

4일차

‘모니터/제어, 클라우드 네이티브 5G 네트워크’

구분	주제	세부 내용
이론	1일차. MSA와 5G 네트워크	<ul style="list-style-type: none"> • MSA(Microservices Architecture) 개요 • 통신 시장의 클라우드 서비스 기술 변화 • 5G 네트워크 서비스의 클라우드화 • Cloud Native Transformation
	2일차. 가상화 (Virtualization) 인프라	<ul style="list-style-type: none"> • 네트워크 가상화 • RAN 가상화 • SDN (Software Defined Networking) • MEC와 하드웨어 가속
	3일차. 클라우드 서비스	<ul style="list-style-type: none"> • 클라우드 5G 서비스 개요 • 컨테이너 기술 • 클라우드 네이티브 인프라 구축 • 서비스 메시
이론/ 실습	4일차. 모니터/제어, 클라우드 네이티브 5G 네트워크 랩 시연/실습	<ul style="list-style-type: none"> • 모니터링 • 네트워크 슬라이싱 • Zero-touch Automation • 5G Networks Lab을 위한 K8s/Helm 설치 (실습) • 쿠버네티스 오퍼레이션 (실습)
	5일차. 관리/보안 MSA 시연/실습	<ul style="list-style-type: none"> • Private 5G Network 인프라 관리 • 통신 보안 • 제조사 솔루션 • Design Pattern • Cloud Native 5G Edge Networks (실습)

랩(Lab)시연/실습 별도교재

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❖ When we experience problems in development or production, we resort to debugging, logging and monitoring tools to find the root cause of the problem. Some of the tools which we should be familiar with are:

- strace
- SAR (System Activity Reporter)
- tcpdump
- GDB (GNU Project Debugger)
- syslog
- Nagios
- Zabbix.

MSA 수준
로깅과 모니터링

마이크로서비스가 생성한 요청과
응답에 관한 정보를 저장하여 오류
시 필요 정보 제공



참고: 부록6. System Monitoring Software

strace: <https://strace.io/> SAR (System Activity Reporter): <https://www.linode.com/docs/guides/how-to-use-sar>



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❖ K8s Logging / Alert (예)

Cluster Logging

① We will use Fluentd to collect stdout/stderr logs from each container and the log files which exist under path `/var/log/containers` on each host. The logs can be shipped to a target you configure below.

None

Elasticsearch

Splunk

Kafka

Syslog

Fluentd

Logging is disabled in the current cluster.

Save

v2.3.2 Help & Docs Forums Slack File an Issue English Download CLI

Cluster Alerts Add Alert Group

Deactivate Delete

Search

<input type="checkbox"/>	State	Name	Target	Condition	Notifiers	
A set of alerts for etcd Alert for etcd leader existence, db size Add Alert Rule						
<input type="checkbox"/>	Active	A high number of leader chan...	Metric	Greater Than 3	Not Configured	
<input type="checkbox"/>	Active	Database usage close to the q...	Metric	Greater Than 524288000	Not Configured	
<input type="checkbox"/>	Active	Etdc is unavailable	System Service	Unhealthy	Not Configured	
<input type="checkbox"/>	Active	Etdc member has no leader	Metric	Not Equal 1	Not Configured	
A set of alerts for kube components Alert for kube components api server, scheduler, controller manager Add Alert Rule						
<input type="checkbox"/>	Active	Controller Manager is unavaila...	System Service	Unhealthy	Not Configured	
<input type="checkbox"/>	Active	Scheduler is unavailable	System Service	Unhealthy	Not Configured	



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- ❖ We can use the same tools on bare metal and VMs, but containers bring interesting challenges:
 - Containers are ephemeral, so, when they die, all the metadata (e.g. logs) gets deleted as well, unless we store it in some other location.
 - Containers do not have kernel space components. Check
 - We want to have a container's footprint as low as possible. Installing debugging and monitoring tools increases the footprint size.
 - Collecting per container statistics, debugging information individually and then analyzing data from multiple containers is a tedious process.

Ephemeral (일시적인)

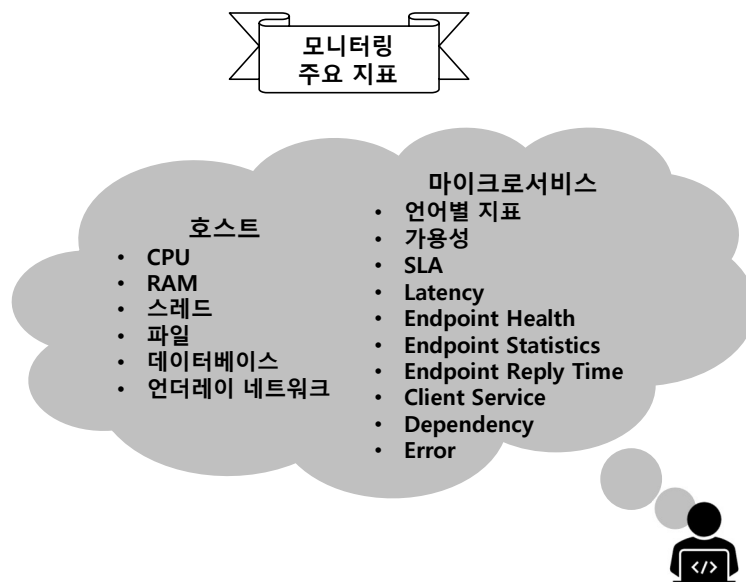


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❖ Below are some of the tools which we can use for containerized applications:

- **Debugging:** Docker CLI, Sysdig
- **Logging:** Docker CLI, Docker Logging Driver
- **Monitoring:** Docker CLI, Sysdig, cAdvisor/Heapster, Prometheus, Datadog, New Reli



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❖ Native Docker Features for Debugging

- **Debugging:**

1. docker inspect
2. docker logs

- **Logging:**

1. docker logs
2. Docker Logging Drivers: With the logging driver we can choose a Docker daemon wide or per container logging policy. Depending on the policy, Docker forwards the logs to the corresponding drivers. Docker supports the following drivers: jsonfile, syslog, journald, gelf (Graylog Extended Log Format), fluentd, awslogs, splunk. Once the logs are saved in a central location, we can use the respective tools to get the insights.

- **Monitoring:**

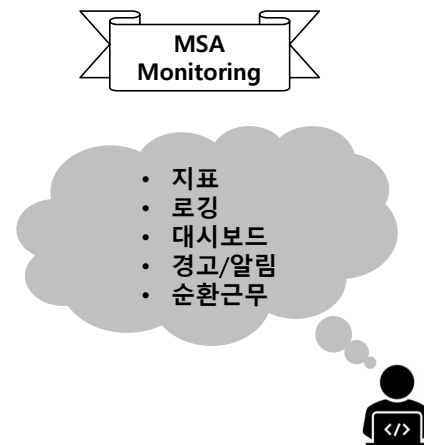
1. docker stats
2. docker top



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- ❖ Sysdig provides an on-cloud and on-premise platform for container security, monitoring and forensics. According to sysdig.com, sysdig is
 - "strace + tcpdump + htop + iftop + lsof + awesome sauce".



