrete floors vs raised floors in data centers
- Power dissipation in COs is limited to < 4.5 kW per cabinet whereas no such limit exists in DC rack (~12 kW)
- In COs, equipment depth is ~12 in (600 mm) vs 800-900 mm in DCs

Many Operators have empty space at CO

- How to use it - sell or sell & lease back or keep?
- Adapt to the constraints or redesign the facility as a data center?

Adapt to exisiting Constraints?

Convert to raised floors, filtered air, and advanced AC?

Tear-down and rebuild?

Data Center in a POD?
最適な配置とビジネス性を見据えたエッジへの設備投資

Latency | Cost of Backhaul
Operational Complexity | Cost of Infrastructure | Economy of Scale

<table>
<thead>
<tr>
<th>Location</th>
<th>Constrained Locations</th>
<th>Location Constraints Varies</th>
<th>Proper DC Facilities. Focus of Present NFV Deployments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Site / Access</td>
<td>10000’s</td>
<td>Only viable location for vBBU or vDU</td>
<td>Becoming Sweet Spot for Edge Computing Apps &amp; Services</td>
</tr>
<tr>
<td>C-RAN Hub / Pre-Agg.</td>
<td>1000’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO / Agg / MSO / HE</td>
<td>100’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional DC</td>
<td>10’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central DC</td>
<td>&lt;10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peering Points</td>
<td>~10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
アプリケーションの配置の例：アプリケーションの特性と要件に応じて最適なエッジへの配置ができるインフラを構築することが重要です。

Connectivity Service: vRAN
Edge Computing: CDN, IOT, Localized AR, Analytics

Connectivity Service: vRAN (vCU, vBBU)
For some SP's: EPC/BNG CUPS, Edge services

Connectivity Service: Packet Core, Policy, IMS, Conn Optimization: CDN, NAT, FW, Video/TCP Opt...
Managed Svc: vMS Video: SP Video CP/DP

Managed Service: Cloud Services Interconnect

Conn. Service: Packet Core, Policy
Managed Svc: CPE / SD-WAN, FW SaaS Services

SaaS Services

For some SP's: EPC / BNG CUPS, Edge services

Connectivity Service: Packet Core, Policy, IMS, Conn Optimization: CDN, NAT, FW, Video/TCP Opt...
Managed Svc: VMS Video: SP Video CP/DP

Managed Service: vMS Video: SP Video CP/DP SaaS Services

Happening Now

Next
エッジの変革に向けたシスコの取り組み

- **Cloud Native Network Functions**
  - Network Function の仮想化・Cloud Native 化への開発投資
  - Mobie EPC, Cloud CMTS, Cloud Native BNG, and more...

- **Virtualization & Container Platform**
  - エッジまで拡張できる仮想基盤・コンテナ基盤への開発投資

- **Cloud Native Performance**
  - エッジ上で仮想化・Cloud Native 化された Network Function での高性能パケット処理のための開発投資
Cloud Native Network Functions
デコンポーズ、仮想化をクラウドネイティブ化へ

シスコはNetwork FunctionのCloud Native化を推進

Decomposed Mobile core with Cisco Ultra Services Platform

Cisco Cloud CMTS (cCMTS)
Cloud Native に向かう背景: アプリケーションの進化
専用アプリアンスから仮想マシン・そしてコンテナへ
Microservices
- Modular, loosely coupled software services
- Individually deployed and lifecycle managed

Containers
- Virtualization and management of Microservices
- Highly portable to different deployment targets

Continuous Delivery
- Automated continuous integration, validation and availability of containers

DevOps
- Automate and manage rapid deployments
- Isolate production changes and deploy once validated
Cloud Native 化のアプリケーションにとっての利点
NFV に期待されていた真のメリットを実現

- **Lifecycle Automation**
  - Automated instantiation and placement, upgrade, scale and recovery.

