

Global Cloud EPC & Microservice Market Research

Highly Confidential
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shenzhen China



Agenda

1 Introduction

2 Global Cloud EPC & Microservice Market Overview

3 Global Cloud NFV & EPC Market Size, Forecast and Competitive Landscape

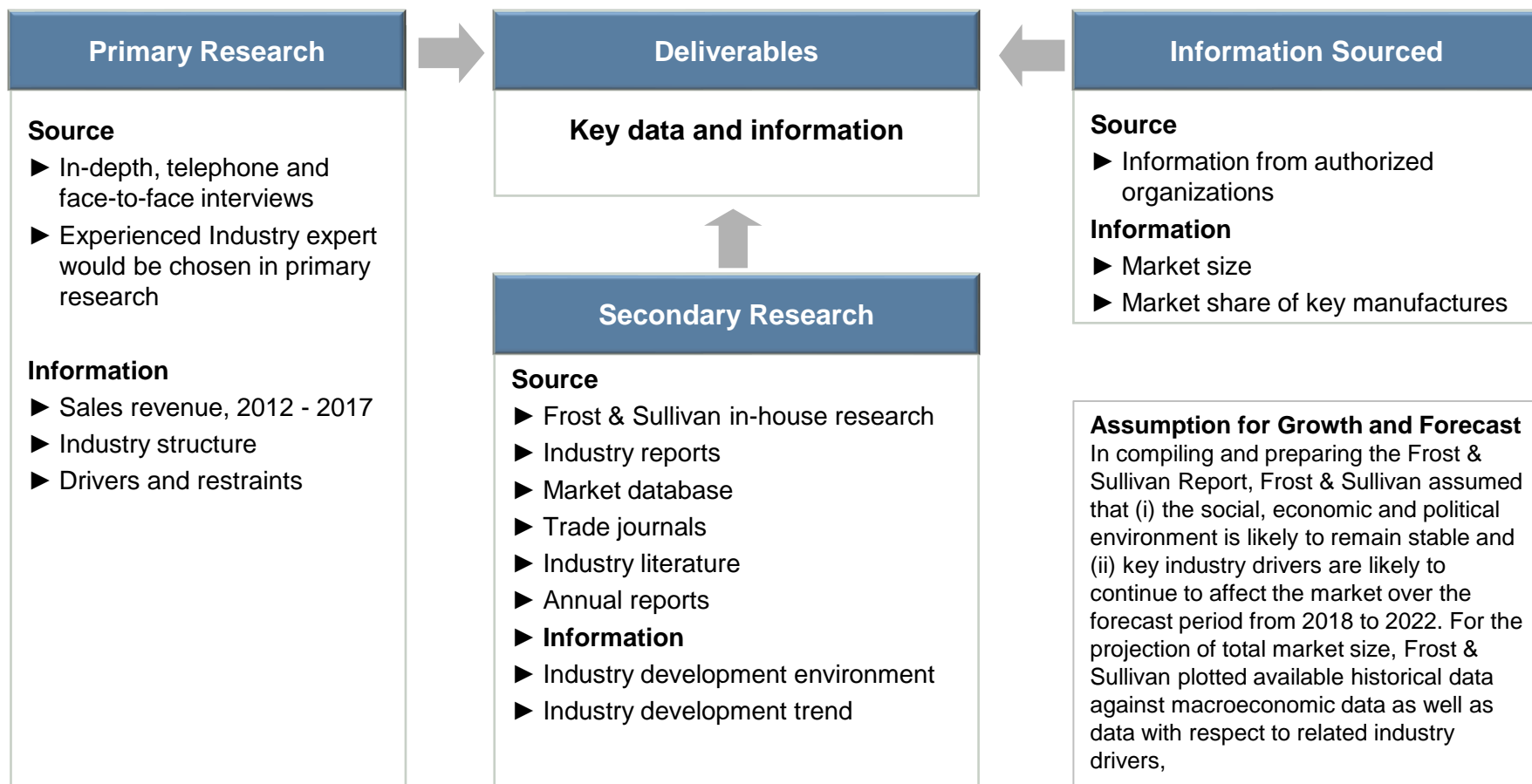
4 Global Microservice Market Size, Forecast and Competitive Landscape

5 Conclusion

6 Appendix

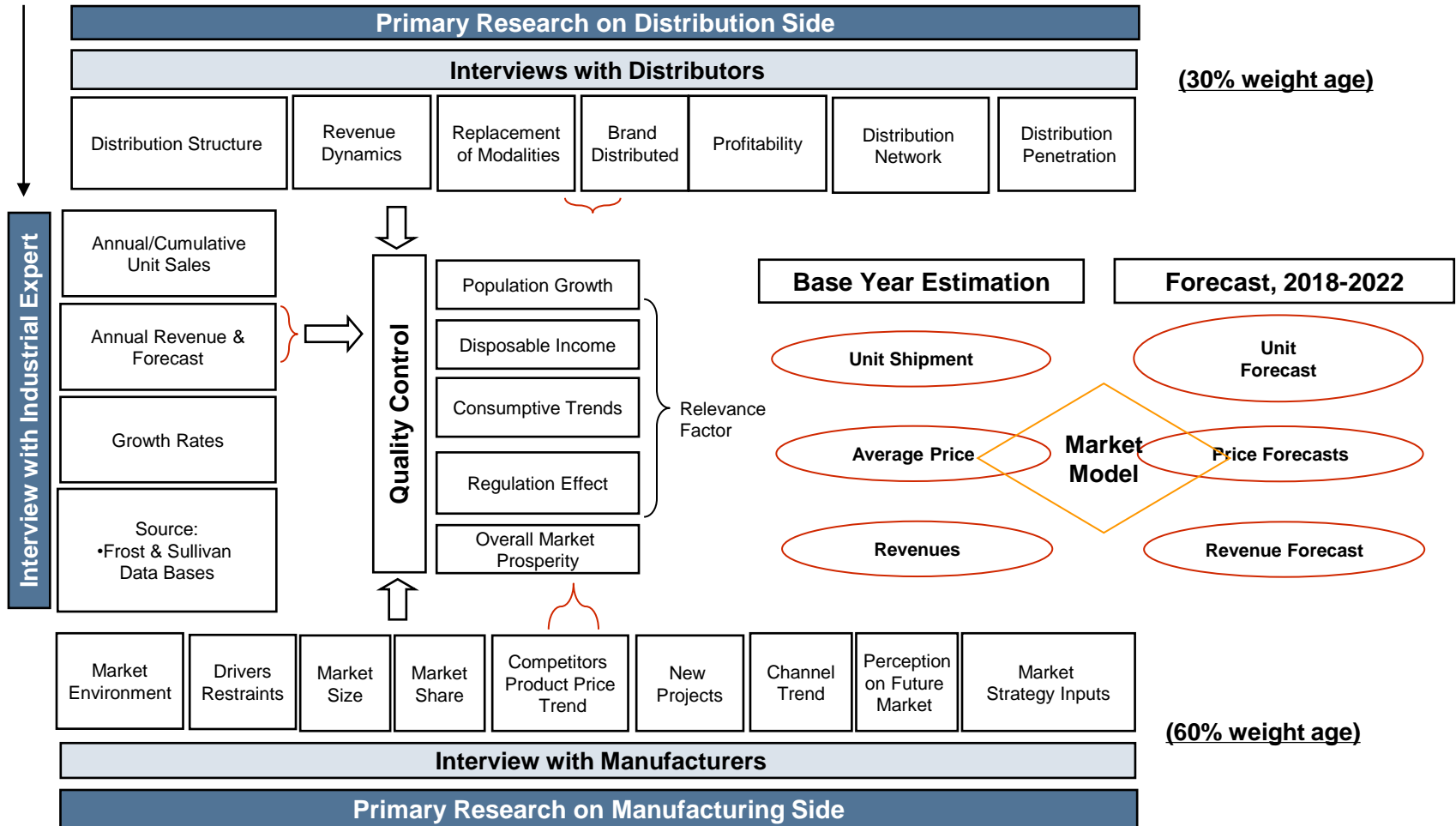
Methodology (1/3)

- ▶ Frost & Sullivan adopts multi-sources methodologies to build up industry data. Initiated from secondary research as a start point, we conducted interviews with industry participants across the industry chain, leading us to reach a market consensus.



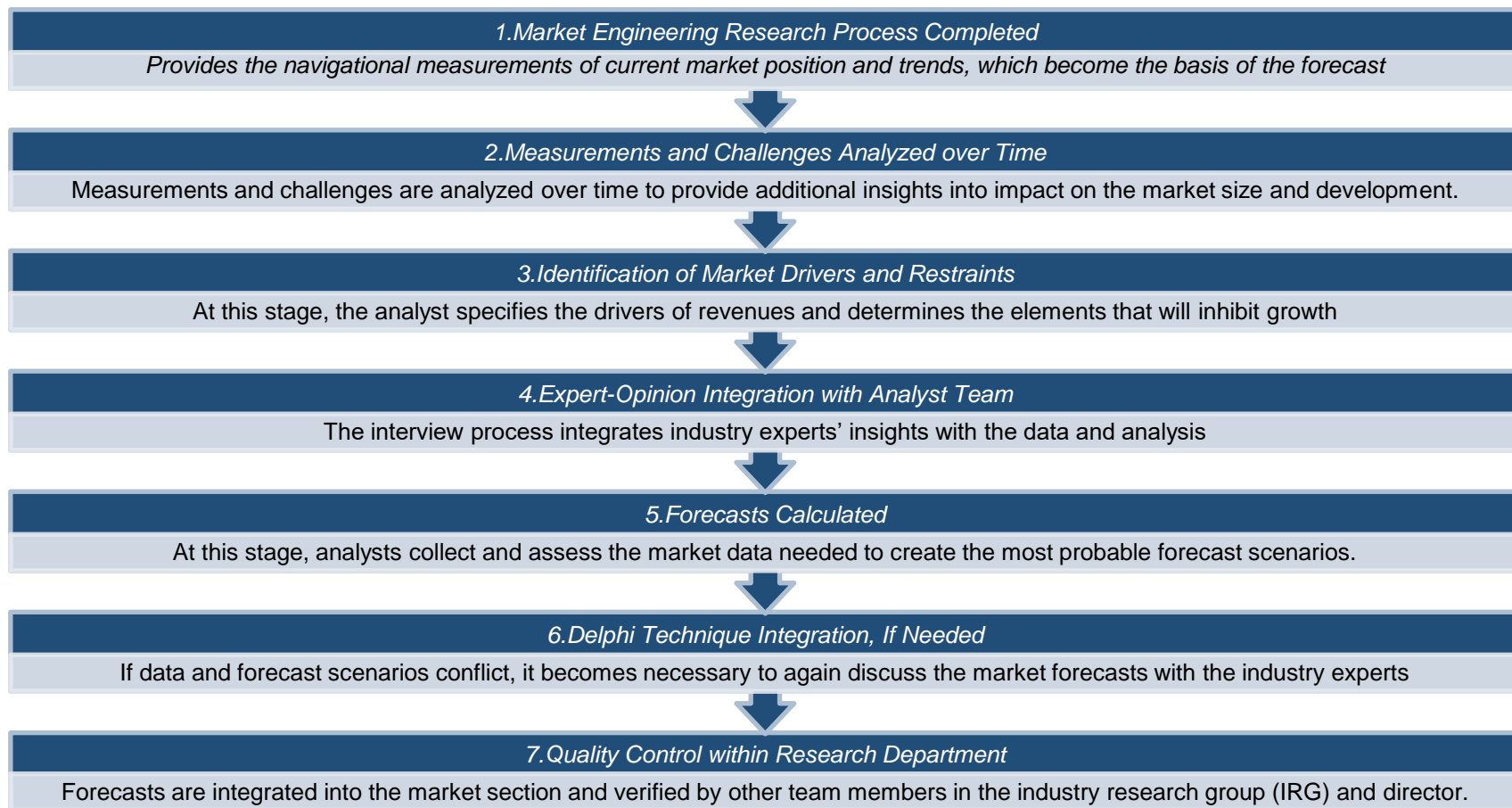
Methodology (2/3)