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- ❖ It has two open source tools along with their paid enterprise class offerings.
 - **Sysdig:** It saves low-level system information from the running Linux instance, on which we can apply filters and do further analysis.
 - **Sysdig Monitor:** It is a paid offering that provides additional features on top of the open source version.
 - **Sysdig Falco:** It is a container-native tool which can help us gain visibility of containers and applications down to the finest details. It can collect information at system, network and file level. With rule-sets, we can provide our container security information and then take action based on them. For example, if a container does not satisfy the security requirements, Falco can kill the container, notify someone, etc.
 - **Sysdig Secure:** It is also a paid offering that provides additional features on top of the open source version.

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❖ Features of Sysdig Tools

- Sysdig tools have native support to many applications, infrastructure and container technologies, including Docker, Kubernetes, Mesos, AWS, and Google Cloud Platform.
- Paid offerings provide alerting, dashboard, team management, etc.
- They offer a programmatic interface with every part of Sysdig Monitor.



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❖ Benefits of Sysdig Tools

- The tools capture low-level system information from the running Linux instance and containers.
- They offer native support for all Linux container technologies like Docker, LXC, etc.
- They are easy to install.
- They are built to run in production, minimizing performance overhead and the risk of crashes.
- They are Kubernetes-aware.



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❖ cAdvisor

- cAdvisor (Container Advisor) is an open source tool to collect resource usage and performance characteristics for the host system and running containers. It collects, aggregates, processes, and exports information about running containers. As of now, it has native support for Docker and should also support other container runtimes out of the box.



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❖ Using cAdvisor

- We can enable the cAdvisor tool to start collecting statistics with the following command:

```
sudo docker run W
--volume=:/rootfs:ro W
--volume=/var/run:/var/run:rw W
--volume=/sys:/sys:ro W
--volume=/var/lib/docker:/var/lib/docker:ro W
--publish=8080:8080 W
--detach=true W
--name=cadvisor W
google/cadvisor:latest
```

- and point the browser to http://host_IP:8080 to get the live statistics. cAdvisor exposes its raw and processed statistics via a versioned remote REST API. It also supports exporting statistics for InfluxDB. cAdvisor exposes container statistics as Prometheus metrics. Prometheus is an open source community-driven system and service monitoring toolkit.



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❖ Heapster

- Heapster enables container cluster monitoring and performance analysis. It currently supports Kubernetes natively. Heapster collects and interprets various signals, like compute resource usage, lifecycle events, etc., and exports cluster metrics via REST endpoints. KubeDashboard, a performance analytics UI for Kubernetes, uses those endpoints.

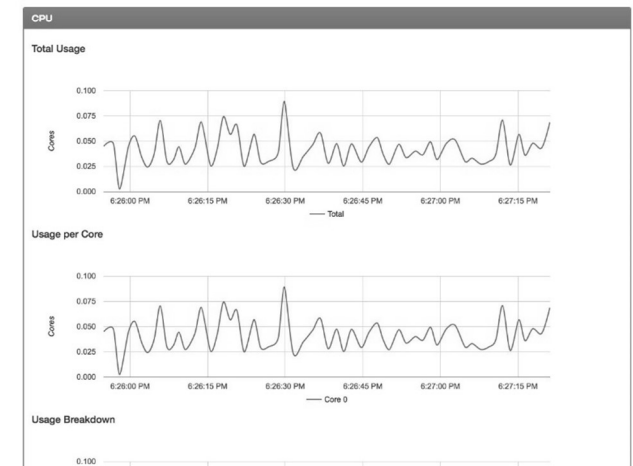


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❖ Host System Resource Usage with cAdvisor

Processes											
User	PID	PPID	Start Time	CPU %	MEM %	RSS	Virtual Size	Status	Running Time	Command	
root	1,536	1,525	12:37	3.00	3.90	38.99 MiB	308.66 MiB	Ssl	00:00:37	cadvisor	
root	1	0	12:35	0.30	0.10	1.71 MiB	9.52 MiB	Ss	00:00:05	init	
root	3	2	12:35	0.20	0.00	0.00 B	0.00 B	S	00:00:03	kssofting/0	
root	1,293	1	12:35	0.20	4.30	42.91 MiB	538.73 MiB	Sl	00:00:03	docker	
root	2	0	12:35	0.00	0.00	0.00 B	0.00 B	S	00:00:00	kthreadd	
root	5	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	kworker/0:0H	
root	7	2	12:35	0.00	0.00	0.00 B	0.00 B	S	00:00:00	rcu_sched	
root	8	2	12:35	0.00	0.00	0.00 B	0.00 B	S	00:00:00	rcu_bh	
root	9	2	12:35	0.00	0.00	0.00 B	0.00 B	S	00:00:00	migration/0	
root	10	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	netns	
root	11	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	perf	
root	12	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	writeback	
root	13	2	12:35	0.00	0.00	0.00 B	0.00 B	SN	00:00:00	ksmd	
root	14	2	12:35	0.00	0.00	0.00 B	0.00 B	S	00:00:00	kworker/0:1	
root	15	2	12:35	0.00	0.00	0.00 B	0.00 B	SN	00:00:00	khugepaged	
root	16	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	crypto	
root	17	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	kintegrityd	
root	18	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	bioset	
root	19	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	kblockd	
root	20	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	ata_sff	
root	21	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	devfreq_wq	
root	22	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	rpciod	
root	25	2	12:35	0.00	0.00	0.00 B	0.00 B	S	00:00:00	kswapd0	
root	26	2	12:35	0.00	0.00	0.00 B	0.00 B	S<	00:00:00	vmstat	
root	27	2	12:35	0.00	0.00	0.00 B	0.00 B	S	00:00:00	fenotify_mark	



