1일차

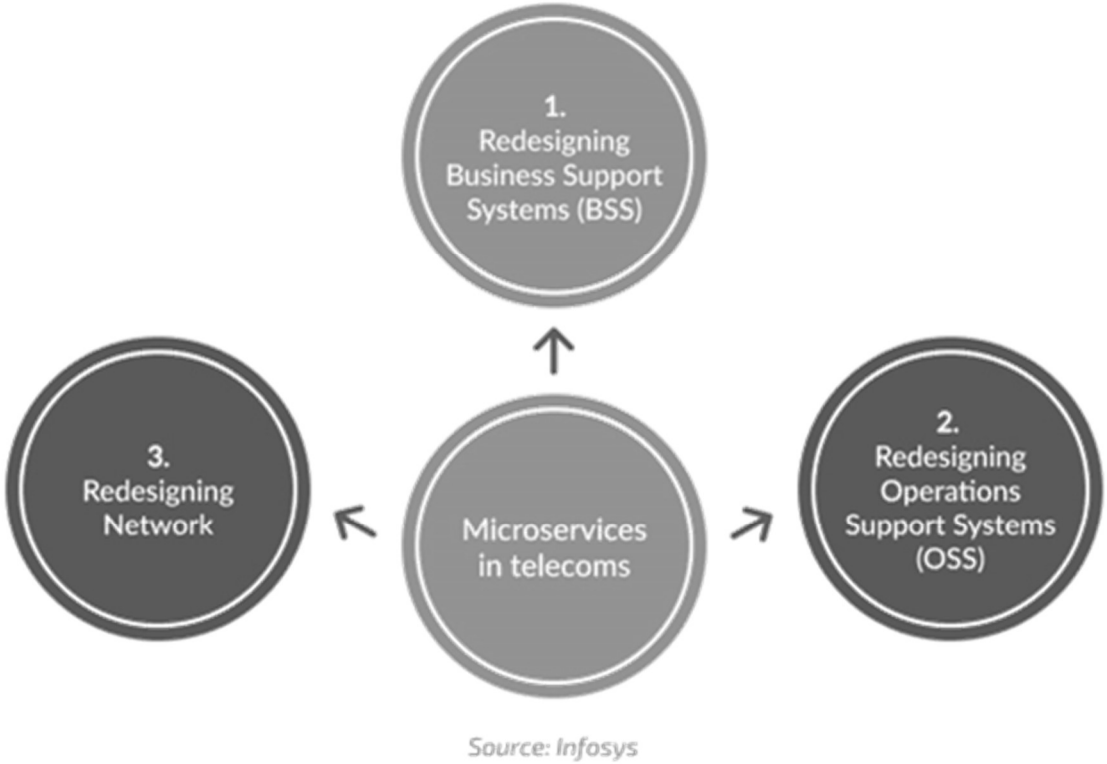
‘MSA와 5G 네트워크’

구분	주제	세부 내용
이론	**1일차. MSA와 5G 네트워크**	**• MSA(Microservices Architecture) 개요 • 통신 시장의 클라우드 서비스 기술 변화 • 5G 네트워크 서비스의 클라우드화 • Cloud Native Transformation**
	2일차. 가상화 (Virtualization) 인프라	• 네트워크 가상화 • RAN 가상화 • SDN (Software Defined Networking) • MEC와 하드웨어 가속
	3일차. 클라우드 서비스	• 클라우드 5G 서비스 개요 • 컨테이너 기술 • 클라우드 네이티브 인프라 구축 • 서비스 메시
이론/ 실습	4일차. 모니터/제어, 클라우드 네이티브 5G 네트워크 랩 시연/실습	• 모니터링 • 네트워크 슬라이싱 • Zero-touch Automation • 5G Networks Lab을 위한 K8s/Helm 설치 (실습) • 쿠버네티스 오퍼레이션 (실습)
	5일차. 관리/보안 MSA 시연/실습	• Private 5G Network 인프라 관리 • 통신 보안 • 제조사 솔루션 • Design Pattern • Cloud Native 5G Edge Networks (실습)

1일차. ‘MSA와 5G 네트워크’

❖ 텔코의 마이크로서비스: How to embrace microservices in telecom (infosys)

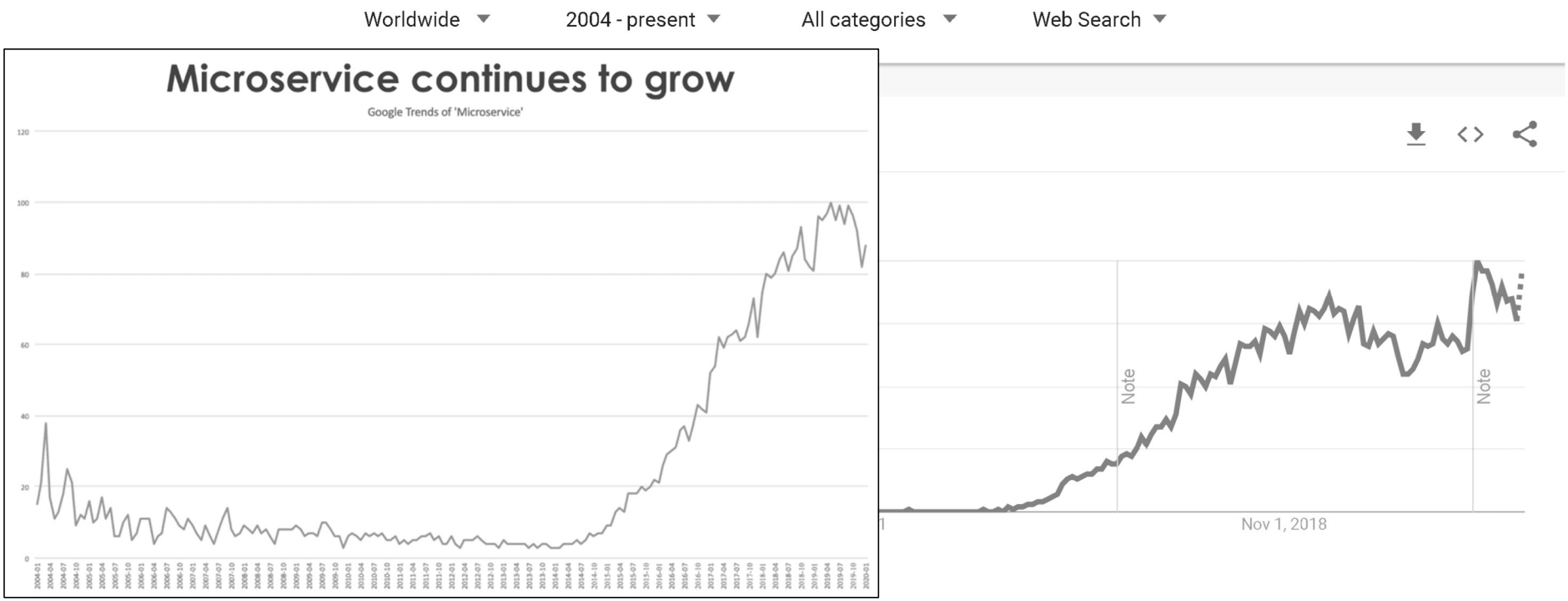
- Redesigning BSS
- Redesigning OSS
- Redesigning Network



Source: https://www.n-ix.com/implement-microservices-in-telecoms-effectively/

1일차. ‘MSA와 5G 네트워크’

❖ **구글 트렌드의 마이크로서비스: Interest in microservices has grown exponentially, as demonstrated by search trends on Google. (2022)**

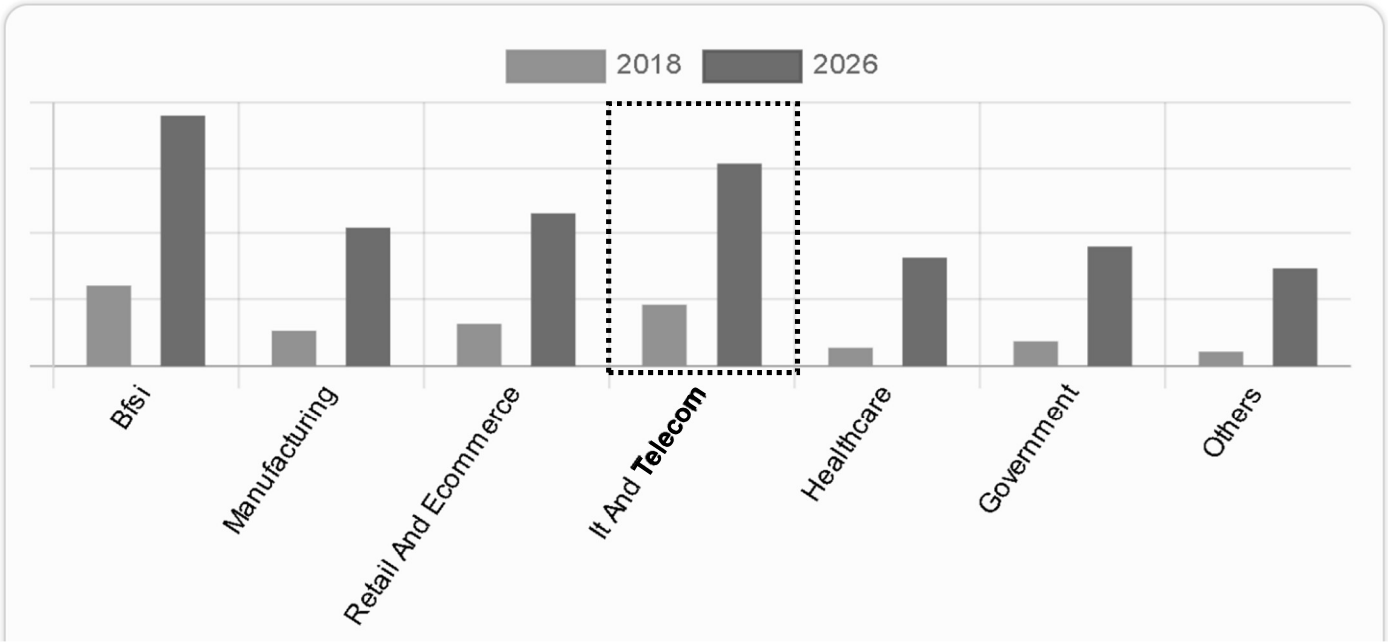


Source: https://www.linuxfoundation.org/blog/blog/the-tars-foundation-the-formation-of-a-microservices-ecosystem

1일차. ‘MSA와 5G 네트워크’

❖ 시장별 마이크로서비스: Microservices Architecture Market by Industry Vertical (2020)

- **According to a report by Allied Market Research, the global microservices architecture market size estimates to reach $8073 million by 2026, registering a CAGR of 18.6% from 2019 to 2026.**



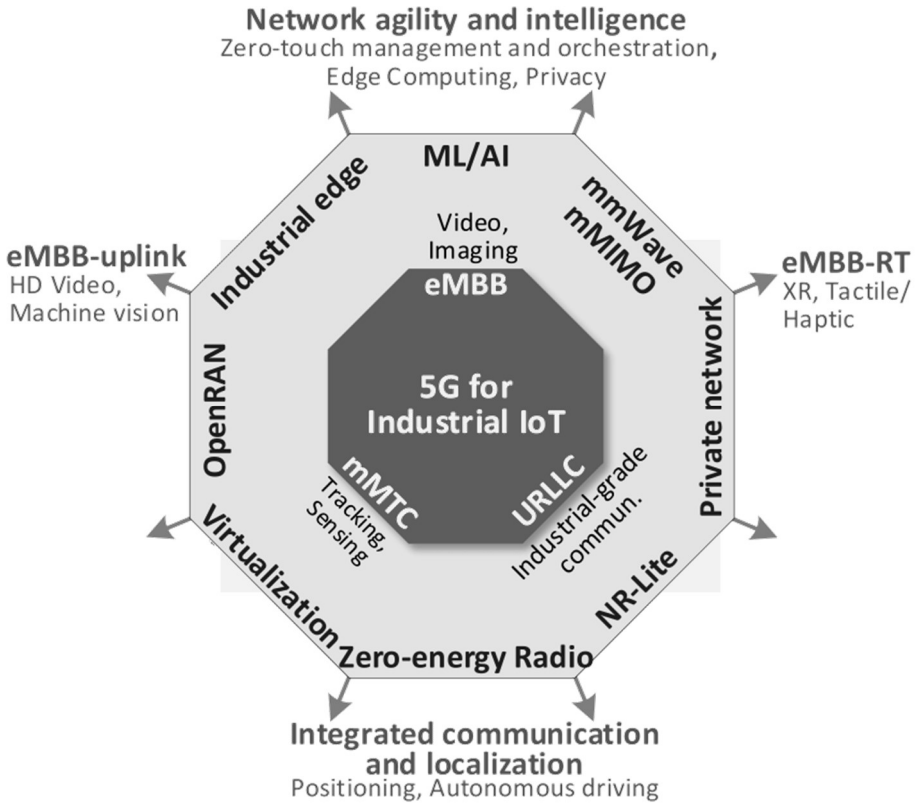
Banking, financial services and insurance (BFSI)

Source: https://www.alliedmarketresearch.com/microservices-architecture-market#:~:text=The%20global%20microservices%20architecture%20market,18.6%25%20from%202019%20to%202026.

1일차. 'MSA와 5G 네트워크'

❖ **5G 발전 방향과 IIoT(예): Beyond-5G vision, 5G architecture, and design trends for IIoT.**

- **Industrial Edge**
- **ML/AI**
- **mmWave/mMIMO**
- **Private network**
- **NR-Lite**
- **Zero-energy Radio**
- **Virtualization**
- **OpenRAN**



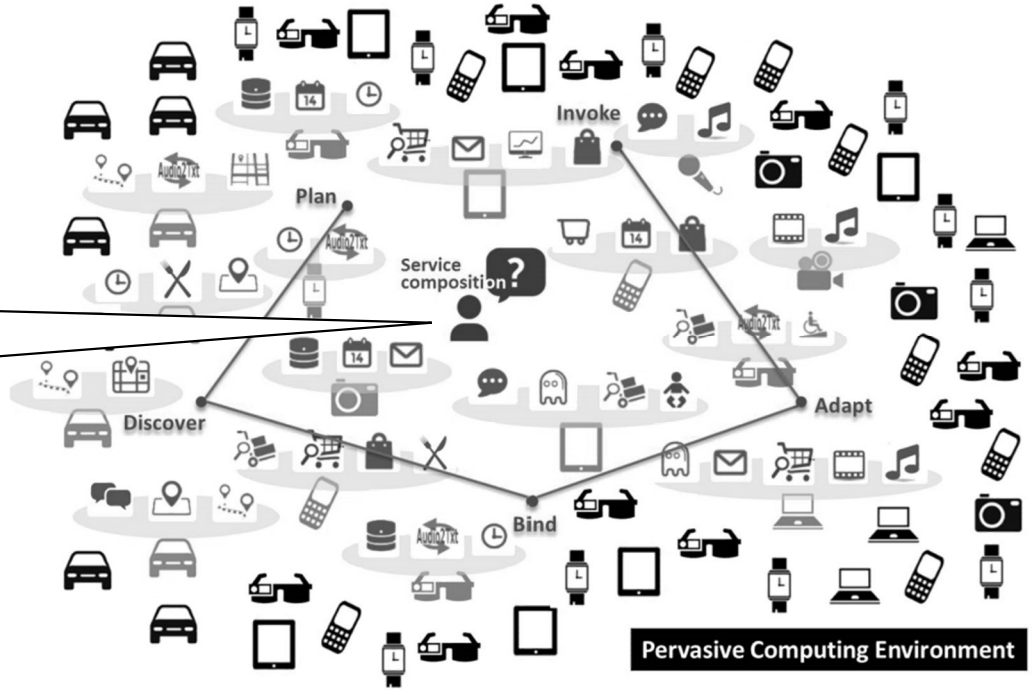
Source: https://www.researchgate.net/figure/Beyond-5G-vision-5G-architecture-and-design-trends-for-IIoT_fig2_354884463

1일차. 'MSA와 5G 네트워크'

❖ 모바일을 위한 마이크로서비스 (예): Motivating scenario 'a smart public space system'.

- A user issues a complex service request to a pervasive computing environment. Connected entities offer their hardware/software capabilities and local data as microservices.

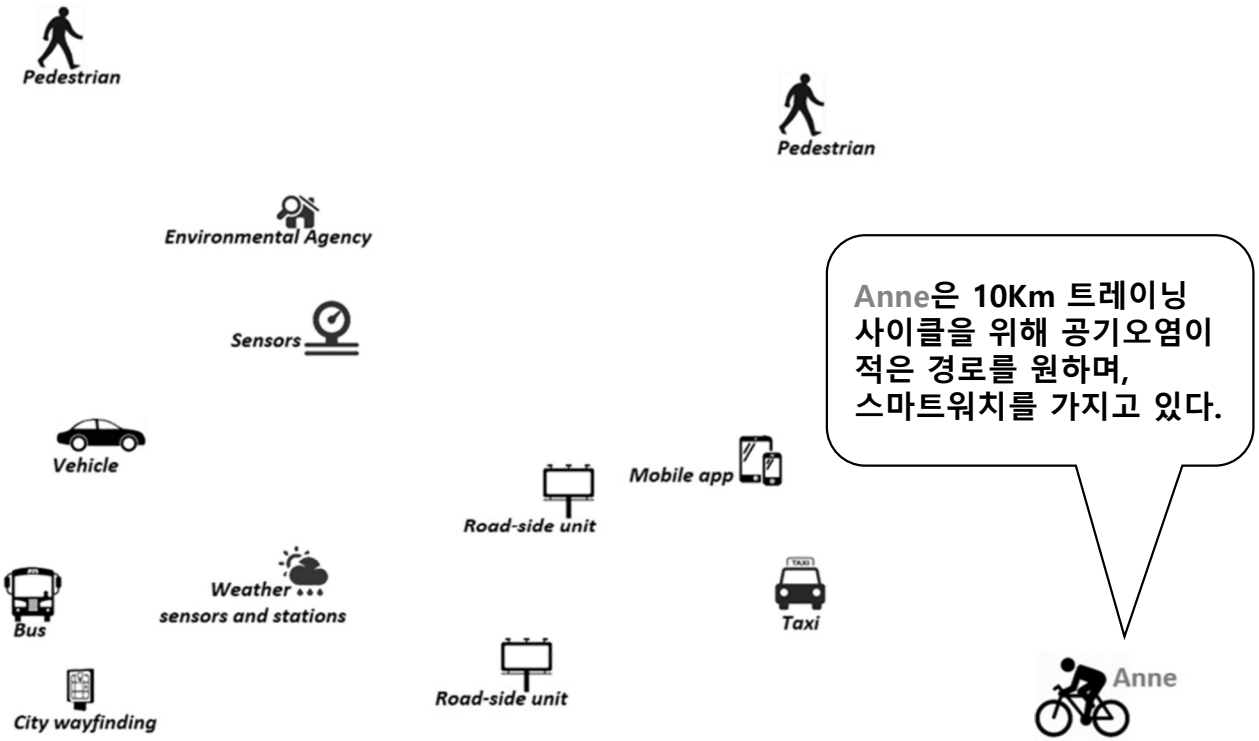
사용자는 복잡한 서비스 요구를
퍼베이시브 컴퓨팅 환경에
요청하며, 커넥티드개체들은
하드웨어/소프트웨어 능력과
데이터를 마이크로서비스로서 제공



Pervasive (퍼지는, 널리 미치는, 스며드는)
Source: Chen, Nanxi. Mobile Microservices (p. 6). CRC Press. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

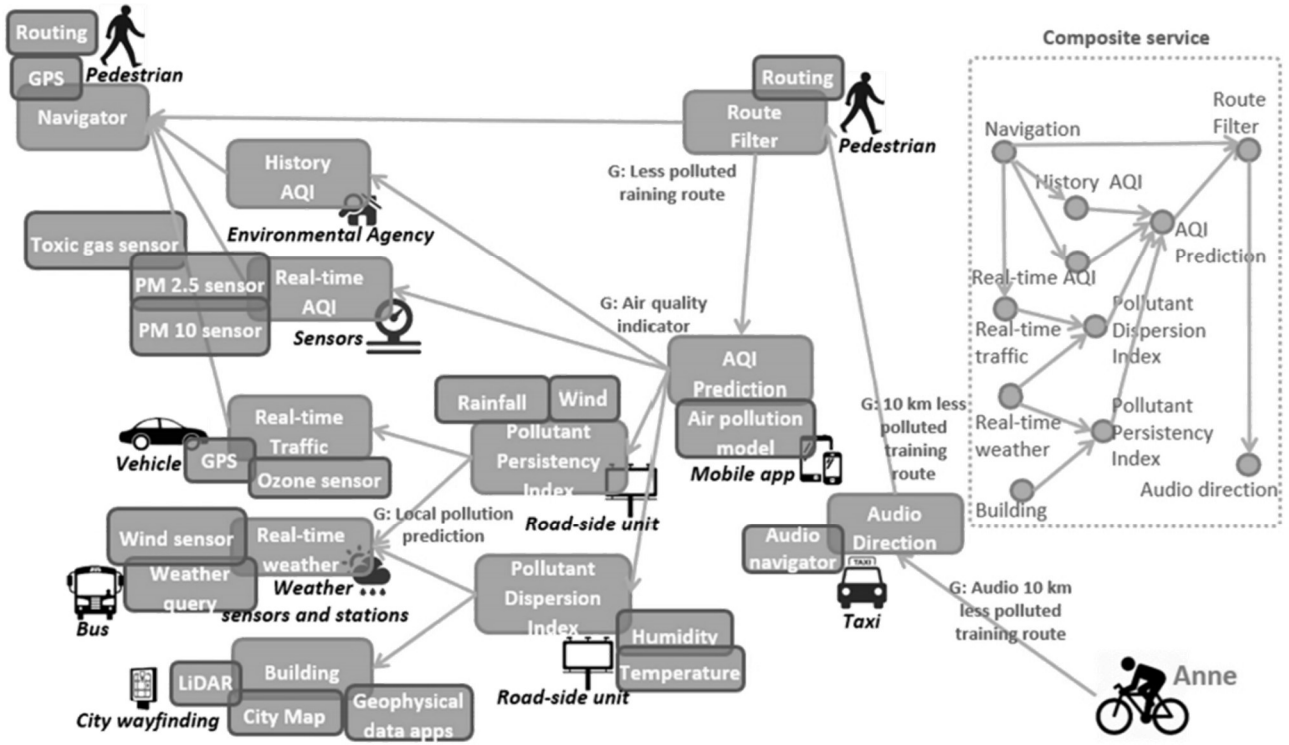
❖ 모바일을 위한 마이크로서비스 (예): A composite service to satisfy a complex task



Source: Chen, Nanxi. Mobile Microservices (p. 7). CRC Press. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

❖ 모바일을 위한 마이크로서비스 (예): A composite service to satisfy a complex task

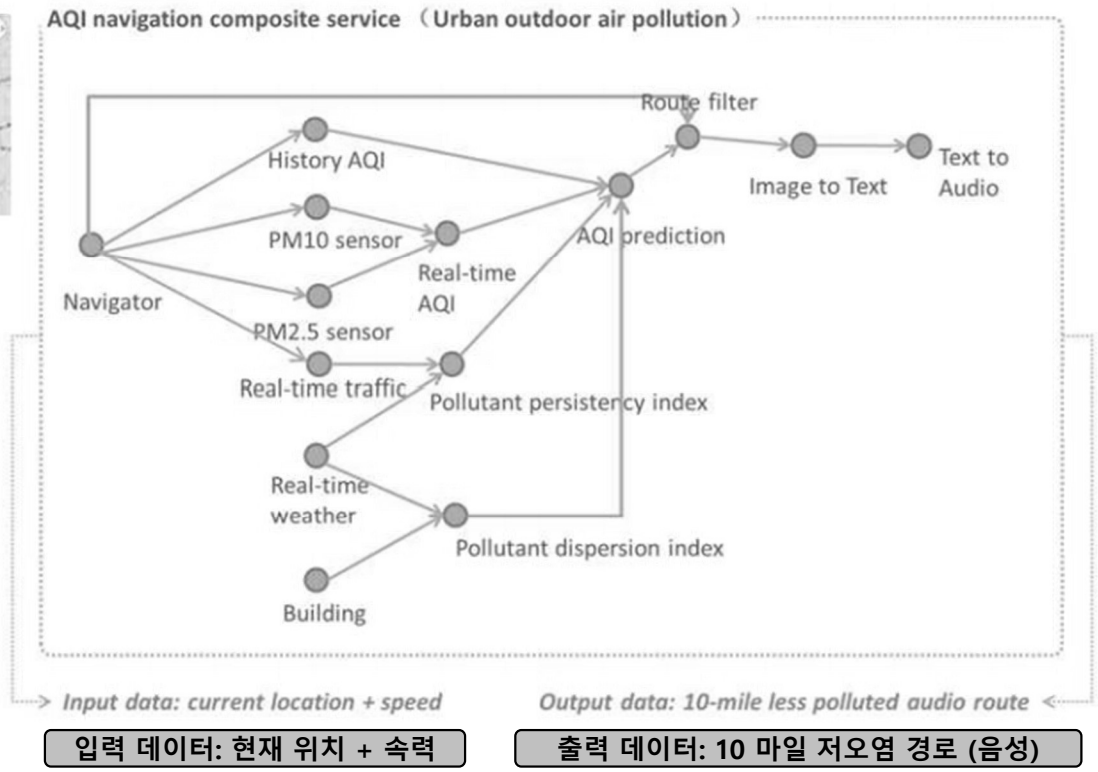


Air Quality Index (AQI)

Source: Chen, Nanxi. Mobile Microservices (p. 7). CRC Press. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

❖ 모바일을 위한 마이크로서비스 (예): Input and output data of the composite service



입력 데이터: 현재 위치 + 속력

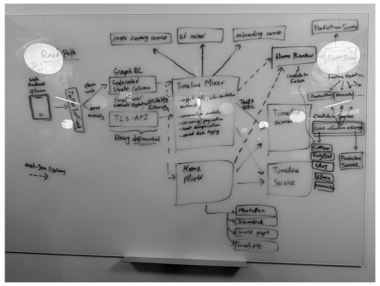
출력 데이터: 10 마일 저오염 경로 (음성)

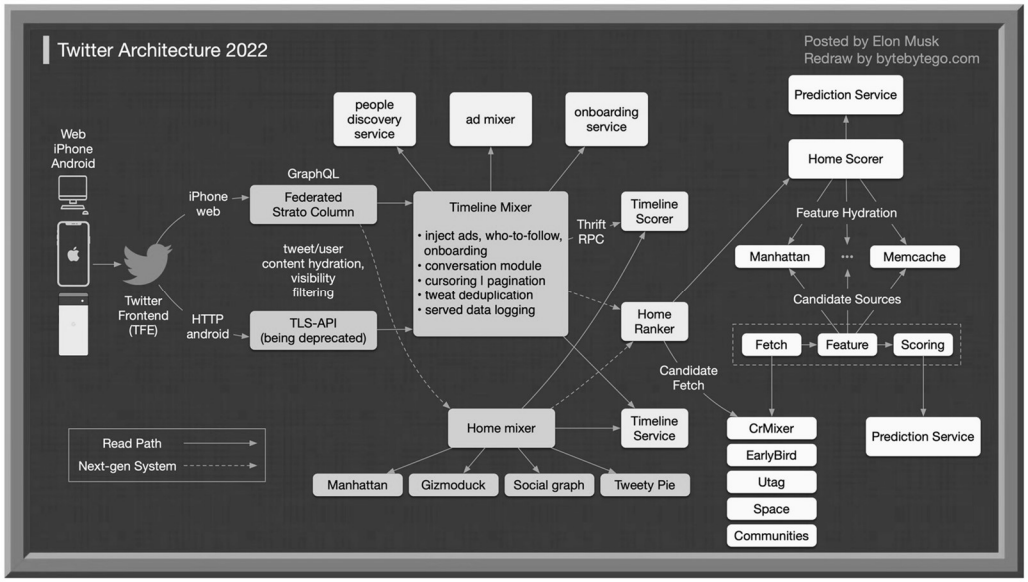
Source: Chen, Nanxi. Mobile Microservices (p. 8). CRC Press. Kindle Edition.

1일차. ‘MSA와 5G 네트워크’

❖ 일론머스크가 직원들과 코드 리뷰 후 공개한 트위터 아키텍처 (2022)

1. 프론트 요청은 REST API(안드로이드용)를 GraphQL(아이폰/웹용)로 이전 중
2. 백엔드 타임라인 및 홈 믹서는 다양한 마이크로 서비스를 참조하여 콘텐츠 생성
3. 이를 위해 다양한 스코어링, 랭킹 서비스 사용





Source: https://twitter.com/elonmusk/status/1593899029531803649?s=46&t=faUozJuMU3hLOC5z73PjRg&fbclid=IwAR10PJtYjeNQ-9GlgQPSH_sx7is49mmuAE2BB3ZCzcniUaWqcXb7UFMJniU

1일차. 'MSA와 5G 네트워크'

❖ 마이크로서비스 아키텍처 MSA (TTA의 정의)

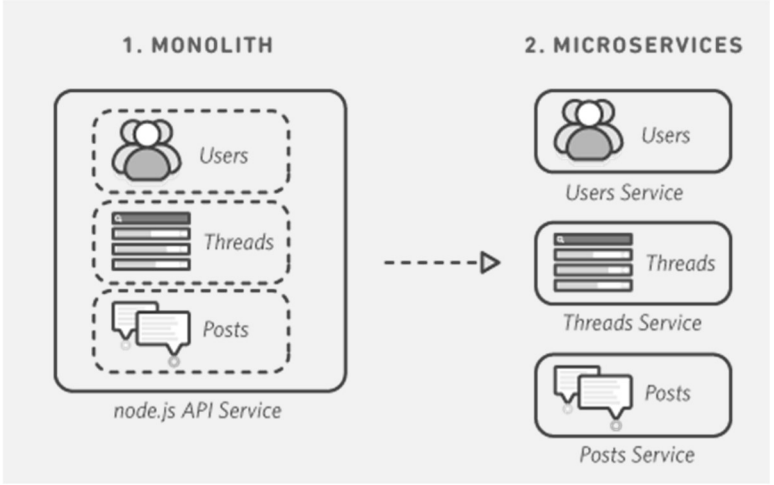
- MSA 대규모 소프트웨어 개발에 적용하기 위한 것으로 단독으로 실행 가능하고 독립적으로 배치될 수 있는 작은 단위(모듈)로 기능을 분해하여 서비스 하는 아키텍처.
- 작은 단위로 기능을 분할할 때 수직 방향의 기능별로 절단
- 절단된 독립적인 작은 모듈인 마이크로서비스는 공유나 프로세스 간 통신이 없이도 독립적으로 실행되며 운영 관리
- 마이크로서비스 간 연결은 응용 프로그래밍 인터페이스(API: Application Programming Service)를 이용
- 마이크로서비스는 표현이나 데이터 관리 등에 있어 기능적으로 완전
- 마이크로서비스 아키텍처 사용으로 개발자들이 클라우드 망을 통해 공유하고 협업하여 자유롭게 소프트웨어를 개발
- 개발 및 유지보수에 드는 시간과 비용이 절감
- 기존 모놀리식(monolithic) 방식과 반대되며, 서비스 지향 아키텍처(SOA: Service-Oriented Architecture) 방식보다 더 세분화

Source: http://www.tta.or.kr/data/weeklyNoticeView.jsp?pk_num=5193 - depleted

1일차. ‘MSA와 5G 네트워크’

❖ 마이크로서비스 (아마존 AWS의 MSA 정의)

- 마이크로서비스는 소프트웨어가 잘 정의된 API를 통해 통신하는 소규모의 독립적인 서비스로 구성되어 있는 경우의 소프트웨어 개발을 위한 아키텍처 및 조직적 접근 방식입니다. 이러한 서비스는 독립적인 소규모 팀에서 보유합니다.
- 마이크로서비스 아키텍처는 애플리케이션의 확장을 용이하게 하고 개발 속도를 앞당겨 혁신을 실현하고 새로운 기능의 출시 시간을 단축할 수 있게 해 줍니다.



Source: https://aws.amazon.com/ko/microservices/

1일차. 'MSA와 5G 네트워크'

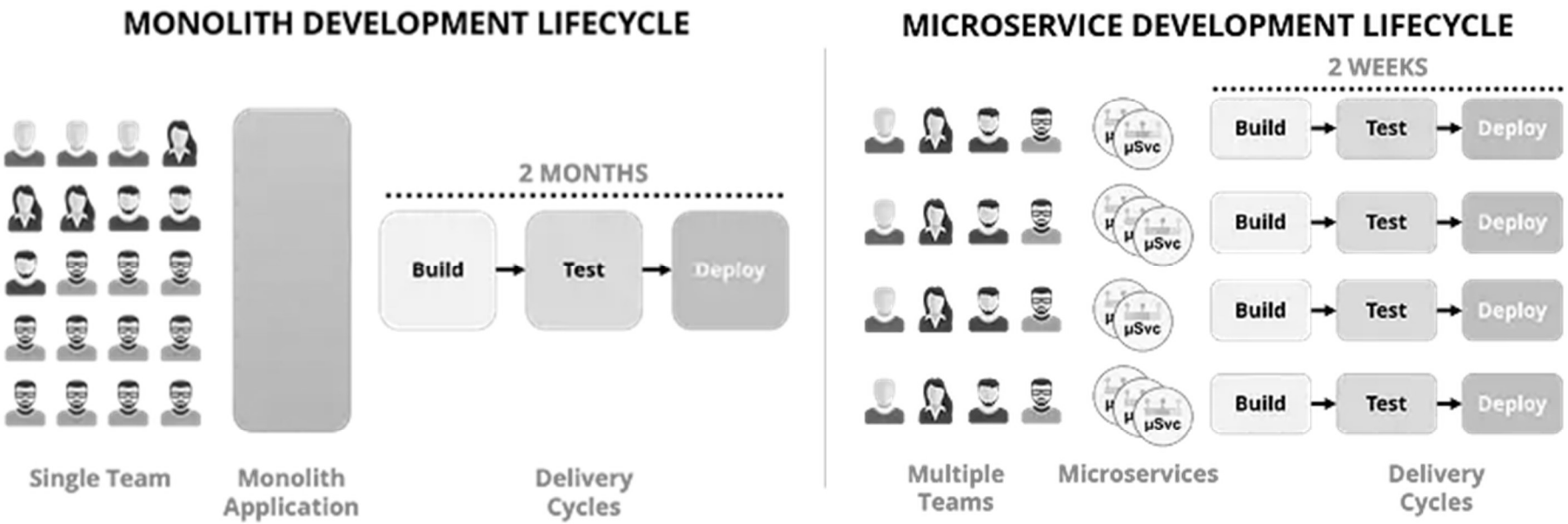
❖ 마이크로서비스 (마이크로소프트 Azure의 MSA 정의)

- 마이크로 서비스는 작고, 독립적이며, 느슨하게 결합되어 있습니다. 하나의 소규모 개발자 팀이 작성하고 유지 관리할 수 있습니다.
- 각 서비스는 작은 개발 팀이 관리할 수 있는 개별 코드베이스입니다.
- 서비스를 독립적으로 배포할 수 있습니다. 팀이 전체 애플리케이션을 다시 빌드한 후 재배치하지 않고도 기존 서비스를 업데이트할 수 있습니다.
- 서비스가 해당 데이터 또는 외부 상태를 유지해야 합니다. 이는 별도의 데이터 레이어가 데이터 지속성을 처리하는 기존 모델과의 차이점입니다.
- 서비스가 잘 정의된 API를 사용하여 서로 통신합니다. 각 서비스의 내부 구현 세부 정보는 다른 서비스에서 숨겨집니다.
- 다중저장소 프로그래밍을 지원합니다. 예를 들어 서비스가 동일한 기술 스택, 라이브러리 또는 프레임워크를 공유할 필요가 없습니다.