(10% weight age)



Methodology (3/3)

- ▶ **Methodology integrates several forecasting techniques with the Market Engineering measurement-based system. It relies on the expertise of the analyst team in integrating the critical market elements investigated during the research phase of the project. These elements include:**



Limitations

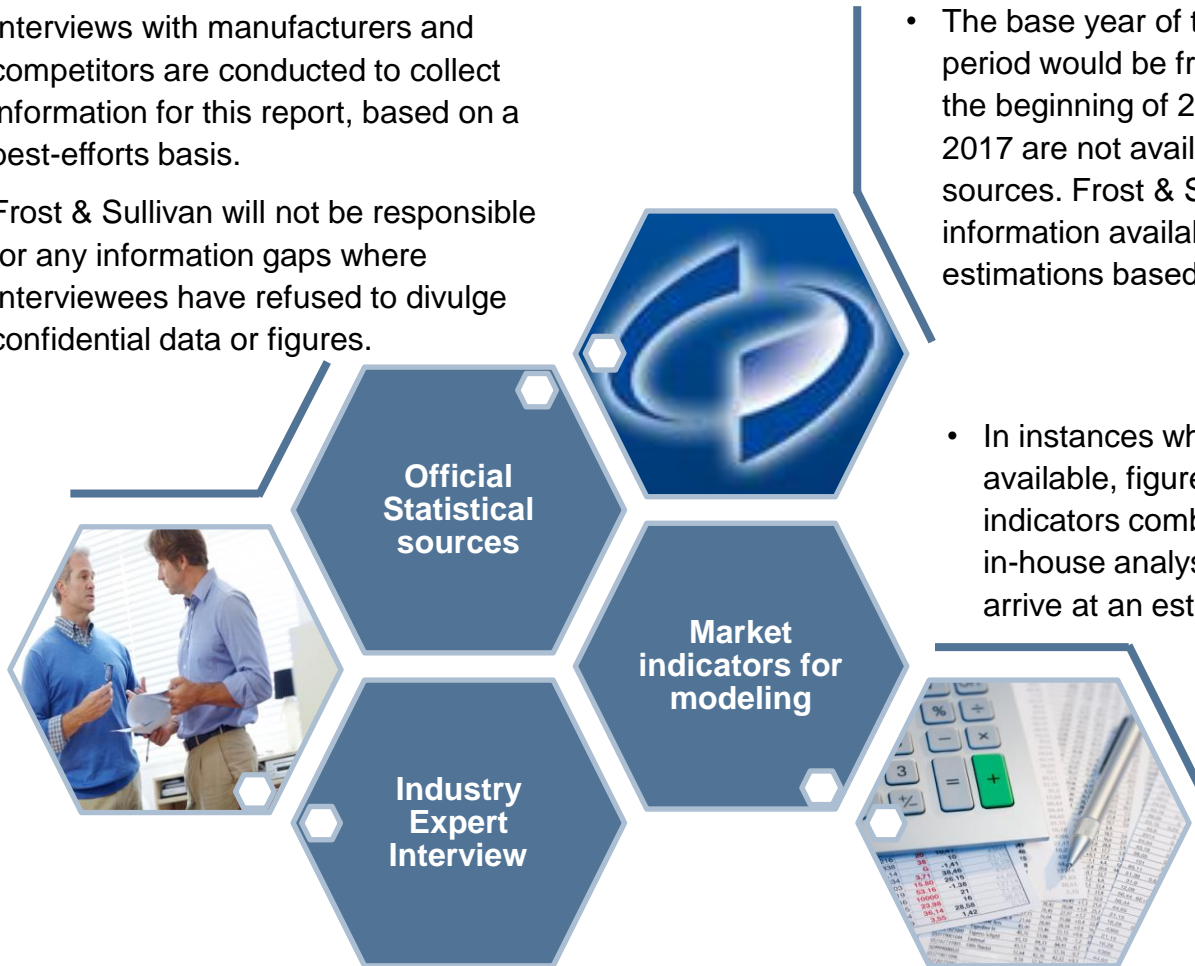
► Source of Information

- Interviews with manufacturers and competitors are conducted to collect information for this report, based on a best-efforts basis.
- Frost & Sullivan will not be responsible for any information gaps where interviewees have refused to divulge confidential data or figures.

- The base year of this study is 2017, the forecast period would be from 2018 to 2020. However, in the beginning of 2018, most of the macro figures of 2017 are not available from public statistical sources. Frost & Sullivan will use the latest information available (e.g. 2016) or make estimations based on past years' trend

- In instances where information is not available, figures based on similar indicators combined with Frost & Sullivan in-house analysis will be deployed to arrive at an estimate.

- Frost & Sullivan will state the information sources at the bottom left hand corner of each slide for easy reference.



Scope

▶ The Project Scope is Defined as Followings

Review Period

- ▶ Historical Year: 2016 to 2019
- ▶ Base Year: 2020
- ▶ Forecast Year: 2021E*-2025E

Geographic Scope

- ▶ Global

Target Market

- ▶ Cloud EPC Market
- ▶ Microservice Market

**Note: E refers to Expected*

Definition and Abbreviation

Definition

- **NFV:** Network Functions Virtualization is committed to decoupling software from hardware for traditional telecom equipment. It aims to use general-purpose computing, storage, and network devices to provide pool and share infrastructure with telecom network functions to improve management and maintenance efficiency, and enhance system flexibility. NFV is key enabler technology for cloud transformation which will reconstruct the telecommunication operator's network, service, and even operation.
 - **EPC:** Evolved Packet Core(EPC) is a framework standardized in Release 8 of the 3GPP for giving data and converged voice on a network based on 4G Long Term Evolution(LTE). Evolved Packet Core is based on a constant network connection or an always-on connection. Evolved Packet Core helps in combining voice and data on an Internet Protocol(IP) service architecture. This helps service operators in operations as well as deploying one packet network for 2G, 3G, LTE, WLAN or fixed access such as cable or DSL.
 - **Cloud EPC:** Technological and business trends are driving a deployment model of the EPC where the EPC functions are deployed as services on a virtualized platform in a cloud computing infrastructure. These trends, known as network function virtualization(NFV), can be combined with software-defined networking(SDN) to implement the EPC in an all software deployment in a cloud.
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Abbreviation

- | | |
|--|---|
| ▶ NFV: Network Functions Virtualization | ▶ Cloud EPC: Cloud Evolved Packet Core |
| ▶ LTE: Long Term Evolution | ▶ Cloud OS: Cloud Operating System |
| ▶ MME: Mobility Management Entity | ▶ SGSN: Serving GPRS Support Node |
| ▶ PDN GW: Packet Data Network Gateway | ▶ GGSN: Gateway GPRS Support Node |
| ▶ SGW: Serving Gateway | ▶ TGW: Trusted Gateway |
| ▶ DevOps: Development Operations | ▶ CG: Charging Gateway |
| ▶ DNS: Domain Name Server | ▶ NEs: Network Elements |

Definition and Abbreviation

Definition

- **Microservice Structure:** Microservice Structure is a variant of service-oriented architecture(SOA).Contrary to Monolithic Structure, Microservice decouples numbers of small service modules from the whole application and store them in cloud. In addition to strong cloud-based computing power, Microservice structure is highly flexible compared to Monolithic Structure, allowing faster package expansion and easier module adjustment.
- **PCRF:** Policy and Charging Rules Function(PCRF) is a software designated for real-time service policy rules determination of a multimedia network. PCRF aggregates information in and out of the network in real time, automatically setting rules and policy for each user over the network. Such network might provide multiple services such as quality of services, charging rules etc. PCRF can be integrated with different platforms like billing, rating, charging, and subscriber database or also be deployed as a standalone entity.
- **HSS:** Home Subscriber Server(HSS) is a server in charge of storing and updating all user subscription information, such as IP address, user identification like IMSI (International Mobile Subscriber Identity) and MSISDN (Mobile Subscriber ISDN Number) or mobile telephone number.

Abbreviation

- | | |
|---|--|
| ▶ SOA: Service-Oriented Architecture | ▶ MSA: Microservice Structure |
| ▶ MNA: Monolithic Structure Architecture | ▶ PCRF: Policy and charging rules Function |
| ▶ QoS: Quality of Services | ▶ HSS: Home Subscriber Server |
| ▶ IMSI: International Mobile Subscriber Identity | ▶ MSISDN: Mobile Subscriber ISDN Number |
| ▶ HLR: Home Location Register | ▶ AuC: Authentication Center |
| ▶ E-UTRAN: Evolved UMTS Terrestrial Access Network | ▶ PDF: Policy Decision Function |
| ▶ CRF: Charging Rules Function | ▶ UMTS: Universal Mobile Telecommunications Service |

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5 Conclusion

6 Appendix

Global Cloud EPC Market Overview

The Significance of Cloud EPC Product or Solution

Cloud Transformation

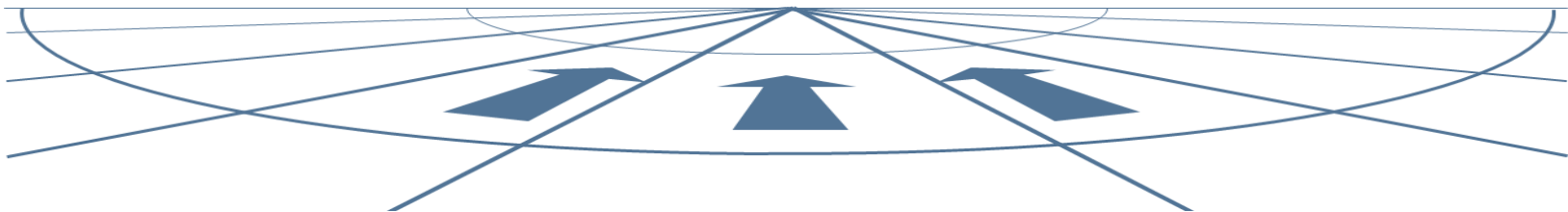
- The core network is telecom networks' switch and control center. After the shift to cloud, the core network must continue to offer operator-class services, such as high reliability, high performance, and fault recovery, in addition to open architecture. To meet these requirements, the core network must adopt a cloud-based software design. Therefore, as one of the core network virtualization products, cloud EPC is based on the advanced cloud-based software architecture design and will lead the core network's cloud transformation.