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❖ Docker Host Specific Details with cAdvisor

cAdvisor					
Docker Containers					
Docker Containers					
Subcontainers					
client4 (/docker/a2f13ed56bb0a61a7bdde1f368e7dc647ae58624b8f25c611ac6e3010fa3a417)					
cadvisor (/docker/79cad77240e730627f9edea5969dc05181cd3466d4b91d4e12ec5def507fa043)					
client5 (/docker/a1e7af012f5d3624f32004f80769b13e0b67fccfed13cc630c12b82717646519)					
client3 (/docker/244cf16b24b7b73e8b6aa12d5f04c535901c9b8c13d9c83f54d79a0617346119)					
Driver Status					
Docker Version 1.11.1					
Kernel Version 4.4.8-boot2docker					
OS Version Boot2Docker 1.11.1 (TCL 7.0); HEAD : 7954f54 - Wed Apr 27 16:36:45 UTC 2016					
Host Name jenkins					
Docker Root Directory /mnt/sda1/var/lib/docker					
Execution Driver					
Number of Images 3					
Number of Containers 12					
Storage					
Driver aufs					
Dirperm1 Supported true					
Root Dir /mnt/sda1/var/lib/docker/aufs					
Backing Filesystem extfs					
Dirs 69					
Images					
Repository	Tags	ID	Virtual Size	Creation Time	
jenkins	2.0	sha256:c02c54e3a0962024d	679.00 MiB	5/5/2016, 7:32:01 PM	
google/cadvisor	latest	sha256:4bc3588563b107ed7	45.99 MiB	5/13/2016, 12:15:40 AM	
alpine	latest	sha256:13e1761bf172304ec	4.57 MiB	5/6/2016, 8:26:49 PM	

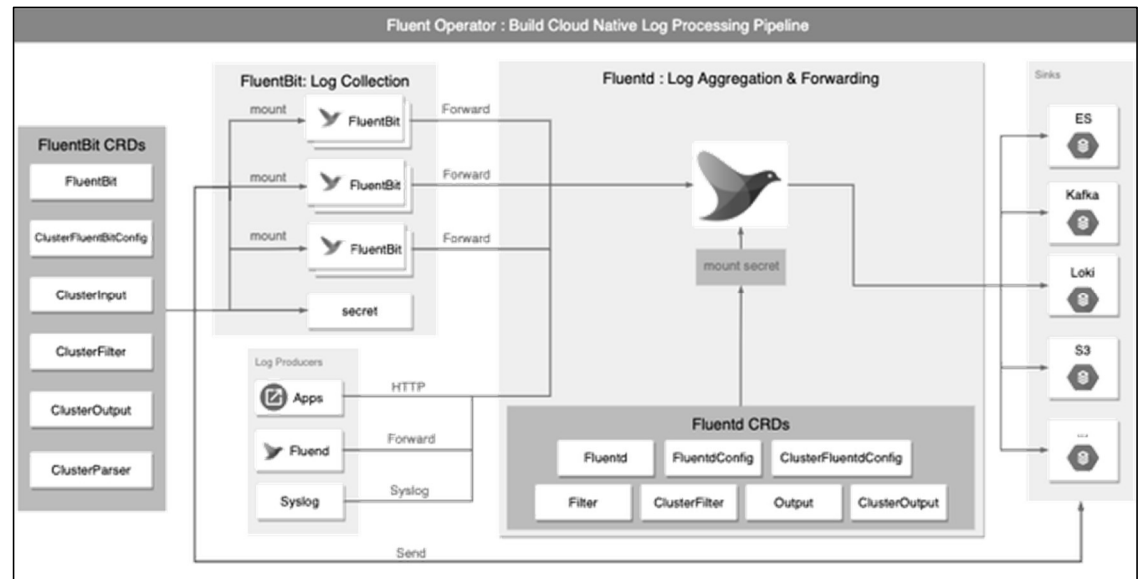
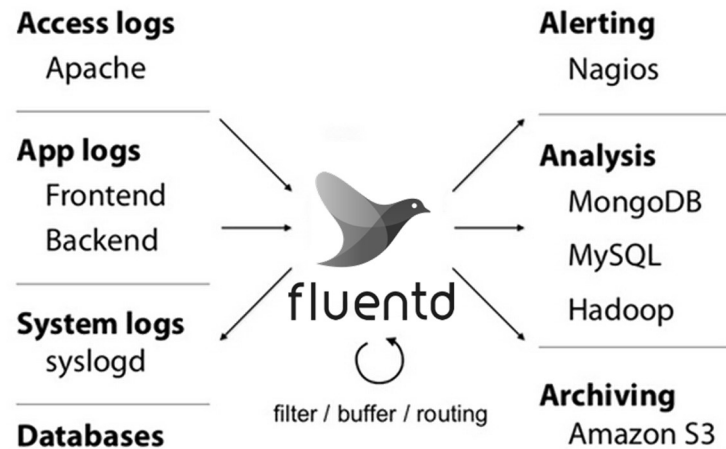


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❖ **Fluentd: an open source data collector for unified logging layer.**



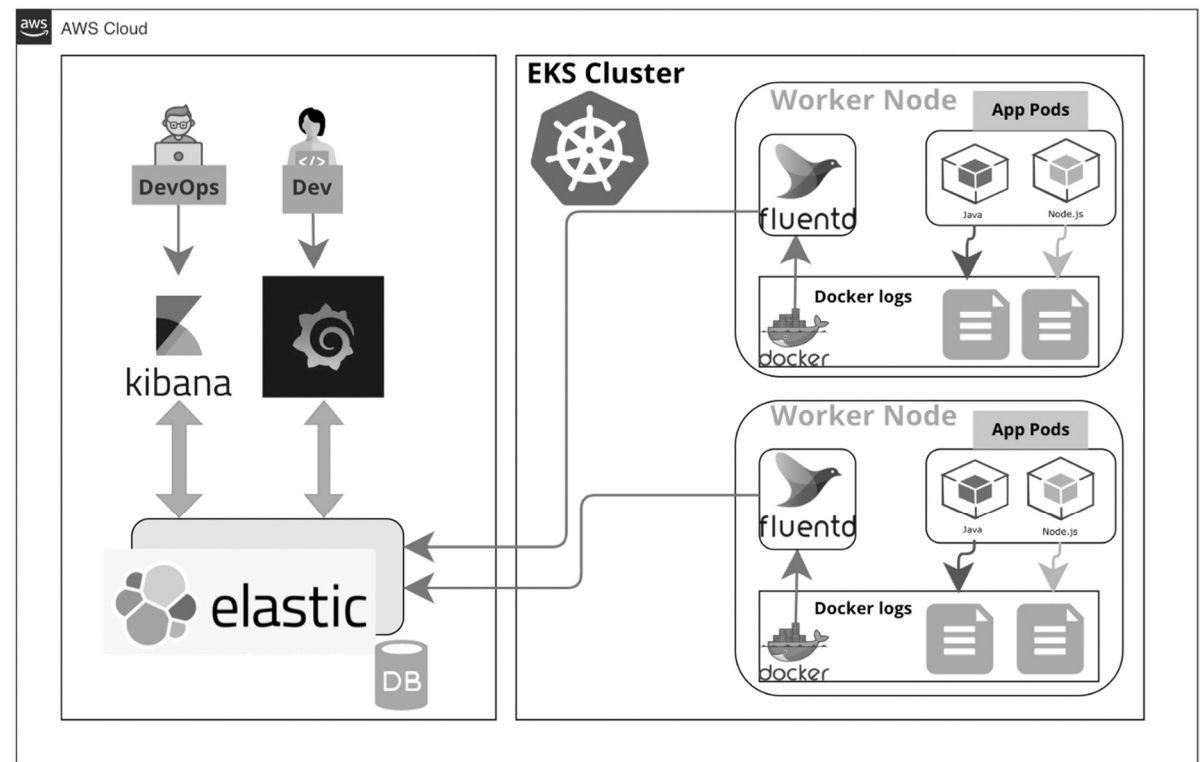
Source: Fluentd Architecture (by Treasure Data, Inc., retrieved from <https://docs.fluentd.org/>)