Loosely Coupled (느슨한 결합) Reference 'OpenStack' : Slide 357, Slide 358
Source: https://docs.microsoft.com/ko-kr/azure/architecture/guide/architecture-styles/microservices

1일차. 'MSA와 5G 네트워크'

❖ **Less dependencies. Business functions are built in parallel, reducing complexity.**



Source: https://beesion.com/development-process/

1일차. 'MSA와 5G 네트워크'

❖ **Benefits of microservices architecture in telecoms** (N-iX)

Increased time-to-market of new services

새로운 서비스의 Time-to-Market 증가

Easy management of seasonal scalability needs

확장 관리 쉬움

Effortless customization and upgrades

수정과 업그레이드 쉬움

Flexible maintenance

유연한 관리

Painless integration with 3rd party applications

제3의 앱 통합 쉬움

Better security

더 나은 보안

Easy adoption of new technologies

신기술 수용 쉬움

No service interruption while testing

운영중 시험

Improvement in resource utilization

자원 효율 향상

Source: https://www.n-ix.com/implement-microservices-in-telecoms-effectively/

1일차. 'MSA와 5G 네트워크'

❖ Key 5G Features in 3GPP Releases 15, 16, and 17

5G Phase 1
Release 15
(2017–2019)

5G System and Packet Core:
- SBA-based architecture
- Massive MTC and IoT
- API Exposure to third party
- Cloud friendly (SBI)
- Network Slice as a Service
- MEC

RAN:
- New Radio specification
- NR NSA (option 3x)
- NR SA (option 2/4/5/7)
- Wide bandwidth (~400 MHz)
- Wide Freq Range (up to 28GHz)

Industry verticals:
- V2X Phase 2
- Mission Critical Interworking
- WLAN and unlicensed spectrum

5G Phase 2
Release 16
(2018–2020)

5G System and Packet Core:
- Anchored NR-U
- Standalone NR-U
- Integrated Access and Backhaul (IAB)
- CAPIF enhanced

RAN:
- NR Positioning
- NR Coverage
- UE power saving techniques
- HARQ enhancement
- Enhanced Scheduling
- Coordinated multi-point (CoMP)

Industry verticals:
- Time-Sensitive Networks
- C-V2X enhancement
- IIoT and URLLC support
- NPN support

Phase 3
Release 17
(2020–2022 expected)

5G System and Packet Core:
- 5G LAN type services
- 5G Wireline and Wireless Convergence
- Edge Computing in 5G
- IAB enhancement
- Network Slicing - phase 2
- Multi-SIM
- Access Traffic Steering

RAN:
- NR Coverage enhancement
- NR Positioning enhancement
- NR Quality of Experience
- NR MIMO
- RAN Slicing
- Multi-Radio DCCA enhanced

Industry verticals:
- IIoT and URLLC enhanced
- NB-IoT and LTE-MTC enhancement
- Unmanned Aerial Systems
- Satellite components
- Enhanced V2X Services
- NPN enhanced

산업 응용 분야 확장

SBA: Service-Based Architecture
RAN: Radio Access Network
MTC: Machine Type Communications
IoT: Internet of Things
API: Applications Programming Interface
MEC: Multi-Access Edge Compute
NSA: Non-Standalone
SA: Standalone
V2X: Vehicle to Everything
WLAN: Wireless Local Area Network
NR: New Radio
NR-U: New Radio Unlicensed
HARQ: Hybrid Automatic Repeat Request
IIoT: Industrial Internet of Things
URLLC: Ultra-Reliable Low-Latency Communications
NPN: Non-Public Networks
LAN: Local Area Networks
MIMO: Multiple Input Multiple Output

Source: https://www.3gpp.org/specifications-technologies/3gpp-work-plan
Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

❖ Key 5G Advanced Features under Study in 3GPP Release 18

SBA: Service-Based Architecture
HAPS: High Altitude Platform System
RAN: Radio Access Network
MEC: Multi-Access Edge Compute
NSA: Non-Standalone
SA: Standalone
V2X: Vehicle to Everything

WLAN: Wireless Local Area Network
NR: New Radio
SFC: Service Functionality Chaining
NTN: Non-Terrestrial Networks
LCS: Location Services
NPN: Non-Public Networks
LAN: Local Area Networks
MIMO: Multiple Input Multiple Output

5G Advanced
Release 18
(2022 - 2023 Dec expected)

5G System and Packet Core:
- Enhanced support for V2X
- High Altitude Platform System (HAPS)
- Dual Active Protocol Stack (DAPS) improvements
- Network slicing enhancements
- Private 5G/Non-Public Network (NPN) enhancements aimed at non-3GPP deployments
- Service Functionality Chaining (SFC) in 5G System
- 5G-enabled fused location service (LCS) capability
- Enhanced 5G Timing Resiliency
- Inclusion of MEC in roaming

RAN:
- Enhancements for eXtended Reality (XR)
- Sidelink Enhancements aimed at unlicensed, power saving enhancements, efficiency enhancements, and so on
- Evolution of Downlink MIMO with enhanced handling of multiple Transmission Reception Points (multi-TRP) and multibeam
- Evolution of Non-Terrestrial Network aimed at 5G NR and IoT
- Inclusion of traffic characteristics and KPIs for AI/ML
- Evolution of V2X with sidelink enhancements
- Enhancements for Unmanned Aerial Vehicle (UAV)
- Enhanced inter-gNB coordination
- Minimization of Drive Test (MDT) and Self Organizing Networks (SON)
- High Altitude Platform System (HAPS)
- UE Power Savings
- Extended support for frequency bands beyond 52.6GHz
- Carrier Aggregation (CA)/Dual Connectivity (DC) enhancements
- Flexible spectrum integration
- Multicast Broadcast Service (MBS)

Industry verticals:
- V2X
- Non Terrestrial Networks
- Railway
- Non-3GPP and unlicensed spectrum

- **AI/ML KPI**
- **Multicast Broadcast Service(MBS)**
- **비지상 네트워크**
- **철도**
- **Non-3GPP 비면허 대역 무선**

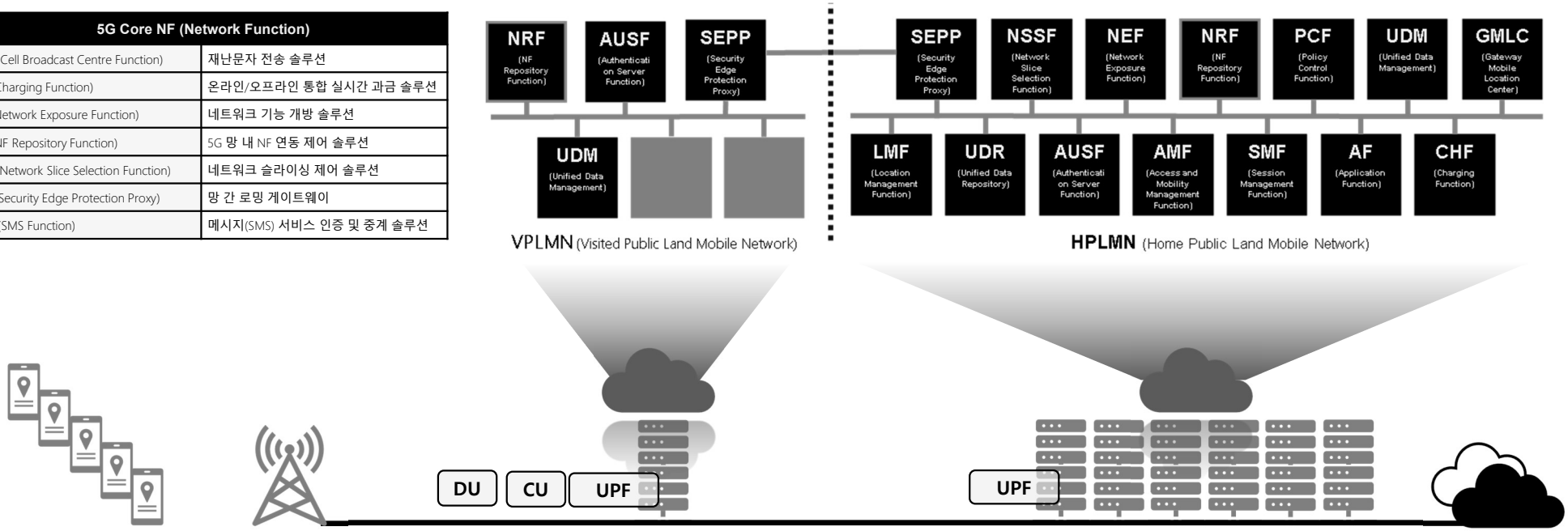
Source: https://www.3gpp.org/specifications-technologies/3gpp-work-plan
Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. ‘MSA와 5G 네트워크’

❖ 5G Core의 클라우드화

- **5G Core와 RAN** (Radio Access Network)

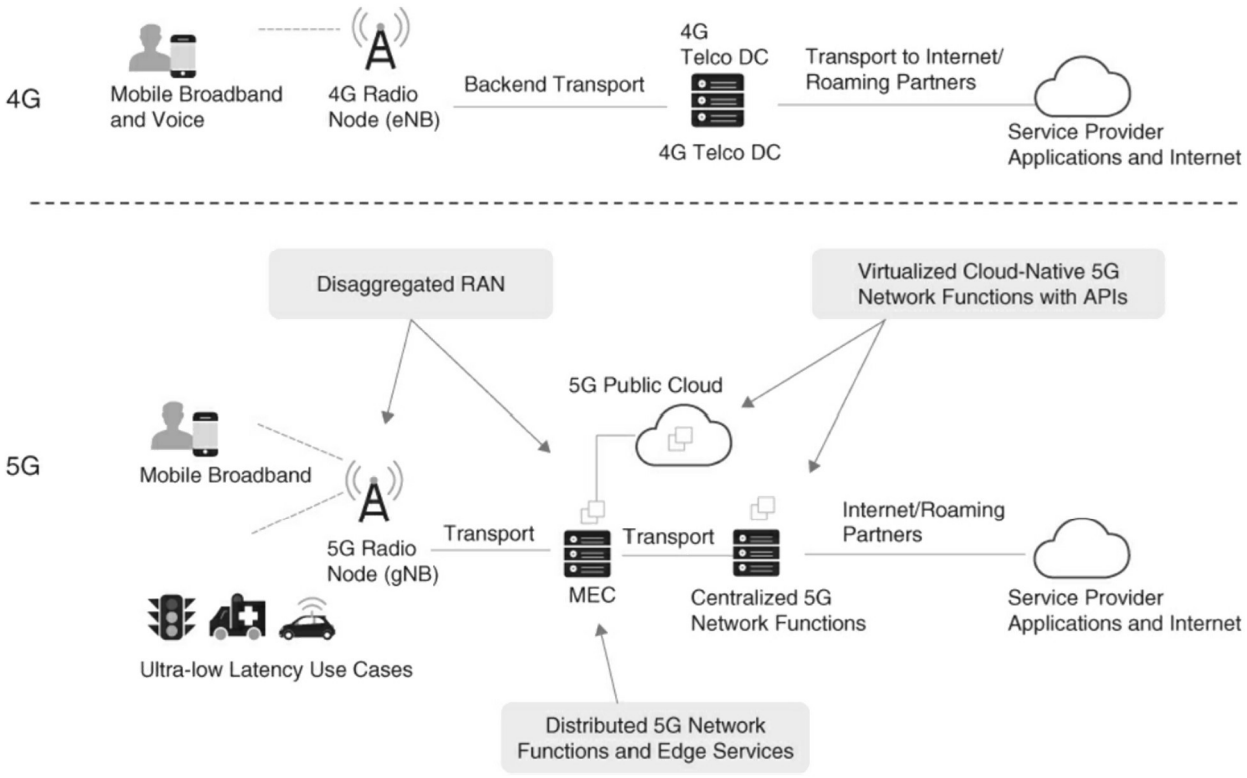
5G Core NF (Network Function)	
CBCF (Cell Broadcast Centre Function)	재난문자 전송 솔루션
CHF (Charging Function)	온라인/오프라인 통합 실시간 과금 솔루션
NEF (Network Exposure Function)	네트워크 기능 개방 솔루션
NRF (NF Repository Function)	5G 망 내 NF 연동 제어 솔루션
NSSF (Network Slice Selection Function)	네트워크 슬라이싱 제어 솔루션
SEPP (Security Edge Protection Proxy)	망 간 로밍 게이트웨이
SMSF (SMS Function)	메시지(SMS) 서비스 인증 및 중계 솔루션



5G Core RAN Reference ’5G 융합서비스 테스트베드’: Slide 360

1일차. 'MSA와 5G 네트워크'

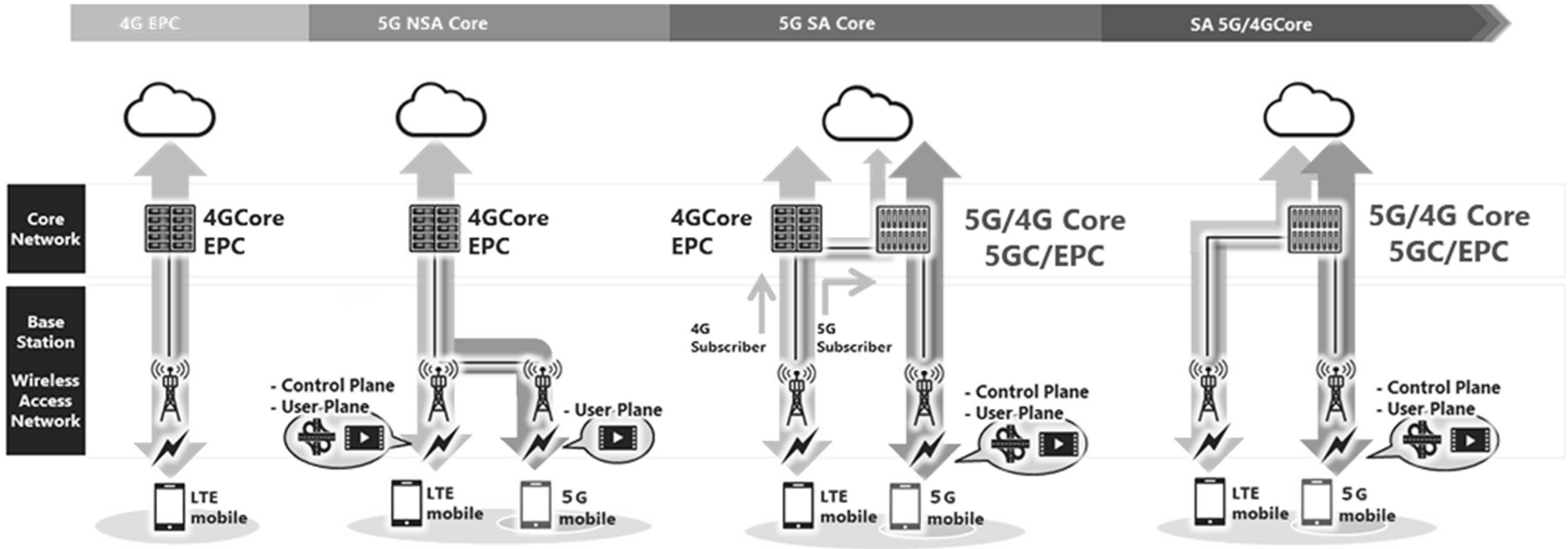
❖ Comparison of 5G and 4G



Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

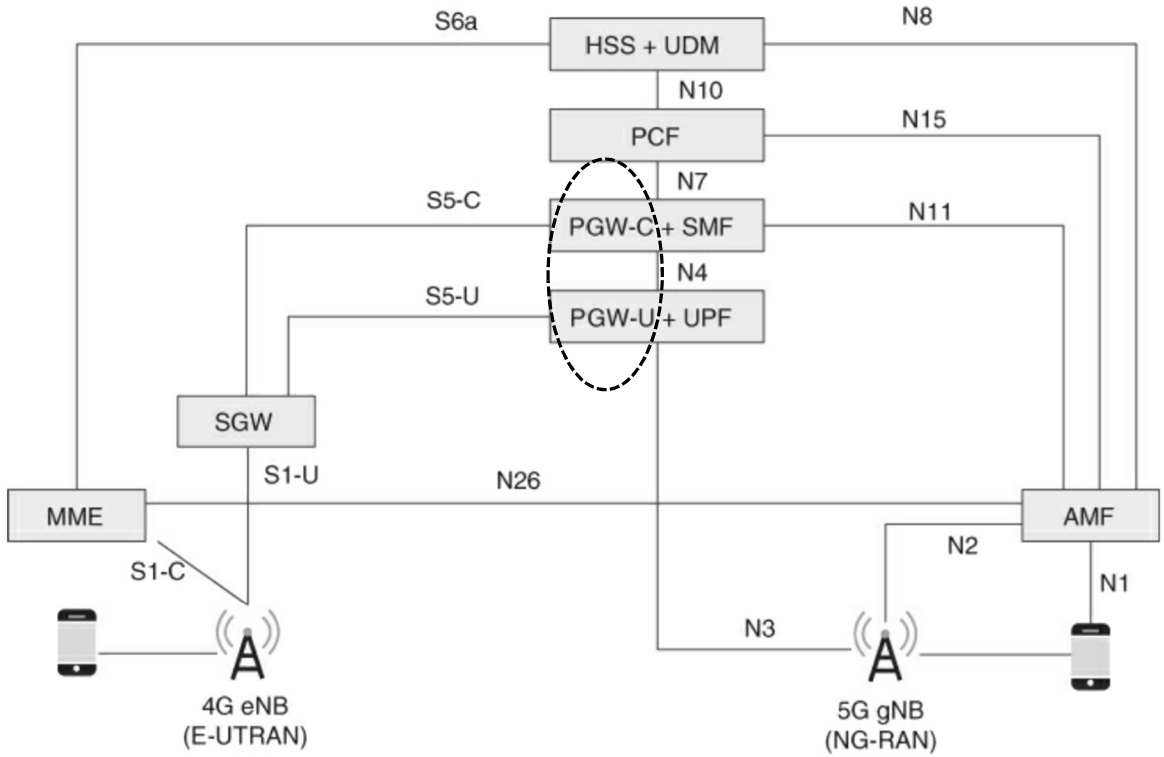
❖ **Migration from 4G to 5G**



Source: https://www.nec.com/en/press/202202/global_20220222_03.html

1일차. 'MSA와 5G 네트워크'

❖ 4G and 5G Interworking



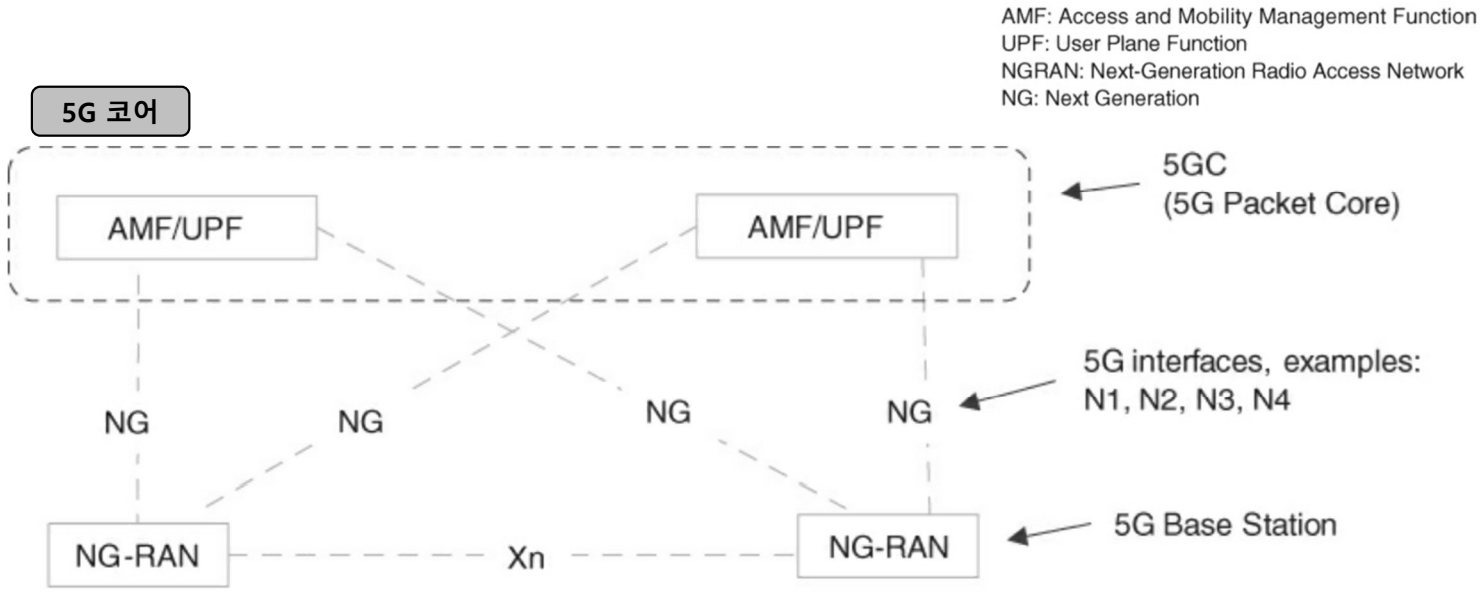
HSS: Home Subscriber Server
UDM: Unified Data Management
PCF: Policy Control Function
PGW-C: PDN Gateway - Control Plane
PDN: Packet Data Network

SMF: Session Management Function
PGW-U: PDN Gateway - User Plane
UPF: User Plane Function
SGW: Serving Gateway
MME: Mobility Management Entity
AMF : Access and Mobility Management Function

Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

❖ 5G SA Architecture

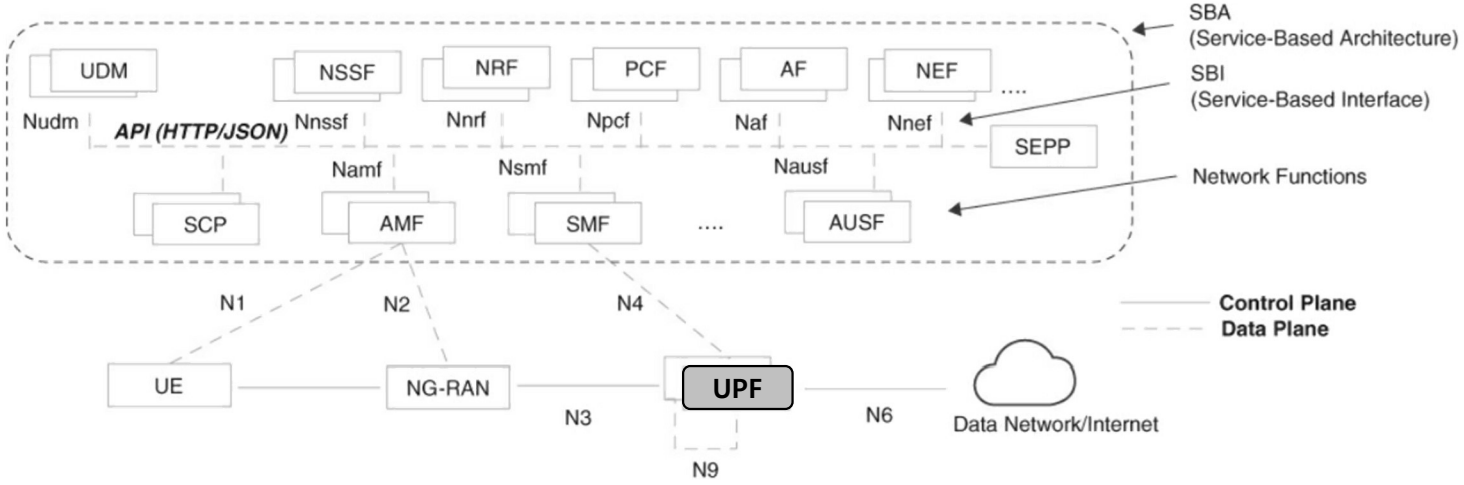


Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

❖ 5G Service-Based Architecture

5G 코어



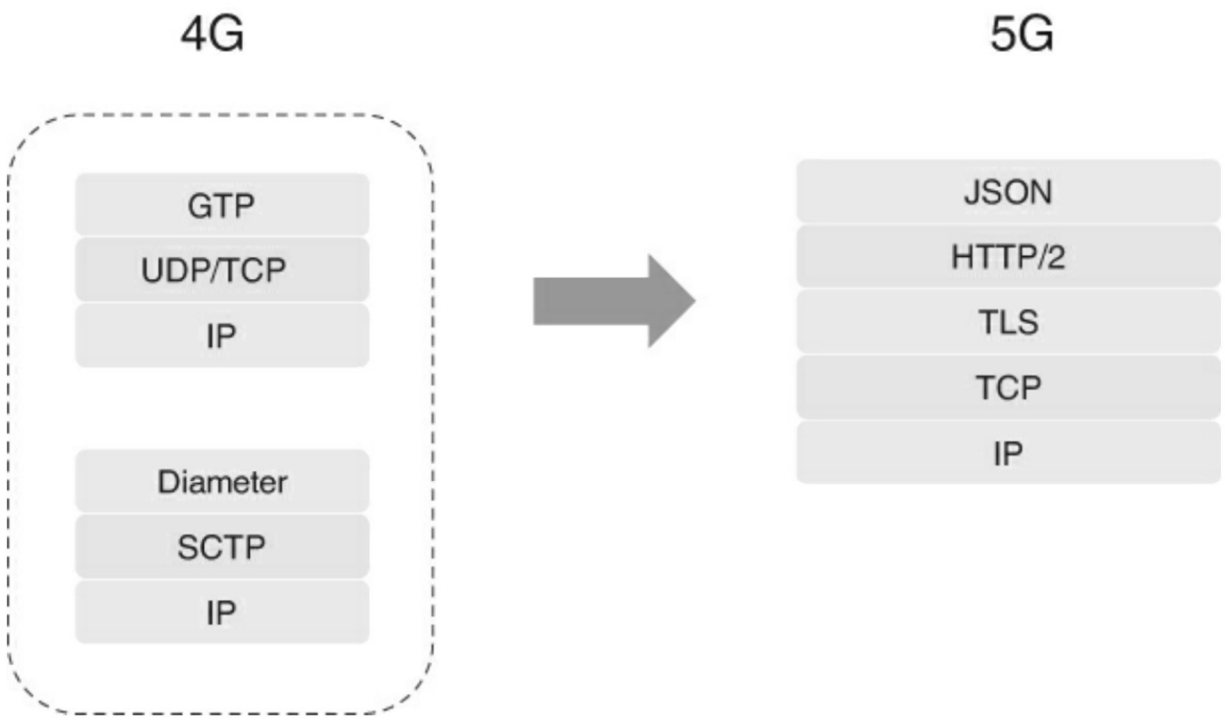
AMF: Access and Mobility Management Function
AUSF: Authentication Server Function
AF: Application Function
SMF: Session Management Function
NEF: Network Exposure Function
NRF: Network Resource Function
PCF: Policy Control Function

NSSF: Network Slice Selection Function
UPF: User Plane Function
UDM: Unified Data Management
UE: User Equipment
SEPP: Security Edge Protection Proxy
DN: Data Network
SCP: Service Communication Proxy
NGRAN: Next-Generation Radio Access Network

Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

❖ **4G 와 5G 제어평면(Control Plane) 프로토콜 비교**

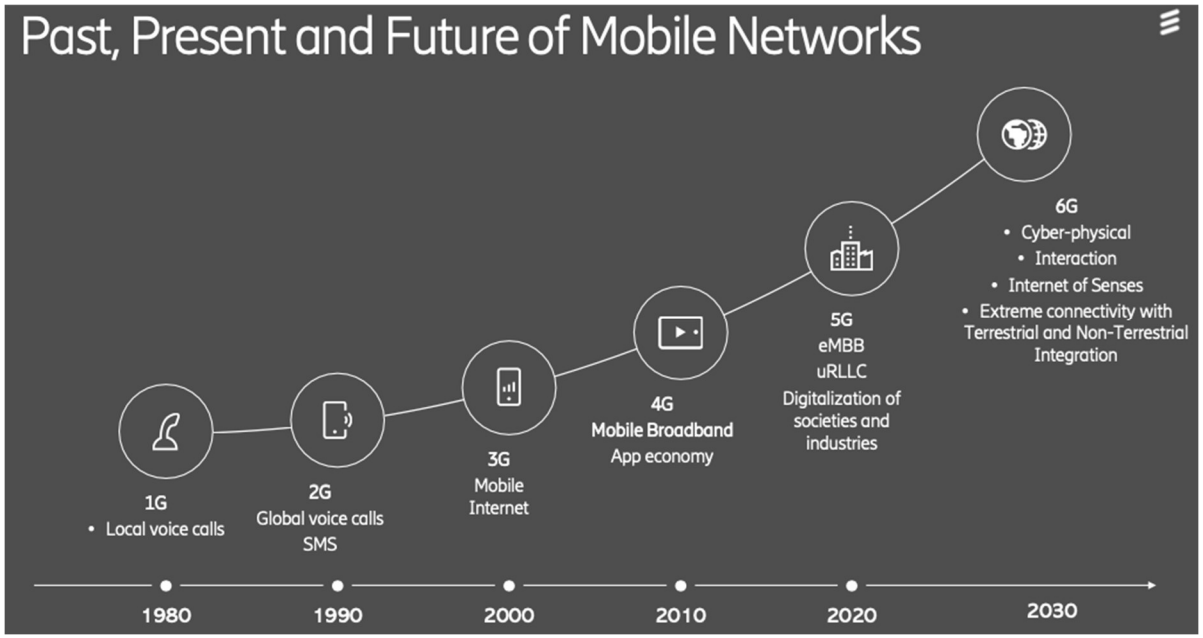


Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

❖ Transitioning From 5G To 6G

- 1G Mobile: AMPS, TOPS, C-450, Radiocom 2000, and All Those Japanese Ones
- 2G: Mobile Goes Digital
- 3G and 4G: The Internet Arrives
- 5G: Connecting All the Things

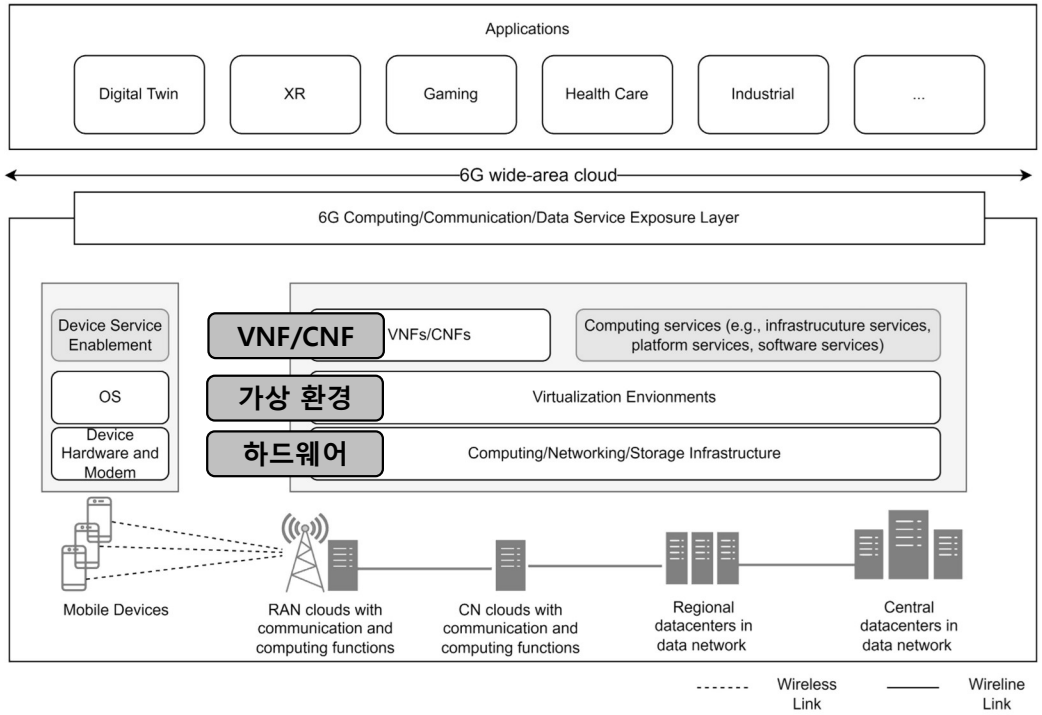


Source: https://semiengineering.com/edps-transitioning-from-5g-to-6g/

1일차. 'MSA와 5G 네트워크'

❖ 6G Cloud-Native System (IEEE)