- **Multi-Cloud Portability**
  - Mobile core disaggregation to the edge across public, private, and hybrid clouds.

- **Lightweight and Fast**
  - Extremely fast startup times improves recovery and scaling event handling.

- **High Performance**
  - Bypass the hypervisor overhead when deployed on bare metal. VPP based forwarding plane and vswitch.

- **Stateless Application Services**
  - State services are separated from the application processing to simplify manageability.

**Keywords:**
- Cloud Native
- NFV
- Stateless Application Services
- High Performance
- Lightweight and Fast
- Multi-Cloud Portability
- Lifecycle Automation
- Mobile core disaggregation
- VPP
- State services
- Application processing
- Manageability

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エッジ変革に向けてシスコが開発する製品＆テクノロジー

- Cisco VIM
- Cisco Container Platform
- Virtual Packet Processor
Cisco SP Virtualization Platform Today
With **Cisco VIM**, Cisco UCS Servers, Cisco Switching and MANO stack

- **SP’s OSS, BSS, Portal, CRM**
- **Service and Resource Orchestration**
  - Cisco NSO (NFV Orchestrator)
  - 3rd Party NFV Orchestrator

**Virtual Network Functions (Cisco and 3rd Party)**
- Mobility Services VNFs
- Wireline Services VNFs
- Managed Services VNF
- 3rd Party VNFs / Apps

**Virtual Infrastructure**
- Virtual Compute (RHEL)
- Virtual Storage (Ceph)
- Virtual Network (Fd.io, SR-IOV, OVS)

**Physical Infrastructure**
- Compute (Cisco / 3rd Party*)
- Network (Nexus / NCS5K)
- Storage (Cisco / 3rd Party*)

**Cisco VIM**
- OpenStack
- Cisco Lifecycle Manager
- Optional Network VIM (ACI / VTS / ML2-VPP)

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# Cisco VIM
## Carrier Grade NFV Platform

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unified Management System</strong></td>
<td>(Multi-Pod &amp; Multi-Site, Single Pane of Glass, RBAC, GUI, REST API)</td>
</tr>
<tr>
<td><strong>Lifecycle Manager</strong></td>
<td>(Day N operations – Pod Mgmt, Update/Upgrades, Reconfig, Power Mgmt)</td>
</tr>
<tr>
<td><strong>Integrated Tools</strong></td>
<td>(Benchmarking: Networking, Storage, Compute)</td>
</tr>
<tr>
<td><strong>Logging &amp; Assurance</strong></td>
<td>(EFK stack, CVIM Monitor, Zenoss, …)</td>
</tr>
<tr>
<td><strong>Health Checks &amp; Failure Recovery</strong></td>
<td>(CloudPulse, Cloud Recovery, REST)</td>
</tr>
<tr>
<td><strong>Control and Data Plane HA</strong></td>
<td>(Compute, Network &amp; Storage)</td>
</tr>
<tr>
<td><strong>Ubiquitous Security</strong></td>
<td>(TLS, SELinux, non-root, RBAC, etc.)</td>
</tr>
<tr>
<td><strong>Performance Enhancement</strong></td>
<td>(Fast Data Stacks like VPP, tuning – CPU pinning, NUMA and many more)</td>
</tr>
<tr>
<td><strong>Integrated SDN Controller</strong></td>
<td>(ACI, VTS)</td>
</tr>
<tr>
<td><strong>Containerized Deployment</strong></td>
<td>(OpenStack Services, CI/CD Capable Platform)</td>
</tr>
<tr>
<td><strong>Fully Automated Installer</strong></td>
<td>(1-click, Modular, Robust)</td>
</tr>
</tbody>
</table>