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❖ Kubernetes application logging using Fluentd



Source: <https://faun.pub/kubernetes-application-logging-using-fluentd-2794c0ce9d24>



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❖ Benefits of Using Fluentd

- It is an open source data collector.
- It is simple, fast, and flexible.
- It is performant and developer-friendly.



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- ❖ Datadog
- ❖ Datadog provides monitoring and analytics as a service for Development and OPs teams. Some of the systems, applications and services it connects to are:
 - Amazon EC2
 - Apache
 - Java
 - MySQL
 - CentOS.

INFRASTRUCTURE	APM	DIGITAL EXPERIENCE
Infrastructure Monitoring	Distributed Tracing	Real User Monitoring
Network Performance Monitoring	Continuous Profiler	Synthetic Monitoring
Network Device Monitoring	Database Monitoring	Continuous Testing
Container Monitoring	CI Visibility	Session Replay
Serverless	Service Catalog	Error Tracking
Cloud Cost Management	Universal Service Monitoring	
		PLATFORM CAPABILITIES
LOGS	SECURITY	CoScreen
Log Management	Cloud Security Management	Dashboards
Sensitive Data Scanner	Application Security Management	Watchdog
Audit Trail	Cloud SIEM	Alerts
Observability Pipelines		Incident Management
		Integrations
		API

Source: <https://www.datadoghq.com/>



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- ❖ A detailed list of integration can be found in the documentation it provides. We need to install an agent in the host system, which sends the data to the Datadog's server. Once the data is sent, we can:
 - Build an interactive dashboard.
 - Search and co-relate matrices and events.
 - Share the matrices and events.
 - Get alerts.

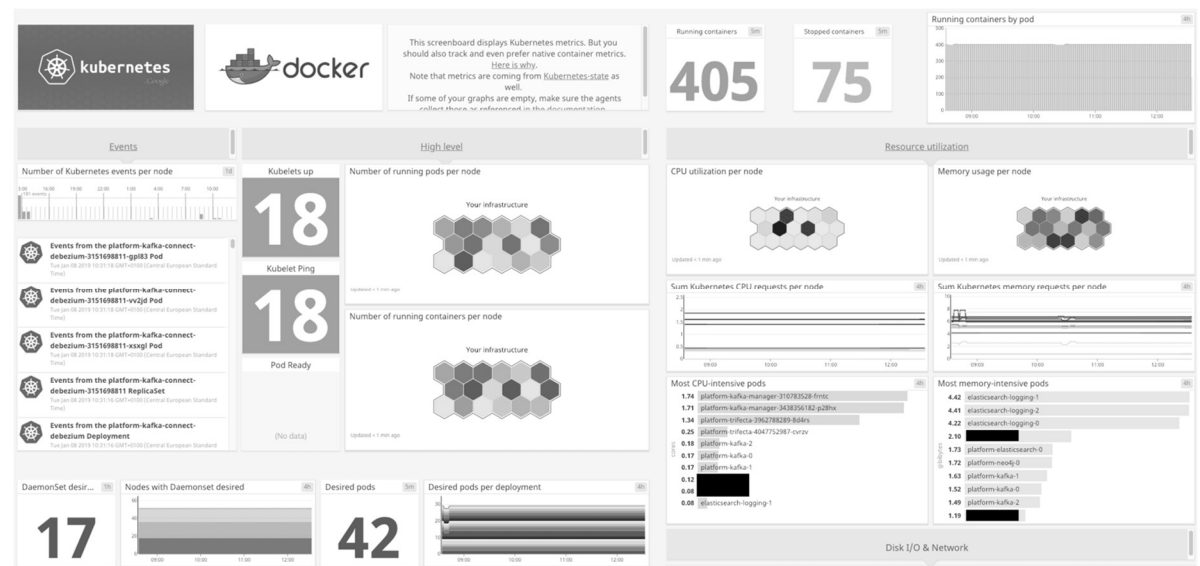


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❖ Docker Containers: Kubernetes Monitoring with Datadog

- The number of nodes in the cluster
- The running and stopped containers
- The most resource-consuming pods
- Docker logs, etc.



Source: Docker Containers - Kubernetes Monitoring with Datadog (by Datadog, Inc., retrieved from <https://www.acagroup.be/en/blog/monitor-kubernetes-cluster-datadog/>)

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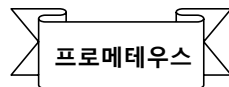
❖ Benefits of Using Datadog

- It comes pre-integrated with well-known third-party applications.
- It provides a seamless workflow, regardless of platform, location or language.
- It configures information filtration to get only needed metrics.
- It allows us to enable the system to send alerts or notifications when serious issues arise.
- It offers tools for team collaboration.
- It is scalable.



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

- ❖ Prometheus
- ❖ Prometheus is an open source tool used for system monitoring and alerting. It was originally developed by SoundCloud and is now one of the incubated projects at CNCF Foundation.
- ❖ Prometheus is suitable for recording any purely numeric time series data. It works well for both machine-centric monitoring like CPU, memory usage, and monitoring of highly dynamic service-oriented architectures. It is primarily written in Go.