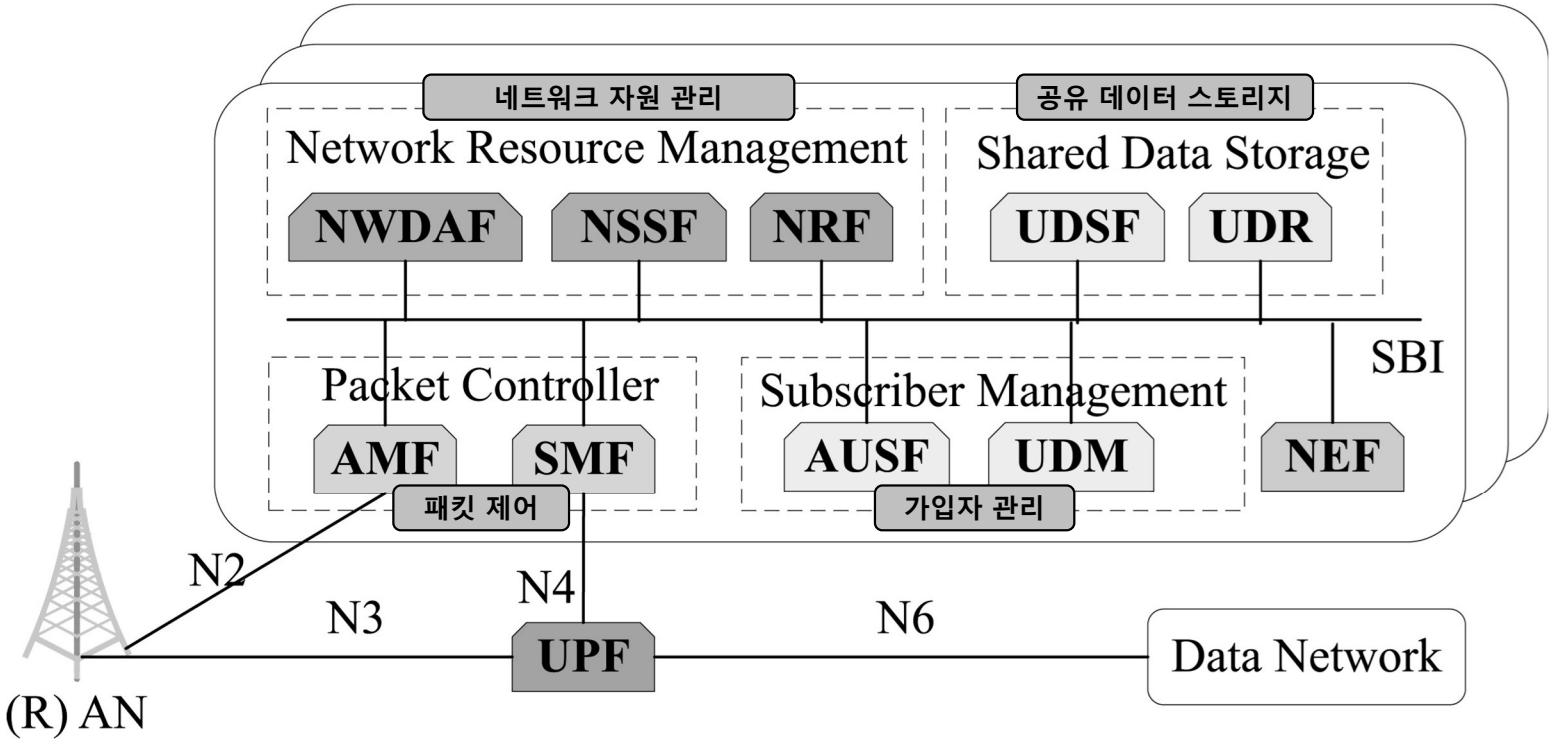
- **Vision/Challenges/Architecture Framework/Enabling Technologie**
  - Wide-area cloud formed on 6G cloud-native system



Source: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9882121

1일차. 'MSA와 5G 네트워크'

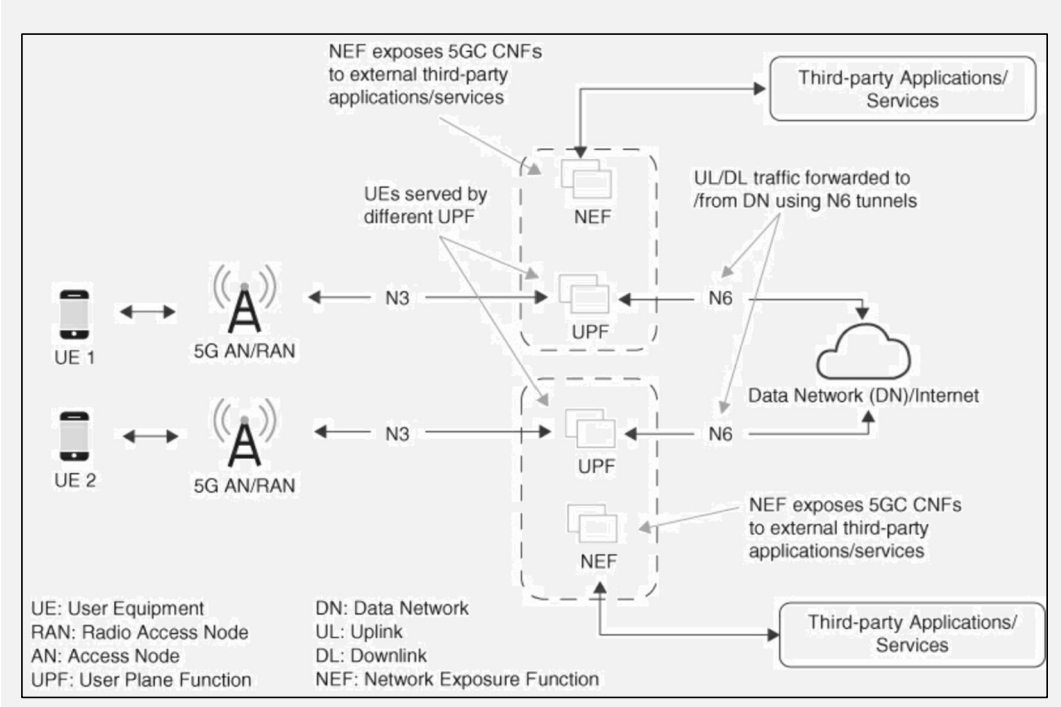
❖ **Service-based architecture for 5G core network.**



Source: https://www.sciencedirect.com/science/article/pii/S2352864822000815

1일차. 'MSA와 5G 네트워크'

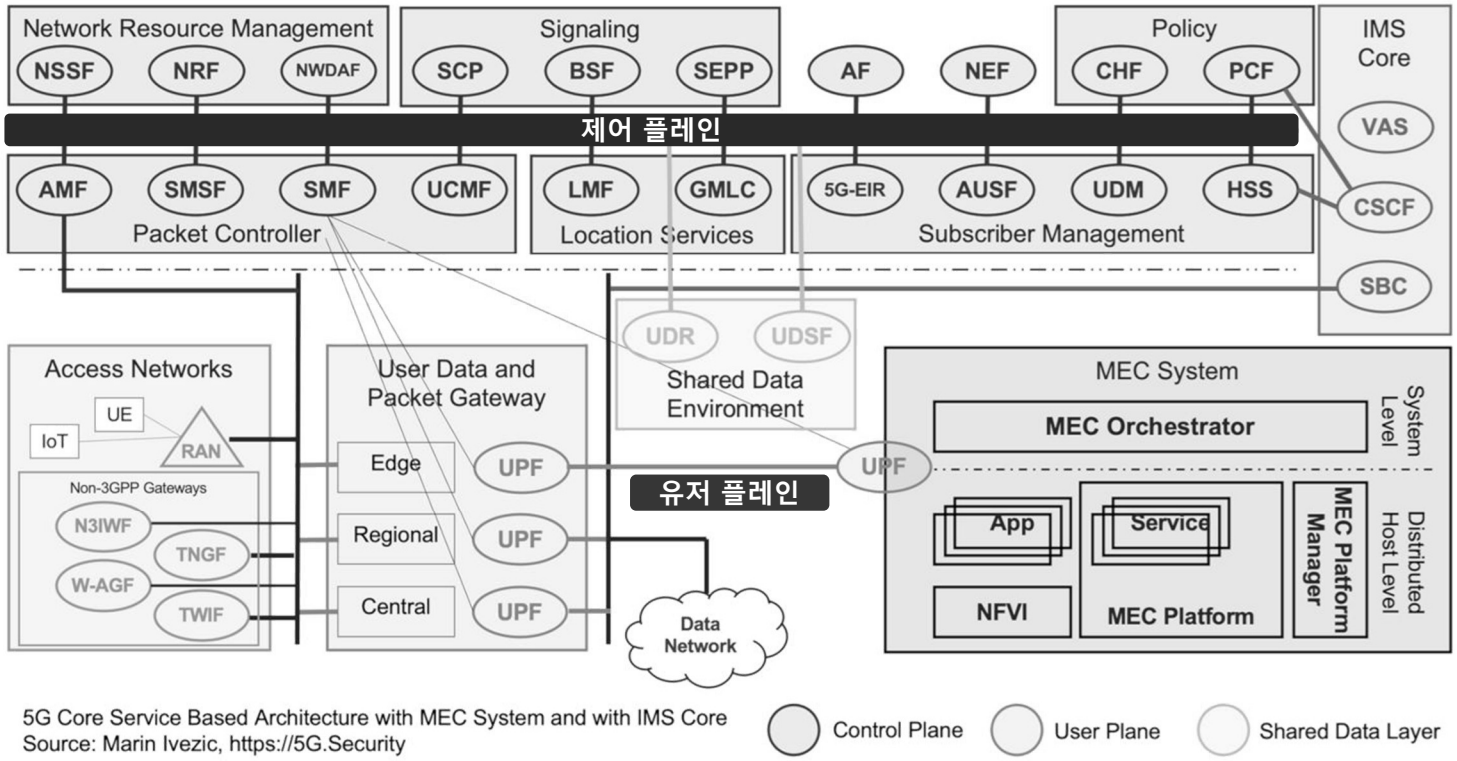
- ❖ NEF의 외부 3rd Praty 애플리케이션이나 서비스 연결
- ❖ N6-Based Traffic Forwarding for 5G LAN-Type Service Deployments



Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.

1일차. 'MSA와 5G 네트워크'

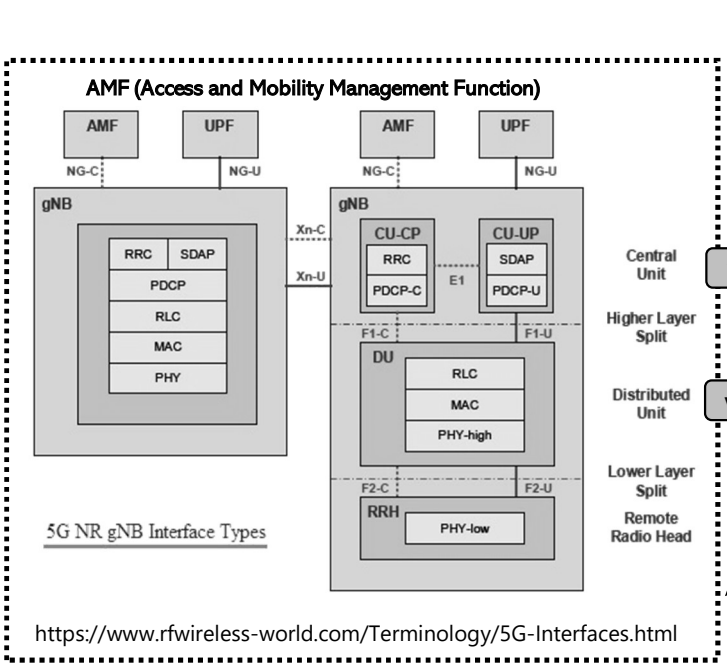
❖ **5G Core SBA along with IMS Core and MEC System. Source: Ivezic 2020**



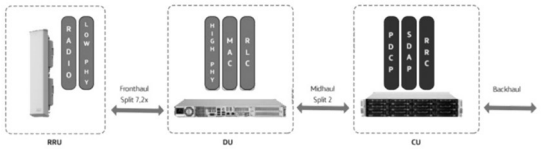
Source: https://devopedia.org/5g-service-based-architecture

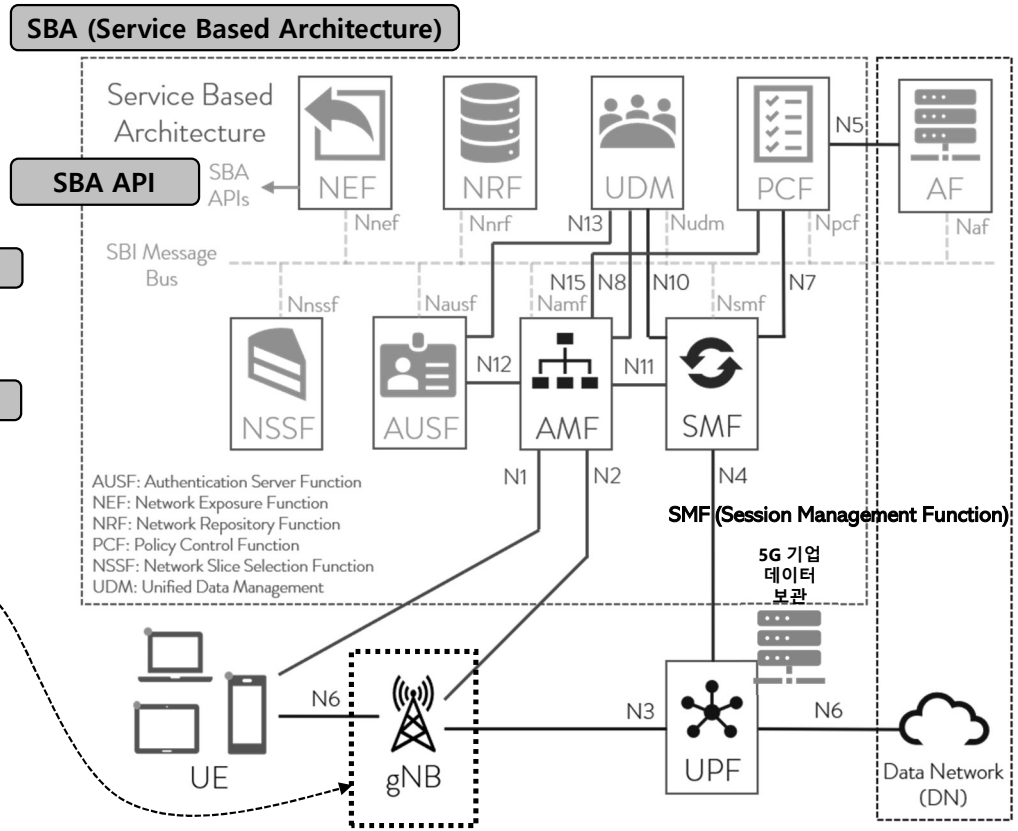
1일차. 'MSA와 5G 네트워크'

❖ 5G Service-Based Architecture



https://www.rfwireless-world.com/Terminology/5G-Interfaces.html

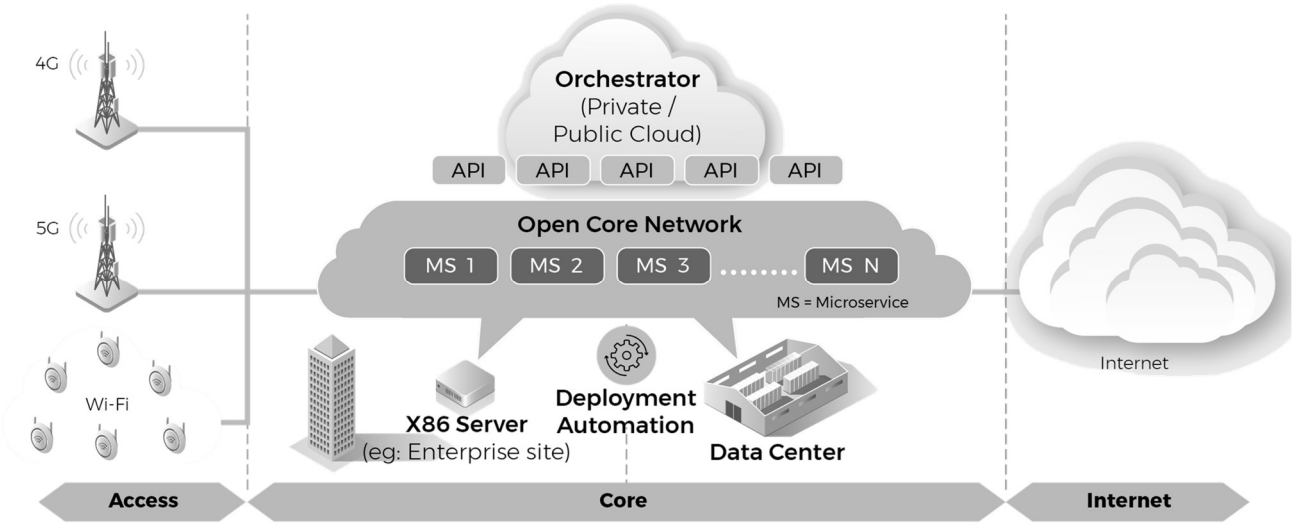




Source: https://www.metaswitch.com/knowledge-center/reference/what-is-the-5g-session-management-function-smf

❖ 오픈 코어 네크워크(예): Open Core Network Project Group

- **The goal is to innovate on the packet core technologies across any access wireless networks operating on licensed, unlicensed and shared spectrum; develop microservice, orchestration and automation frameworks on OCN platform, and support an ecosystem of developers, OEMs, SIs, MNOs, and ISPs around OCN based solutions.**



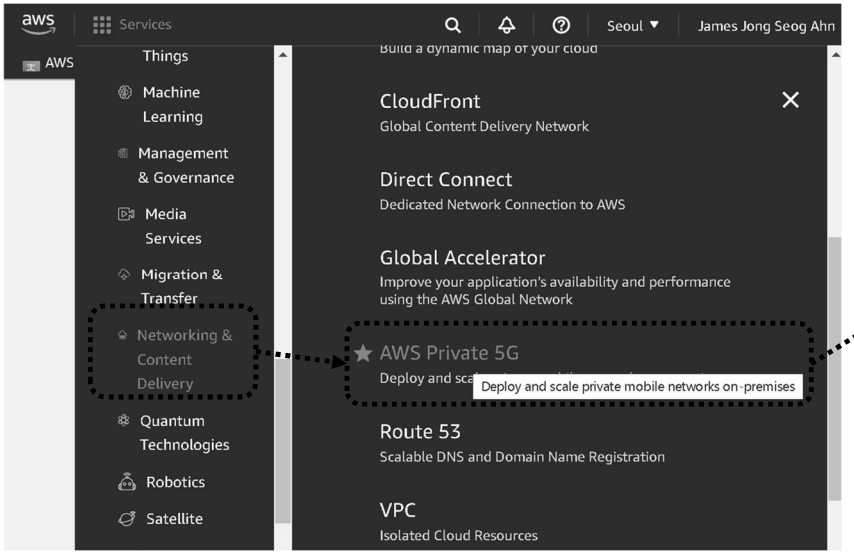
Source: https://telecominfraproject.com/open-core-network/

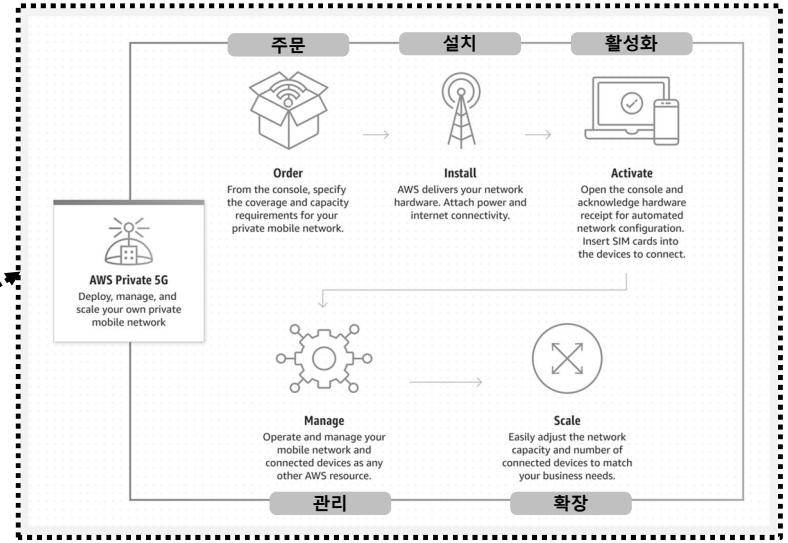
1일차. 'MSA와 5G 네트워크'

❖ 아마존 AWS Private 5G 서비스

- **AWS가 신청 기업으로 AWS Private 5G망 세트를 배송 (3개의 선택 옵션 제공)**

1) 5G 코어 UPF는 기업내, Control Plane(AMF, SMF,...)은 AWS 클라우드(Region 또는 Local Zone)
2) 기업내에는 RU만 두고 나머지는 모두 AWS 클라우드에 두는 경우
3) 5G망 Full Set를 기업내에 설치



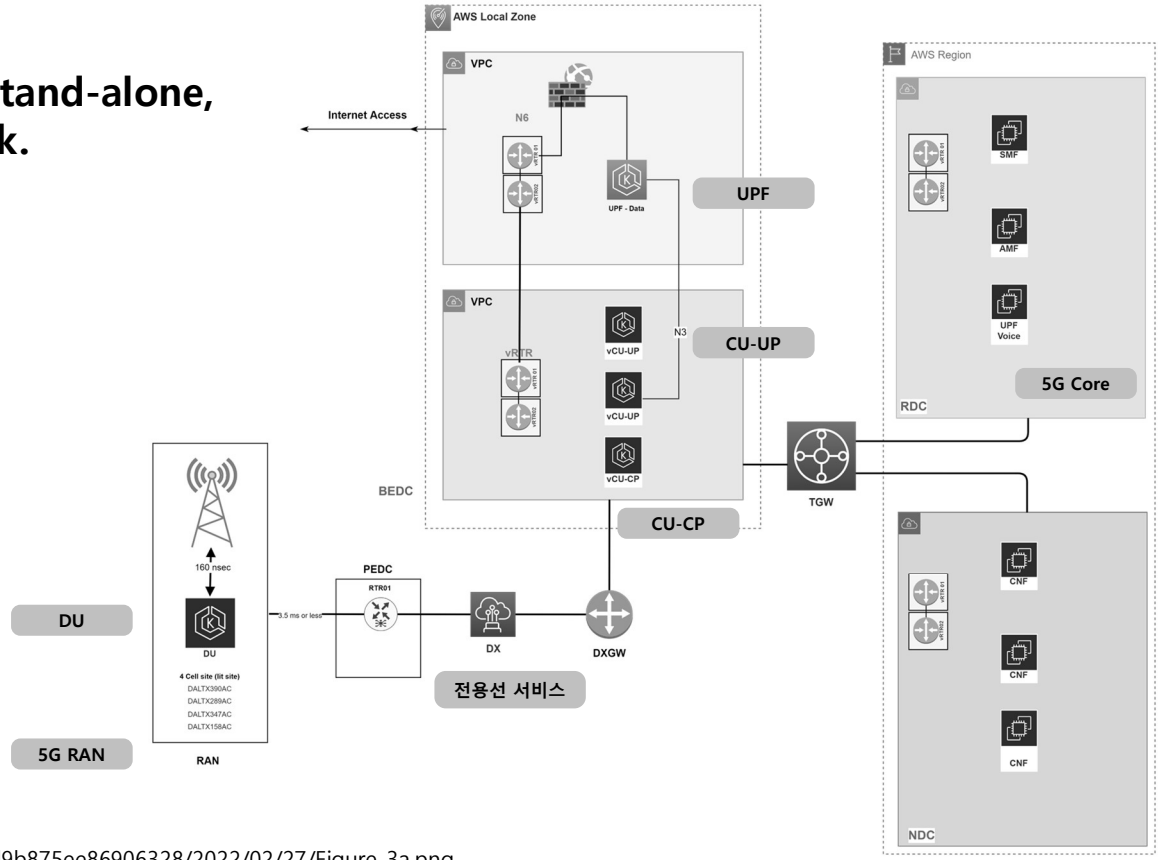


Source: https://ap-northeast-2.console.aws.amazon.com/console/home?region=ap-northeast-2#

1일차. 'MSA와 5G 네트워크'

❖ **Deploying DISH's 5G Network in AWS Cloud**

- **AWS의 RAN 연계**
- **DISH Network is deploying the first stand-alone, cloud-native, autonomous 5G network.**



Source: https://d2908q01vomqb2.cloudfront.net/c5b76da3e608d34edb07244cd9b875ee86906328/2022/02/27/Figure-3a.png

1일차. 'MSA와 5G 네트워크'

❖ 아마존 AWS Private 5G 서비스 Price

- **Example 1: IoT devices in a manufacturing facility**

	Cost calculation	Total cost
AWS Private 5G radio unit	1 x $7,200 x 2	$14,400
Data transfer intra-Region	13 GB x $0.02 x 2	$0.52
	60-day cost	**$14,400.52**

- **Example 2: Video streaming from security cameras at a construction site**

	Cost calculation	Total cost
AWS Private 5G radio unit	1 x $7,200 x 2	$14,400
	60-day cost	**$14,400**

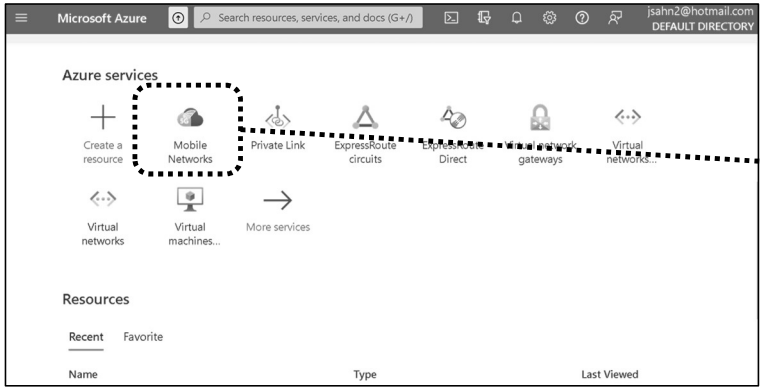
- **Example 3: Higher education campus—Outdoor coverage for staff**

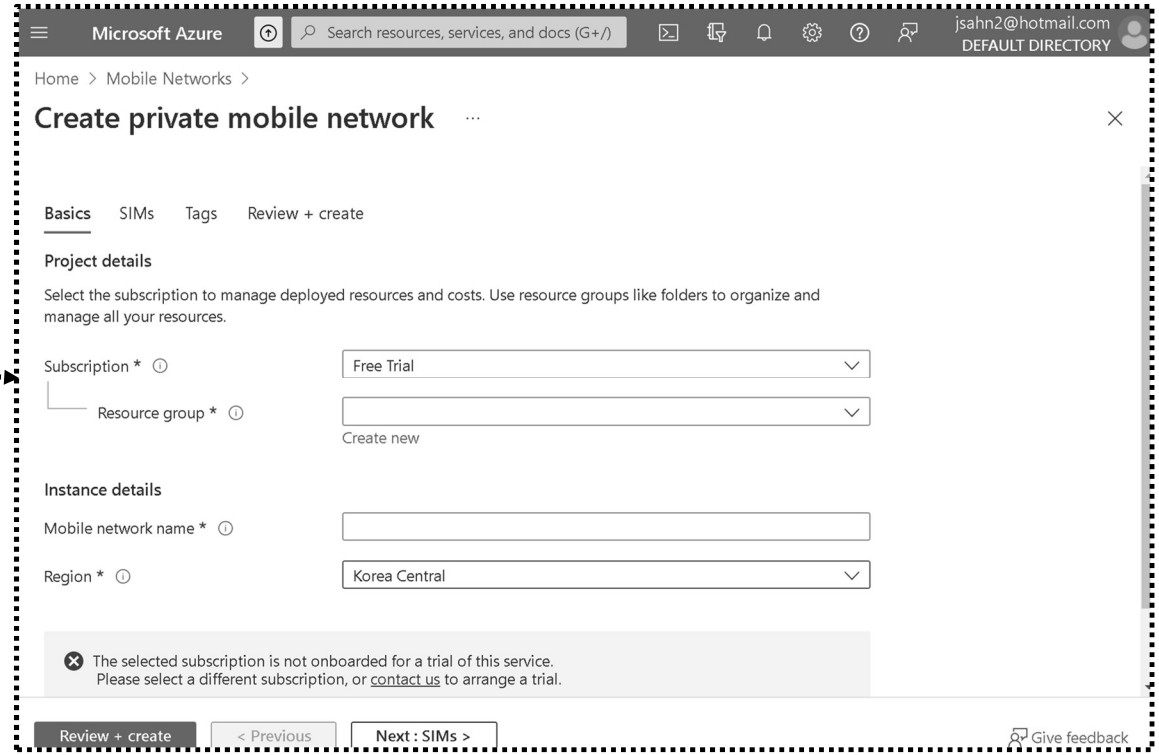
	Cost calculation	Total cost
AWS Private 5G radio unit	1 x $7,200 x 2	$14,400
Data transfer out, under the global monthly AWS Free Tier	100 GB x $0.00 x 2	$0
Data transfer out to web services and to tablets	2,760 GB x $0.09 x 2	$496.80
	60-day cost	**$14,896.80**

Source: https://ap-northeast-2.console.aws.amazon.com/console/home?region=ap-northeast-2#

1일차. ‘MSA와 5G 네트워크’

❖ 마이크로소프트 Azure ‘private mobile network’

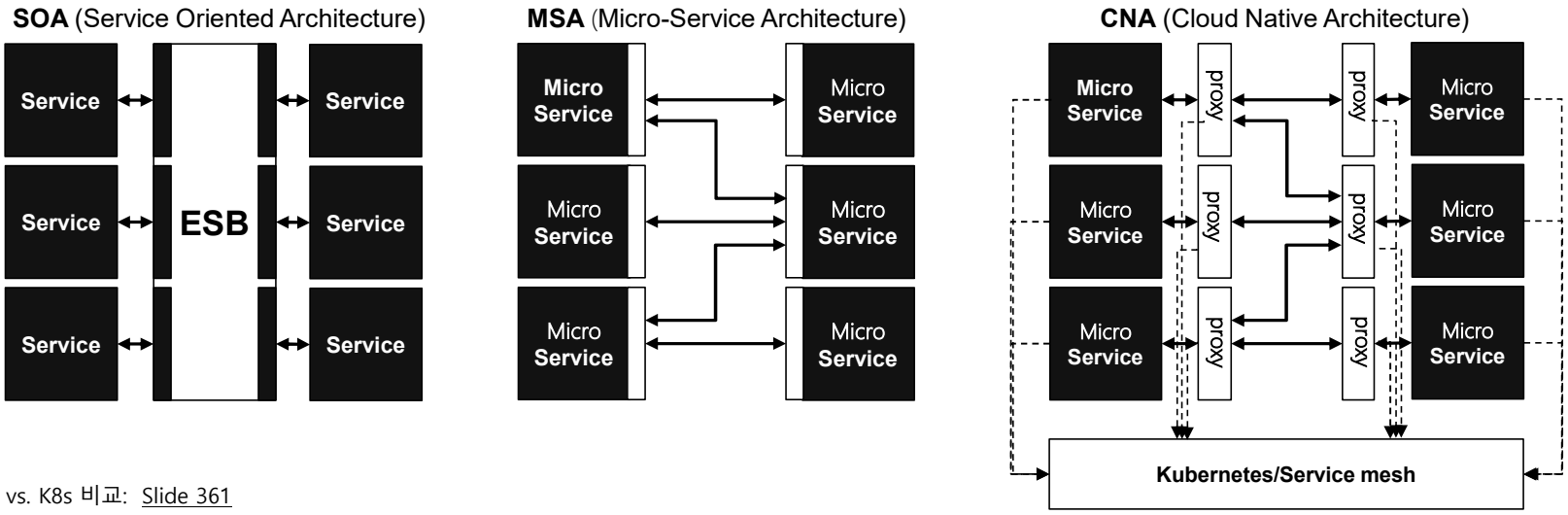




Source: https://portal.azure.com/#view/HubsExtension/BrowseResource/resourceType/Microsoft.MobileNetwork%2FmobileNetworks

1일차. 'MSA와 5G 네트워크'

- ❖ Service Oriented Architecture (SOA)
- ❖ Microservice architectures (MSA)
- ❖ Cloud Native Architecture (CNA) Microservice Based Architecture



Spring Cloud vs. K8s 비교: Slide 361

1일차. 'MSA와 5G 네트워크'

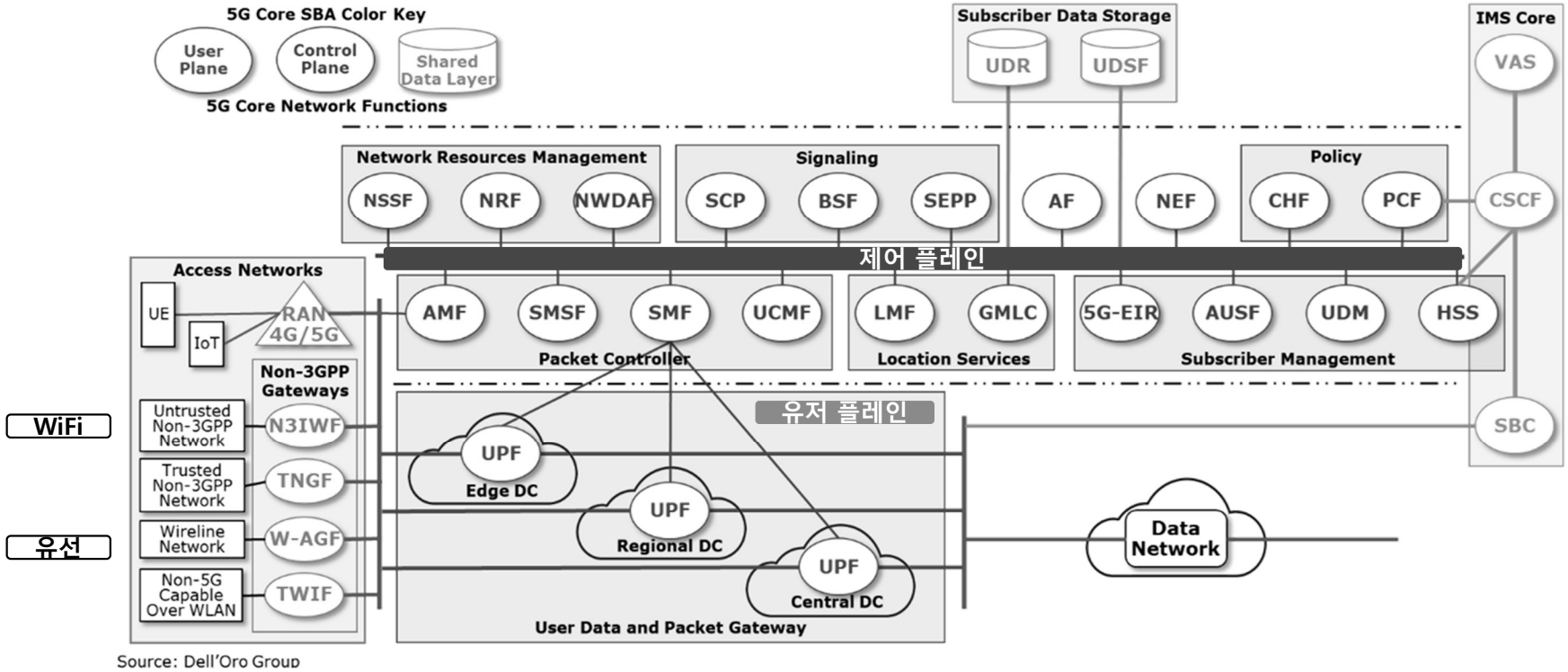
❖ **Comparing SOA, microservices, SBA and monolithic architecture.**