Efficient Use of Resource

- A large number of sites build data centers to integrate hardware resources. However, by sharing virtualized hardware resources, cloud EPC optimizes hardware resource utilization and reduces types of hardware in use, therefore enabling carriers to respond to market promptly and to reduce device purchase and maintenance costs.

Flexibility and Openness

- Third-party apps can be integrated to the cloud EPC so that carriers can provide innovative services and due to the standard interfaces, various virtualization software is supported. Various hardware devices are supported and the hardware devices and virtualized cloud platform constitute the telecom cloud infrastructure layer to provide virtual resources and services for the service layer, which largely increases openness and flexibility.



Source: Frost & Sullivan

Global Cloud EPC Market Overview

Market Drivers, Challenges and Development Trend

Drivers

Growing Network Infrastructure

The digitization of various industries have arouse demand for stable, convenient and fast-transmission network and cloud service.

Quarantine during Covid-19 lead to further penetration of online business, online education and so on, which promote the expansion of cloud EPC.

CapEx and OpEx Minimization

Increasing numbers of enterprises of different industries are making great efforts to realize the minimization of CapEx(capital expenditure) and OpEx(operating expense). This infrastructure management trend will boost the application of virtualization., which may further facilitate the development of cloud.

Challenges

SLA Guarantee

Ensuring the service quality, high performance and high reliability after moving up the service to cloud is challenging for most operators.

Hardware and Software Compatibility

Going to cloud will lead to layered system, software-hardware separation and other problems which must increase operation difficulties as most hardware and software are from different suppliers. Besides, due to the inconsistency of update frequency, the disparity of hardware and software life cycle may result in various compatibility problems.

Development Trend

Larger Bandwidth and Reliability

Mobile devices have become the major entertainment and working terminal nowadays. During the Covid-19 quarantine, people has consumed more video content and interact more frequently online via multi-media, which promoted demand for larger bandwidth and reliability. In the future, 5GC will provide better user experience while further support industrial requirement on bandwidth and reliability.

Openness and Cloudification

Telecom operators need to fulfil customers' sophisticated demands with more flexible and open architecture. Cloud EPC could enable dynamic resource allocation and offer more virtualization capabilities.

Source: Frost & Sullivan

Global Cloud EPC Market Overview

Significant Features of Cloud EPC Product

Carrier-grade Reliability & Performance

The cloud-based network must provide the same level of service quality, reliability and security as a traditional network.

Automated O&M

With COTS hardware, Cloud OS and SDN technology, services and network resources can be orchestrated automatically. Traditional O&M need a long time ahead to plan service development. Cloud-based network has the ability to schedule resources in the data center and escalate its service. In this way, the lifecycle of network services can be done automatically, including planning, onboarding, scaling, healing and termination. Automated lifecycle management is important for operators to reduce their TCO.

Capability of Agile Application DevOps

By introducing DevOps into CT service operation, operators can deliver new services to their users much faster, and react to user requirements much faster. The TTM of traditional network service is too long. Operators want to have the agility of internet companies.

Ability of Smooth Evolution to 5G

Smooth evolution towards 5G is a key requirement for cloud-based network. The network architecture must be agile and elastic, so that it is easy to make changes to the structure and functions of the network. Network slicing should be easily realized on the network.

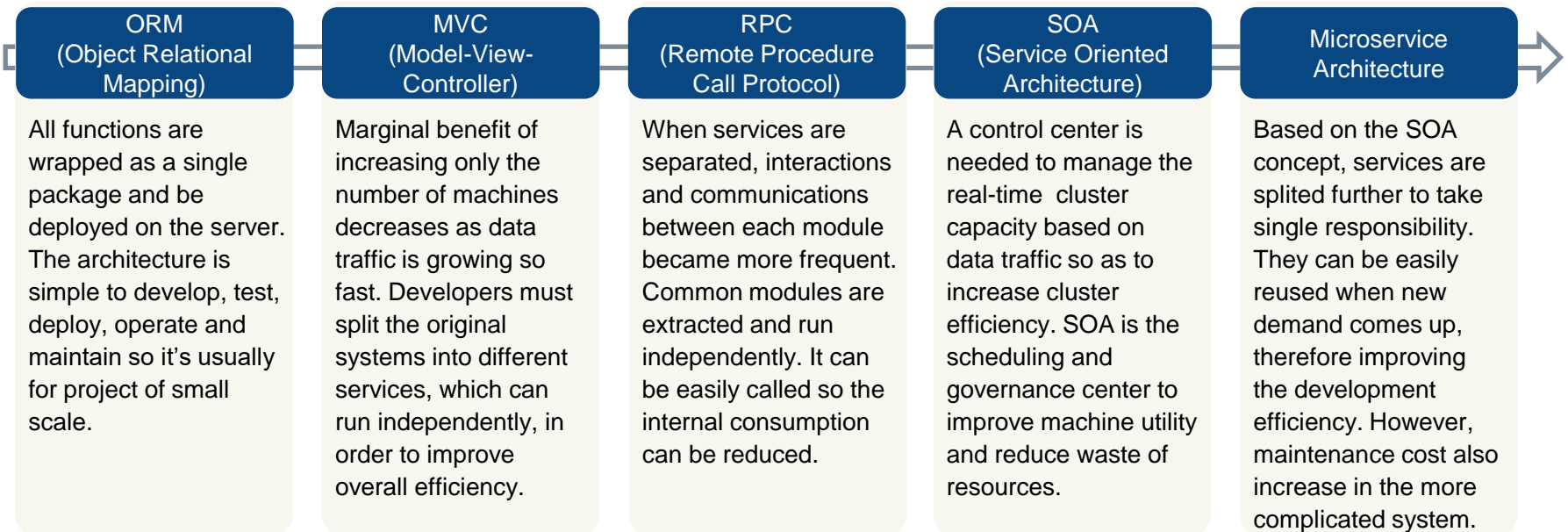
Source: Frost & Sullivan

Global Microservice Market Overview

Development from Monolith to Microservice

From Monolith to Microservice

- Traditionally, software are developed as the monolith architecture like ORM (Object Relational Mapping), which is for simple services at early time, with all the functions coupled and integrated together. The initial cost is low but the difficulty of secondary development and deployment is high, and it's not flexible enough to deal with the rapidly increasing user scale and data traffic.
- As Internet population booming all over the world and services getting more and more complicated, monolith architecture is under great pressure to deal with the high data traffic environment. Software architecture has to evolve to fulfill the emerging demands, and till now there're major stages including MVC (Model- View- Controller), RPC (Remote Procedure Call), SOA (Service Oriented Architecture) and Microservice, each representing a evolutionary direction for specific demands.



Source: Frost & Sullivan

Global Microservice Market Overview

Significant Features of Microservice Architecture

Independent Development & Deployment

Each service is decoupled from the others and can be developed and deployed independently. Iteration of one service won't lead to test and re-deployment of the whole system, which is common in monolith architecture, and could result in high cost for complex system.

Fault Isolation

The microservice is design at process-level, and runs independently as it's isolated by process. The fault scope can be effectively controlled compared to monolith, one single fault won't affect the whole system so it's more reliable than monolith system.

Scalability

While monolith architecture can only be scaled as a whole system, microservice allows Operators to scale up on a more precise granularity based on the real requirement on specific resources.

Architecture Evolution

Granularity of microservice architecture is more precise and the impact on the whole system is smaller. It won't require large-scale restructuring but minor modifications of individual module. Note that there's a tradeoff between granularity and system performance, since smaller granularity would incur difficulties in maintenance and integration, which may weaken the performance.

Fast Delivery

Each microservice can be independently developed, tested and deployed in parallel, which improve delivery efficiency greatly and enable faster product iteration.

Source: Frost & Sullivan

Global Microservice Market Overview

Operators' Demand on Microservice

Business Demand

► Intensive Management

Three major domestic operators in China are establishing centralized IT systems to meet the access needs of different businesses and different provinces. Microservice is a solution due to the feature of independent deployment and rapid iteration.

► Diversified Business Model

Traditional operators has transformed as a provider of diversified services. Business complexity results in system complexity, which cannot be fulfilled by monolith system. Microservice architecture is more flexible and reliable to meet the need of diversified business model.

System Demand

► Redundancy Reduction

Systems in Operators have been developed for decades with different purposes at different levels. They're isolated and not will-managed and too complexed provide prompt responses. Microservice is a solution to the redundance and low efficiency due the existing isolated systems.

► Autonomous and Controllable

Existing monolith systems are mainly provided by external suppliers, with solid technology stack that autonomous R&D team cannot easily enter. Microservice with interface layer interaction and the contract-driven model is more beneficial for improving autonomous and controllable.

Technology Maturity

► New Standard in Communication Technology

Originated from Information Technology, microservice has matured in Communication Technology that many of the major authorities such as 3GPP, ETSI have applied microservice as the standard in NFV during could transformation. 5G technology is a typical example.

► Matured Technical Condition

Microservice architecture has matured with the support of technology ecological environment (containerization, DevOps tool chain, development language framework, design and development methodology, etc.). Many Internet companies and organizations have verified the unique advantages of microservice architecture in practice.