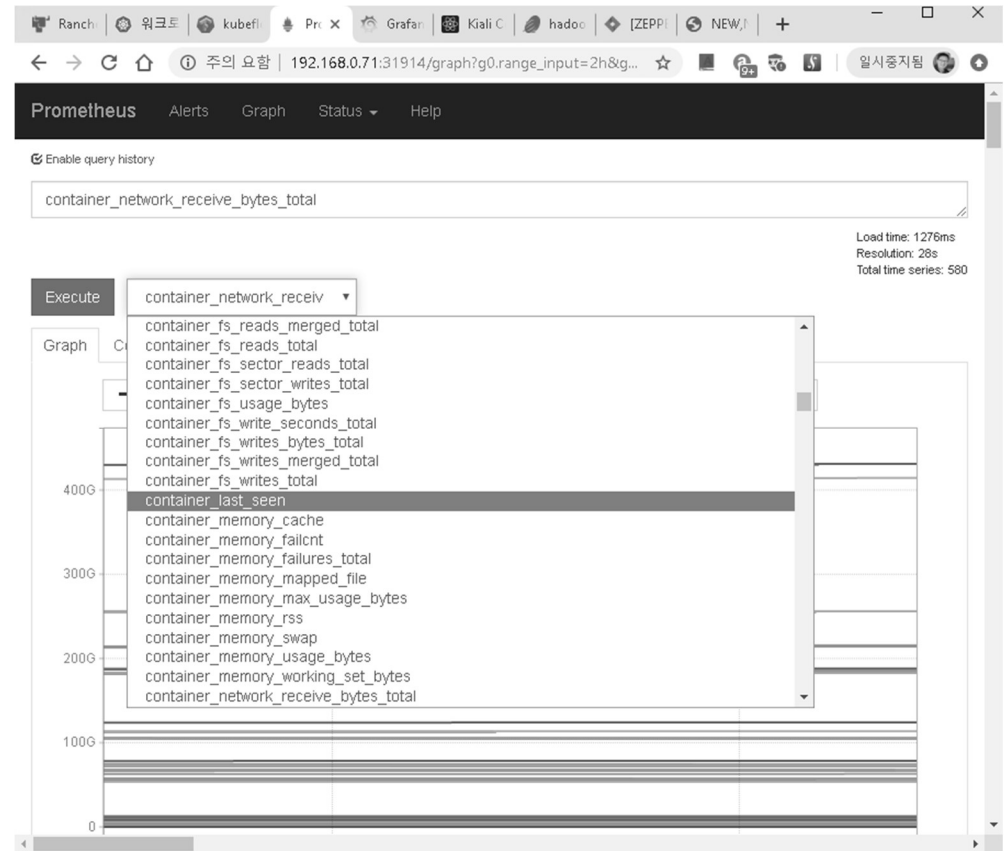
다차원 시계열 데이터베이스로서
경고 문자와 그래프 계산을 지원



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❖ Prometheus



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❖ Prometheus Features

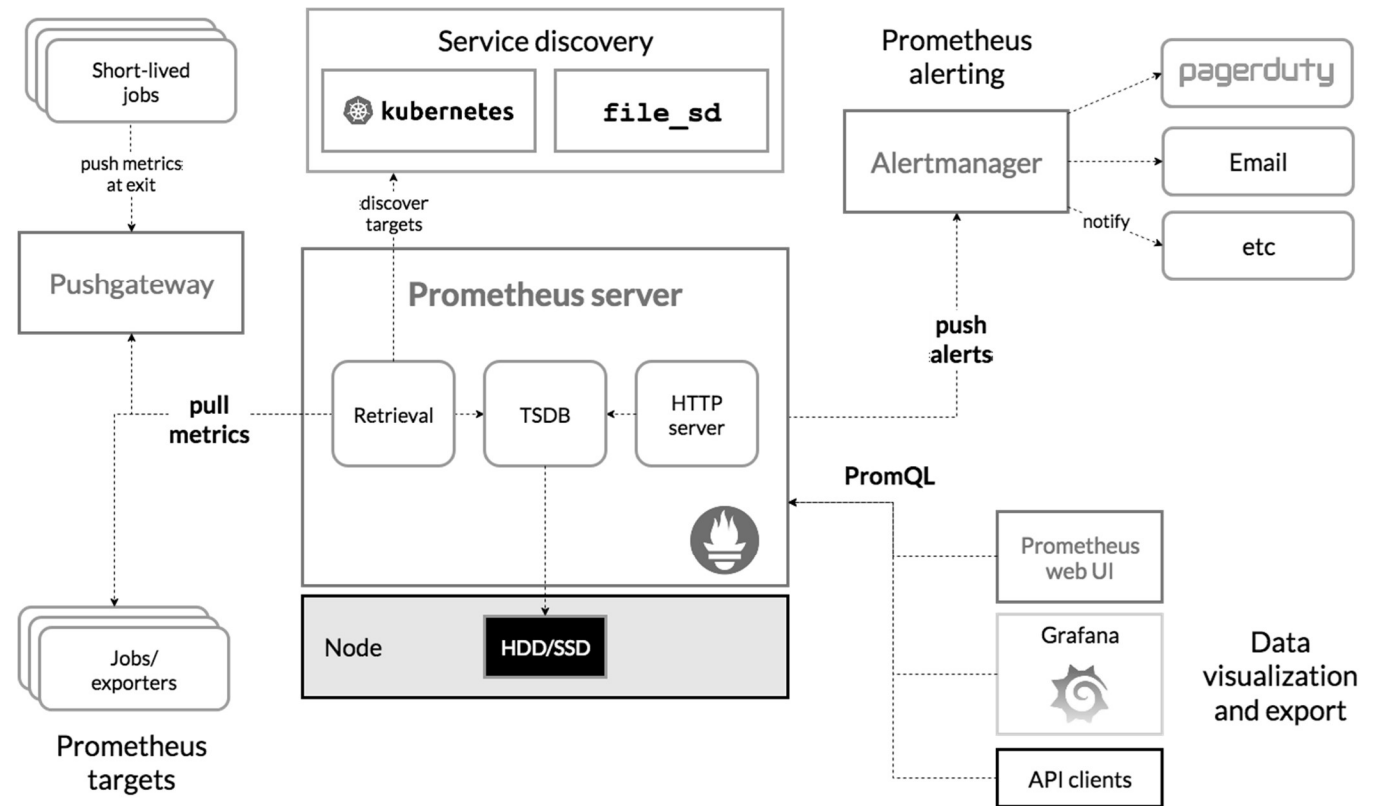
- It is very reliable.
- It supports multi-dimensional data model with time series data identified by metric name and key/value pairs.
- It supports a query language to effectively query the collected time series data.
- It support metrics collection through pull- and push-based mechanism.
- It can discover target endpoints via service discovery or static configuration.
- It can connect with external tools like Grafana and Pagerduty for dashboarding and alerting.
- It supports client libraries for programming language like Go, Java, Python, etc. to add instrumentation to their code.