Architecture / Criterion	SOA	µ-service architecture	SBA	Monolithic
Agility	Low	High	Medium	Low
Deployment	Low	High	Medium	Low
Testability	Low	High	Medium	Medium
Scalability	Medium	High	Medium	Low
Performance	Low	Medium	Medium	High
Simplicity	Low	Medium	Medium	High

Source: Comparing SOA, microservices, SBA and monolithic architecture. Source: 5G-PPP 2018, table
Source: https://devopedia.org/5g-service-based-architecture

1일차. 'MSA와 5G 네트워크'

❖ **5G System with 5G Core Service Based Architecture(SBA) + IMS Core**

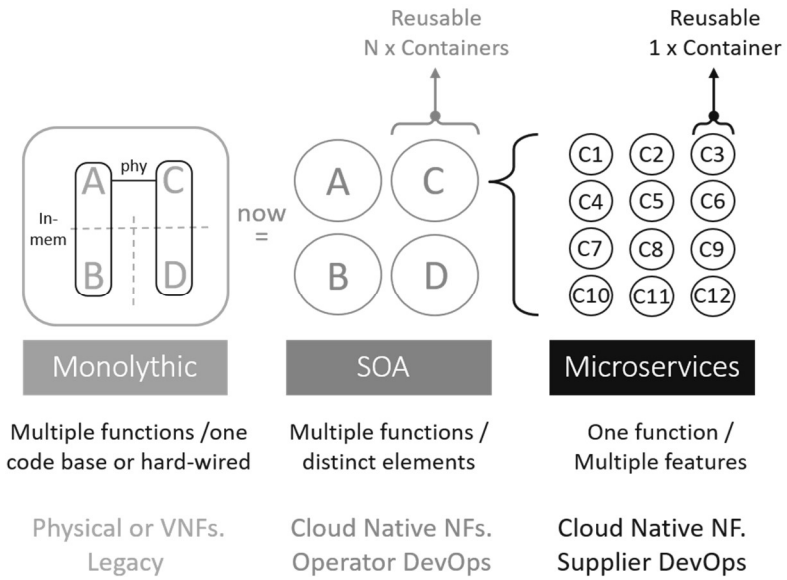


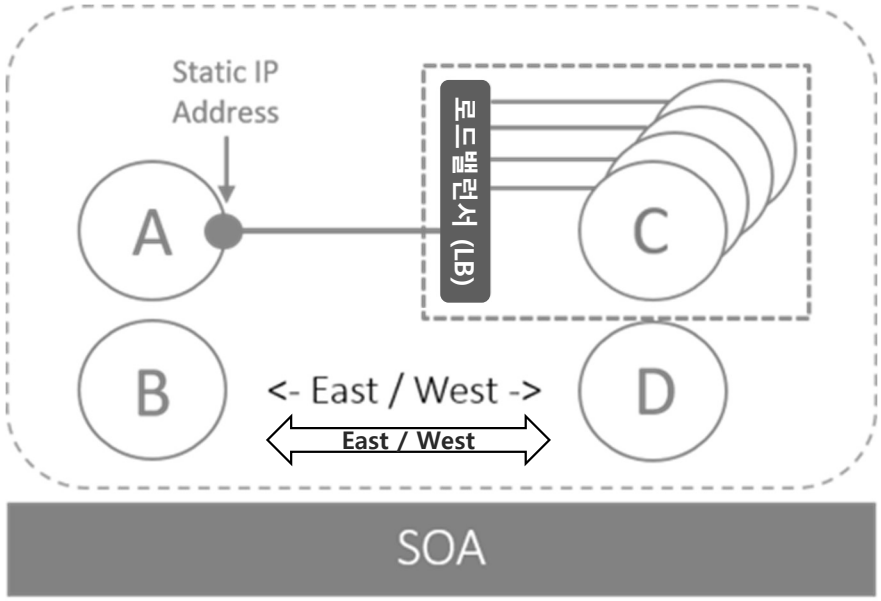
Source: https://www.delloro.com/5g-core-are-we-ready/

1일차. 'MSA와 5G 네트워크'

❖ 제조사 (예): Metaswitch

- 5G Caught Up in a Service Mesh
- Service Oriented Architectures



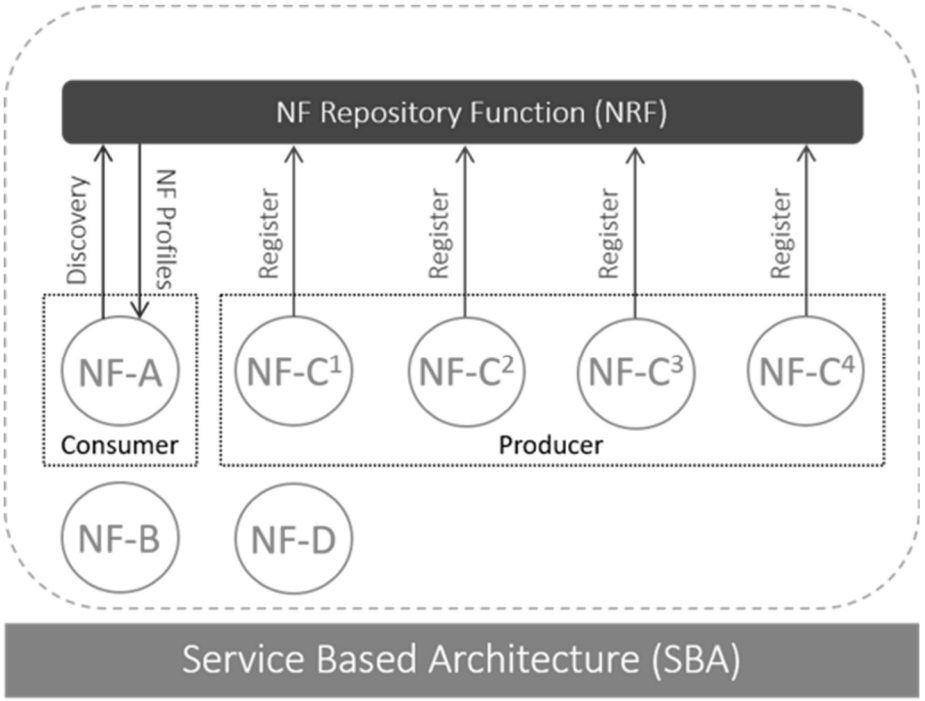


Source: https://www.metaswitch.com/blog/the-service-communication-proxy-5g-caught-up-in-a-service-mesh

1일차. ‘MSA와 5G 네트워크’

❖ 제조사 (예): Metaswitch

- The NRF meets the requirement of our macro SOA controller in the 5G SBA

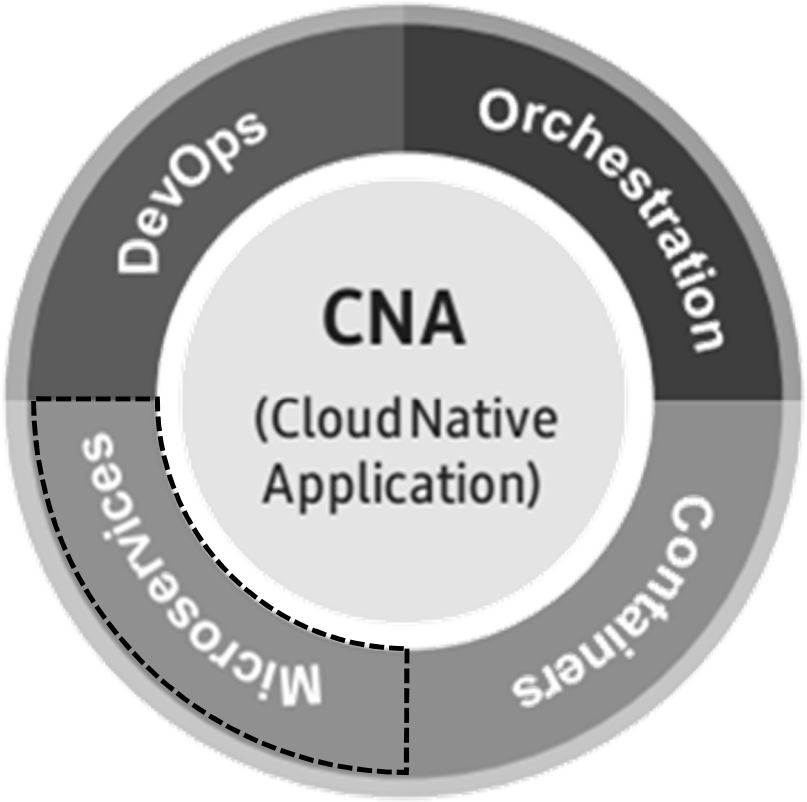


Source: https://www.metaswitch.com/blog/the-service-communication-proxy-5g-caught-up-in-a-service-mesh

1일차. 'MSA와 5G 네트워크'

❖ 5G Cloud Native

- DevOps
- Microservices
- Containers
- Orchestration



** Check 'KubeVirt'
Source: Cloud-Native Application, Source: Samsung
Source: https://moniem-tech.com/2021/06/24/what-does-5g-cloud-native-means/

1일차. 'MSA와 5G 네트워크'

❖ Transitioning From 5G To 6G

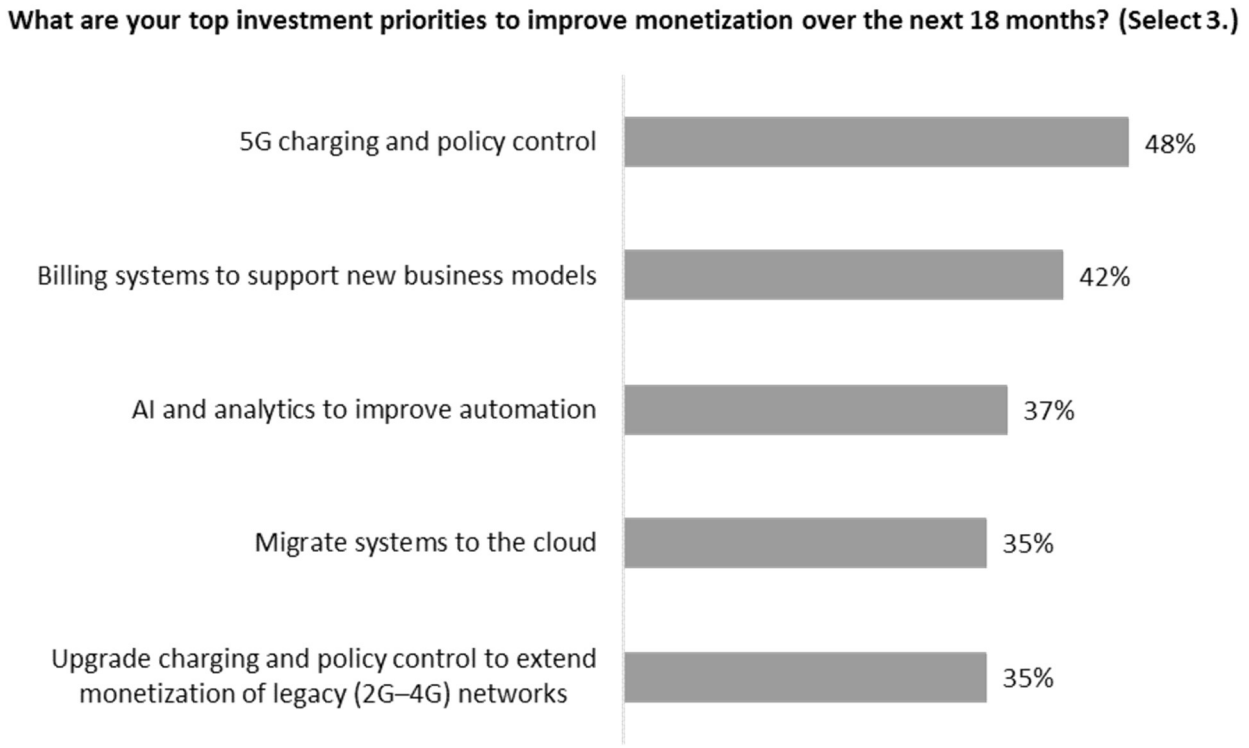
Past 10 years (Central Cloud)	Next 10 years (Decentralization driven by Distributed cloud)
Applications: Monolithic	**Microservices**
Application Migration: On-Prem to Central Cloud	Applications distributed across multi-cloud or micro-DCs
Applications: Non-real time	**ultra-low latency** Applications
Centralized Hyperconverged Infrastructure **(HCI)**	**Decentralized** Converged Infrastructure driven by integrated connectivity, compute and storage
Cloud: Siloed (Migration is not seamless)	**Multi-Cloud** (Seamless Applications migration)
Centralized AI/ML algorithms for training and inference	**Distributed**, federated, coordinated real time explainable systems (for decentralized training and inference)
Traditional Software Release mgmt.,	Automated Software Release Mgmt with DevOps and CI/CD
VM Based (little of Container)	Container based, Serverless
Fragmented orchestration systems & Siloed Clouds	**Kubernetes for multi-cloud** (Telco, Enterprise and public cloud)
Event, Static Management driven	Data driven, Autonomic Services Management

NOVEMBER 10TH, 2022 - BY: PAUL MCLELLAN

Source: https://semiengineering.com/edps-transitioning-from-5g-to-6g/

1일차. 'MSA와 5G 네트워크'

❖ Telco BSS priorities



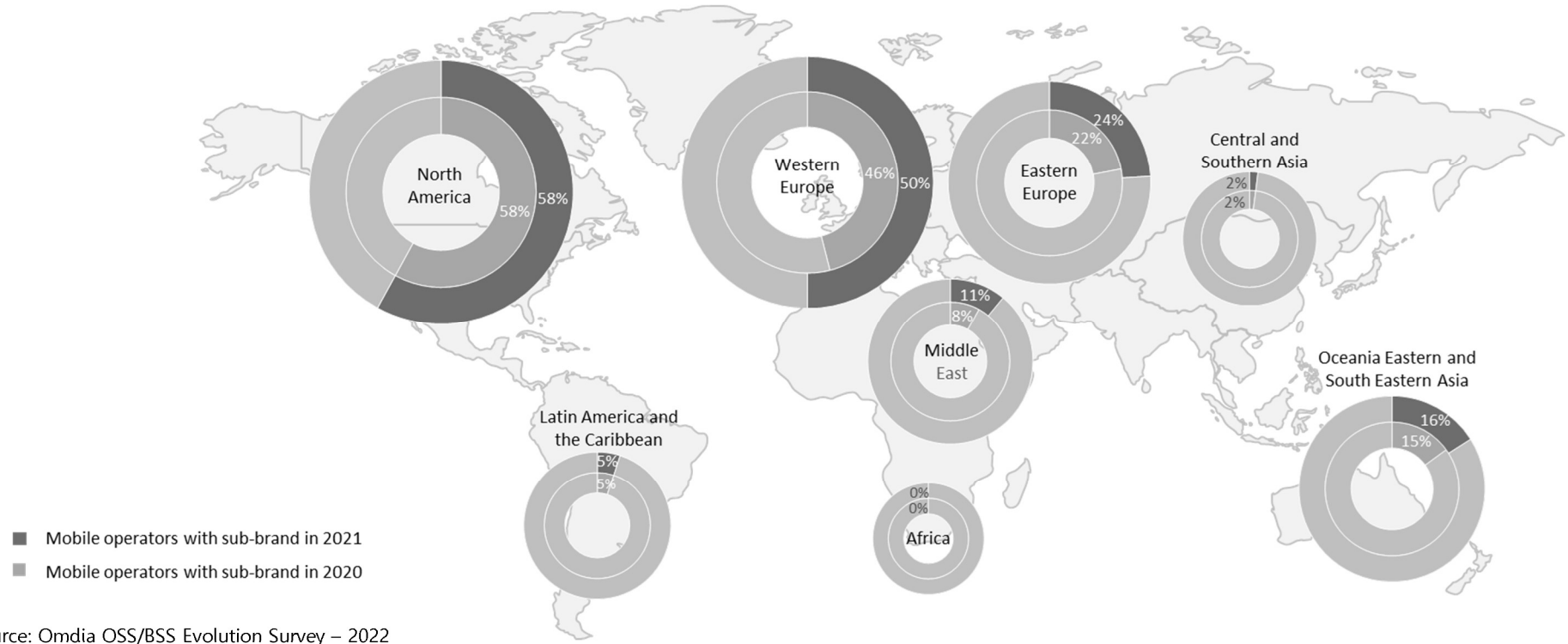
BSS (Business Support System): 비즈니스 지원 시스템의 줄임말인 BSS는 통신 조직이 모든 고객 대면 활동을 관리하고 간소화하는 데 도움이 되는 다양한 소프트웨어 프로그램

Source: Source: Omdia OSS/BSS Evolution Survey – 2022
Source: https://www.oracle.com/a/ocom/docs/corporate/analystrelations/technology-analysis-converged-charging-in-5g.pdf

1일차. 'MSA와 5G 네트워크'

❖ **Adoption of sub-brands by MNOs around the world**

- **target specific consumer and enterprise segments**

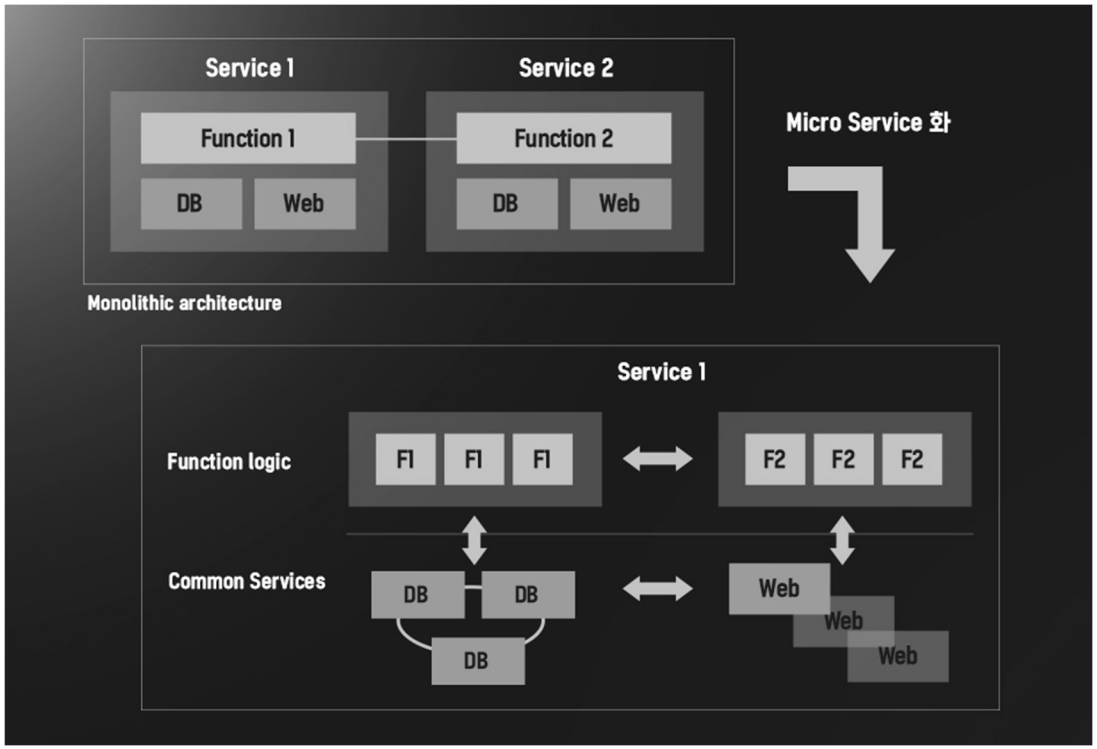


Source: Source: Omdia OSS/BSS Evolution Survey – 2022
Source: https://www.oracle.com/a/ocom/docs/corporate/analystrelations/technology-analysis-converged-charging-in-5g.pdf

1일차. 'MSA와 5G 네트워크'

❖ 5G 인프라와 마이크로 서비스 아키텍처

- Function(임의의 기능)/DB/Web 기능이 하나의 모듈에 들어가 있는 모노리틱 아키텍처를 MSA화

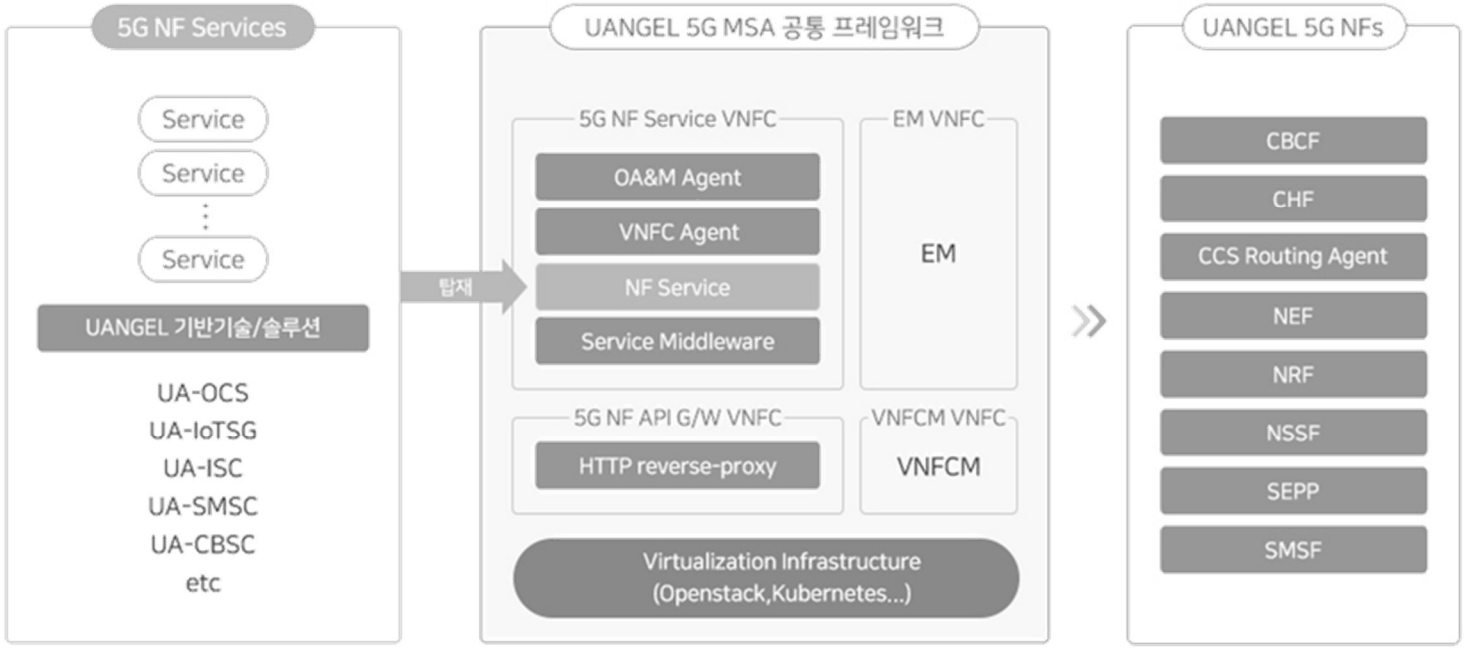


Source: https://news.sktelecom.com/112011

1일차. 'MSA와 5G 네트워크'

❖ **5G 코어 네트워크의 Micro Service Architecture(MSA) 개발(예)**

- **유엔젤: Service-Based Architecture(SBA)와 Micro Service Architecture(MSA) 최적화 개발, 오픈소스들을 활용, 서비스 개발 환경인 CI/CD 환경 구축을 통해 Cloud Native 구조**



Source: http://www.uangel.com/kr/index.php/products/5g/5g-core/

1일차. ‘MSA와 5G 네트워크’

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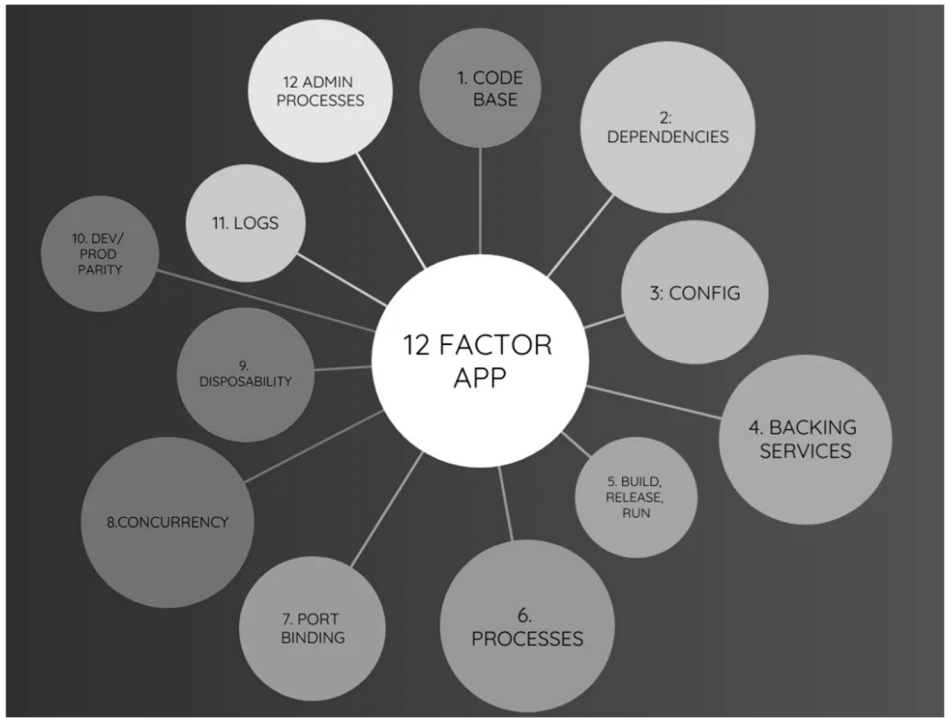

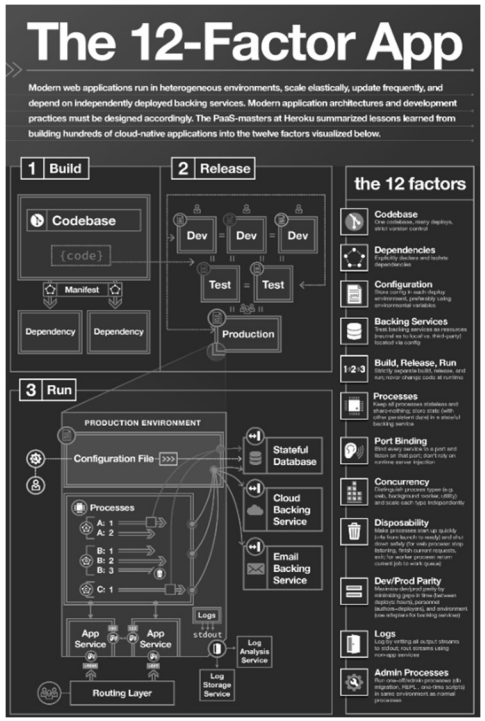

Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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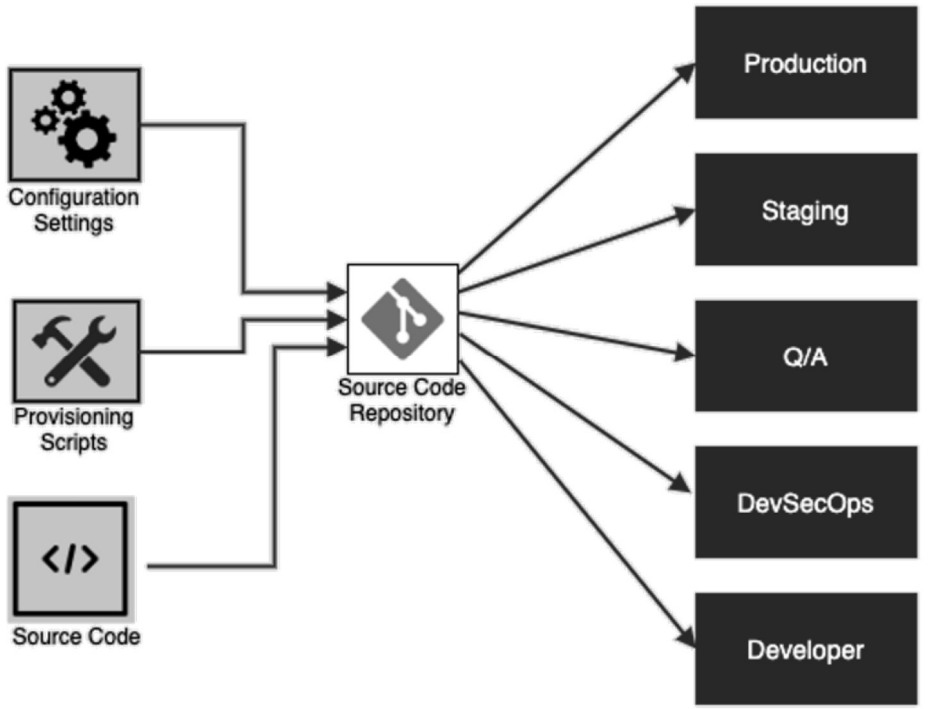

Source: https://www.redhat.com/architect/sites/default/files/styles/embed_large/public/2021-02/codebase.png?itok=hOd-QvBN
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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Makes use of...

```
<dependencies>
    <!-- Provided dependencies -->
    <dependency>
        <groupId>jakarta.platform</groupId>
        <artifactId>jakarta.jakartaee-api</artifactId>
        <version>8.0.0</version>
        <scope>provided</scope>
    </dependency>
    <dependency>
        <groupId>org.eclipse.microprofile</groupId>
        <artifactId>microprofile</artifactId>
        <version>4.0.1</version>
        <type>pom</type>
        <scope>provided</scope>
    </dependency>
    <!-- For tests -->
    <dependency>
        <groupId>org.junit.jupiter</groupId>
        <artifactId>junit-jupiter</artifactId>
        <version>5.7.1</version>
        <scope>test</scope>
    </dependency>
```

Source: https://developer.ibm.com/developer/default/articles/creating-a-12-factor-application-with-open-liberty/images/images02.png
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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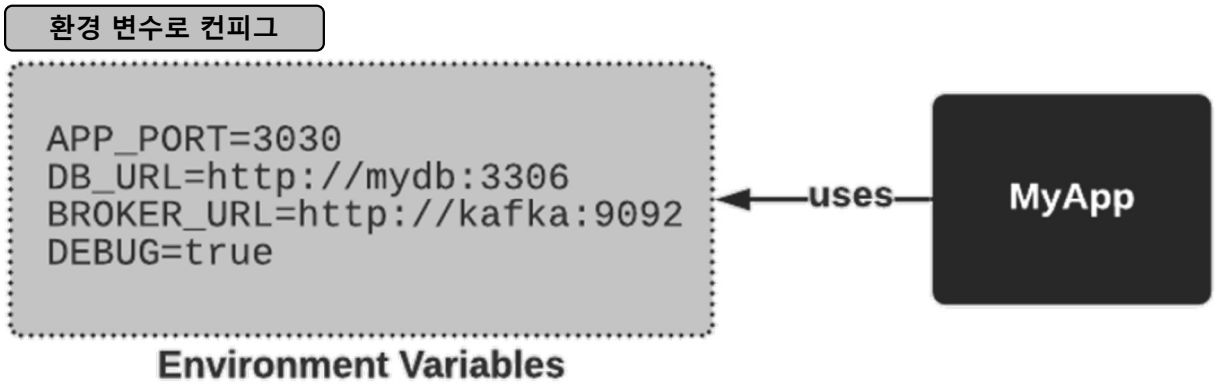

Source: https://www.redhat.com/architect/sites/default/files/styles/embed_large/public/2021-02/config.png?itok=BmjfdjDH
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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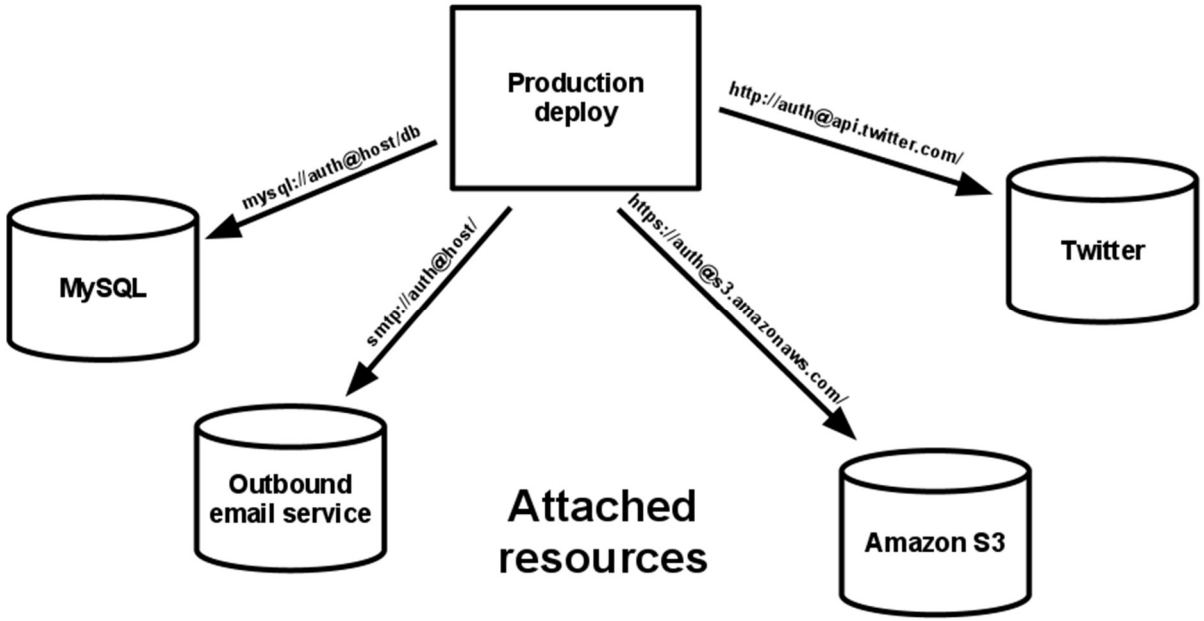