Source: Frost & Sullivan

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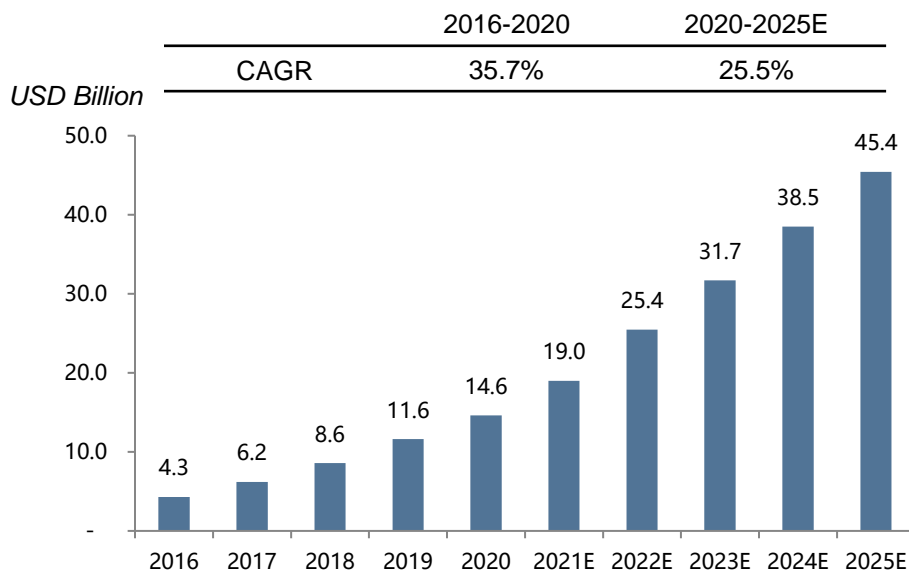
6 Appendix

Market Size and Forecast

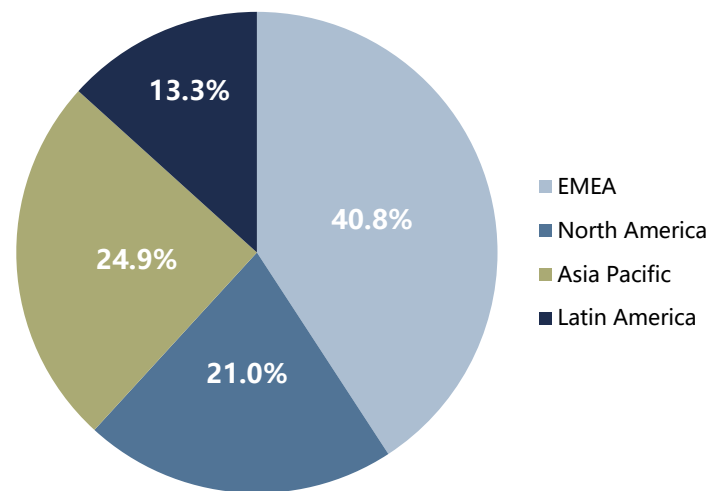
Global NFV Market Size and Forecast

- ▶ The global NFV market has kept increasing from 2016 to 2020, at a Compound Annual Growth Rate (CAGR) of 35.7%. It is predicted that the global NFV market will maintain a rapid growth in coming years mainly owing to abundant demands from operators. Simultaneously, NFV is widely applied in datacenter networking, access network as well as 5G network architecture transformation, which are regarded as remarkable drivers to the development of NFV market.
- ▶ NFV enables a variety of network functions including Evolved Packet Core (EPC), Broadband Remote Access Server (BRAS), Customer Premise Equipment (CPE), IP Multimedia System (IMS) and Service Router (SR) to be implemented cost effectively in software. Benefited from cost saving and centralized management, more and more operators are tending to utilize NFV.
- ▶ With the matured cloud infrastructure and the establishment of the ETSI Industry Specification Group for Network Functions Virtualization (ETSI ISG NFV), North America, Western Europe, East Asia and the Middle East are already advanced in NFV implementation. Coming demands for NFV is expected to grow rapidly in developing countries in Asia-Pacific Region, Latin America and Africa, etc.

Global NFV Market Size, 2016-2025E



Market Share by Region, 2020



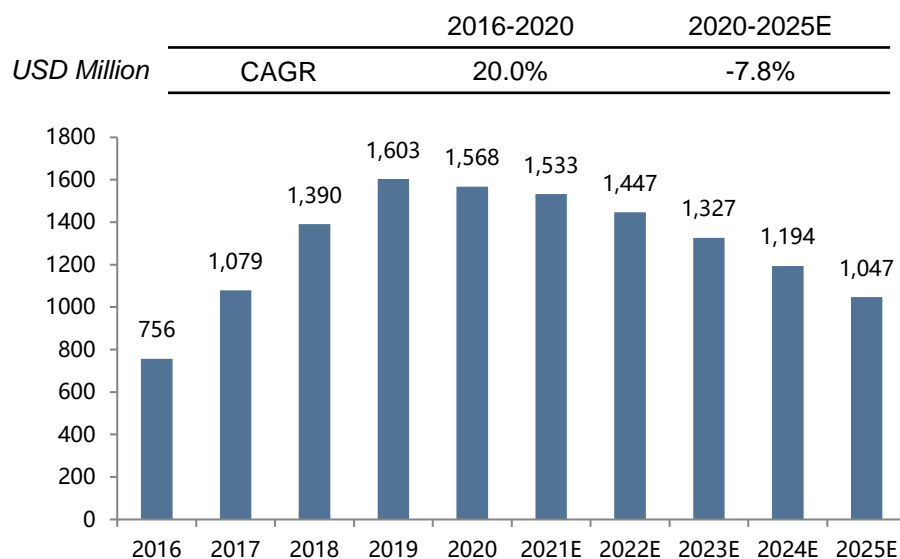
Source: Frost & Sullivan

Market Size and Forecast

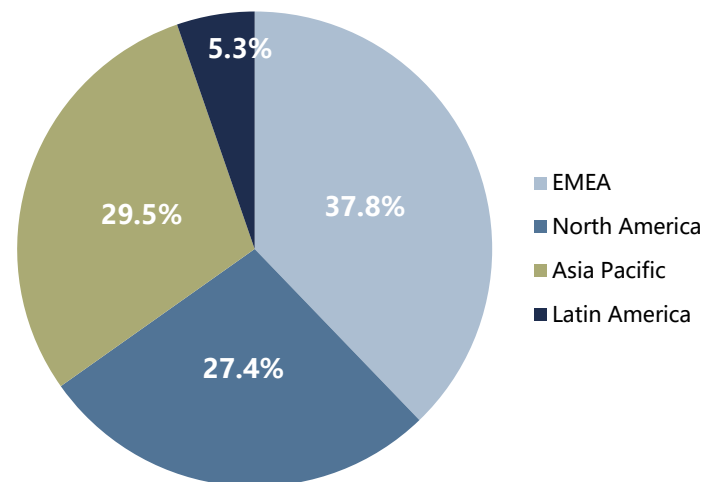
Global Cloud EPC Market Size and Forecast

- ▶ The global cloud EPC market registered a rapid increase from 2016 to 2020, with a CAGR of 20.0%. The market has reached the top in 2019, then turned around due to the implementation of 5G NGC. It's estimated that the cloud EPC market will be declining at the CAGR of -7.8% from 2020 to 2025.
- ▶ Currently cloud EPC is applied to support the implementation of 5G with VoLTE and data service at the NSA stage. However, as the 5G deploys further to SA stage, the current EPC network will be transformed to NGC, thus turning the market around.
- ▶ The past few years have witnessed rapid growth of the cloud EPC market in EMEA and Asia Pacific, accounting for around 70% of global market share in 2020. It's expected that demands is decreasing globally as 5GC construction will be the operators' priority in the coming years.

Global Cloud EPC Market Size, 2016-2025E*



Market Share by Region, 2020



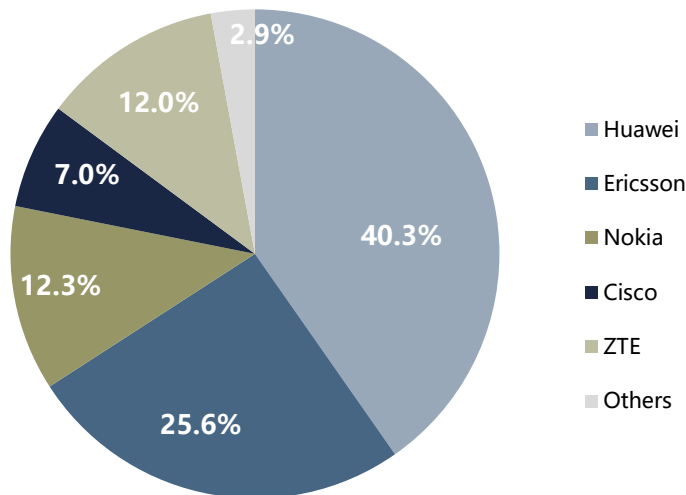
Source: Frost & Sullivan

Global Market Competitive Landscape

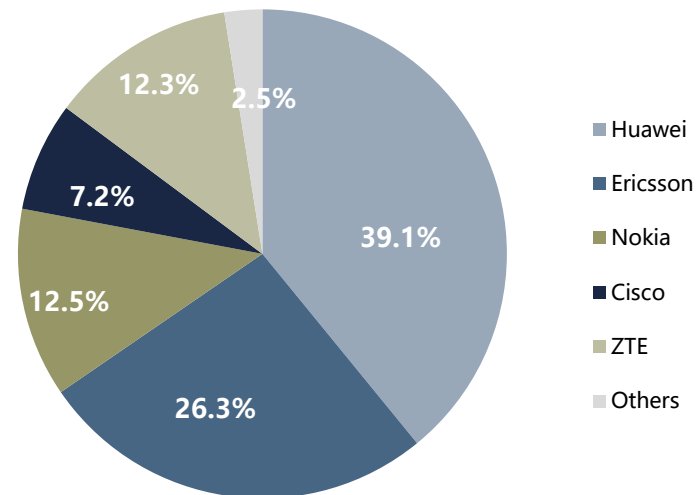
Competitive Landscape - Shipment and Cut-over

- ▶ At the NSA stage of 5G, cloud-based evolved packet core is applied for the compatibility of 4G and 5G, as well as enabling functions such as CUPS, slicing, etc. before 5G NGC is ready, improving the efficacy and efficiency of the Operators. Among all the solution suppliers, Huawei as the initiator, is leading the market in 2020, by the number of solutions shipped to customers. From the perspective of large-scale commercially applied cut-over, Huawei still dominates the market of nearly 40.3% for the market share.
- ▶ As Operators gradually evolve to 5G network, the competition between service providers will shift to 5G core net work as well. As an early mover, Huawei establishes industry standard and is able to fulfil customers' demand with advanced technology and reliable solutions, which has been proven with certain business practice featured with strong disaster backup and recovery ability, fully going-to-cloud architecture, SVC (Single Voice Core) solution, core-edge coordination, data security, etc.