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❖ Prometheus Architecture



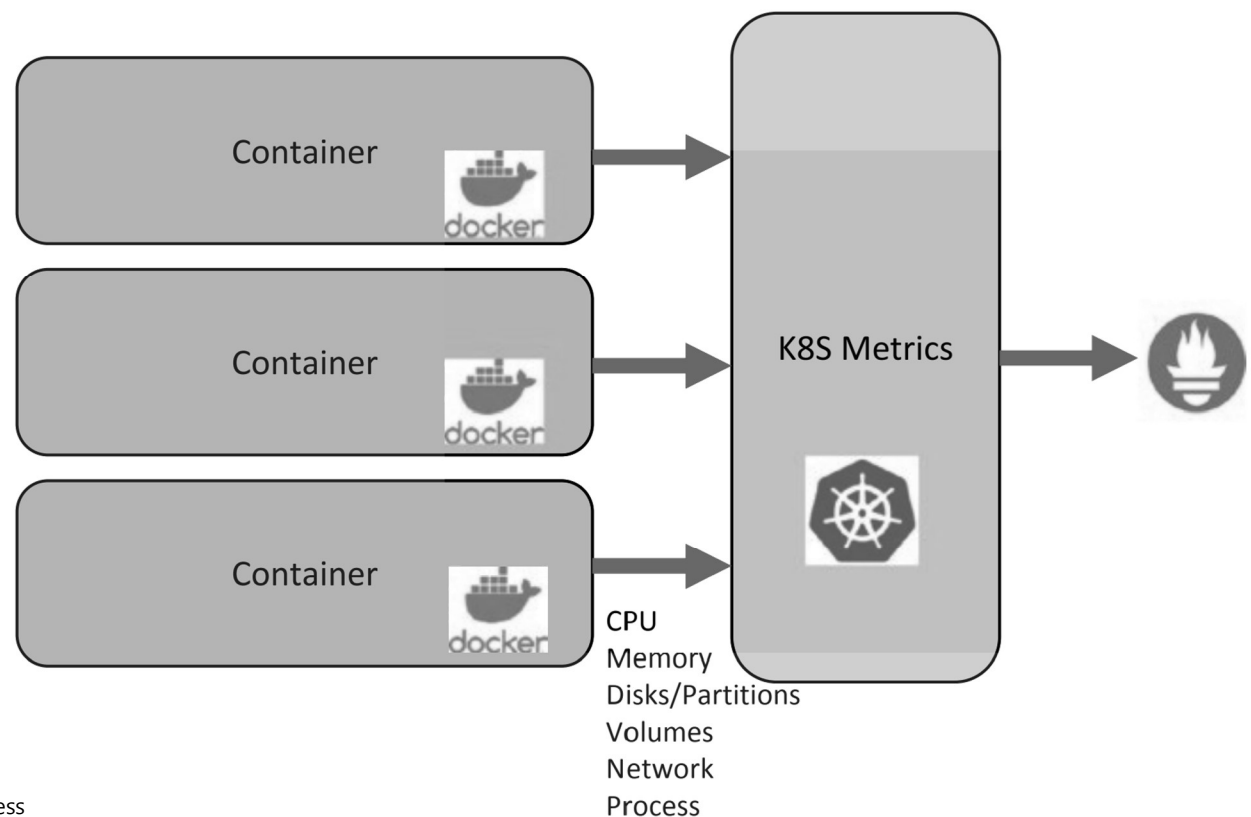
Source: <https://prometheus.io/docs/introduction/overview/>



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❖ 컨테이너와 클러스터 모니터링 (Container and cluster monitoring)



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

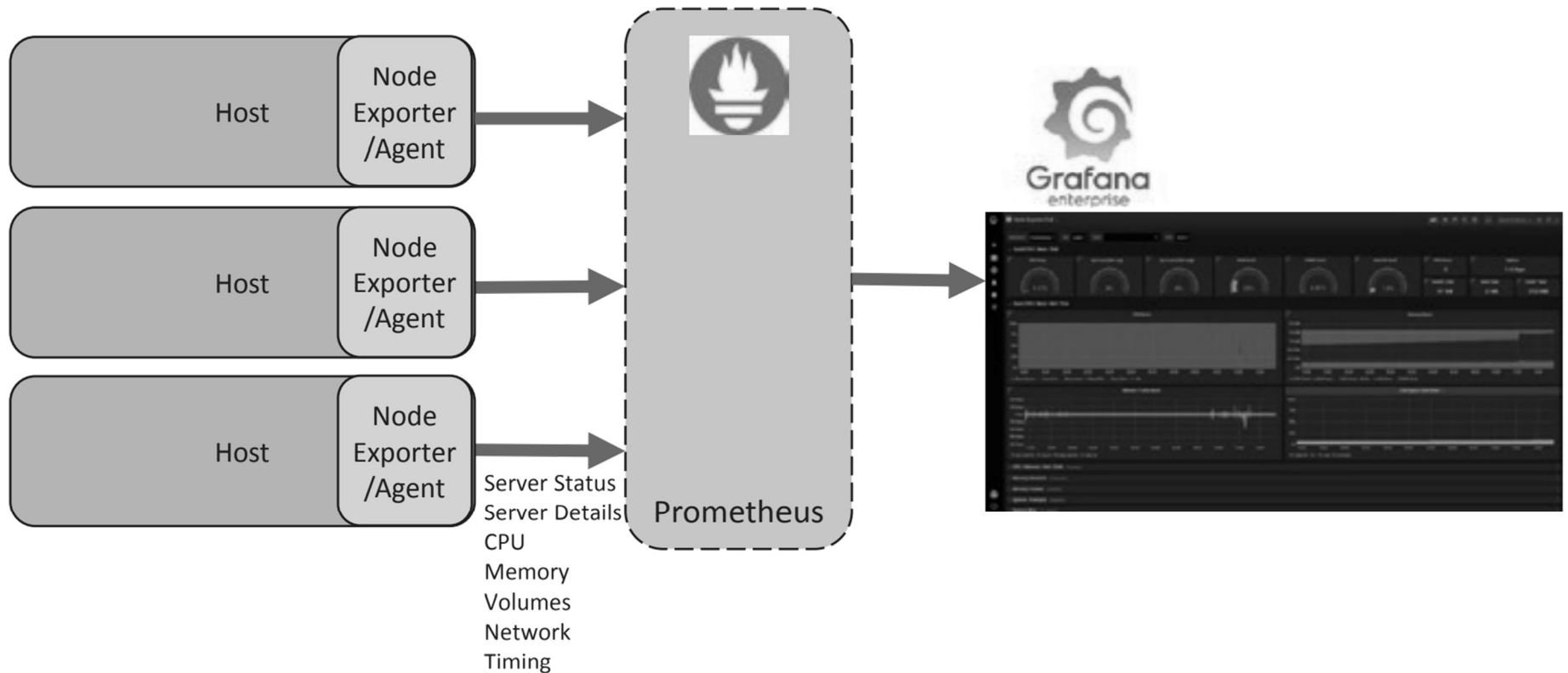


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❖ 호스트 수준 모니터링 (Host-level monitoring)