Source: https://12factor.net/images/attached-resources.png
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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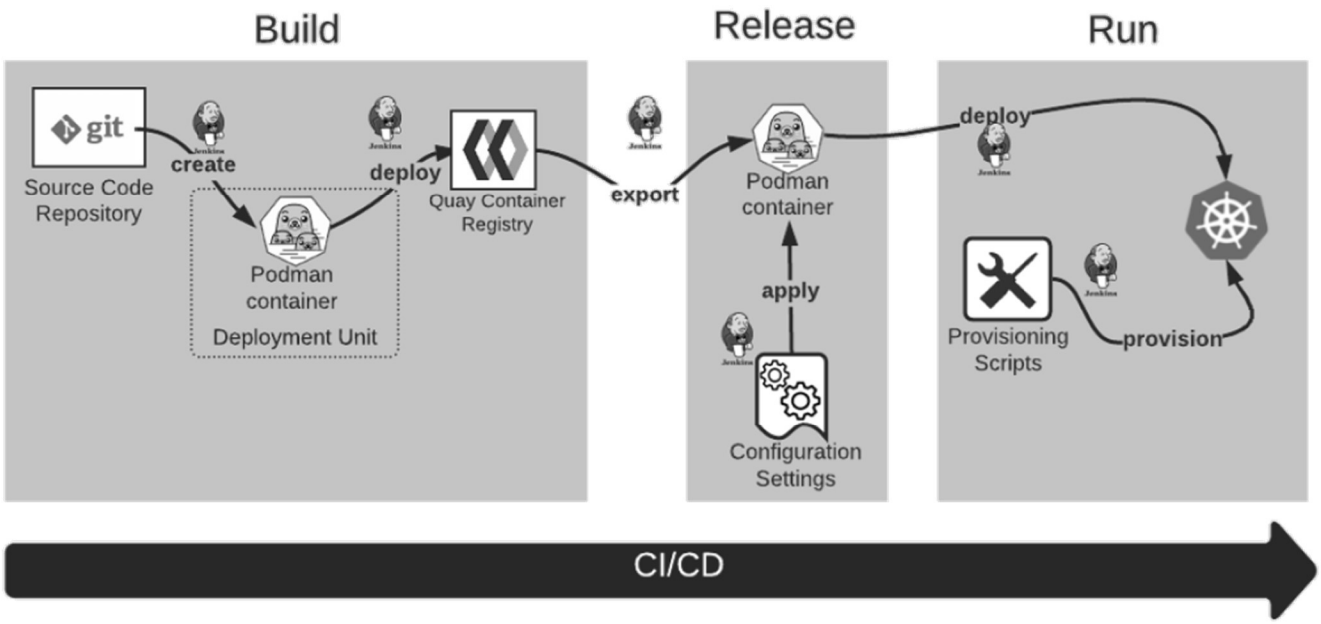

Source: https://www.redhat.com/architect/sites/default/files/styles/embed_large/public/2021-02/buildreleaserun.png?itok=tU10QwgC
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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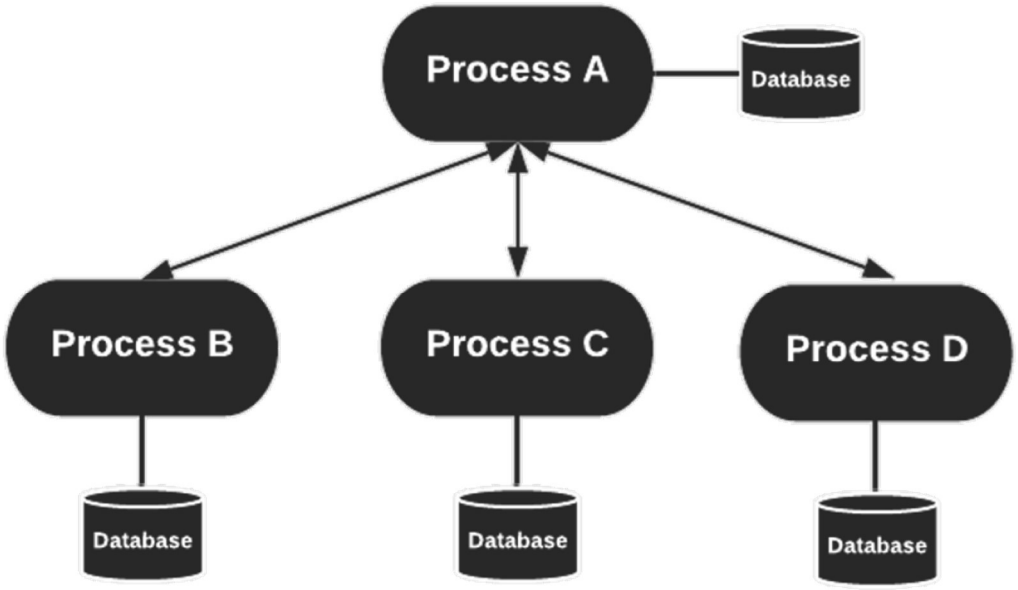

Source: https://www.redhat.com/architect/sites/default/files/styles/embed_large/public/2021-02/process.png?itok=sKKO87wh
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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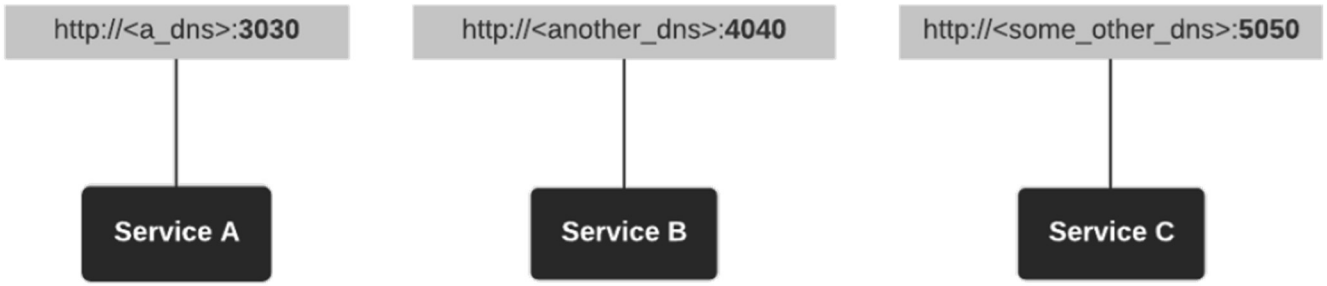

Source: https://www.redhat.com/architect/sites/default/files/styles/embed_large/public/2021-02/portbindings.png?itok=d8Le0wh-
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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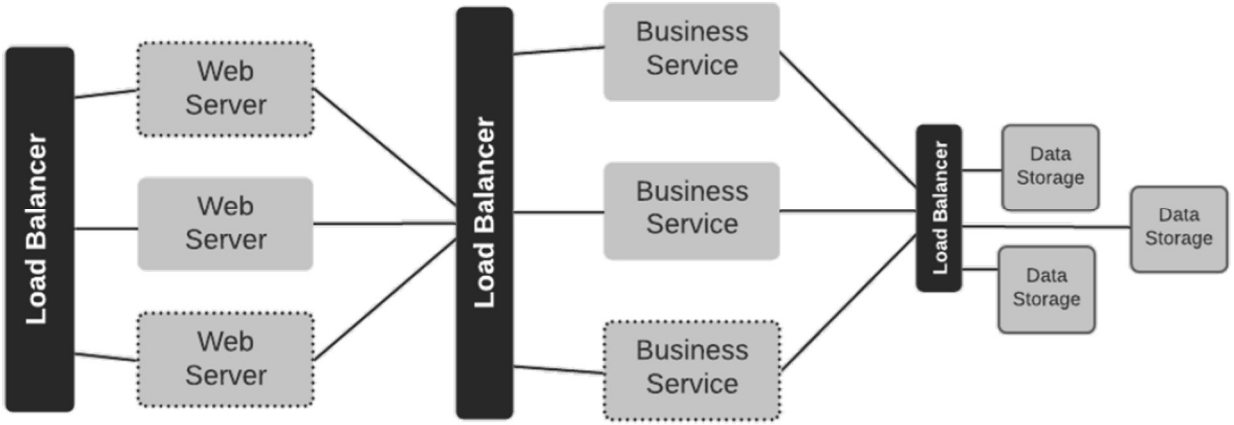

Source: https://www.redhat.com/architect/sites/default/files/styles/embed_large/public/2021-02/concurrancy.png?itok=aqNxheba
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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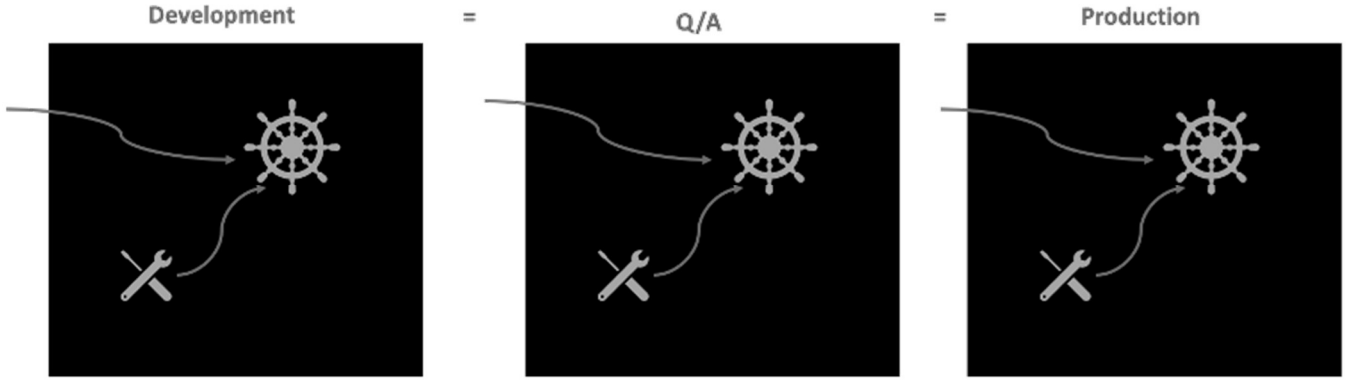

Source: https://developer.ibm.com/developer/default/articles/creating-a-12-factor-application-with-open-liberty/images/image10.png
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

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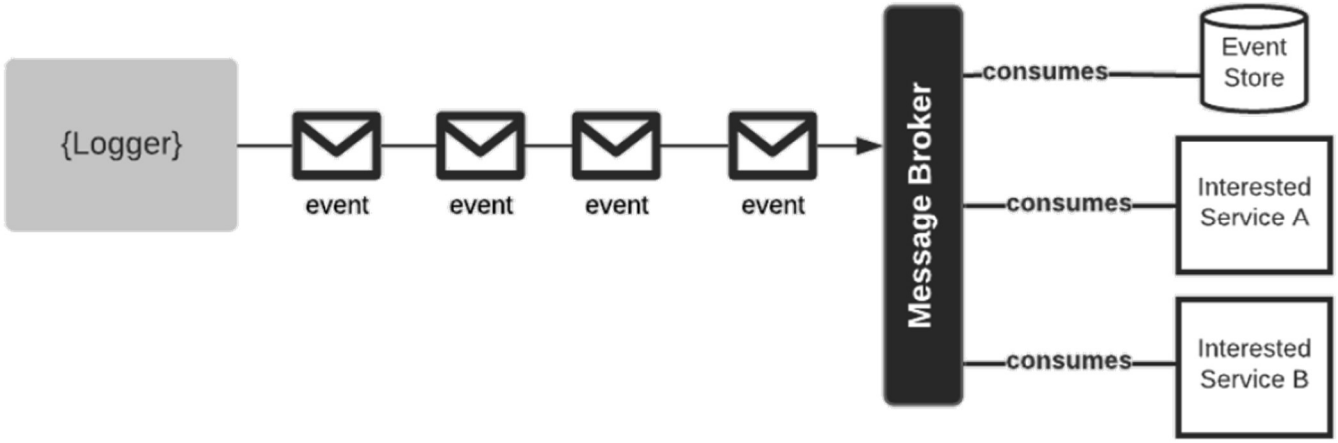
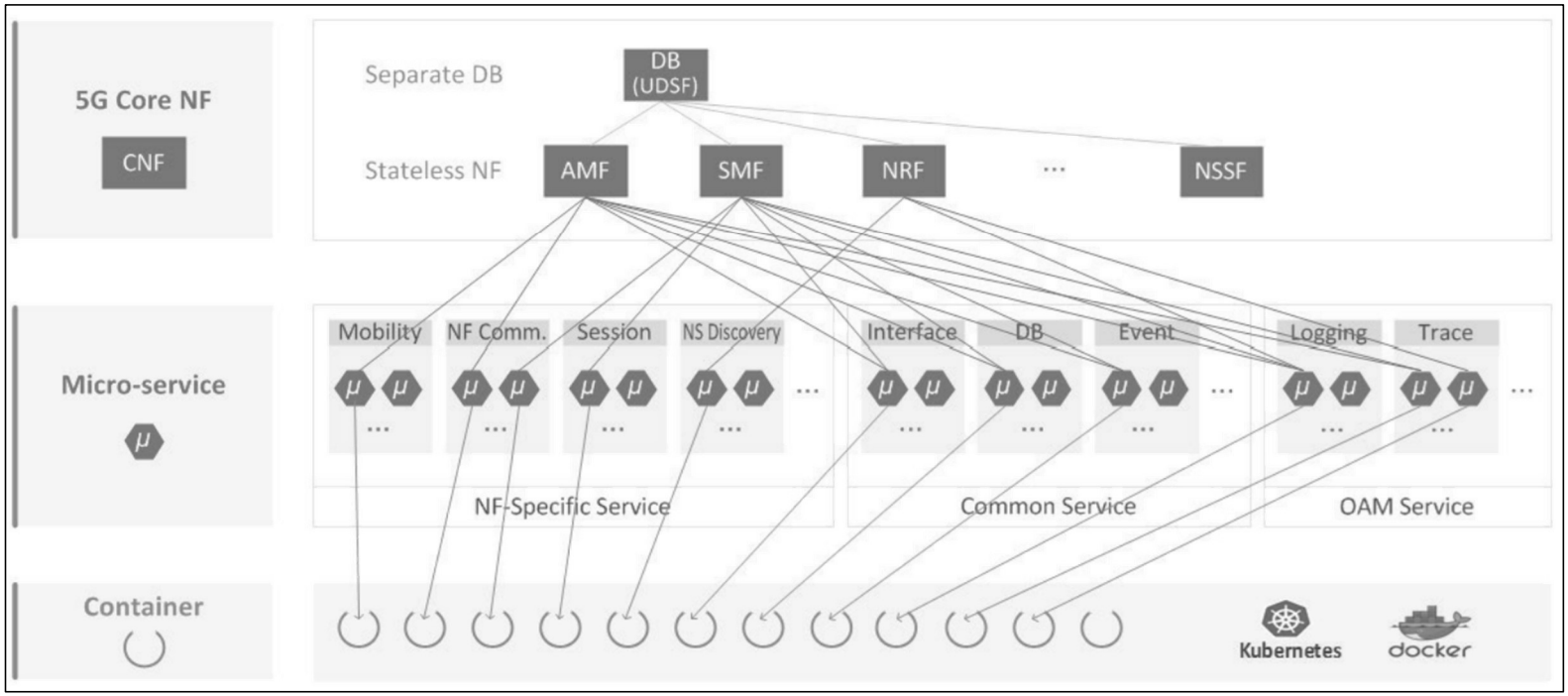


Source: https://developer.ibm.com/developer/default/articles/creating-a-12-factor-application-with-open-liberty/images/image10.png
Source: https://medium.com/javarevisited/do-you-know-about-the-12-factor-app-in-microservices-architecture-50bd34551bd8

1일차. 'MSA와 5G 네트워크'

❖ 제조사 (예): Cloud Native Architecture

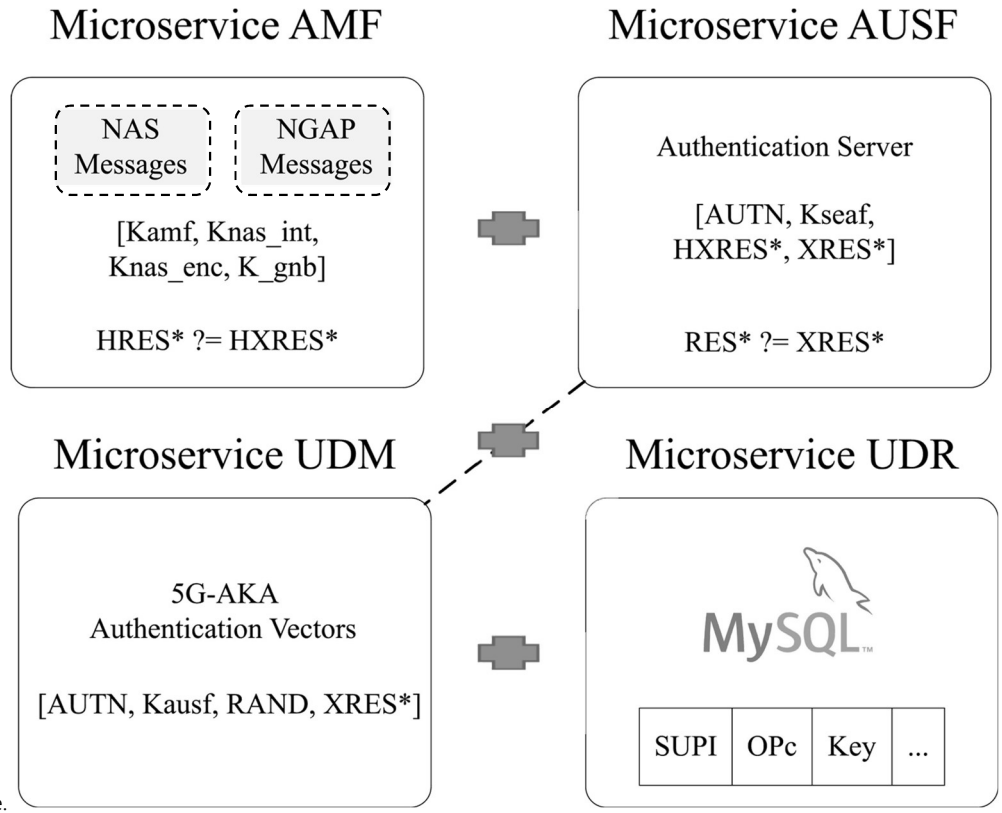
- **Samsung 5G Core: Cloud Native Architecture**



Source: https://images.samsung.com/is/content/samsung/p5/global/business/networks/insights/white-paper/5g-core-vision/5G-Core-Vision-Samsung-5G-Core-Vol.1.pdf

1일차. 'MSA와 5G 네트워크'

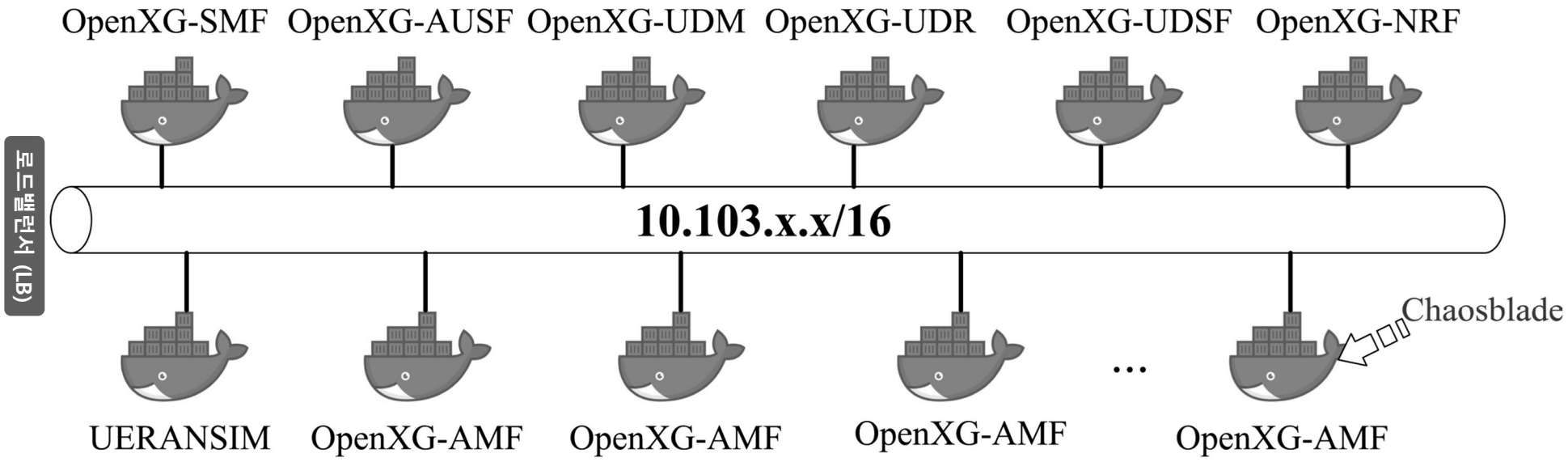
❖ **Function decoupling (complaint with 3GPP)**



The current monolithic OpenXG-AMF is decoupled into multiple microservices as depicted in the figure.
Source: https://www.sciencedirect.com/science/article/pii/S2352864822000815

1일차. ‘MSA와 5G 네트워크’

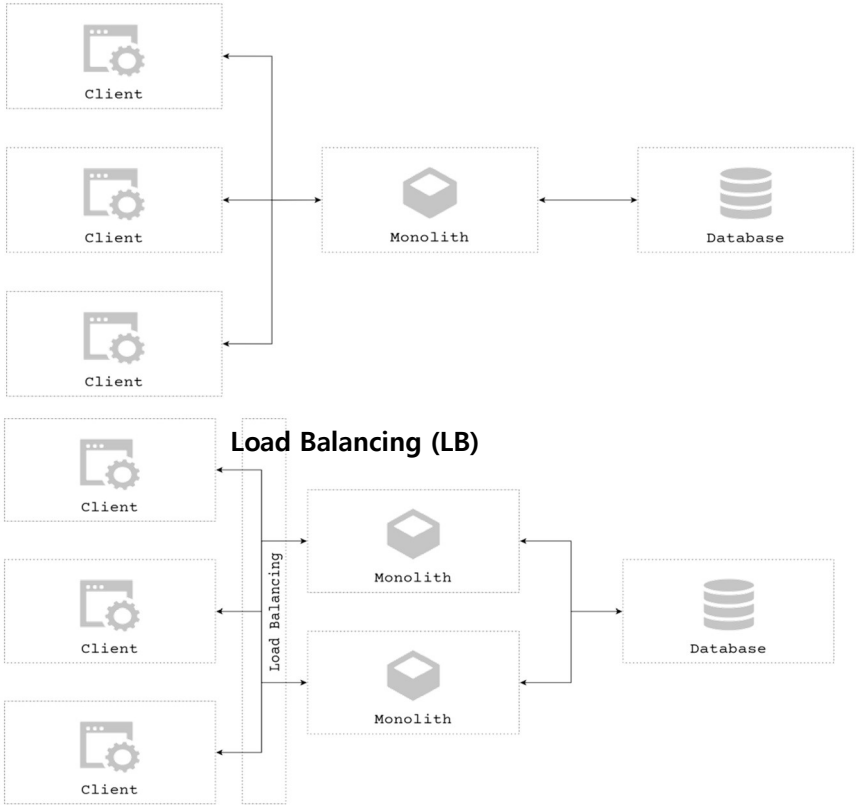
❖ **Experimental topology.**

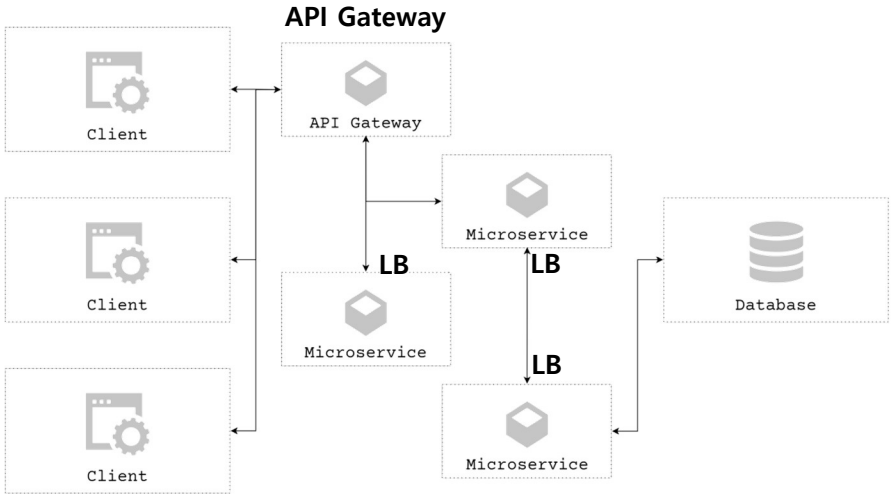


Source: https://www.sciencedirect.com/science/article/pii/S2352864822000815

1일차. 'MSA와 5G 네트워크'

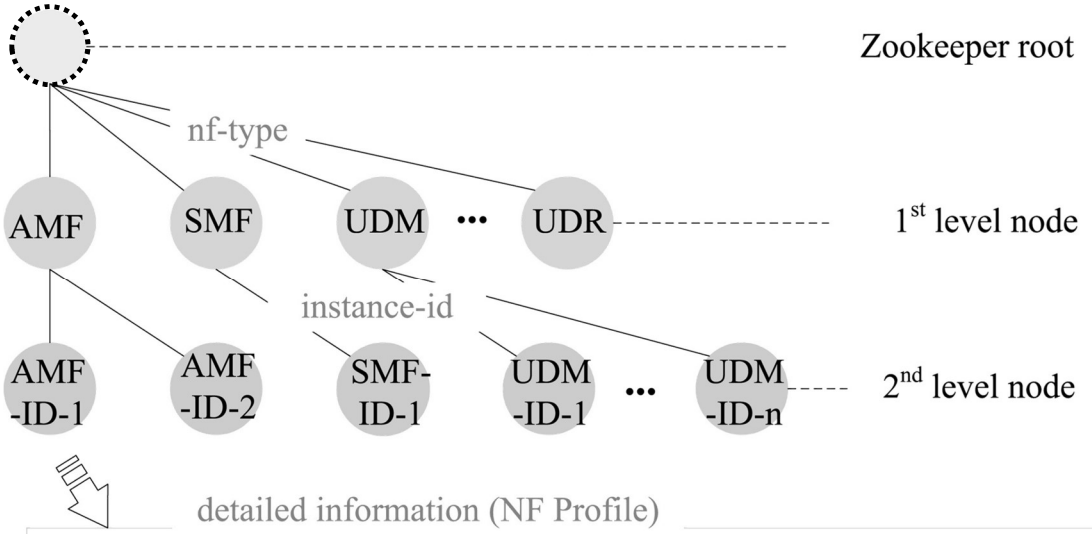
❖ **monolithic vs. monolithic with load balancing vs. microservices architecture.**





Source: https://www.mdpi.com/2071-1050/14/4/2173

❖ A tree-like data storage based on Zookeeper

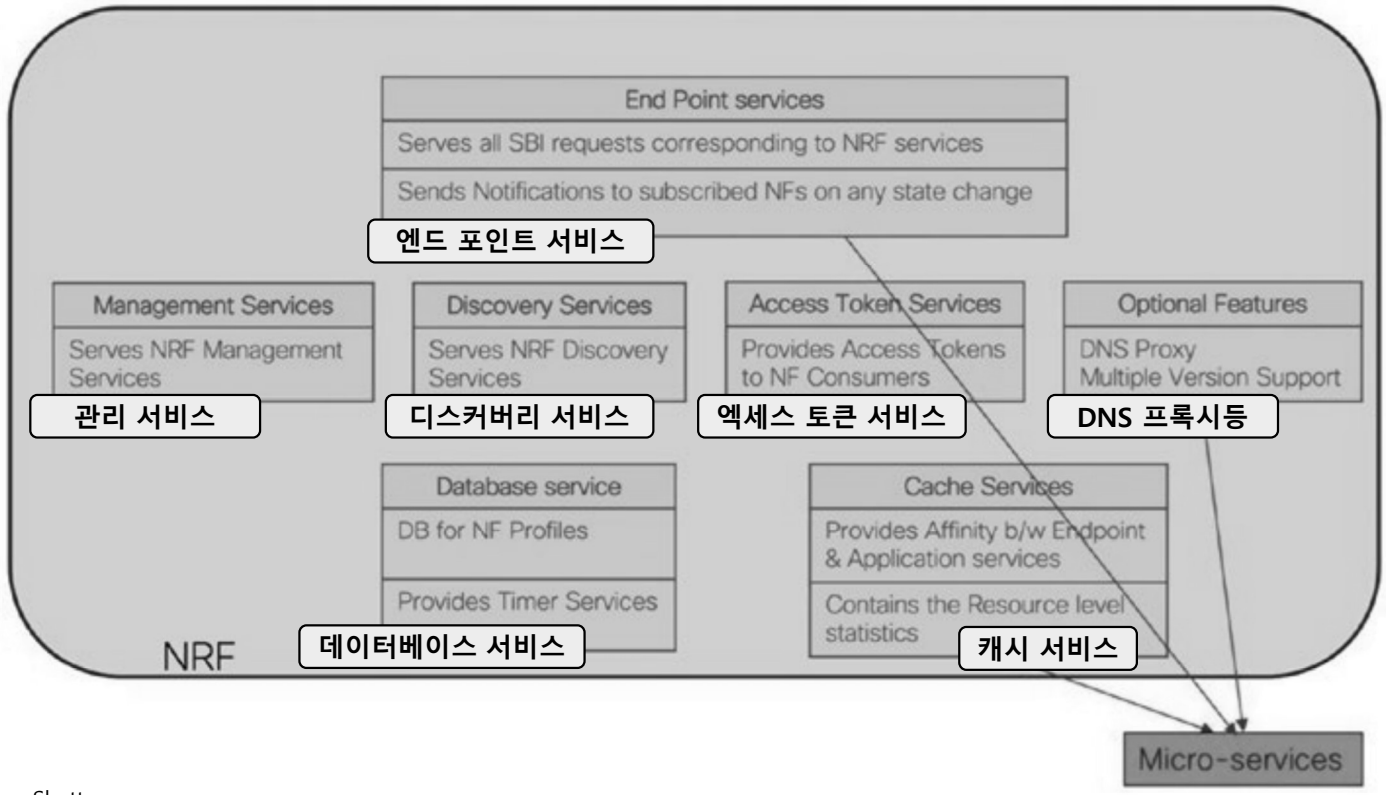


주키퍼(zookeeper)는 분산 애플리케이션을 위한 코디네이션 시스템이며, 안정적인 서비스를 할 수 있도록 분산되어 있는 각 애플리케이션의 정보를 중앙에 집중하고 구성 관리, 그룹 관리 네이밍, 동기화 등의 서비스를 제공 (경쟁 가능한 대체는?)