Global Cloud EPC Shipment, Market Share, 2020



Global Cloud EPC Commercial Cut-over Amount, 2020



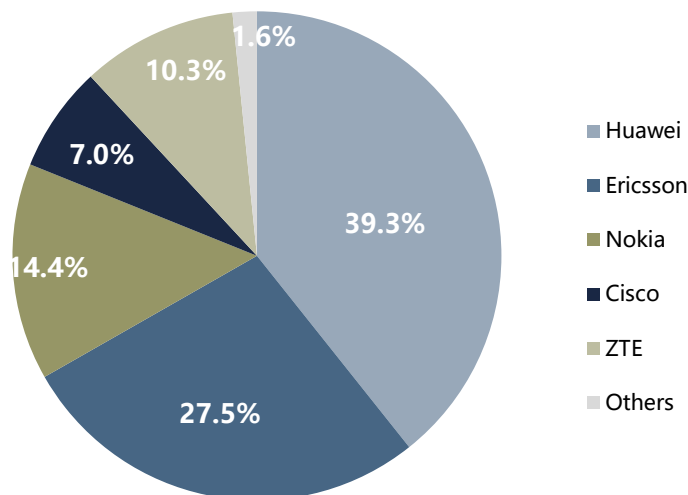
Source: Frost & Sullivan

Global Market Competitive Landscape

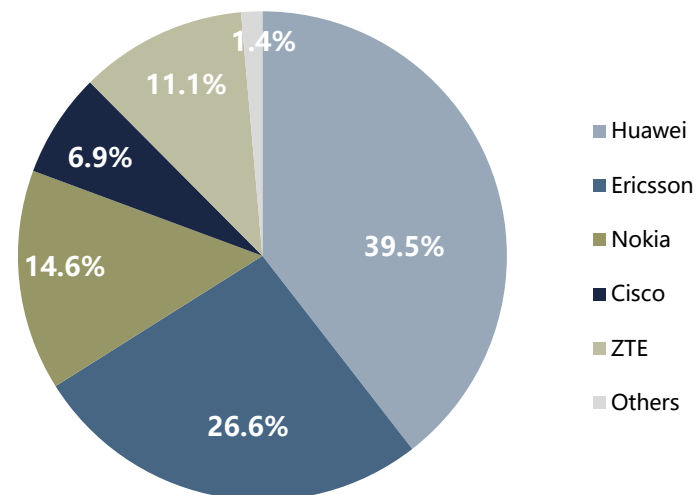
Competitive Landscape - Online SAU and Internet Flow

- ▶ Increasing user amount, connected devices and data traffic as well as transition to 5G are the key factors that driving the cloud EPC market in the past. Global monthly mobile data traffic has exceeded 29 exabytes by the end of 2019, 140% higher than that in 2017. Besides, global mobile devices and connections have reached 10 billions in 2019. All of these are calling for a massive amount and stability of Virtualized Evolved Packet Core devices as well as infrastructure. Cloud EPC provides openness and more importantly, the great ability to maintain stability while the internet flow or users are reaching the peak.
- ▶ With leading devices amount and advanced use case with Operators, Huawei gains its competitive advantages outweigh other market players so far.

Shares of Global User Amount of Cloud EPC (SAU), 2020



Shares of Global Data Traffic on Cloud EPC (Tbps), 2020



Source: Frost & Sullivan

Global Cloud EPC Market Competitive Landscape

Competitive Landscape – Key Feature Performance

► Cloud EPC can be evaluated according to the four layers in the software stack: infrastructure layer, software architecture layer, network architecture layer, and capability exposure layer. The key features of each layer are listed as following:

(1) Business Enabling Layer: Agility of introducing new services into network / flexibility of consolidating Gi-LAN service into EPC

(2) Network Architecture Layer: CUPS (Control Plane & User Plane Separation) / MEC

(3) Software Architecture Layer (Cloud Native): Stateless design / service decomposition & on-demand composition / support for light virtualization (containers) / System Automation (Continuous Integration & Continuous Deployment, CI & CD)

(4) Infrastructure Layer: Open to COTS hardware and various Cloud OS / Cloud OS Optimization / Multi-architecture Hardware Platform

Not every vendor is able to conduct carrier grade optimization on the infrastructure layer. Huawei CloudEPC provides comprehensive technology to optimize its own COTS hardware (FusionServer) and Cloud OS (FusionSphere). The optimization includes FPGA acceleration cards, CPU binding, huge page, pass through, and interrupt aggregation, etc. Meanwhile, Ericsson has Cloud Execution Environment, Cisco has Unified Computing System (UCS) hardware and its own NFVI software., Nokia has CloudBand Infrastructure Software, ZTE has Cloud Infrastructure Solution, but the major trend is developing 5GC architecture.

For software architecture layer, mainstream service providers have built consensus on cloud native, including stateless design (service and data decoupling), service decomposition & on-demand composition, support for light virtualization (containers) and system automation (continuous integration & continuous delivery, CI & CD). Huawei started on cloud native architecture from the very beginning. Huawei first released highly reliable virtualized EPC with stateless design, implemented service based architecture through service decomposition and obtained CI/CD as well as gray scale upgrade capability ready for DevOps, going ahead of their competitors.

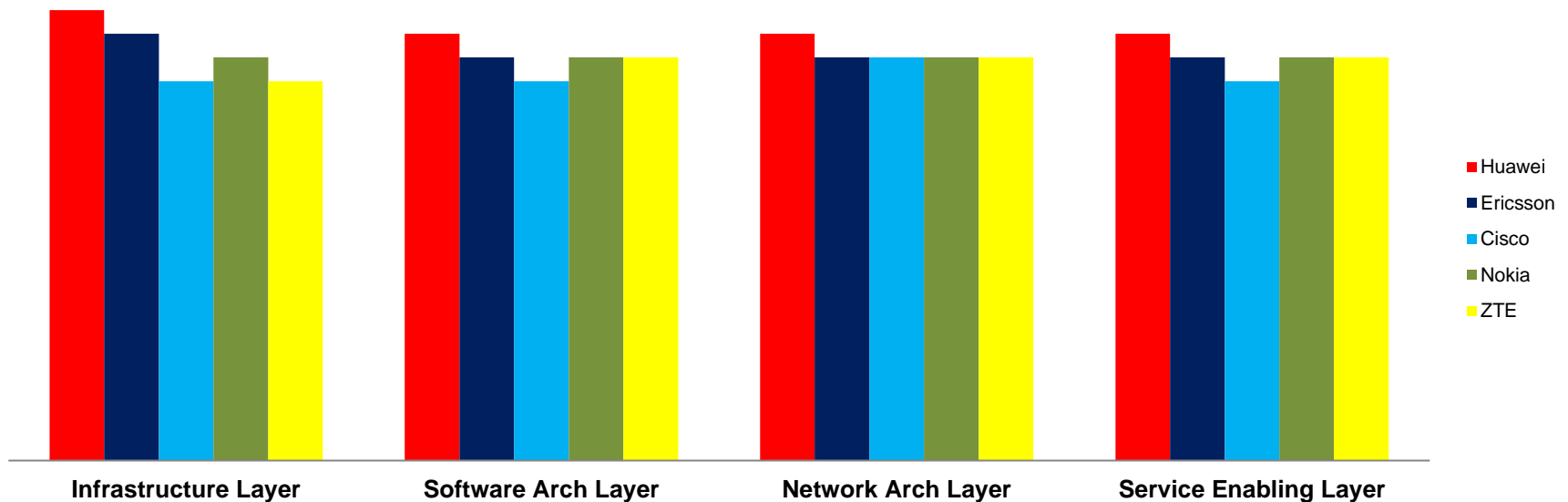
Global Cloud EPC Market Competitive Landscape

Competitive Landscape – Key Feature Performance

On network architecture, CUPS and MEC are key technologies towards 5G evolution. After years of development and market practice, both CUPS and MEC have become more matured. CUPS enables the operators to increase data transmission efficiency and improve user experience, while MEC will perform better in 5G SA architecture to support network function and the coming IoT era as well. Huawei has participated in a number of 5G projects in the recent years, which keeps them in the leading position.

On service enabling layer, Huawei Cloud EPC introduces machine learning technology for service awareness in order to identify encrypted traffic types for data monetization. Huawei also uses machine learning in IoT behavior detection and KPI detection for China Mobile. Ericsson, Cisco Nokia and ZTE also use AI technology in their cloud EPC solutions, but mostly for network automation and user experience optimization.

Comprehensive Evaluation of Major Vendors on the Four Layers of Cloud EPC



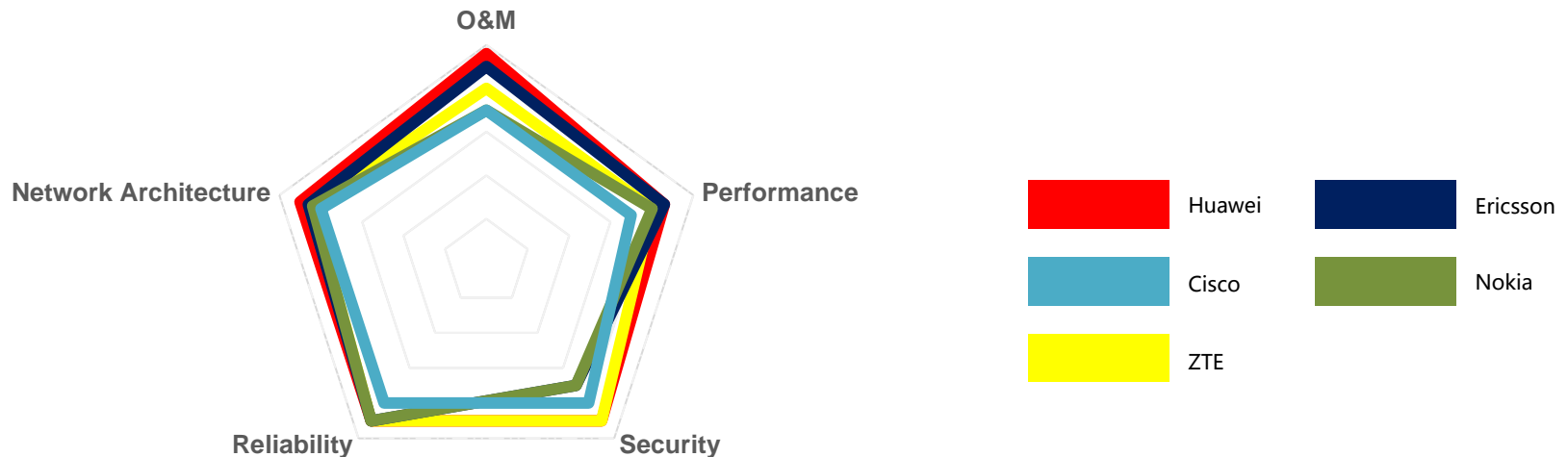
Source: Frost & Sullivan

Global Cloud EPC Market Competitive Landscape

Competitive Landscape – Key Feature Performance

- There are 5 top concerns of commercial deployment for cloud EPC (by a survey conducted on service providers), which are:
- (1) O&M:** automation for network design & deployment, enabling CI & CD , A/B test for rapid iteration of new services, cross layer troubleshooting & self healing for daily maintenance
 - (2) Performance:** optimization of COTS hardware and infrastructure software to obtain carrier grade performance
 - (3) Reliability:** redundancy mechanisms, ability of recovery, self-healing, dealing with high concurrency, fast load balancing, etc. on various levels such as network, VNF, hardware, infrastructure layer, CloudOS, VM, network element, network across DC and so on.
 - (4) Network Architecture:** flexible architecture enabling IP-based scaling, automated network management, etc.
 - (5) Security:** systematic solution against external and internal attacks