## OpenStack Platform
- Ceph Storage

## Operating Systems
- Linux
- Cisco NX-OS
- Cisco IOS-XR

## Hardware
- Cisco UCS Servers
- Cisco Nexus 9000
- VIC
- 3rd Party Servers
- NIC
- H/W Accelerator*
- FPGA*

## Turn Key Packaged Software

## Cisco VIM

## Day 0
- OpenStack, Linux & Storage Distribution

## Day N
- Integrated Tools
- Control and Data Plane HA
- Lifecycle Manager
- Logging & Assurance
- Health Checks & Failure Recovery
- Ubiquitous Security
- Performance Enhancement
- Integrated SDN Controller
- Containerized Deployment
- Fully Automated Installer

* Future
Expand Virtualization Platform to the Edge
CVIM Deployment Models

Scale Up

Full POD (64 Nodes)

Central / Reg. Telco DCs

HyperConverged (64 Nodes)

Central / Reg. Telco DCs

Cisco VIM on Public Cloud

Scale Down

Full Pod (128 Nodes)

Central / Reg. Telco DCs

Micro-POD (4 Nodes Min.)

CO / Pre-Agg.

EdgePOD (3 Nodes Min at Site)

Central Storage & Management

EdgePOD

EdgePOD
Cisco Container Platform

ネイティブ Kubernetes（100 % アップストリーム）
オープンソースコミュニティでの更新やベストプラクティスを直接適用

ハイブリッドクラウドの最適化
例：Google 等

統合
ネットワーク | 管理 | セキュリティ | 分析

柔軟な導入モデル
VM | ベアメタル ↔ HX、ACI | パブリッククラウド

ターンキー ソリューションでの製品レベルのコンテナ環境

容易な導入、展開、管理 | オープンでありながら一貫性を維持 | 拡張可能なプラットフォーム | 世界レベルのアドバイザリとサポート

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Cisco Container Platform

技術面での差別化要因

- 高度な自動化、キュレーション
- アップストリームのKubernetes上で100% 動作
- シームレスなコンテナネットワーキング
- 組み込みでのセキュリティとロード バランシング（L4/L7）
- エンタープライズ クラスの永続ストレージ
- 統合されたモニタリングとログイン

Kubernetes でのライフサイクル管理  
Kubernetes での認証と認可

K8s マスター 1  
K8s マスター n

K8s ノード  
ネットワーク

ロード  
バランサ

エンタープライズ クラスの永続ストレージ  
外部ネットワーク

IaaS

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Virtualization Platform – Cisco VIM Evolution
toward container support

VM based NFV
- Cisco VIM Tooling & Automation
- VNIFS (VM)
- Cisco VIM
- Validated Hardware (Servers, Switches)

Adding Container in VM Support
- Consistent Tooling & Automation
- VNIFS (VM)
- CNIFS (Container in VM)
- CCP (K8s)
- Cisco VIM
- Validated Hardware (Servers, Switches)

Container on Bare Metal Support Model 1
- Consistent Tooling & Automation
- VNIFS (VM)
- CNIFS (Container on Bare Metal)
- CCP (K8s)
- Cisco VIM (Ironic BM)
- Validated Hardware (Servers, Switches)

Container on Bare Metal Support Model 2
- Consistent Tooling & Automation
- VNIFS (VM)
- CNIFS (Container on Bare Metal)
- CCP (K8s)
- Cisco VIM (Ironic BM)
- Common Bare Metal Manager
- Validated Hardware (Servers, Switches)
VPP (Vector Packet Processing)
Virtual Networking Data Plane – For Containers, VMs, and VNF’s Data Plane

https://fd.io/

- Project at Linux Foundation: Open & Wide Adoption
- VPP / Fd.io to serve as a key foundation on our platform – Cisco is committed to it
- Becoming Universal data plane in our solution:
  - Infrastructure vSwitch
  - Data Plane for Containerized Network Functions
- Software Dataplane
  - High throughput (up to terabit on multiple cores)
  - Low and Predictable Latency & Jitter
  - Feature Rich
  - Resource Efficient
  - Bare Metal / VM / Container format
  - Multi-platform (x86, ARM...) support
  - SR and SRv6 ready