Source: https://www.sciencedirect.com/science/article/pii/S2352864822000815

1일차. 'MSA와 5G 네트워크'

❖ NRF 의 마이크로서비스(예) Bundling of microservices within an NRF



Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress

1일차. 'MSA와 5G 네트워크'

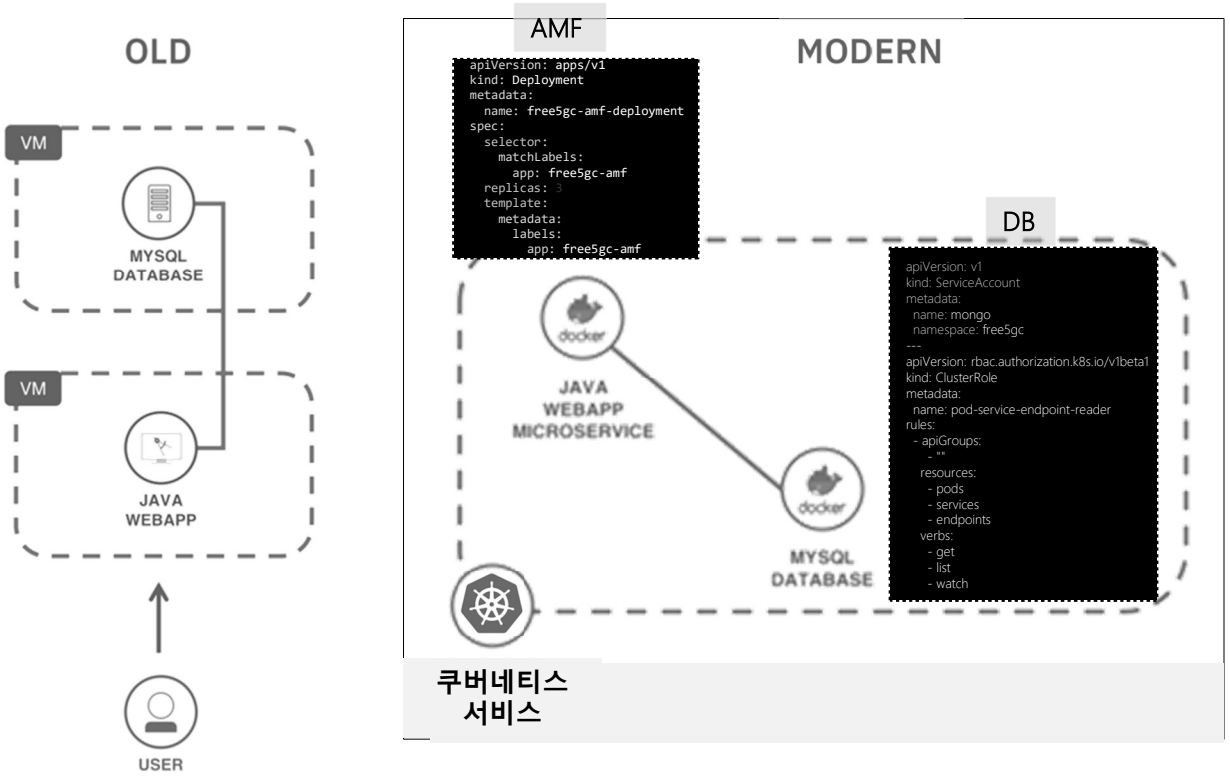
❖ **CSP(예): 클라우드 앱 현대화 방식 7가지**

- **Retire: 소명을 다한 앱은 그만 놓아주기**
- **Replace: 기존 앱을 SaaS, 상용, 혹은 오픈소스 앱으로 대체하기**
- **Relocate: 클라우드로 앱을 이전하기**
- **Replatform: 운영 가치가 있는 요소는 리플랫폼**
- **Reuse: 재사용-기존 앱의 데이터 모델, 서비스, API 등을 재사용**
- **Refactor: 리팩터링 - 기존 코드를 리팩토링해 성능, 보안, 유지보수 용이성을 개선**
- **Rebuild: 재구축 - 기능 개선, 결점 보완 혹은 기술적 부채 감축을 위해 모듈을 재구축**

Source: https://www.ciokorea.com/news/262720#csidx2c4c411f6f3346c829c9dbc37a8610b

1일차. 'MSA와 5G 네트워크'

❖ **Modern App (예)**



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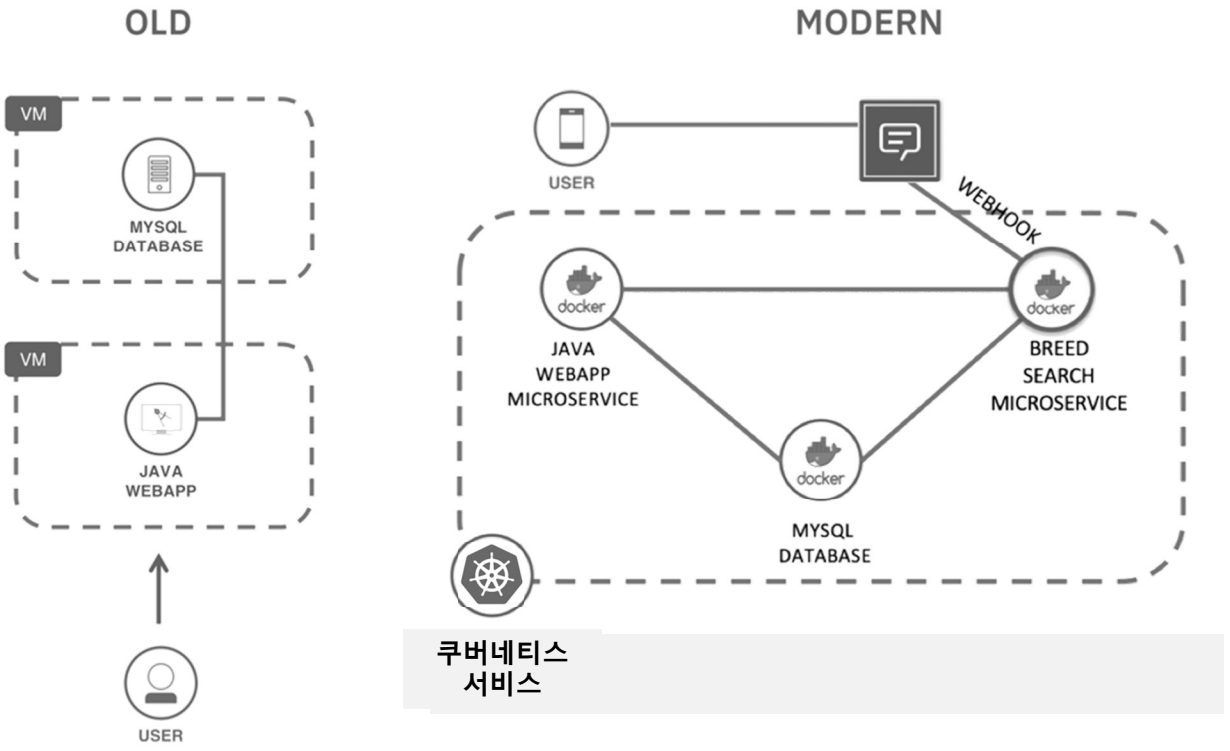
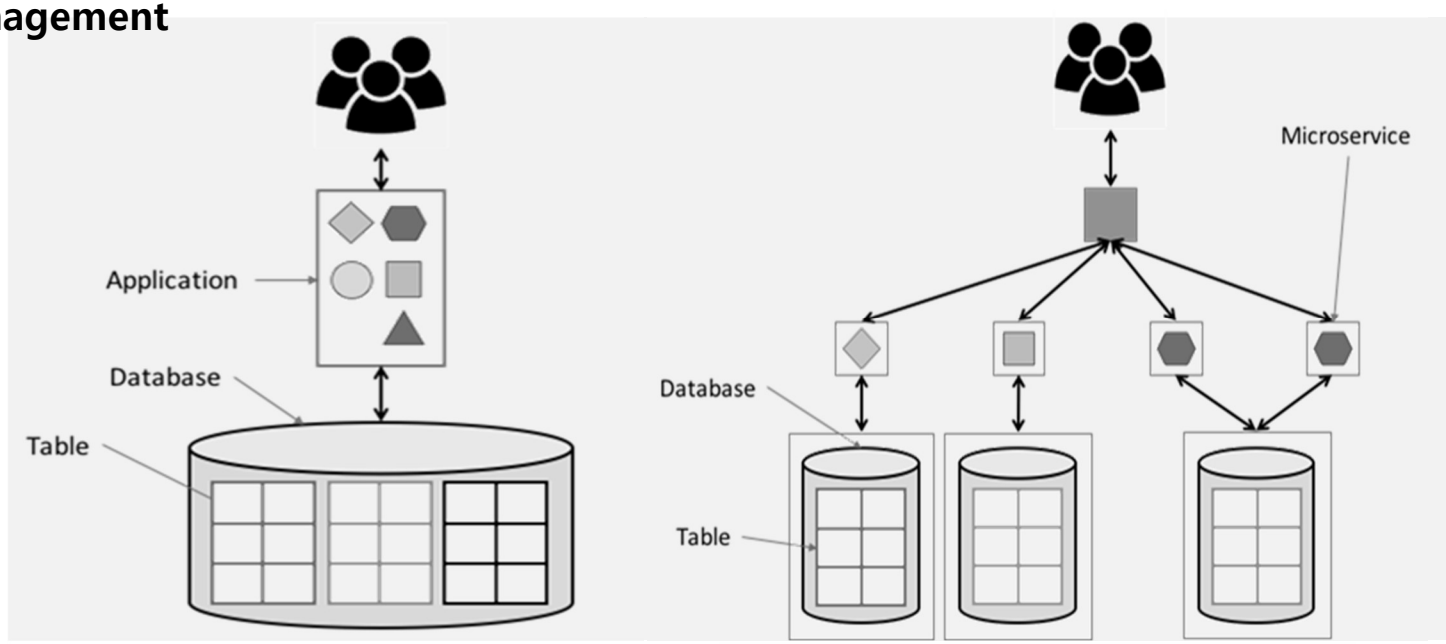
❖ **Modern App (예)**



❖ **Refactoring (from Monolithic Module to MSA)**

- **Decentralized business and messaging rules**
- **Decentralized governance**
- **Decentralized data management**

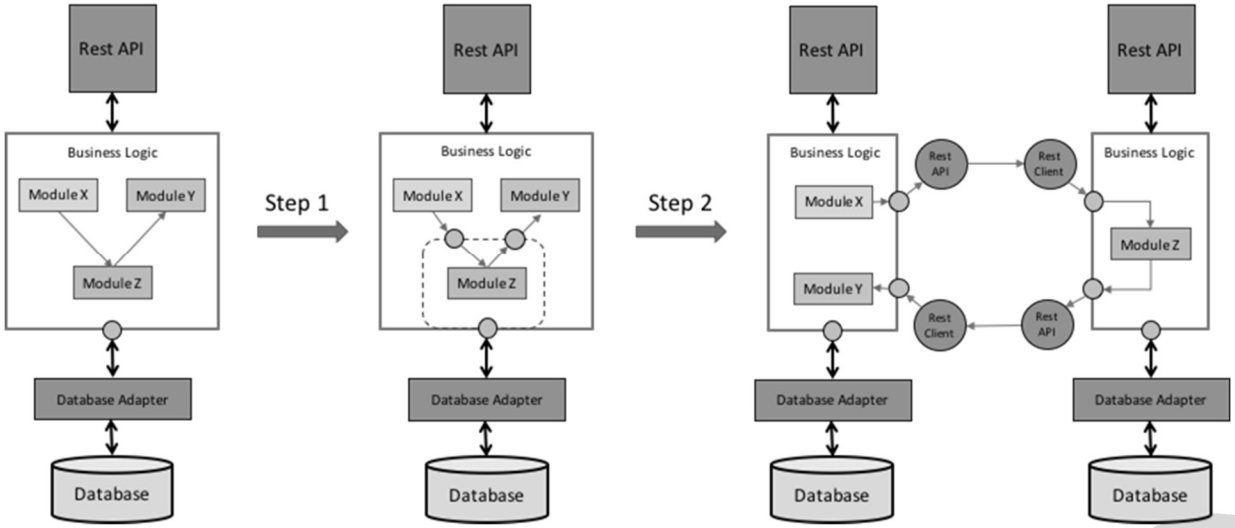


Monolithic Database *Microservices Distributed Database*

1일차. 'MSA와 5G 네트워크'

❖ Refactoring (from Monolithic Module to MSA)

- 서비스 모듈간 메시지 송수신 필요 (API 사용)



Source: https://haloworld.tistory.com/24 [Halo World]

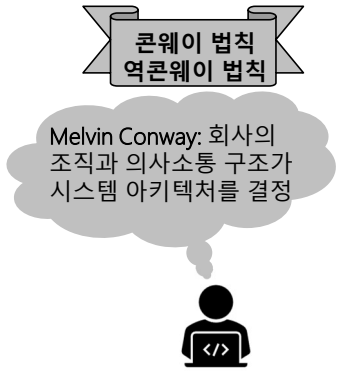
1일차. 'MSA와 5G 네트워크'

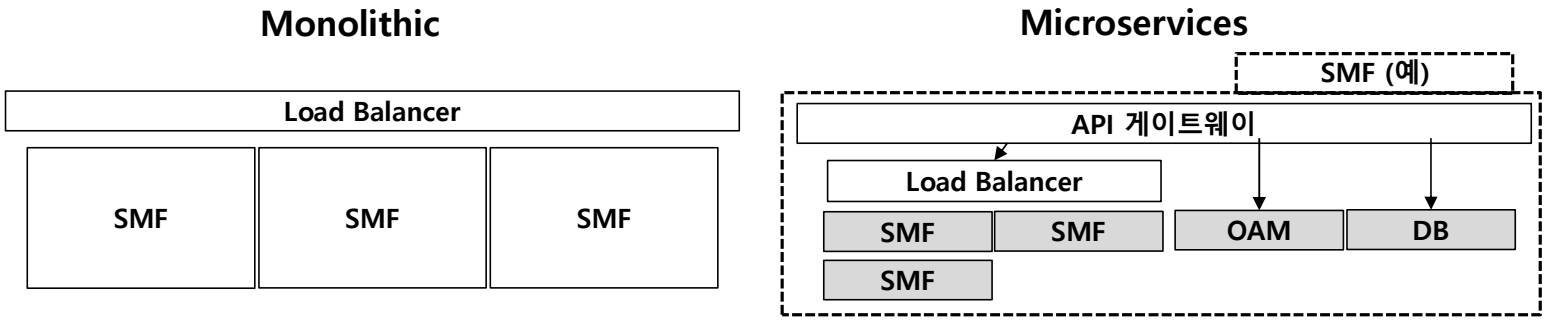
❖ 조직의 Learning Curve 고려

- 단일 마이크로서비스 (Standalone Microservice) 많이 필요시
- 과도한 의존성으로 시간이 많이 필요하고 코드의 품질이 낮아질 때
- 한가지 요소로 애플리케이션 장애 시

❖ 마이크로서비스 전환 시 추가 기능 고려

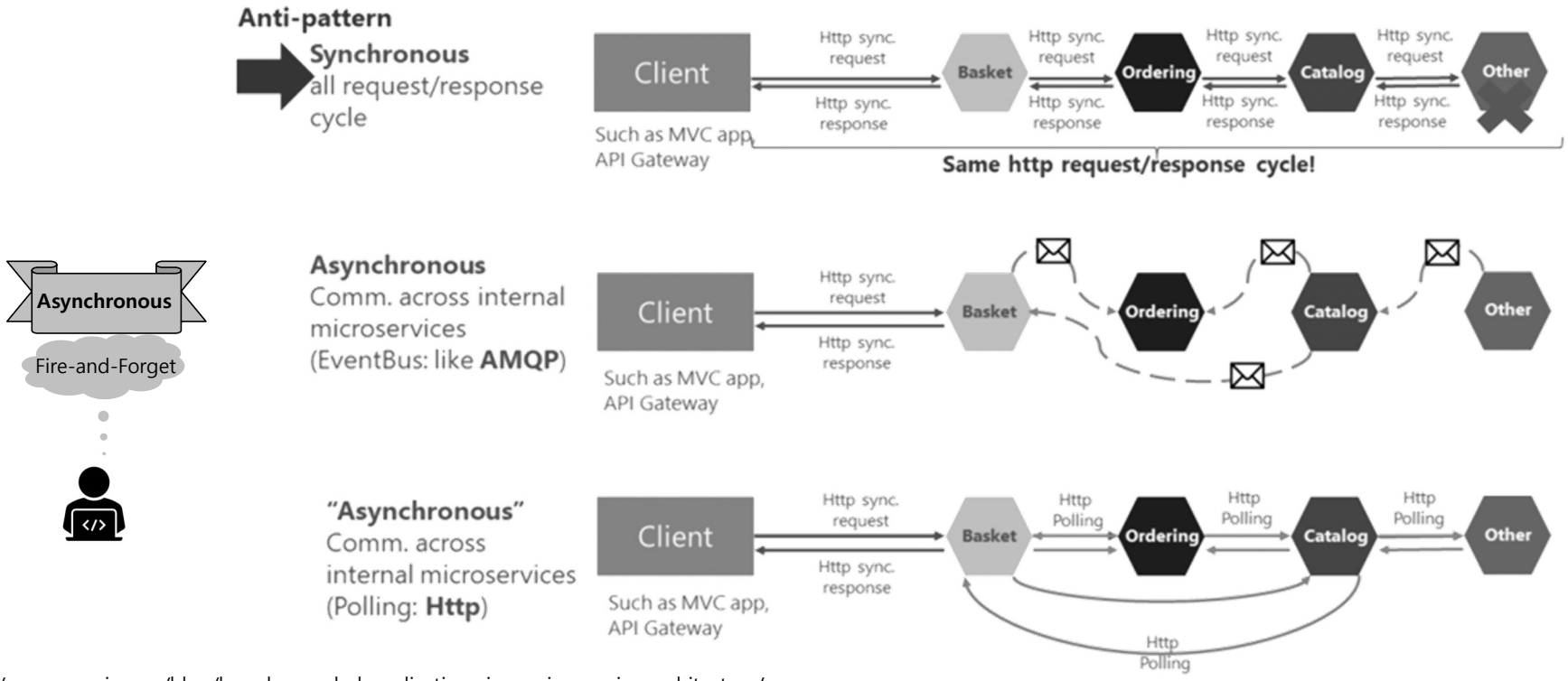
- 비즈니스 기능을 위한 서비스 연결
- 스탠드얼론 and/or 서비스의 부분 적용
- 각 엔지니어링 팀은 비즈니스 영역의 이해하고 책임을 소유





1일차. 'MSA와 5G 네트워크'

❖ Synchronous vs. async communication across microservices

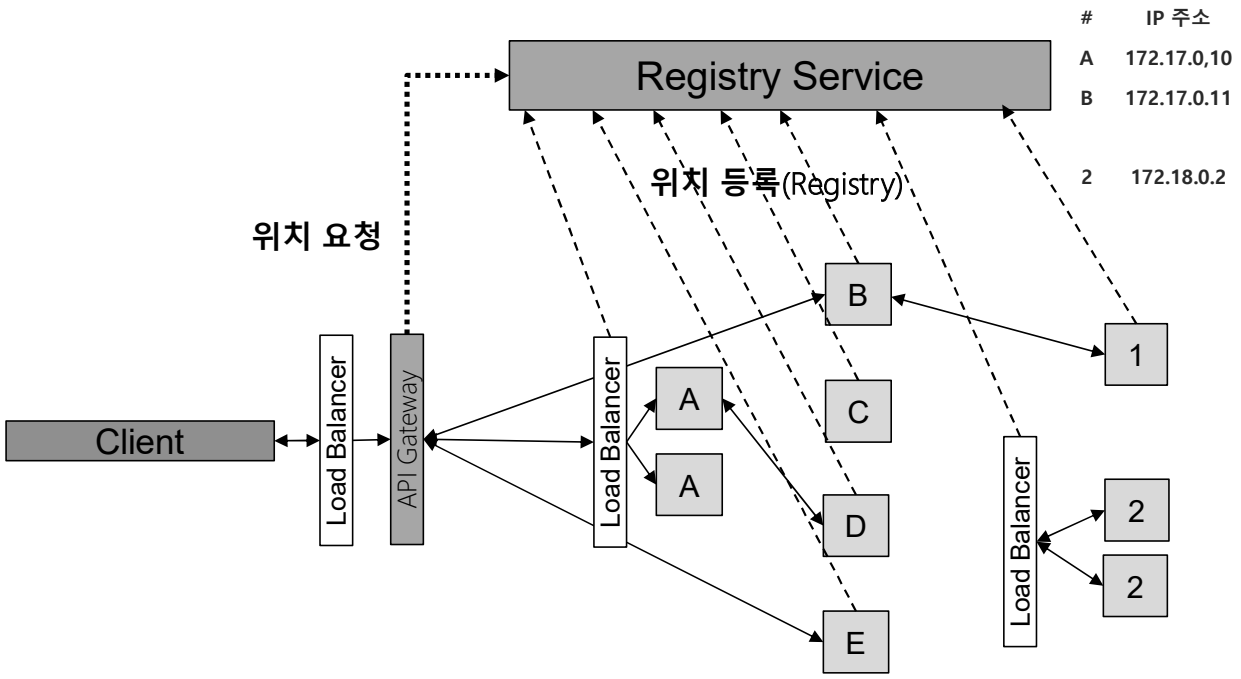


Source: https://www.emagiz.com/blog/loosely-coupled-applications-in-a-microservice-architecture/

1일차. 'MSA와 5G 네트워크'

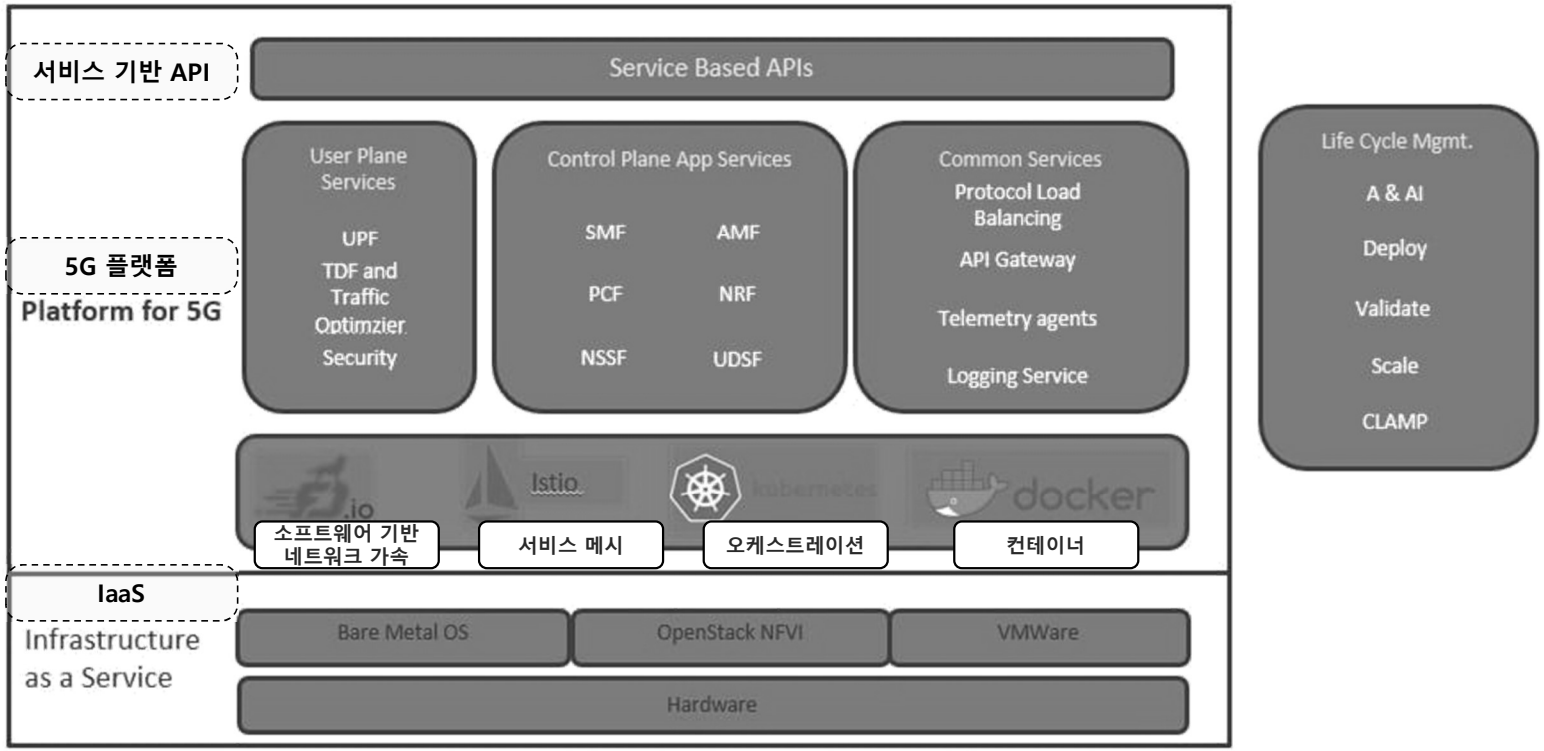
❖ 로드밸런서 추가 시 Service registry

- API Gateway는 모든 서비스에 대한 IP 주소를 알아야 하며 이의 DB 필요
- Registry 데이터의 안정성을 위해 오픈소스 사용(Consul이나 SkyDNS)



1일차. 'MSA와 5G 네트워크'

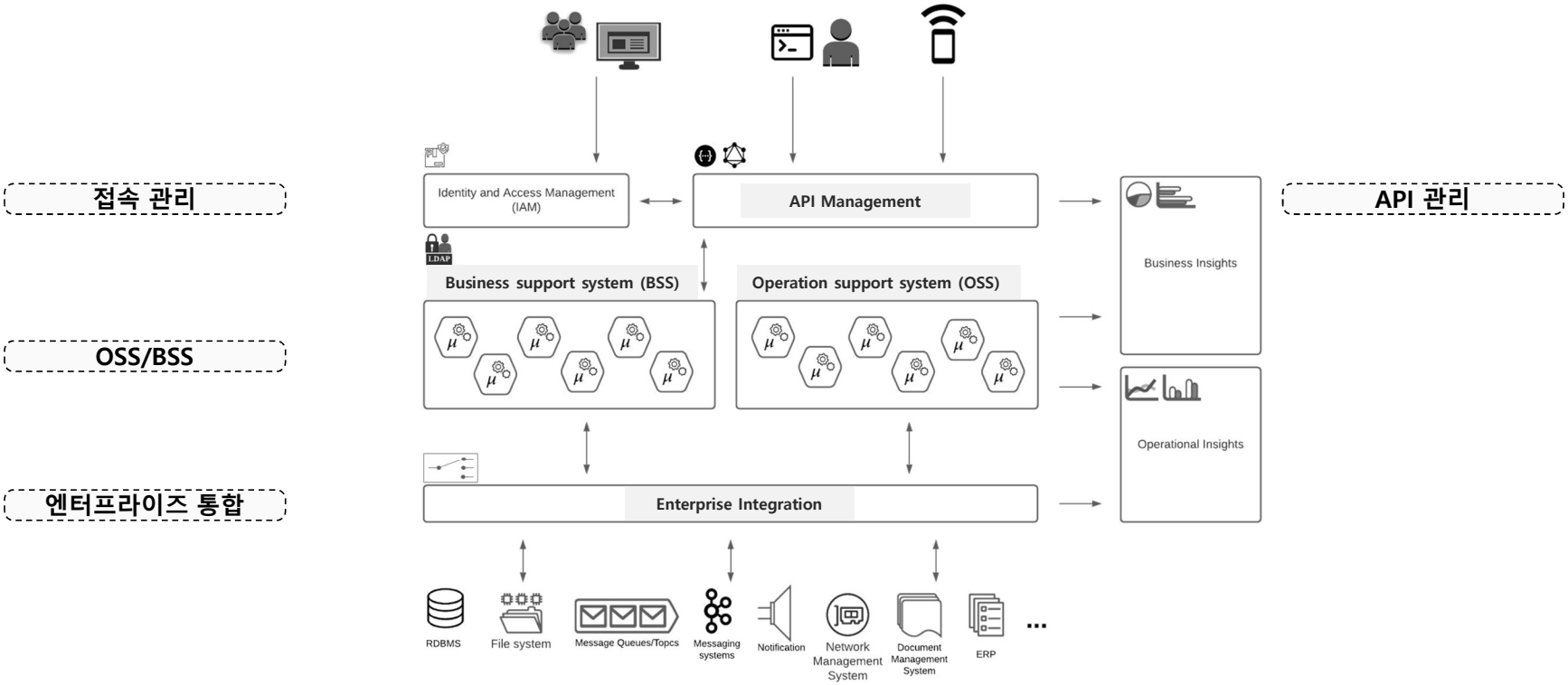
❖ The Role of API Gateways



Source: https://techblog.comsoc.org/2021/03/22/787465/

1일차. ‘MSA와 5G 네트워크’

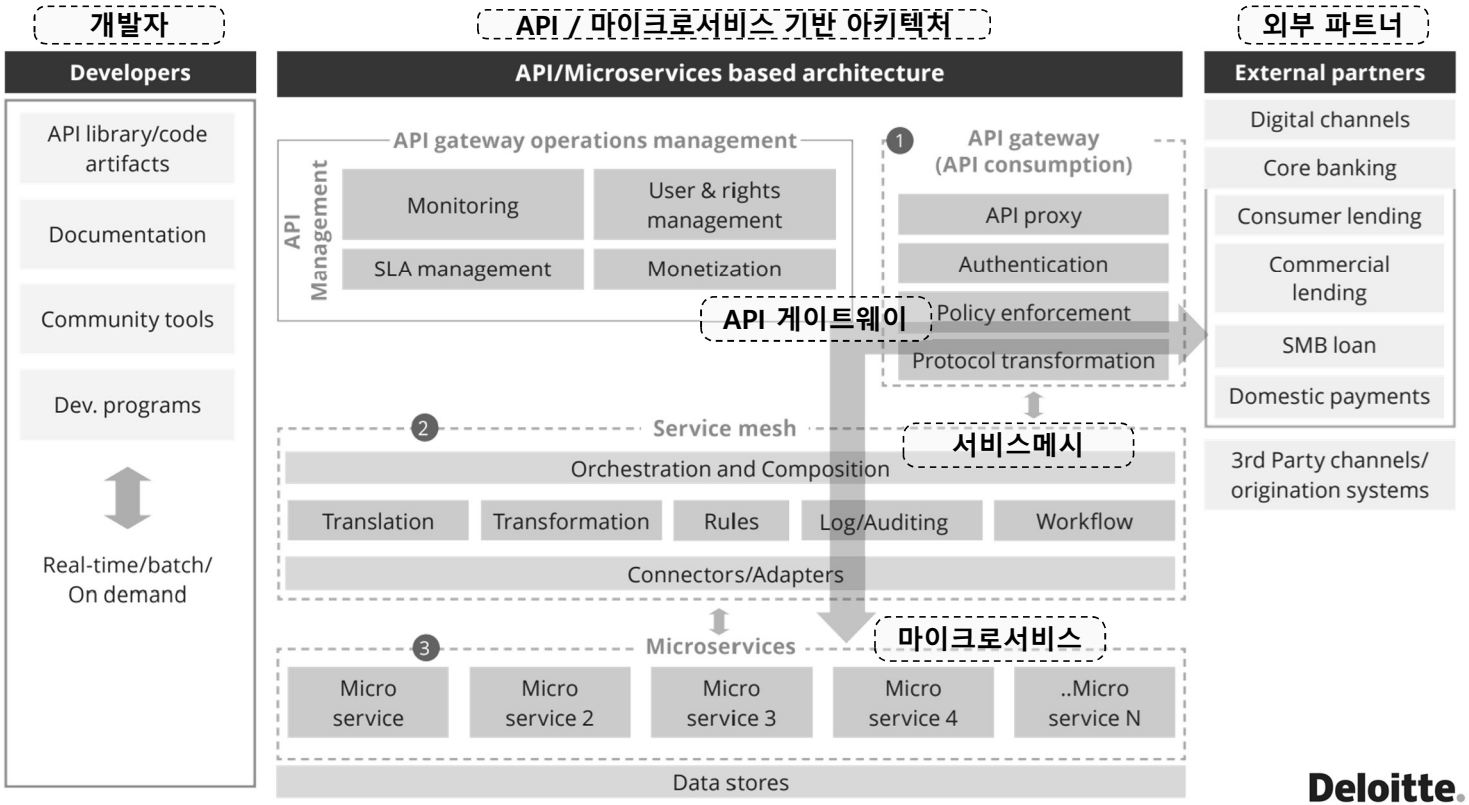
❖ 서비스 모델(예): Reference Architecture for telecom enterprise platform



Source: https://medium.com/codex/reference-architecture-for-a-telecom-enterprise-application-platform-257769a4a8d0

1일차. 'MSA와 5G 네트워크'

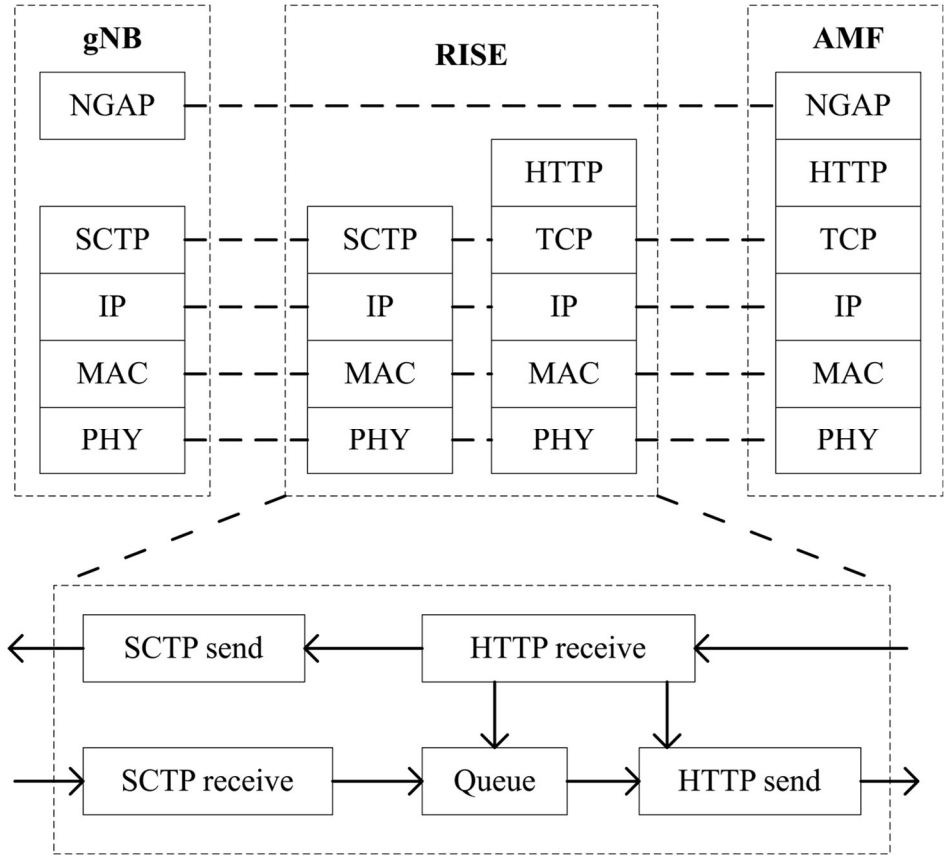
❖ Microservices-based architecture (예)



Source: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-enabling-platform-banking-pov.pdf

1일차. ‘MSA와 5G 네트워크’

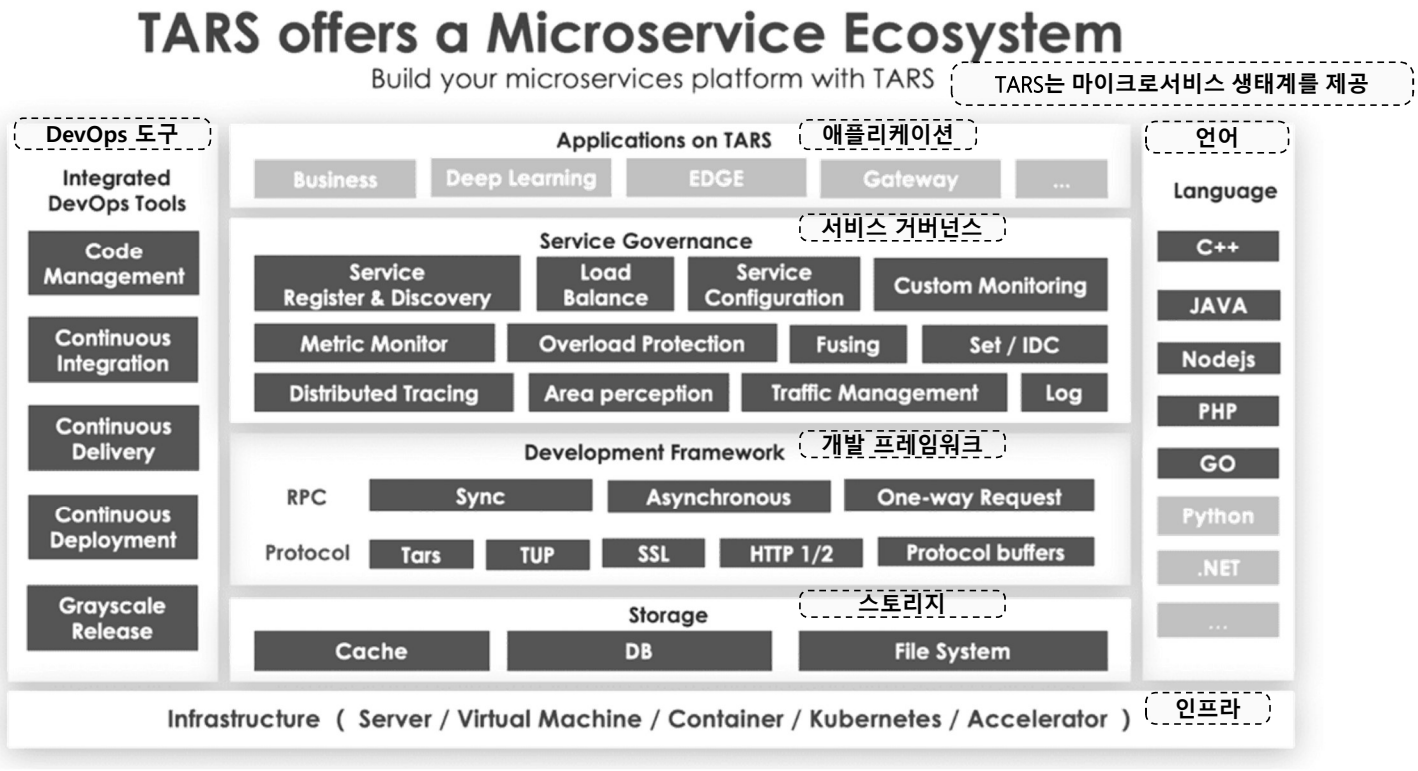
❖ **The software architecture of RISE.**