Key Character Performance of Different Cloud EPC Brand

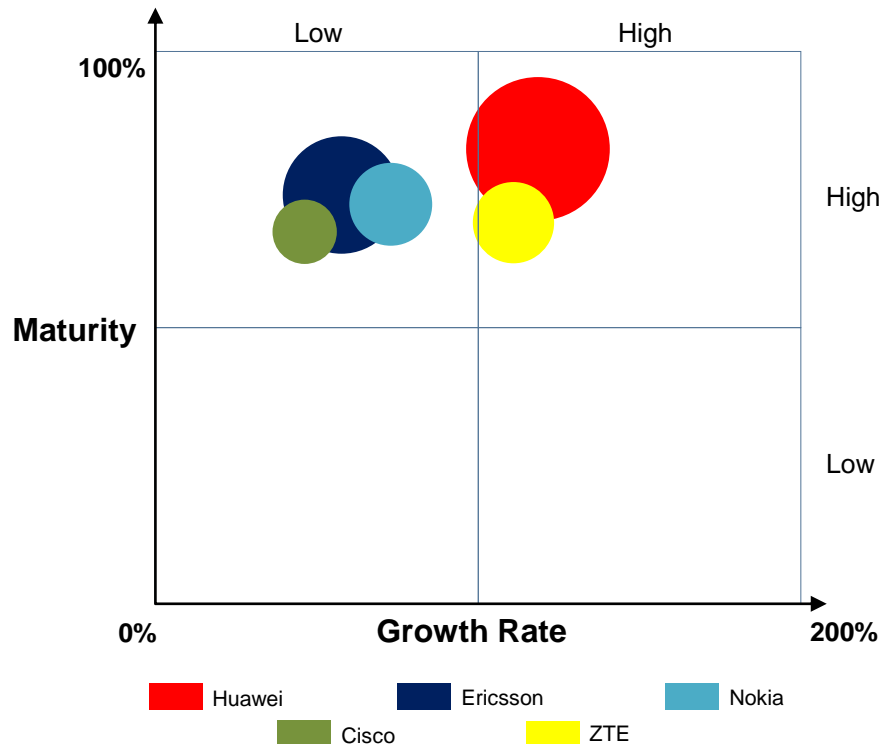


Source: Frost & Sullivan

Global Cloud EPC Market Competitive Landscape

Market-oriented Competitive Landscape

Global Cloud EPC Competitive Landscape, 2020, by Market Share, Growth Rate and Product Maturity



Market Share: The market share of each competitor is calculated by signed cloud EPC deployment contracts during 2020, from which the size of the bubbles that showing on the graph is dimensioned.

Growth Rate: The growth rate of each competitor is the CAGR of increasing cloud EPC deployment contracts amount during the past three years. This value is reflecting on the position on coordinate axis X, ranging from 0% - 200% since the industry is growing rapidly.

Maturity: The maturity is defined as to what extent the cloud EPC product provided by each competitor can fulfill the customers' demand and keep the pace on market trend.

Overview: From the graph it indicates that Huawei is leading in market size, growth as well as product technology maturity. Though Ericsson, Nokia, Cisco had grabbed market share from Huawei especially in North America and Europe market., Huawei is incontrovertibly more advanced in technology and application with the Operators, which boost its market performance with proven success cases.

Hints:

1. The values for the coordinates x refers to Growth Rate, ranging from 0% - 200%
2. The values for the coordinates y refers to Product Maturity, ranging from 0% - 100%
3. size of the bubbles refers to Market Share

Source: Frost & Sullivan

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1

Introduction

2

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3

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4

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5

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6

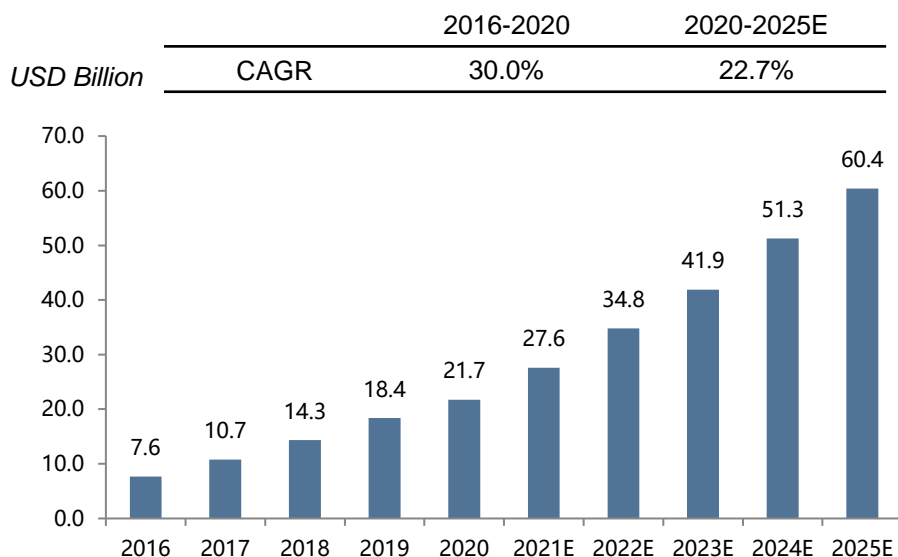
Appendix

Market Size and Forecast

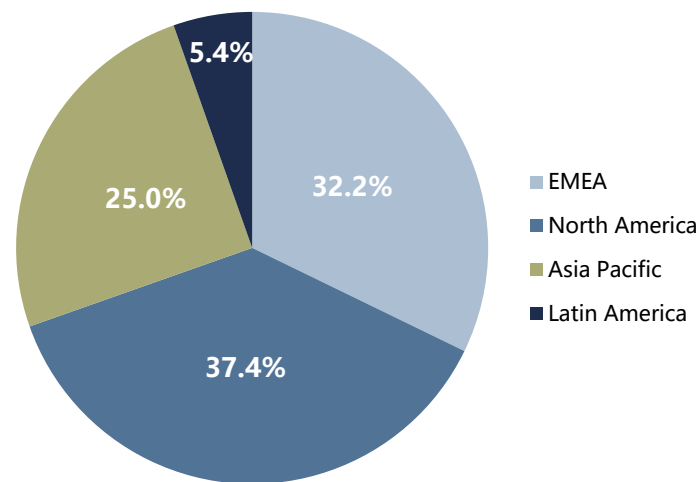
Global Microservice Market Size and Forecast

- ▶ The operators microservices market extrapolated to grow from 21.7 billion in 2020 to 60.4 billion by 2025 at CAGR of 22.7%. It's trending that operators are switching to microservice architecture from monolith to achieve agility, automation and intelligence of communication network operation and maintenance.
- ▶ Operators employing microservice architecture could better manage the more diversified business model and challenging customer demand, especially in the 5G era. Switching to microservice provides the ability of independent development, flexible deployment and fast delivery as well, but it requires not only technology readiness or hardware update, but also organization transformation to match the new operation model and make the best use of microservice architecture.
- ▶ Microservice architecture is more matured in Europe and North America, which contribute to more than 50% of the global market.

Global Microservice Market Size, 2016-2025E*



Market Share by Region, 2020



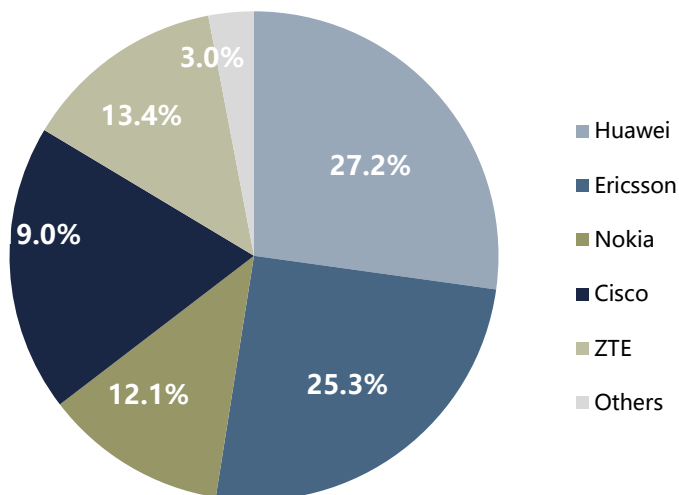
Source: Frost & Sullivan

Global Market Competitive Landscape

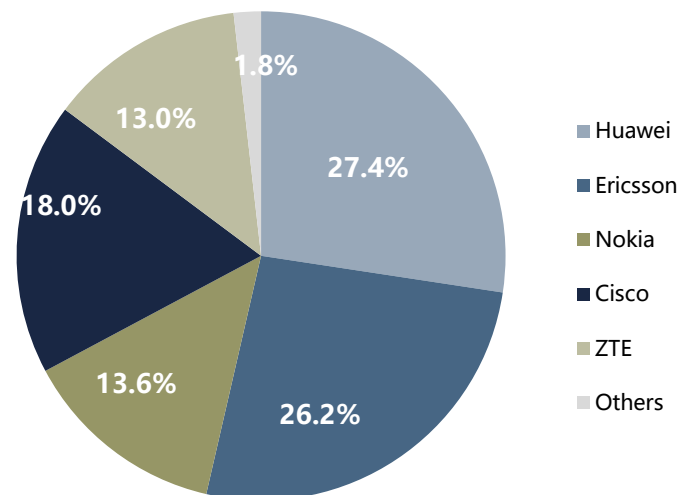
Competitive Landscape – Data Traffic and Revenue

- ▶ Because of the benefit of microservice architecture, it's a trend that the operators are switching from monolith to this flexible architecture in order to support the digital business model of 5G. Microservices providers can help operators to achieve the transformation from infrastructure level to system level .
- ▶ Among the providers, the leaders include Huawei, Ericsson, Nokia, Cisco and ZTE. Huawei is leading in the market with a market share of 27.2% in terms of data traffic and 27.4% from the perspective of revenue, Ericsson and Cisco are closely behind. Being advanced in technology, application and business cases, Huawei is widely recognized and has provided proven business solutions in upscale market.

Global Microservice Data Traffic, Market Share, 2020



Global Microservice Revenue, Market Share, 2020



Source: Frost & Sullivan

Global Cloud Microservice Market Competitive Landscape

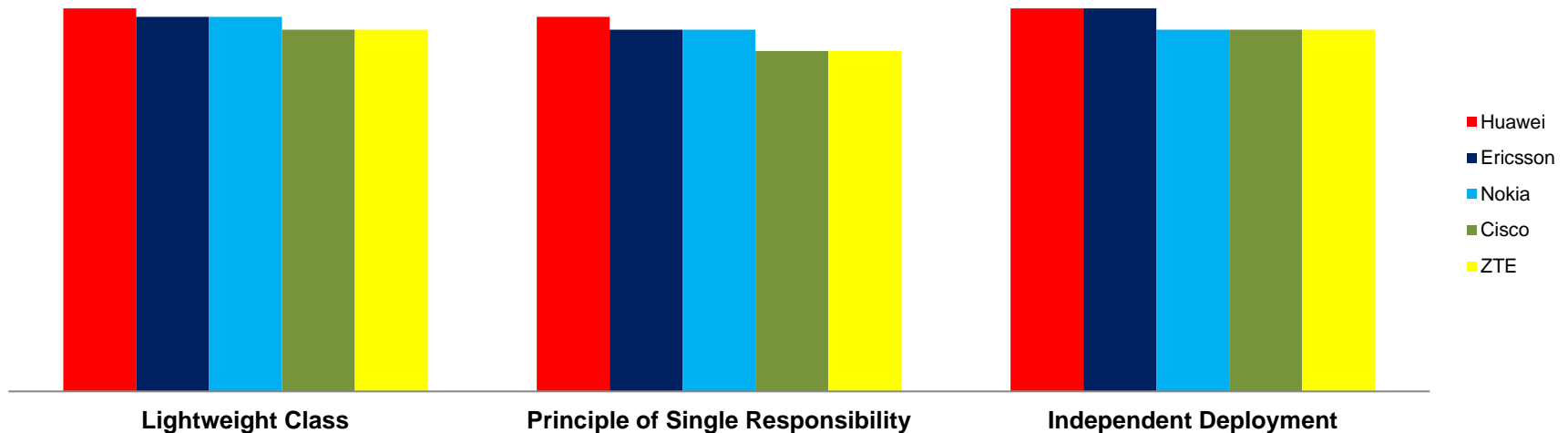
Competitive Landscape – Key Feature Performance

Within the microservice architecture, an application is developed as a suite of small services. Each of the services runs in its own process and communicates with lightweight mechanisms, usually an HTTP resource API.