SR: Segment Routing
SRv6: Segment Routing IPv6
Multi-party: Broad Contribution
Evolution to Cloud Native Virtualization Platform

- Cisco VIM (OpenStack)
- Cisco Container Platform
- BMaaS
- Fast Networking (VPP)
- Operational Tools

Multi-Site, Multi-POD Manager including Cloud Management for Multi-tenant Operations

Fast Networking, Consistent Policy & Security, Operational Tooling

Deployment & Lifecycle Automation

Bare Metal & ZTP Automation at Edge

Host OS, Packages, Drivers

UCS / 3rd Party

C-VIM

CCP

BMaaS

C-VIM

CCP

C-VIM

CCP

C-RAN Hub / Pre-Agg.

CO/Agg/MSO/HE

Regional DC

Central DC

Public Cloud Provider

Public Cloud Provider

Needs only Containers

Needs Containers, VM, BMaaS

Needs Containers, VM

Needs Containers, VM
Example - Full Solution at New Disruptive MNO
Cisco is driving the Telco Cloud and Edge Computing Deployment

Zero touch, automated, fully virtualized cloud native network to offer global services

~4000 Edge DC/Cloud

2 Central Data Centers

Distributed Carrier-Grade Telco Cloud Platform

Software Defined, Programmable Infrastructure

1. Open, Virtualized & disaggregated RAN
2. Fully Virtualized with Common & distributed Telco Cloud
3. Edge Computing – Enhanced Customer Experience & New Apps
4. New business models, Cross-Monetization with OTT Content
5. Common HW SKUs for “Any-Service, Anywhere”
6. End-to-End Closed Loop Automation
5G に向けたネットワークアーキテクチャの変革が段階的に進む 仮想化 > コンテナ化 > エッジの変革 > クラウド化

<table>
<thead>
<tr>
<th>Phase 4 - Edge Service Cloud</th>
<th>Phase 2 - Distributed Telco Cloud</th>
<th>Phase 1 - Central/Regional Telco Cloud</th>
<th>Phase 3 - Public Cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hosting of Edge/Fog Applications (IoT, Gaming, V2X, etc.)</td>
<td>• Virtualization of User Plane (UP, MEC/CDN, vRAN, etc.)</td>
<td>• Virtualization of Core Functions (CP, UP, Gi-Services, IMS, CDN, etc.)</td>
<td>• Hosted Platforms and Applications (Device mgmt, IoT, Analytics, etc.)</td>
</tr>
<tr>
<td>• Micro-Services</td>
<td>• SDN and Virtualization</td>
<td>• SDN Fabric and Orchestration</td>
<td>• Cross borders</td>
</tr>
<tr>
<td>• 1000s locations</td>
<td>• Approx. 40 – 100 locations</td>
<td>• &lt;10 locations</td>
<td>• Lab Test and Validation</td>
</tr>
<tr>
<td>• &lt; 10 VMs</td>
<td>• &lt; 100 VMs</td>
<td>• 100+ VMs</td>
<td></td>
</tr>
</tbody>
</table>

5G Architecture
Summary

- 通信事業者様のビジネスにおいて 5G がエッジ (MEC; Multi-Access Edge Computing) の変革を主導している。エッジのインフラ構築は必須、かつ、新規ビジネス創出のチャンスに

- ビジネス創出に向けた産業界や企業・アプリケーション開発者とのエコシステム構築が鍵を握る

- エッジの変革を見据えたシスコの開発投資の方向性
  - **Cloud Native Network Functions:**
    エッジに対応した Network Function の仮想化・Cloud Native 化への開発投資
  - **Cloud Native Platforms:**
    エッジまで拡張できる仮想基盤・コンテナ基盤への開発投資
  - **Cloud Native Performance:**
    エッジ上で仮想化・Cloud Native 化された Network Function での高性能パケット処理への開発投資：VPP / fd.io