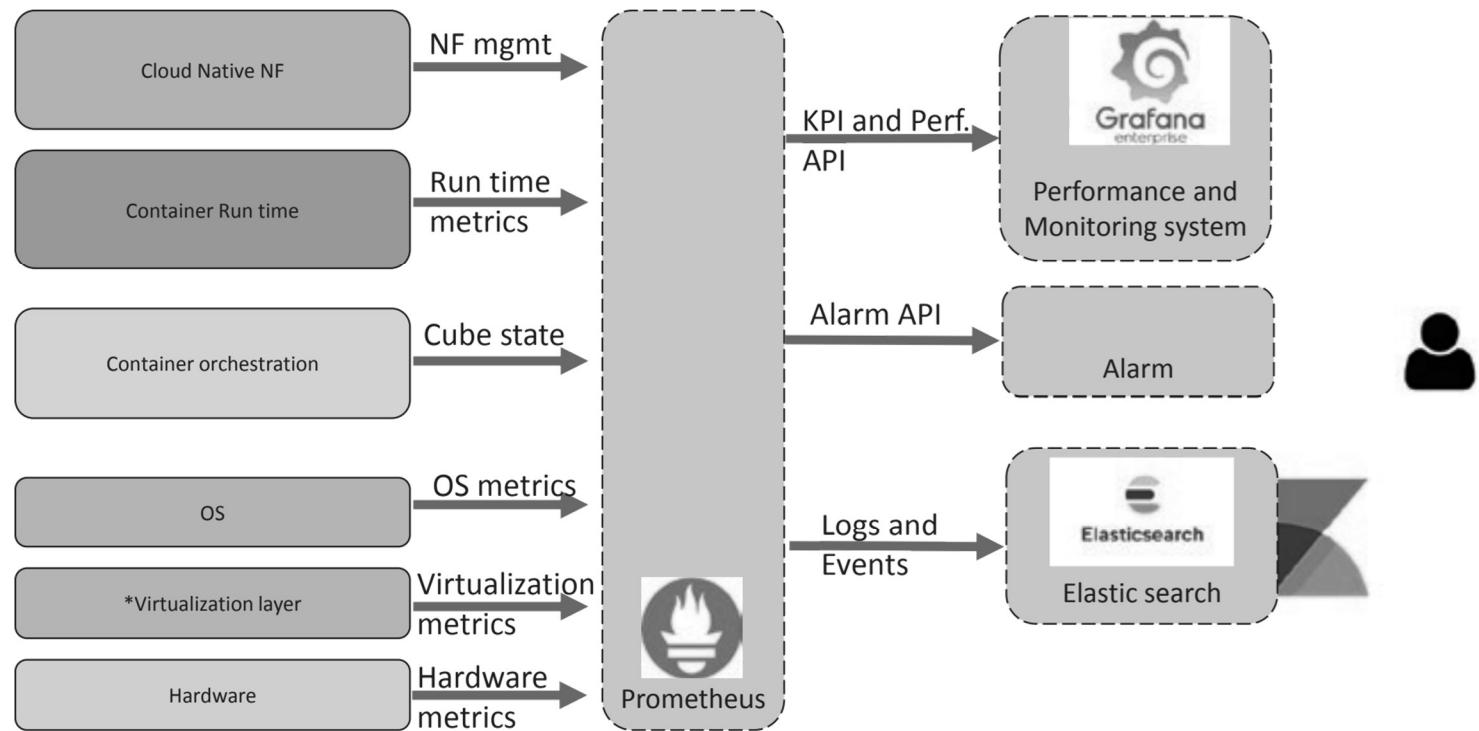
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



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❖ 모니터링과 장애해결 (Illustration of monitoring and troubleshooting)



*optional

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



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

268

❖ Direct and Indirect Communication for NF and NF Services



5G NF: 5G Network Function
API: Application Programming Interface
SCP: Service Communication Proxy

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



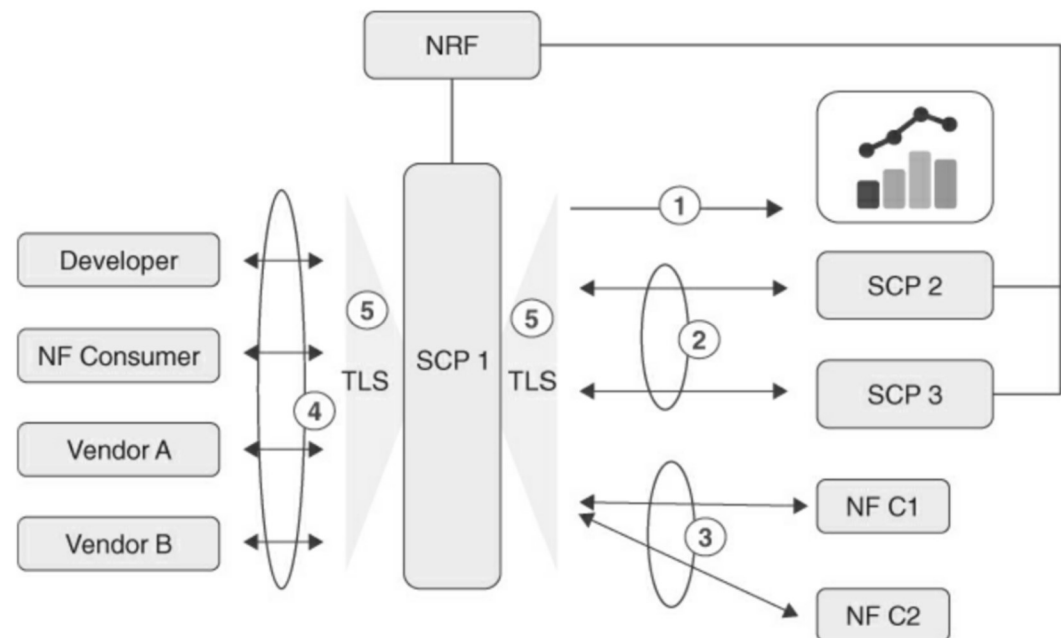
JS Lab

4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

269

❖ Key Functions of SCP

- ① Centralized monitoring
- ② Distributed SCP deployment
- ③ Load balancing
- ④ Resilient integration with third-party vendors and application developers
- ⑤ Encrypted communications