The single responsibility principle requires that classes should be highly coupled internally and a change to a specific area of the class should affect all dependent classes. The illustration is simple but hard to follow in real practice because of the dynamic business demand, service granularity and reusability, as well as the interlinkage between microservices.

Microservices are loose coupling with each other, thus can be deployed and iterated independently without influencing other processes, which lower the maintenance cost. Running in its own process, microservice can be compiled in different languages with flexibility to take advantage of the best option.

Comprehensive Evaluation of Major Vendors on the three principles of Microservice



Source: Frost & Sullivan

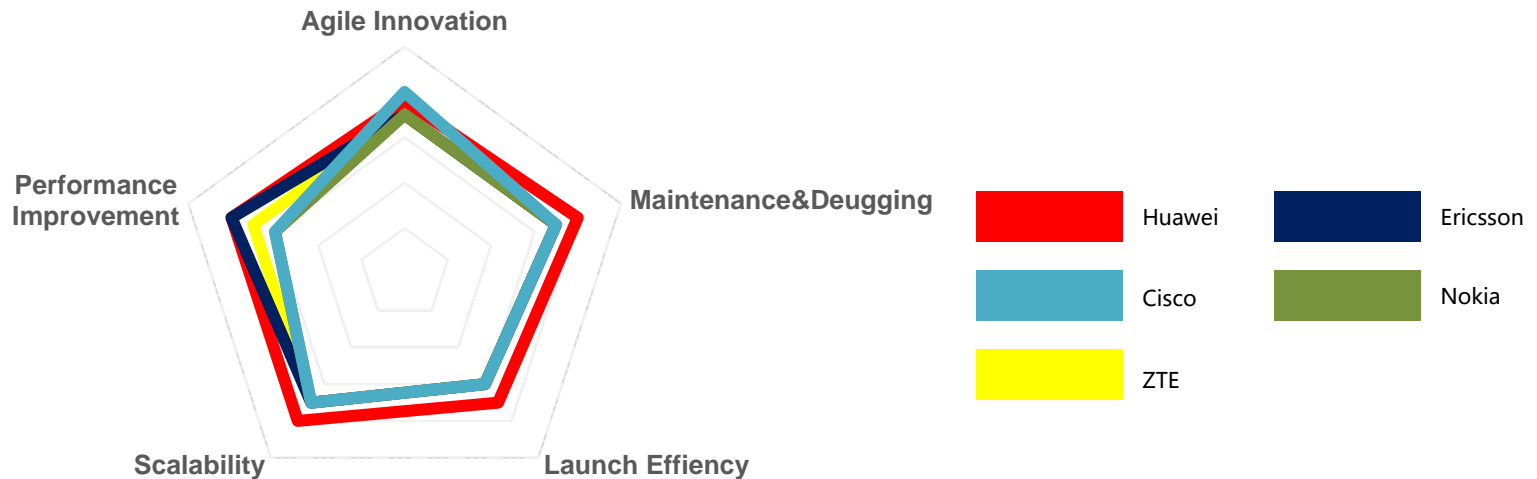
Global Cloud Microservice Market Competitive Landscape

Competitive Landscape – Key Feature Performance

► There are 5 top concerns of commercial deployment for microservice architecture provider, which are:

- (1) Agile Innovation:** ability to develop specific solutions for operators diversified demand
- (2) Maintenance & Debugging:** prompt and reliable maintenance service with low cost incurred, ability of auto maintenance, grey scale upgrade, partial upgrade, etc.
- (3) Launch Efficiency:** independently developed, tested and deployed in parallel; fast delivery
- (4) Scalability:** allows Operators to scale up on a more precise granularity based on the real requirement on specific resources rather than scale the whole system as a monolithic entity
- (5) Performance Improvement:** reorganized resources distribution, low redundancy, better customer demand fulfillment

Key Character Performance of Different Microservice Brand

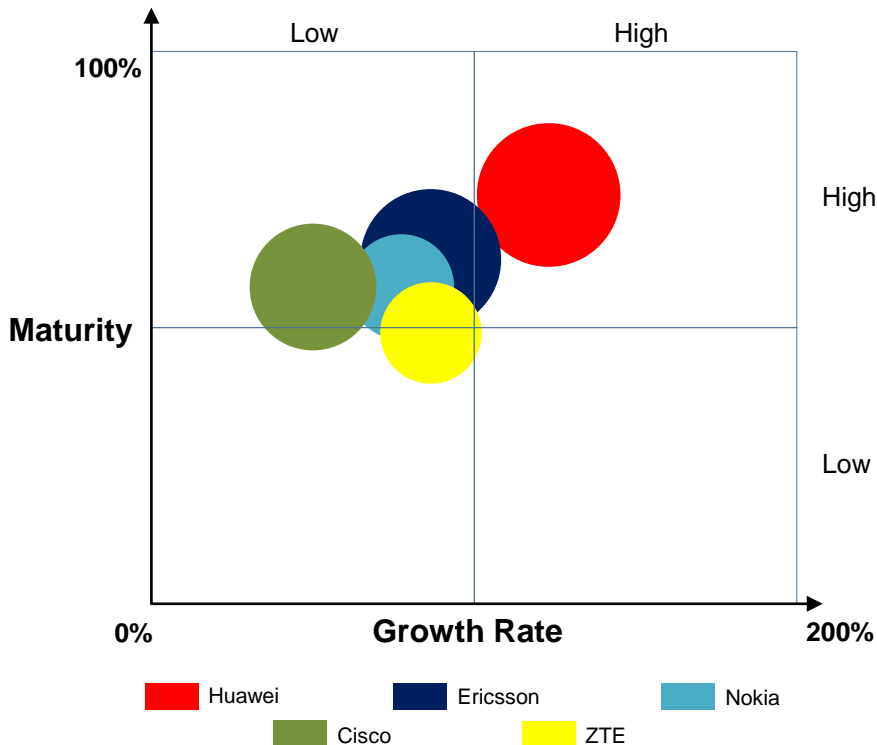


Source: Frost & Sullivan

Global Microservice Market Competitive Landscape

Market-oriented Competitive Landscape

Global Microservice Competitive Landscape, 2020, by Market Share, Growth Rate and Product Maturity



Market Share: The market share of each competitor is calculated by the data traffic during 2020, from which the size of the bubbles that showing on the graph is dimensioned.

Growth Rate: The growth rate of each competitor is the CAGR of increasing data traffic amount during the past three years. This value is reflecting on the position on coordinate axis X, ranging from 0% - 200% since the industry is growing rapidly.

Maturity: The maturity is defined as to what extent the microservice product provided by each competitor can fulfill the customers' demand and keep the pace on market trend.

Overview: From the graph it indicates that Huawei and Ericsson are leaders in the microservice market, followed by Cisco, Nokia and ZTE. With more user cases and continuing R&D expense, Huawei is able to quickly iterate to fulfill customer demand with advanced solutions, thus improving its share. As the operators accelerate the transition to microservice architecture, market leaders must enjoy a relatively fast growth rate due to the elevation of market demand.

Hints:

1. The values for the coordinates x refers to Growth Rate, ranging from 0% - 200%
2. The values for the coordinates y refers to Product Maturity, ranging from 0% - 100%
3. size of the bubbles refers to Market Share

Source: Frost & Sullivan

Agenda

1 Introduction

2 Global Cloud EPC & Microservice Market Overview

3 Global Cloud NFV & EPC Market Size, Forecast and Competitive Landscape

4 Global Microservice Market Size, Forecast and Competitive Landscape

5 **Conclusion**

6 Appendix

Conclusion(1/4)

Benefits of Cloud EPC Solution

Obviously the telecom operators will benefit a lot from the application of cloud EPC, while more outcomes will be delivered such as the innovation of new business models and industry combination.

- ▶ **Reducing equipment costs.** Through the construction of data center, the combination and dynamic fusion between infrastructure resource and software resource will contribute to the centralized management. This can largely reduce the cost of infrastructure deployment while increasing the efficiency based on the existing infrastructure and be fast-reacting.
- ▶ **More efficient using of energy.** Cloud EPC can achieve the flexible resource offering which not only optimizes virtual resource but also save a lot of energy.
- ▶ **Flexible and easy to deploy.** Cloud EPC enables operators to transform their business to software layer. Thus virtual resource can be offered to satisfy telecom operators with customized services while cutting down the deployment period by more than 80%.
- ▶ **Opportunities to explore new business models.** Given the flexibility by dynamic resource allocation, it is much easier to innovate and to find new opportunities between own business model and the new one to explore fresh monetization methods.

Source: Frost & Sullivan

Conclusion(2/4)

Market Size and Forecast

- ▶ The Global NFV Market and cloud EPC markets have both witnessed a rapid increase in the past few years. Due to the great improvement of NFV and related technologies, over the period from 2016 to 2020, the market size of global NFV market grew rapidly from USD4.3 billion to USD14.6 billion, representing a CAGR of 35.7%. With the growing maturity of the market, the growth rate will decrease for the coming few years. The market is estimated to grow to USD45.4 billion in 2025 from 2020, representing a CAGR of 25.5%.
- ▶ Compared to that, Global EPC market has received a CAGR of 20.0% from 2016-2020, and this market will be declining from USD1568 million in 2020 to USD1047 million in 2025, with an estimated CAGR of -7.8%.

Competitive Landscape

- ▶ Being as the largest vendor in cloud EPC market, Huawei continues to grow its market performance with advanced technology and proven user cases. Though the scale of cloud EPC is decreasing due to 5G NGC implementation, Huawei has already dominated the new market and therefore keep the leading position in the whole WPC market.
- ▶ From the perspective of technology application, Huawei has excellent performances in Cloud Structure, degree of openness to other platforms, automated integration solutions and DevOps capability, which will support Huawei to deal with challenges happened when operators switch to NGC from EPC.