Source: https://www.sciencedirect.com/science/article/pii/S2352864822000815

1일차. 'MSA와 5G 네트워크'

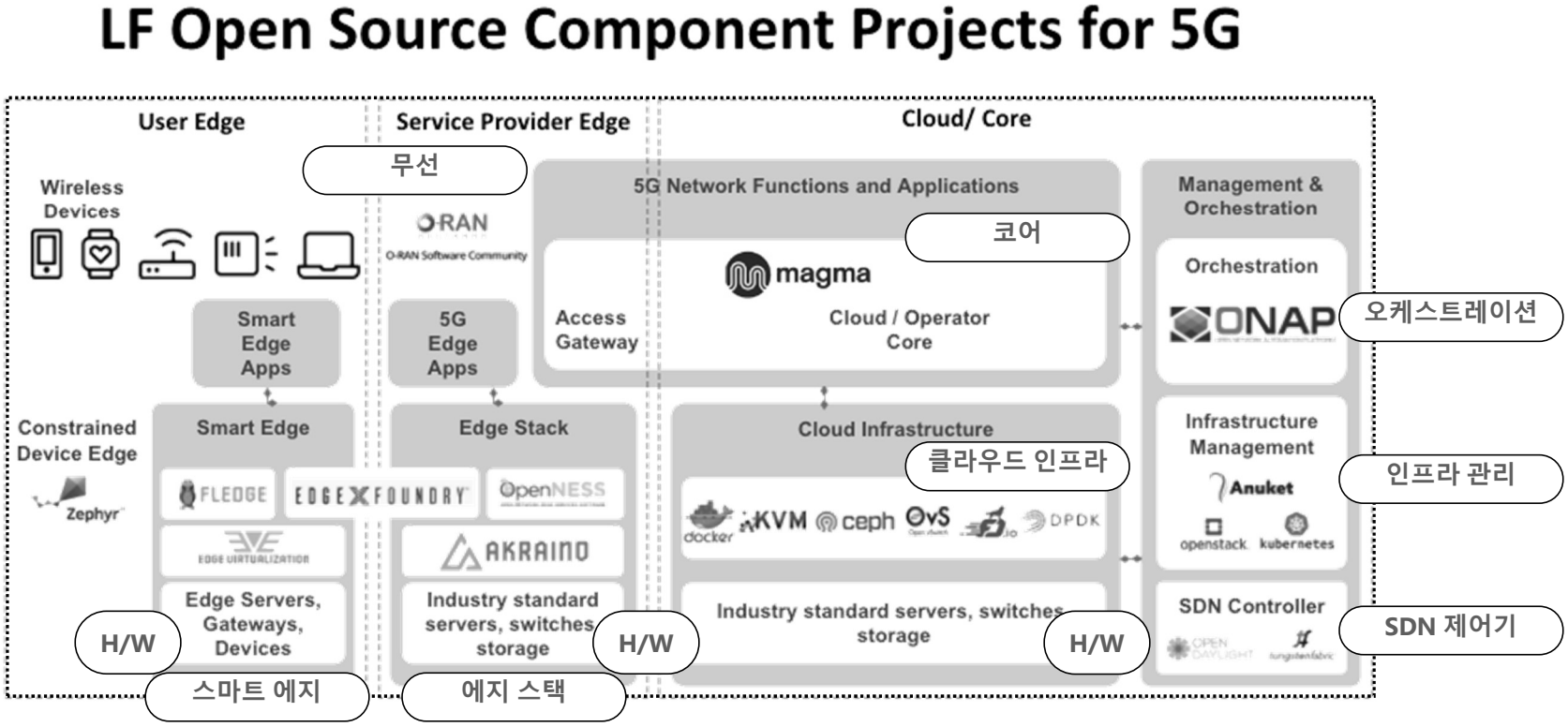
❖ 리눅스재단의 TARS 프로젝트



Source: https://www.linuxfoundation.org/blog/the-tars-foundation-the-formation-of-a-microservices-ecosystem/

1일차. 'MSA와 5G 네트워크'

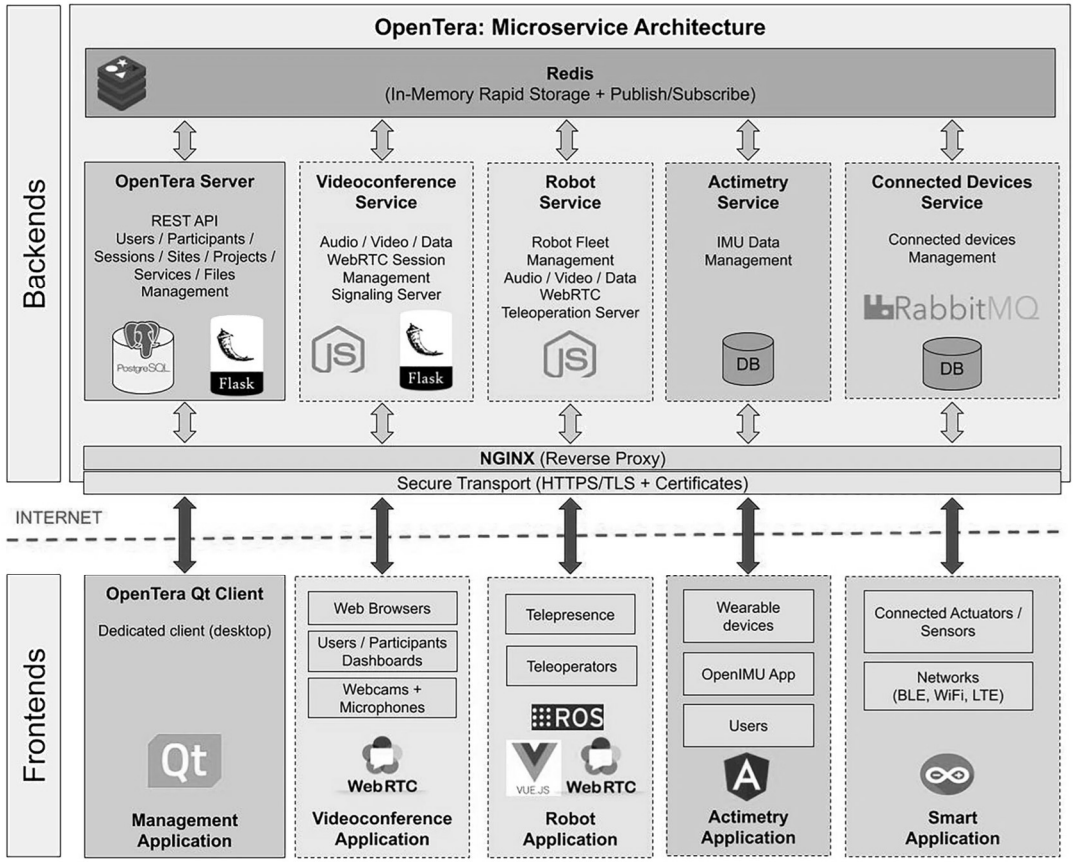
❖ 리눅스재단(LF): ONAP's Cloud Native Journey (오케스트레이션)



Source: https://www.lfnetworking.org/5g-super-blueprint/

1일차. 'MSA와 5G 네트워크'

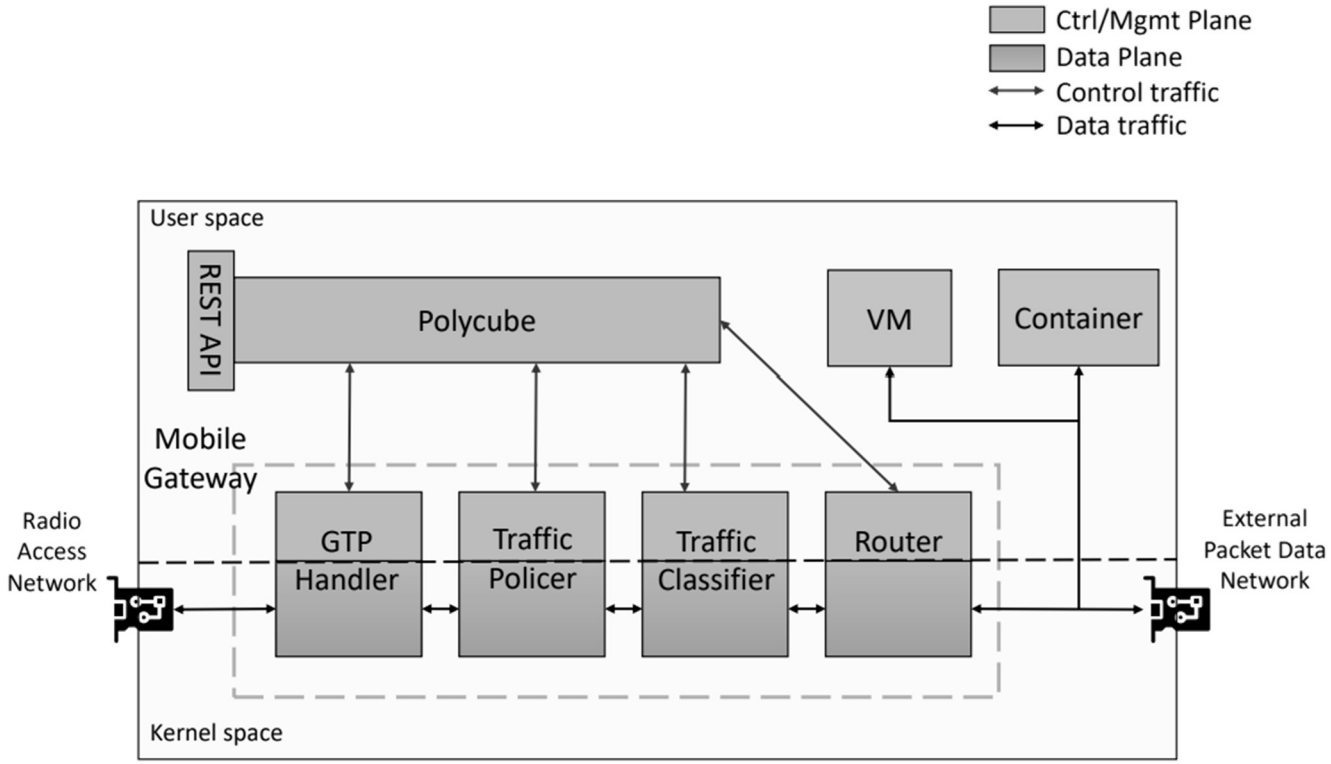
❖ **OpenTera microservice architecture**



Source: https://link.springer.com/article/10.1007/s12553-021-00636-5

1일차. 'MSA와 5G 네트워크'

❖ **A Proof-of-Concept 5G Mobile Gateway with eBPF (2020)**

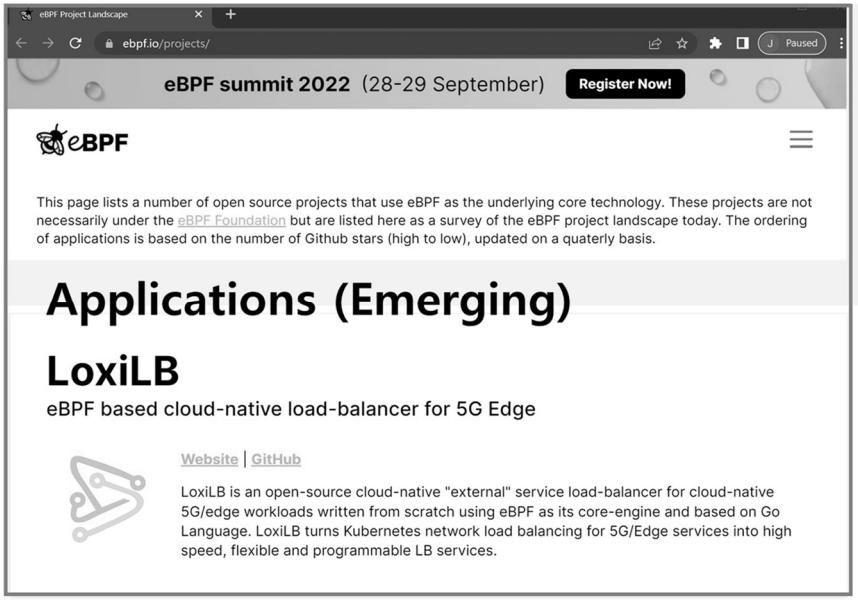


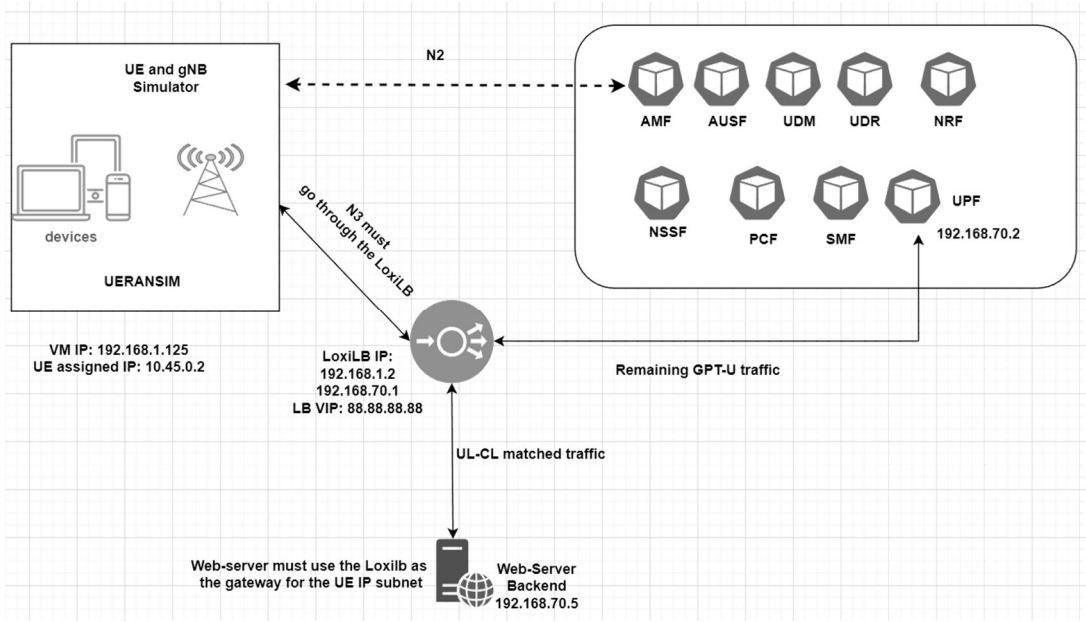
Source: https://sebymiano.github.io/publication/2020-5g-ebpf-mgw/2020-5g-ebpf-mgw.pdf?fbclid=IwAR3OsfpIZGQeBOUFGhH-47XzZTwSjqV7P9E0UQOA-XrGidxJmYj0XRoUYUs

1일차. 'MSA와 5G 네트워크'

❖ Cloud Native 5G 에지 LB 오픈소스 (예): LoxiLB

- **5G Uplink Classifier Using Loxilb**



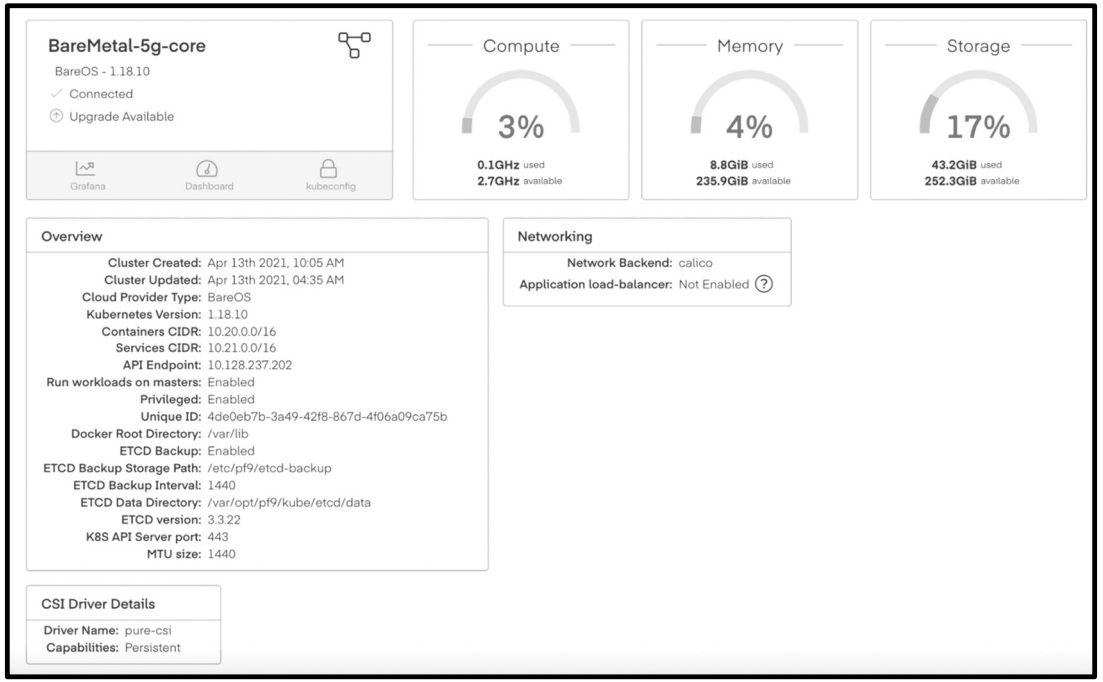


Source: https://futuredon.medium.com/5g-uplink-classifier-using-loxilb-7593a4d66f4c

1일차. ‘MSA와 5G 네트워크’

❖ CSP의 오픈소스 적용 (예): Free5GC

- **deploy the free5gc core**
  - Kubernetes cluster created by Platform9 Managed Kubernetes. You can create your account here.
  - KubeVirt should be enabled to create Virtual Machines on Ubuntu 18.04 with Linux kernel version 5.0.0-23-generic.
  - Gtp5g Kernel module on Ubuntu Virtual Machine.
  - SCTP support in Kubernetes Services. (Refer to the Appendix section)
  - Kubernetes Cluster backed by Calico CNI or any CNI with the capability to provide static IPs to pods.



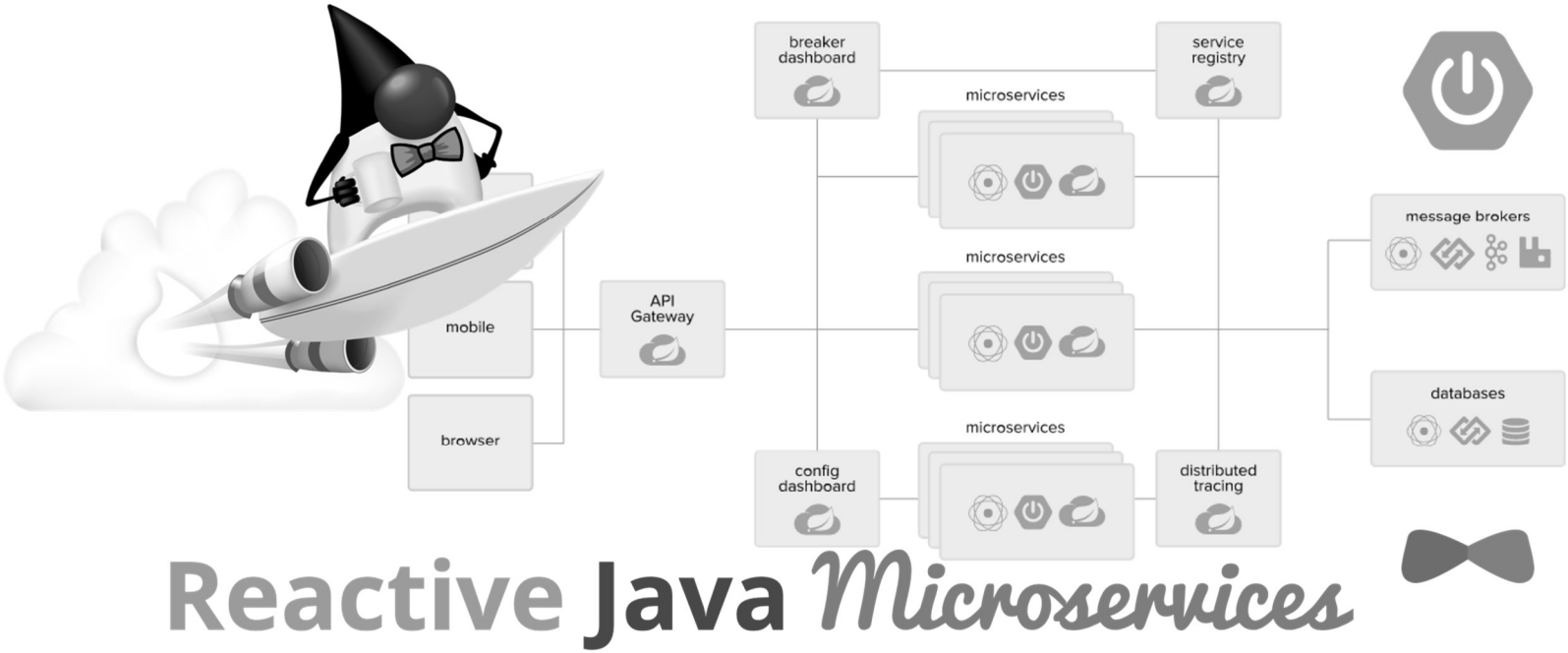
PLATFORM9

Source: https://platform9.com/blog/running-free5gc-on-platform9-managed-kubernetes/

1일차. 'MSA와 5G 네트워크'

❖ Reactive Microservices

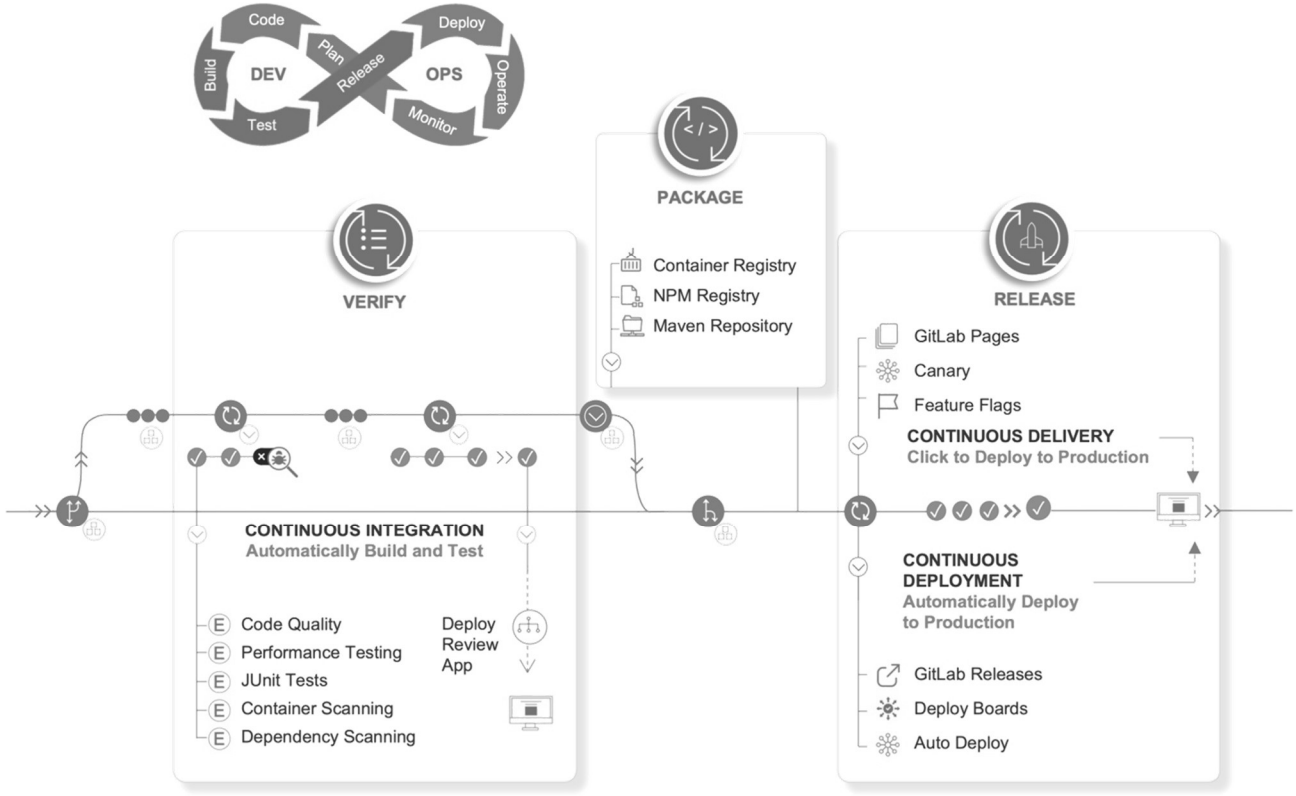
• Reactive Java Microservices



Source: https://medium.com/@sureshbabug/microservices-part1-introduction-to-springboot-spring-webflux-and-spoc-test-frameworks-with-18e8c9bcbb73

1일차. 'MSA와 5G 네트워크'

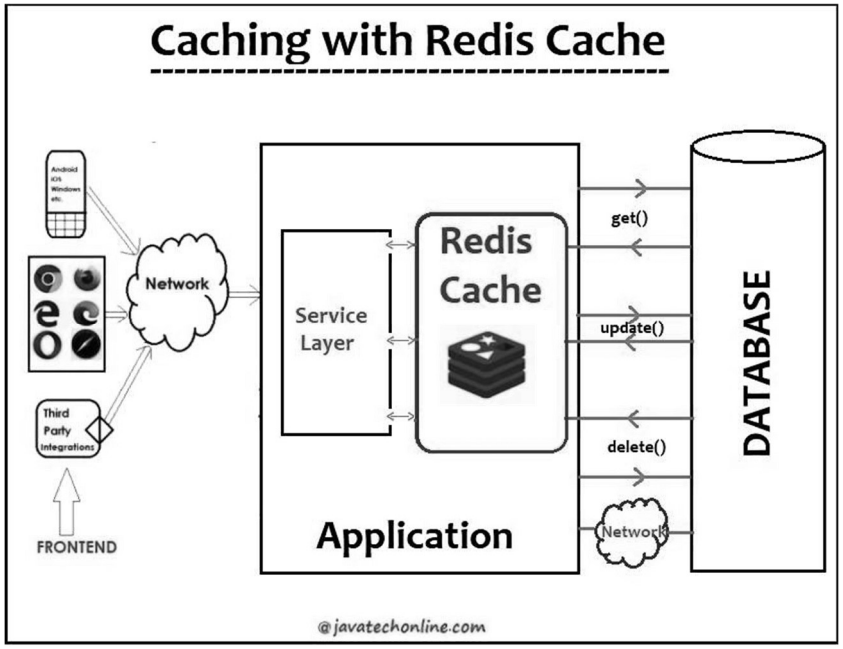
❖ **In a DevOps model uses a process of continuous development, test, and deployment.**



Source: GitLab
Source: https://www.5gtechnologyworld.com/network-automation-takes-the-work-out-of-upgrades/

❖ Redis Cache In Spring Boot Application

- **Redis is an open source (BSD licensed) in-memory remote data structure store (database) that offers high performance, replication, and a unique data model.**

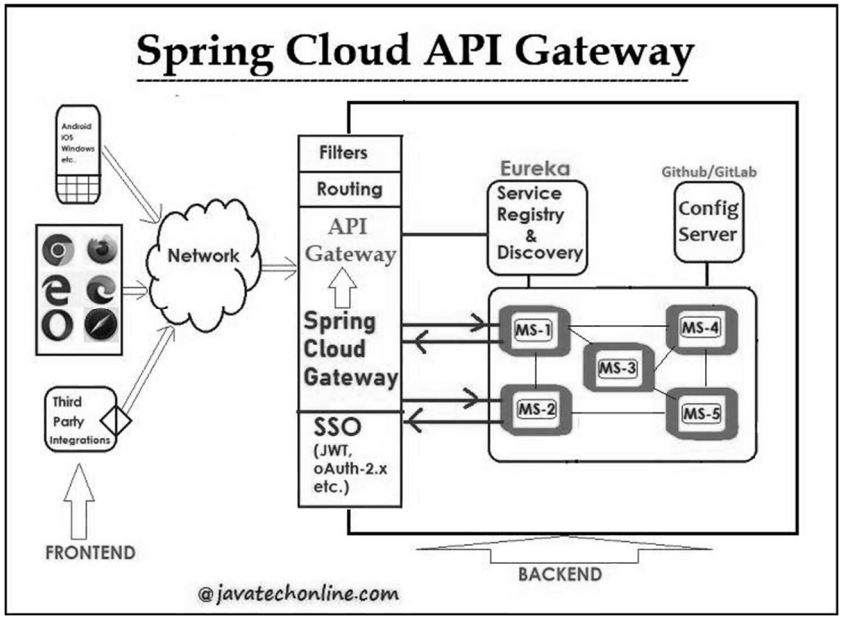


참고 Slide 361

Source: https://javatechonline.com/how-to-implement-redis-cache-in-spring-boot-application/?fbclid=IwAR0utgT8_uRbZAmHqS6pn3MnO9PxyXTVf5feNKJArOEe9j4i0JWJX-QyGew

❖ Spring Cloud Gateway In Microservices

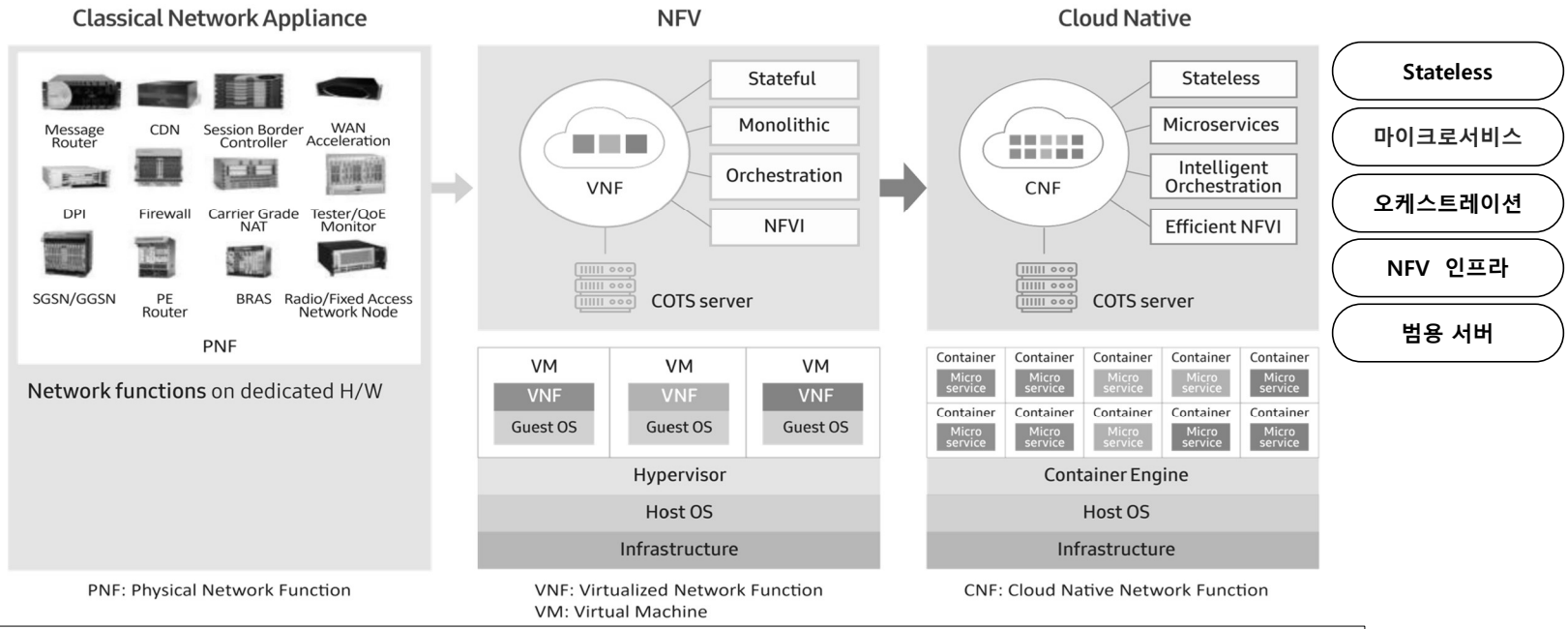
- **Spring Cloud Gateway is a starter project provided by Spring Cloud. It provides an API Gateway built on top of the Spring Ecosystem, including: Spring 5.x, Spring Boot 2.x, Spring WebFlux and Project Reactor. Spring Cloud Gateway targets to offer a simple, yet effective way to route to APIs and provide cross cutting concerns to them such as: security, monitoring/metrics, and resiliency..**



Source: https://javatechonline.com/how-to-implement-redis-cache-in-spring-boot-application/?fbclid=IwAR0utgT8_uRbZAmHqS6pn3MnO9PxyXTVf5feNKJArOEe9j4i0JWJX-QyGew

1일차. 'MSA와 5G 네트워크'

- ❖ PNF(Physical Network Function) *하드웨어 어플라이언스 기반
- ❖ VNF(Virtualized Network Function) *가상머신 VM(Virtual Machine) 기반
- ❖ CNF(Cloud-Native Network Function) *클라우드 네이티브는 컨테이너/VM수용