Source: Frost & Sullivan

Conclusion(3/4)

Benefits of Microservice

Microservice architecture is attracting more and more attention from operators due to it's a better structure for 5G core network compared to traditional monolith. It enables operators to achieve independent development & deployment, fault isolation, Scalability and fast delivery. Though operation efficiency is improved, the incurred management and integration cost due to smaller granularity as well as complicated relation between modules must be taken into consideration.

- ▶ **Easy Iteration with lower cost:** Decoupled services can be developed and deployed independently. Service iteration is independent and lead to test and re-deployment of the whole system, thus lower the cost.
- ▶ **Fault Isolation:** The fault scope can be effectively controlled, one single fault won't affect the whole system.
- ▶ **Scalability:** Microservice allows Operators to scale up on a more precise granularity based on the real requirement on specific resources rather than scale the whole system as a monolithic entity.
- ▶ **Senseless modification:** Modifications of individual micro-services has minor impact on the whole system.
- ▶ **Fast delivery:** Each microservice can be independently developed, tested and deployed in parallel, which improve delivery efficiency greatly and enable faster product iteration.

Source: Frost & Sullivan

Conclusion(4/4)

Market Size and Forecast

- ▶ The Global Microservice Market has witnessed a rapid increase in the past few years. Due to the great development of cloud service and the trending switch from monolith to microservice architecture, over the period from 2016 to 2020, the market size of global Microservice market grew rapidly from USD7.6 billion to USD21.7 billion, representing a CAGR of 30.0%. With the growing maturity of the market, the growth rate will decrease for the coming few years. The market is estimated to USD60.4 billion in 2025 from 2020, representing a CAGR of 22.7%.

Competitive Landscape

- ▶ It's a trend that Operators are switching from monolith to microservices architecture, resulting in a considerably fast growing market. Designing a new system and making it come true, however, is a tough mission, especially from a solid and old-fashioned status. It's a challenge for service providers to miscellaneous stress the issues in the long run.
- ▶ Huawei and Ericsson are strong leaders in the microservice market, all competitors are growing fast. It requires not only continue investment in R&D, but also better understand of operators' demand to improve market share. It's critical to tailor the right and suitable solutions to solve operators' diversified problems, and the one who is advanced in it must perform better.

Source: Frost & Sullivan

Agenda

1

Introduction

2

Global Cloud EPC & Microservice Market Overview

3

Global NFV & Cloud EPC Market Size, Forecast and Competitive Landscape

4

Global Microservice Market Size, Forecast and Competitive Landscape

5

Conclusion

6

Appendix

Appendix

HUAWEI Profile

■ Huawei

Company Introduction, Listed/Private Company, Regional Coverage

- Huawei is a leading global information and communications technology (ICT) solutions provider. The company has established a competitive ICT portfolio of end-to-end solutions in telecom and enterprise networks, devices and cloud computing. The company is an active member of the European Telecommunications Standards Institute's NFV Industry Specification Group (ETSI NFV ISG).
- Private Company
- Regional Coverage: China, EMEA, Asia Pacific, North and Latin America

Business Performance in 2020

Category	USD Billion
Revenue	136.7
YoY	11.2%

Product Portfolio

- | | | |
|--------------------------|---------------------|----------------------|
| Cloud | Pipe | Devices |
| • Application & Software | • Radio Access | • Mobile Phone |
| • Storage | • Fixed Access | • Tablets |
| • Server | • Core Network | • M2M Solutions |
| • OSS | • Network Energy | • Mobile Broadband |
| | • Transport Network | • Home Media Service |



Key Customer

- Huawei is the global leading provider of ICT (information and communications) infrastructure and smart terminals with 194,000 employees. Huawei's business has penetrated into more than 170 countries and regions, serving more than 3 billion people.

Established in

1987

Headquarter

Shenzhen, China

Source: Frost & Sullivan

Appendix

NOKIA Profile

■ Nokia

Company Introduction, Listed/Private Company, Regional Coverage

- Nokia is a Finnish multinational communications and information technology company which serves communications service providers, governments, large enterprises and consumers, with the industry's excellent, end-to-end portfolio of products, services and licensing. The acquisition of Alcatel-Lucent leading IP networking, ultra-broadband access and cloud technology specialist was completed in Jan. 2016.
- Listed on New York Stock Exchange (NYSE), Nasdaq Helsinki, Euronext
- Regional Coverage: Europe, Middle East&Africa, Greater China, Asia Pacific, North America and Latin America

Business Performance in 2020

Category	USD Billion
Revenue	26.5
YoY	-6.3%

Product Portfolio

- Cloud and data centers
- Communications and collaboration
- Customer Experience Management
- Content&video delivery
- Fixed Network
- IP networking
- Mobile broadband
- OSS
- Optical networking
- Routers&switches
- Security
- Wireless access
- Subscriber Data Management



Key Customer

- The company's customers are consisted of mobile network operators, enterprises, governments, transportation industries and verticals.

Established in

1865

Headquarter

Uusimaa,
Finland

Source: Frost & Sullivan

Appendix

ERICSSON Profile

■ Ericsson

Company Introduction, Listed/Private Company, Regional Coverage

- Ericsson is a global company which offers services, software and infrastructure in information and communication technology (ICT) industry. Ericsson is a platinum member of OPNFV, with the aim of speeding up the implementation of network functions virtualization.
- Listed on NASDAQ OMX Stockholm and NASDAQ New York
- Regional Coverage: North America, Latin America, Northern Europe & Central Asia, Western and Central Europe, Mediterranean, Middle East, North East Asia, South East Asia & Oceania, India, Sub-Saharan Africa

Business Performance in 2020

Category	USD Billion
Revenue	28.1
YoY	2.3%

Product Portfolio

- Application Enablement
- Cloud System
- Communication Core
- Infrastructure and Components
- IP Network and Transport
- Operations and Business Support
- Radio System
- TV and Media



Key Customer

- Ericsson serves customers in more than 180 countries and derives most of its sales from large, multi-year agreements with a limited number of significant customers.

Established in

1876

Headquarter

Stockholm,
Sweden

Source: Frost & Sullivan

Appendix

CISCO Profile

■ CISCO

Company Introduction, Listed/Private Company, Regional Coverage

- Cisco designs and sells a broad range of technologies that have been powering the Internet since 1984. Across networking, security, collaboration, and the cloud, our evolving intent-based technologies are constantly learning and adapting to provide customers with a highly secure, intelligent platform for their digital business.
- Listed on NASDAQ Stockholm
- Regional Coverage: Americas; Europe, Middle East, and Africa (EMEA); and Asia Pacific, Japan, and China (APJC)

Product Portfolio

- Security
- IOT
- Collaboration
- Analytics
- Software
- Wireless and Mobility

Networking

- Switches · Routers
- Wireless
- Network Management
- Interfaces & Modules
- Optical Networking



Key Customer

- The company' has field sales offices in 95 countries, and sell products and services both directly and through a variety of channels with support from salesforce, and customers primarily operate in the following markets: enterprise, commercial, service provider, and public sector.

Business Performance in 2020

Category	USD Billion
Revenue	48.0
YoY	-6.9%

Established in

1984

Headquarter

San Francisco, America

Source: Frost & Sullivan

Appendix

ZTE Profile

ZTE

Company Introduction, Listed/Private Company, Regional Coverage

- ZTE is a multinational integrated telecommunications equipment manufacturer and provider of global telecommunications solutions. It is dedicated in the development of next-generation technologies consisting of NFV, SDN, Cloud Computing , the Internet of Things, etc.
- Listed on Shenzhen Stock Exchange (SZSE) and Hong Kong Stock Exchange (HKEX)
- Regional Coverage: North America, Latin America, Europe, CIS, China, Middle East Arica, Asia Pacific

Business Performance in 2020

Category	USD Billion
Revenue	15.6
YoY	11.8%

Product Portfolio

- | | | | |
|-------------------------|---------------------------|-------------------------------|------------------|
| Core Network | Wireless | Cloud Computing&IT | Device |
| • Voice Communication | • Base Station Controller | • Cloud Computing | • Smart Phone |
| • Packet Core | • Network Management | • Data Center | • Home Gateway |
| • Convergence User Data | | Fixed Access | • Mobile Hotspot |
| • Intelligent OSS | | • Optical Access | • Smart Life |
| | | • Copper Access | |
| | | • CPE | |

Key Customer

- The company has provided products and solutions to telecommunications service providers, government and corporate clients in more than 160 countries.

Established in

1985

Headquarter

Shenzhen, China

Source: Frost & Sullivan

Global Cloud EPC Market Competitive Landscape

Competitive Landscape – Key Feature Performance

Key Character Performance of Different Cloud EPC Brand

Character	Huawei	Ericsson	Nokia	Cisco	ZTE
O&M	4.8	4.5	3.5	3.5	4
Performance	4.3	4.3	4	3.5	4
Security	4.5	3.5	3.5	4	4.5
Reliability	4.5	4.5	4.5	4	4.5
Network Architecture	4.5	4.3	4.2	4	4.2

► Character performance of the leading cloud EPC provider

- (1) **O&M:** could EPC solution of Huawei performs well in agile deployment and easy maintenance, Ericsson and ZTE have achieved agile deployment but they're more complex in maintenance.
- (2) **Performance:** both Huawei and Ericsson are featured high concurrency solutions with high efficiency, while Nokia and ZTE are advanced in efficiency as well.
- (3) **Reliability:** in general all providers perform well in Reliability since EPC has been matured for years.
- (4) **Networking:** Huawei has applied more flexible and open architecture that enables automated network management, etc.
- (5) **Security:** Huawei and ZTE apply special security mechanism rather than standard security mechanism of other providers.

Source: Frost & Sullivan

Global Cloud Microservice Market Competitive Landscape

Competitive Landscape – Key Feature Performance

Key Character Performance of Different Microservice Brand

Character	Huawei	Ericsson	Nokia	Cisco	ZTE
Agile Innovation	3.8	3.5	3.5	4	3.5
Maintenance & Debugging	4	3.5	3.5	3.5	3.5
Launch Efficiency	3.5	3	3	3	3
Scalability	4	3.5	3.5	3.5	3.5
Performance Improvement	4	4	3	3	3.5

► Character performance of the leading cloud microservice provider

- (1) **Agile Innovation:** Cisco enjoys high reputation and customer satisfaction with agile response and innovative solutions to operators' diversified demands
- (2) **Maintenance & Debugging:** Huawei provides prompt maintenance and debugging service which ensures the reliability of operators' business.
- (3) **Launch Efficiency:** currently the efficiency level of microservice launching is underdeveloped, though Huawei is more experience in dealing with Operators' system transformation
- (4) **Scalability:** providers assist Operators to transform into microservice architectures which simplifies single service scaling, and Huawei performs better at defining the granularity to decouple the monolith.
- (5) **Performance Improvement:** Huawei actively works with Operators to understand the specific downstream demands and launch microservices architecture that better fulfil them.

Source: Frost & Sullivan

Thank You!