❖ The Status of Open Source for 5G

5G Network Area	Focus	Brief Description	Open Source Effort References
Infrastructure	Hardware	High performance at lower cost by programmability and specialization of tasks	Open Compute Project: https://www.opencompute.org P4: https://p4.org
Infrastructure	Networking	Fast rate packet processing by acceleration techniques	DPDK: http://dpdk.org VPP: https://fd.io
Infrastructure	Operating System	Enabling white box use in carrier grade networks	Linux: https://www.linuxfoundation.org/projects/linux/ Berkle Software Distribution: http://www.bsd.org Disaggregated Network Operating System: https://www.danosproject.org
Access Network	Radio	Implementing 4G LTE and 5G Radio Access Network for NodeB and/or User Equipment	openair5G: https://gitlab.eurecom.fr/oai/openairinterface5g/wikis/home O-RAN: https://www.o-ran.org/
Core Network	Wireless Core Network	Implementing 4G LTE EPC and 5G NGC	openairCN: https://gitlab.eurecom.fr/oai/openairinterface5g/wikis/home M-CORD NGIC: https://software.intel.com/en-us/articles/an-interactive-demo-of-the-next-generation-infrastructure-core-reference-implementation
Management & Control	Networking	Carrier grade packet processing and flow control	OpenDaylight: https://www.opendaylight.org ONOS: https://onosproject.org Open vSwitch: https://www.openvswitch.org M-CORD NGIC: https://software.intel.com/en-us/articles/an-interactive-demo-of-the-next-generation-infrastructure-core-reference-implementation FD.io: https://fd.io
Management & Control	Virtualization	Abstraction of general compute resources to be shared across multiple applications and logical networks	OpenStack: https://www.openstack.org Kubernetes: https://kubernetes.io Docker: https://www.docker.com
Management & Control	Orchestration	Frameworks for describing dynamic function and network deployment policies with specific performance characteristics	Open Source MANO (OSM): https://osm.etsi.org MEF Lifecycle Service Orchestration (LSO): XOS: https://www.opennetworking.org/xos/

Source: 5G Americas

❖ The Status of Open Source for 5G

5G Network Area	Focus	Brief Description	Open Source Effort References
Management & Control	Automation	Frameworks and middleware for enabling Orchestration and Management tools to configure general compute and networking components via virtualization layers	xRAN: http://www.xran.org ONAP: https://www.onap.org Ansible: https://www.ansible.com Terraform: https://www.terraform.io/
Management & Control	Modeling	Modeling tools and languages for defining function and network services for deployment used by Orchestration Frameworks	TOSCA: https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=tosca JuJu: http://jujucharms.com YAML: http://yaml.org YANG: https://tools.ietf.org/html/rfc6020
Management & Control	DevOps	Software development methods to automate process of building, validating and deploying workloads into NFV environments for service agility	Elasticsearch, Logstash, Kibana (ELK): https://www.elastic.co/elk-stack Consul: https://www.consul.io Etcd: https://coreos.com/etcd/ Jenkins: https://jenkins.io/ Puppet: https://puppet.com Chef: https://www.chef.io/chef/
Management & Control	Testing Tools		
Management & Control	Analytics	Data streaming protocols for continuous analysis of the service monitoring	Apache Kafka: https://kafka.apache.org/ Apache Spark: https://spark.apache.org/
Management & Control	AI	Framework for use of AI in Network	Automation https://www.acumos.org/
Management & Control	Edge Compute	Open source software for Edge	Computing https://www.akraino.org/
Management & Control	Cybersecurity	Security framework for Virtual network infrastructures	SHIELD: https://torsec.github.io/shield-h2020/about/summary.html

Source: 5G Americas


THANK
YOU

부록1. OPENSTACK (1 OF 3)

❖ Loosely coupled architecture

- **Default ports**

서비스 배포는 API를 사용하는 컨테이너 또는
쿠버네티스의 POD로 구현 가능 구조

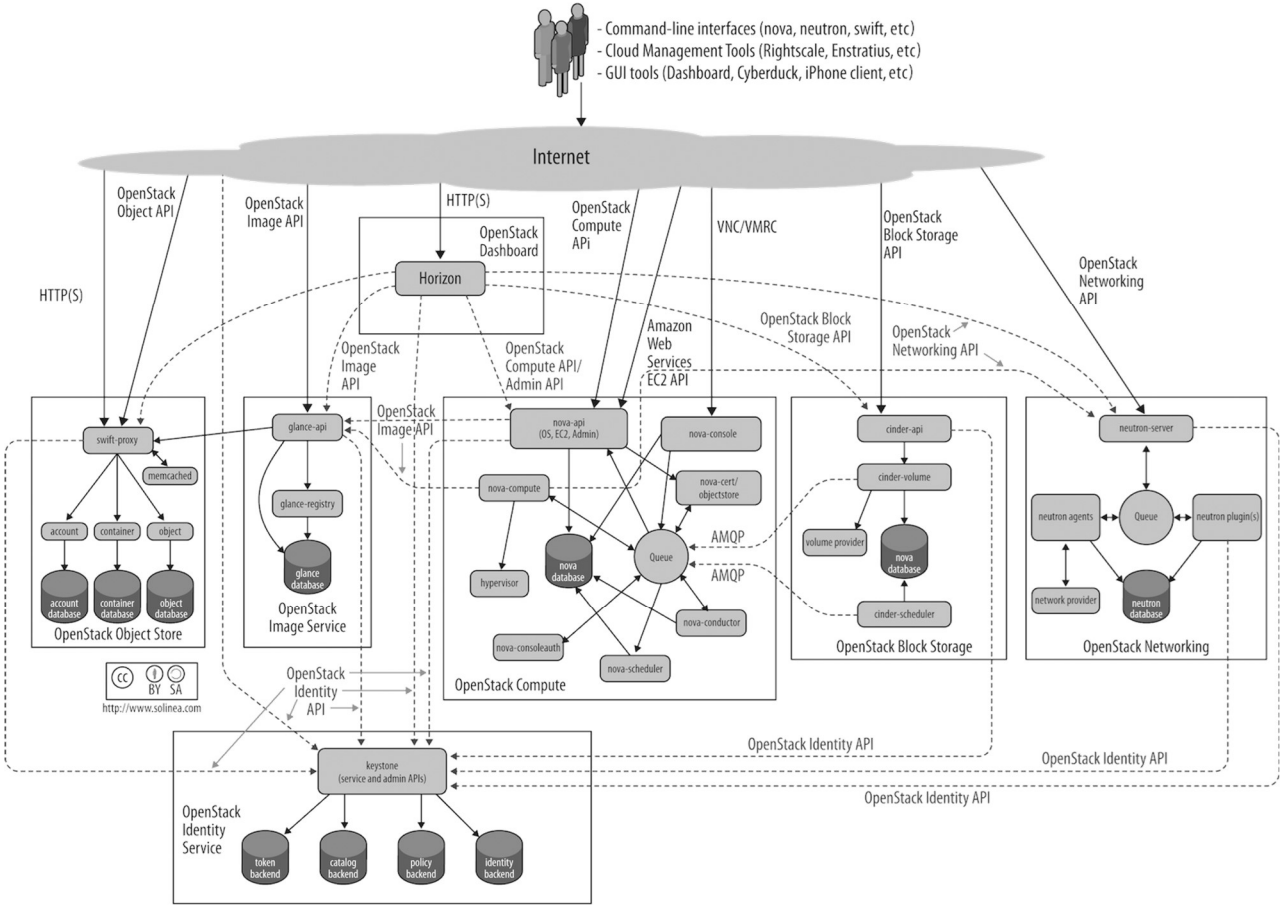
Default ports that secondary services related to OpenStack components use

Service	Default port	Used by
HTTP	80	OpenStack dashboard (Horizon) when it is not configured to use secure access.
HTTP alternate	8080	OpenStack Object Storage (swift) service.
HTTPS	443	Any OpenStack service that is enabled for SSL, especially secure-access dashboard.
rsync	873	OpenStack Object Storage. Required.
iSCSI target	3260	OpenStack Block Storage. Required.
MySQL database service	3306	Most OpenStack components.
Message Broker (AMQP traffic)	5672	OpenStack Block Storage, Networking, Orchestration, and Compute.

OpenStack components use	Default ports
Application Catalog (murano)	8082
Backup Service (Freezer)	9090
Big Data Processing Framework (sahara)	8386
Block Storage (cinder)	8776
Clustering (senlin)	8777
Compute (nova) endpoints	8774
Compute ports for access to virtual machine consoles	5900-5999
Compute VNC proxy for browsers (openstack-nova-novncproxy)	6080
Compute VNC proxy for traditional VNC clients (openstack-nova-xvpvncproxy)	6081
Container Infrastructure Management (Magnum)	9511
Container Service (Zun)	9517
Data processing service (sahara) endpoint	8386
Database service (Trove)	8779
DNS service (Designate)	9001
High Availability Service (Masakari)	15868
Identity service (keystone) endpoint	5000
Image service (glance) API	9292
Key Manager service (Barbican)	9311
Loadbalancer service (Octavia)	9876
Networking (neutron)	9696
NFV Orchestration service (tacker)	9890
Object Storage (swift)	6000, 6001, 6002
Orchestration (heat) endpoint	8004
Orchestration AWS CloudFormation-compatible API (openstack-heat-api-cfn)	8000
Orchestration AWS CloudWatch-compatible API (openstack-heat-api-cloudwatch)	8778
Placement API (placement)	8003
Proxy port for HTML5 console used by Compute service	6082
Rating service (Cloudkitty)	8889
Registration service (Adjutant)	5050
Resource Reservation service (Blazar)	1234
Root Cause Analysis service (Vitrage)	8999
Shared File Systems service (Manila)	8786
Telemetry alarming service (Aodh)	8042
Telemetry event service (Panko)	8977
Workflow service (Mistral)	8989

부록1. OPENSTACK (2 OF 3)

❖ **OpenStack Design**



Return: 1일차. 'MSA와 5G 네트워크'

부록1. OPENSTACK (3 OF 3)

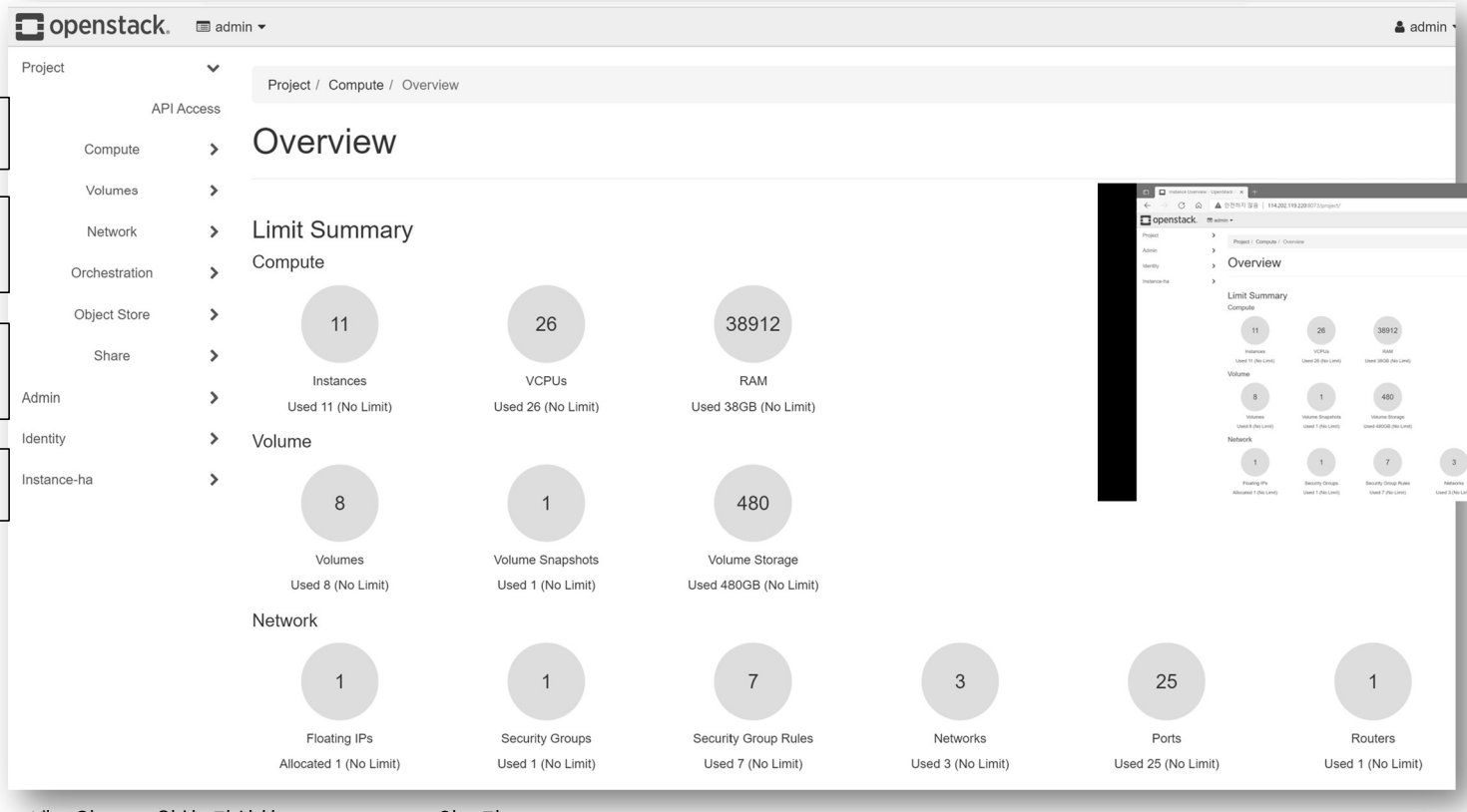
❖ OpenStack Horizon (Web Frontend)

Compute
NOVA Compute Service

Networking
NEUTRON Networking
OCTAVIA Load balancer

Storage
SWIFT Object store
CINDER Block Storage

Orchestration
HEAT Orchestration

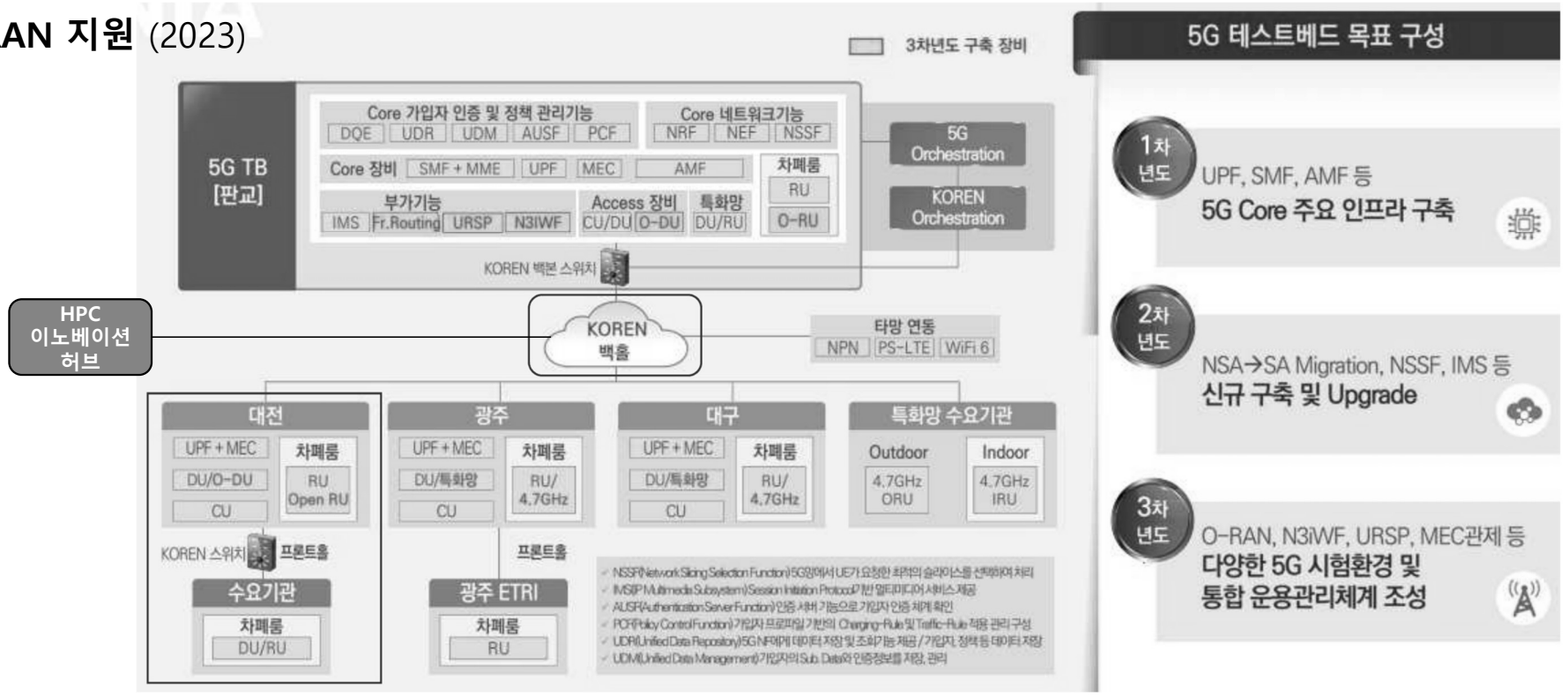


Return: 1일차. 'MSA와 5G 네트워크', 2일차 '가상화 (Virtualization) 인프라'

부록2. 5G 융합서비스 테스트베드 (1 OF 2)

❖ 5G 융합서비스 테스트베드 (@KOREN)

- **O-RAN 지원** (2023)



Source: https://ettrends.etri.re.kr/ettrends/197/0905197007/060-069_%EC%98%88%EC%B6%A9%EC%9D%BC_197%ED%98%B8.pdf

부록2. 5G 융합서비스 테스트베드 (2 OF 2)

❖ **5G 융합서비스 테스트베드 (@KOREN)**

- **대전 거점 (ETRI)**

Return: Slide 21

부록3. SPRING CLOUD (1 OF 2)

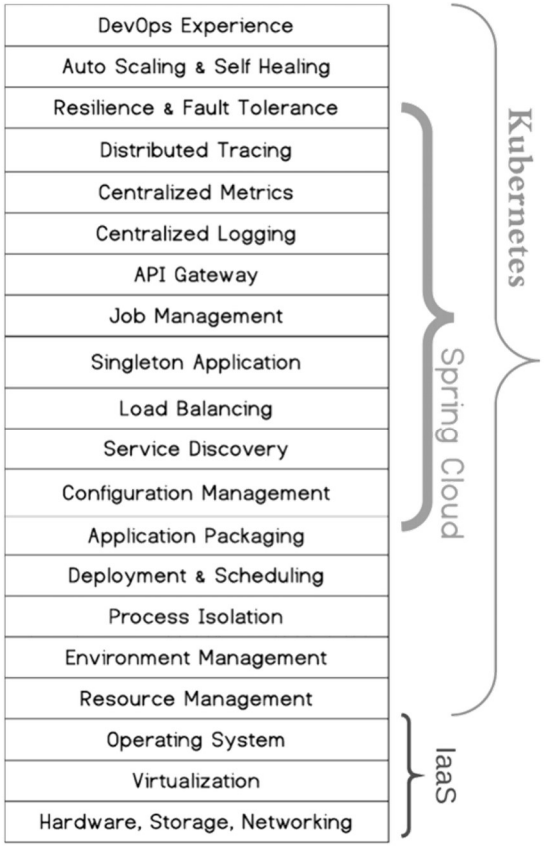
❖ **Spring cloud vs Kubernetes**

Microservices Concern	Spring Cloud & Netflix OSS	Kubernetes
Configuration Management	Config Server, Consul, Netflix Archaius	Kubernetes ConfigMap & Secrets
Service Discovery	Netflix Eureka, Hashicorp Consul	Kubernetes Service & Ingress Resources
Load Balancing	Netflix Ribbon	Kubernetes Service
API Gateway	Netflix Zuul	Kubernetes Service & Ingress Resources
Service Security	Spring Cloud Security	-
Centralized Logging	ELK Stack (LogStash)	EFK Stack (Fluentd)
Centralized Metrics	Netflix Spectator & Atlas	Heapster, Prometheus, Grafana
Distributed Tracing	Spring Cloud Sleuth, Zipkin	OpenTracing, Zipkin
Resilience & Fault Tolerance	Netflix Hystrix, Turbine & Ribbon	Kubernetes Health Check & resource isolation
Auto Scaling & Self Healing	-	Kubernetes Health Check, Self Healing, Autoscaling
Packaging, Deployment & Scheduling	Spring Boot	Docker/Rkt, Kubernetes Scheduler & Deployment
Job Management	Spring Batch	Kubernetes Jobs & Scheduled Jobs
Singleton Application	Spring Cloud Cluster	Kubernetes Pods

Share: https://velog.io/@formin/Spring-Cloud%EB%A5%BC-%ED%99%9C%EC%9A%A9%ED%95%9C-MSA-%EC%84%A4%EC%B9%98-%EB%B0%8F-%EA%B5%AC%EC%84%B1

부록3. SPRING CLOUD (2 OF 2)

❖ **Spring cloud vs Kubernetes**



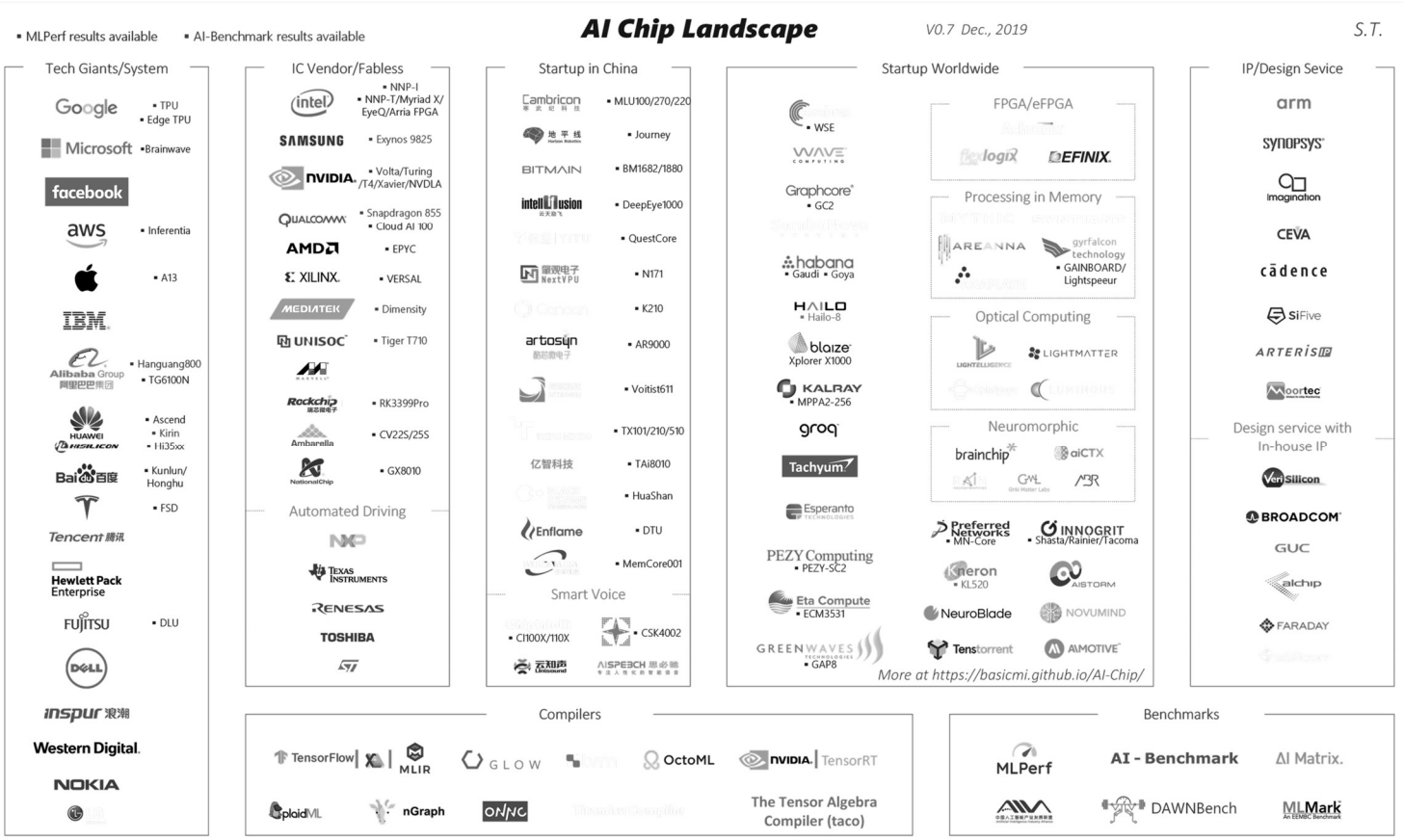
Return: 1일차. 'MSA와 5G 네트워크' 39p , 1일차. 'MSA와 5G 네트워크' 87p

Share: https://www.steemcoinpan.com/hive-101145/@wonsama/msa

부록4. AI CHIP LANDSCAPE

❖ AI Chip Landscape

- Tech Giants/System
- IC Vendor/Fabless
- Startup
- IP/Design Service
- Compilers
- Benchmarks

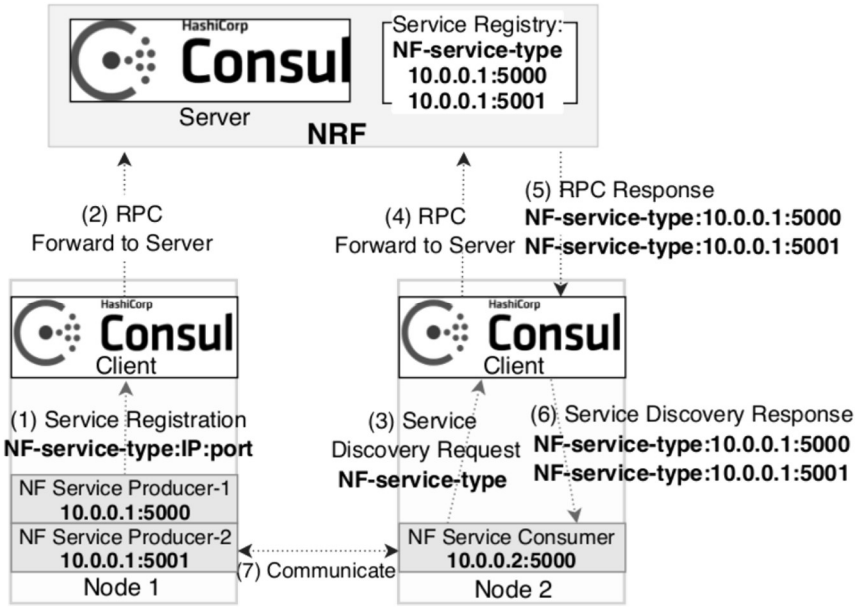


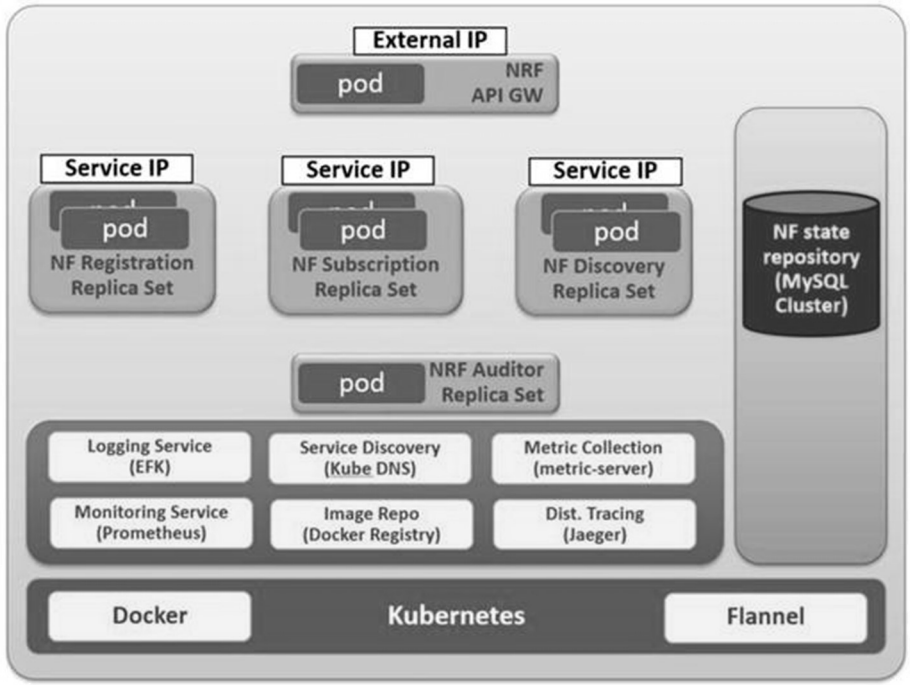
Return: 2일차 '가상화 (Virtualization) 인프라'

Source: https://github.com/basicmi/AI-Chip

부록5. 제조사 NRF (1 OF 2)

- ❖ 해시코프: NRF implementation using Consul
- ❖ 오라클: Communications Network Repository Function (NRF) Cloud Native



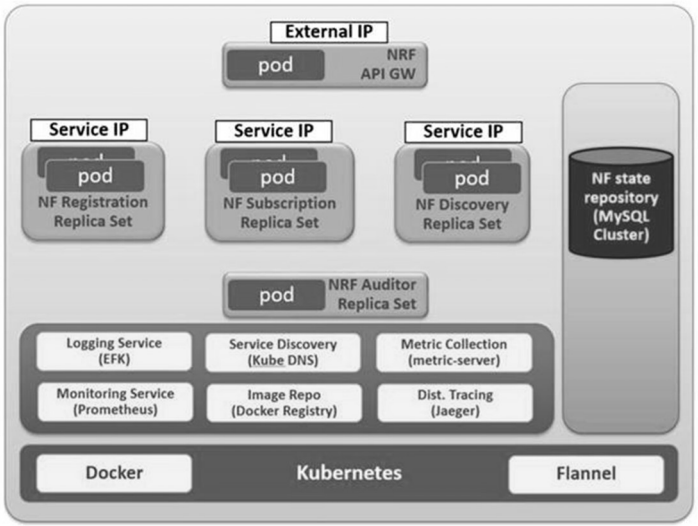


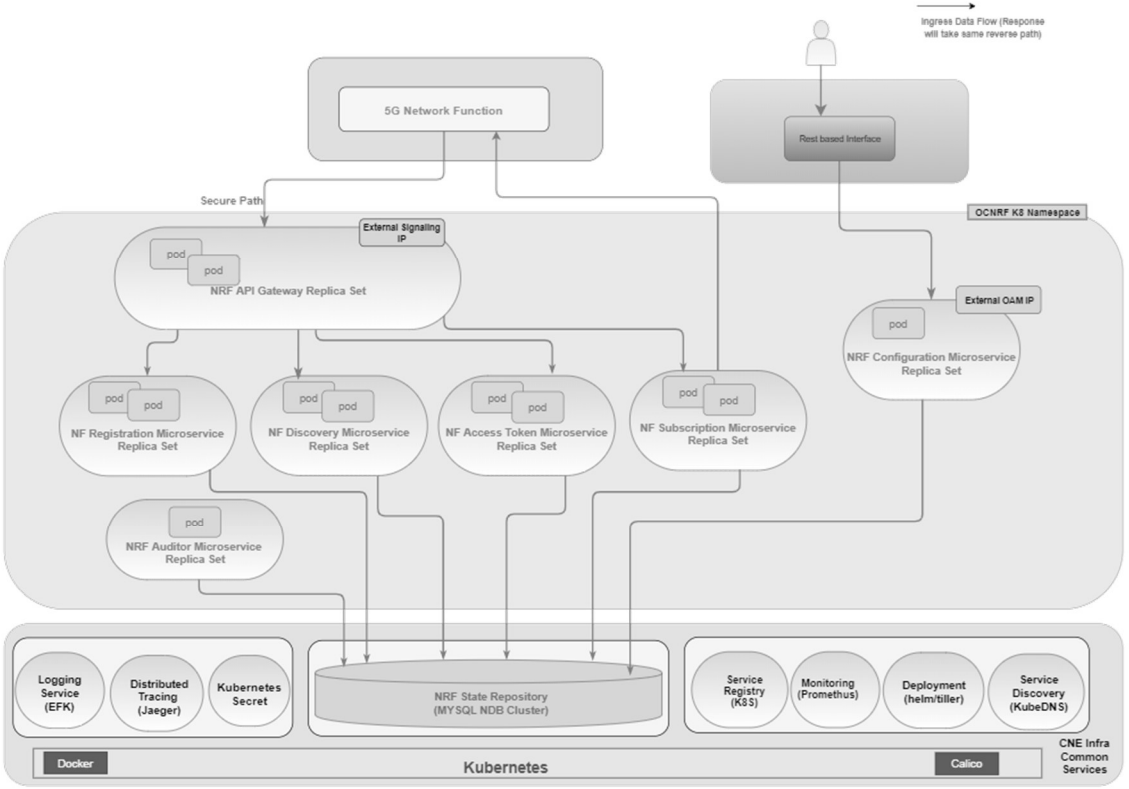
Source: https://pdfs.semanticscholar.org/52f6/001a27f827d3c724a8718e6768cd35ceb178.pdf

Source: https://docs.oracle.com/communications/F21353_01/docs.10/NRF%20User%27s%20Guide/GUID-72930D10-8817-4F82-83C2-695FC4B5589B.htm

부록5. 제조사 NRF (2 OF 2)

❖ 오라클: Communications Network Repository Function (NRF) Cloud Native





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Source: https://docs.oracle.com/communications/F25434_01/docs.10/NRF%20User%27s%20Guide/GUID-72930D10-8817-4F82-83C2-695FC4B5589B.htm

부록6. SYSTEM MONITORING SOFTWARE

❖ System Monitoring Software

1.NinjaOne (Formerly NinjaRMM)
2.SolarWinds Server and Application Monitor
3.Atera
4.eG Innovations
5.Datadog
6.Site24x7
7.Sematext
8.PRTG Network Monitor
9.Zabbix
10.Spiceworks Network Monitor
11.Nagios
12.OpManager by ManageEngine
13.WhatsUp Gold
14.Cacti
15.Icinga
16.OpenNMS

1. Sematext Monitoring
2. SolarWinds Server & Application Monitor
3. Atera
4. Datadog Infrastructure Monitoring
5. Site24x7 Server Monitoring
6. Paessler PRTG Network Monitor
7. ManageEngine Applications Manager
8. Nagios
9. Zabbix
10. NinjaOne
11. Spiceworks

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Source: https://www.softwaretestinghelp.com/system-monitoring-software/ , https://sematext.com/blog/system-monitoring-tools/