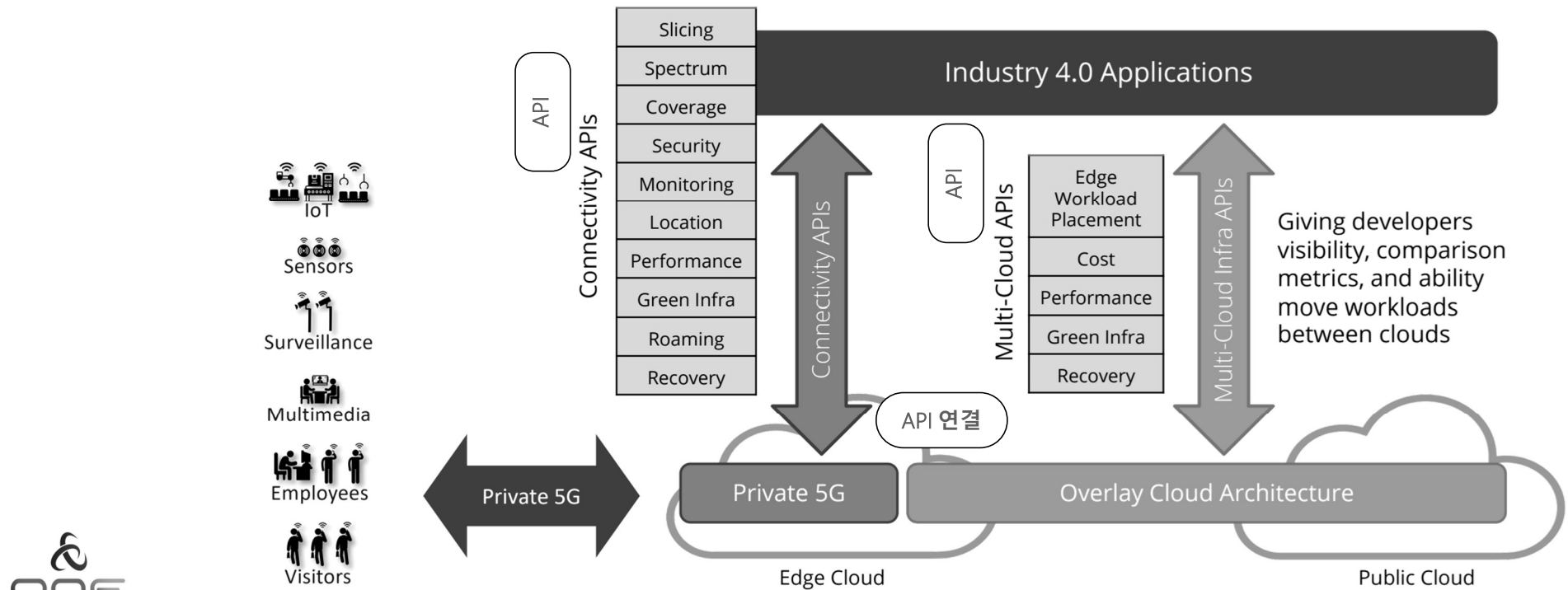
Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

270

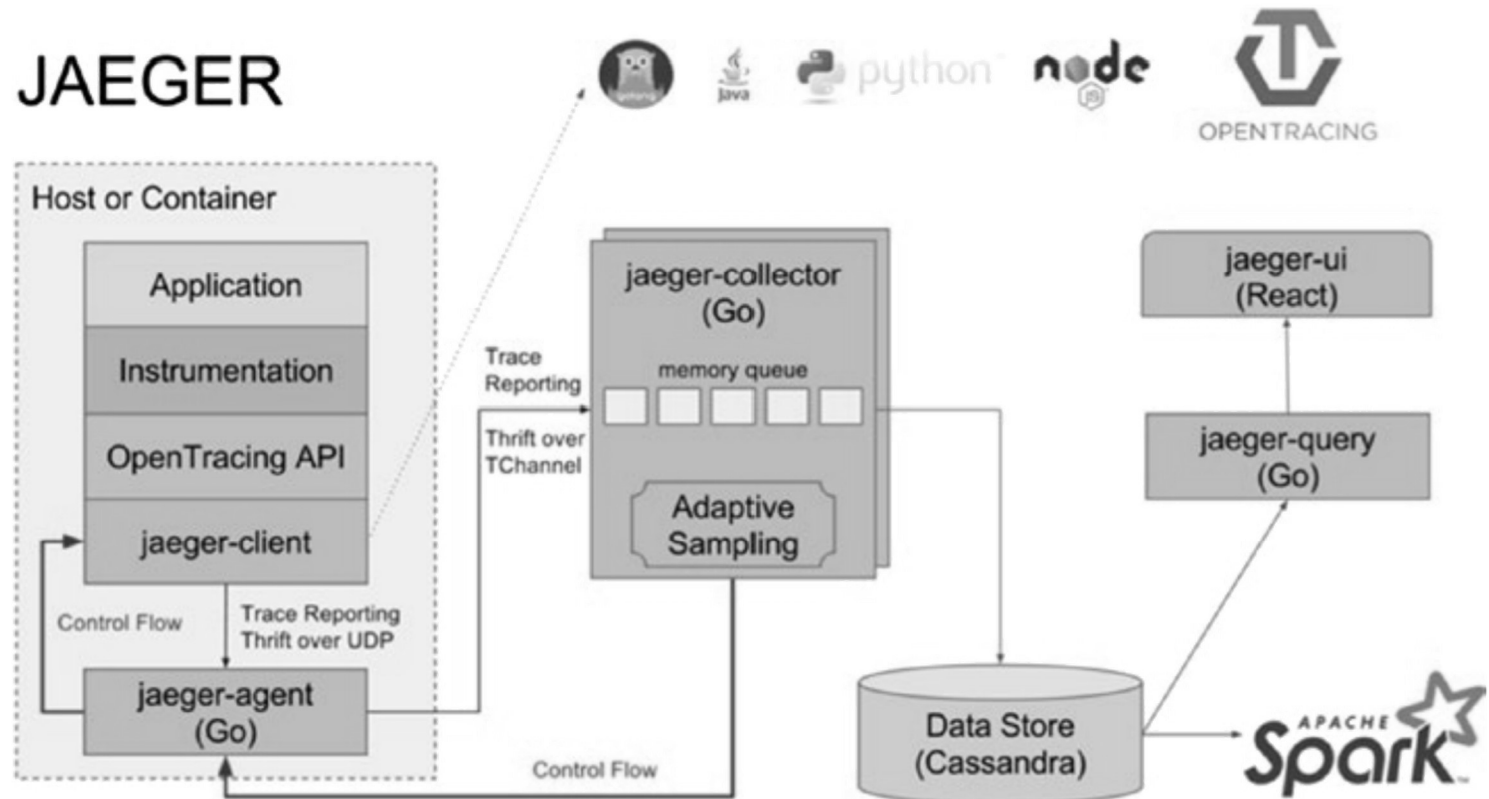
❖ IoT-5G-Edge Architecture (ONF)



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

271

❖ 분산 트레이스 (Distributed tracing)



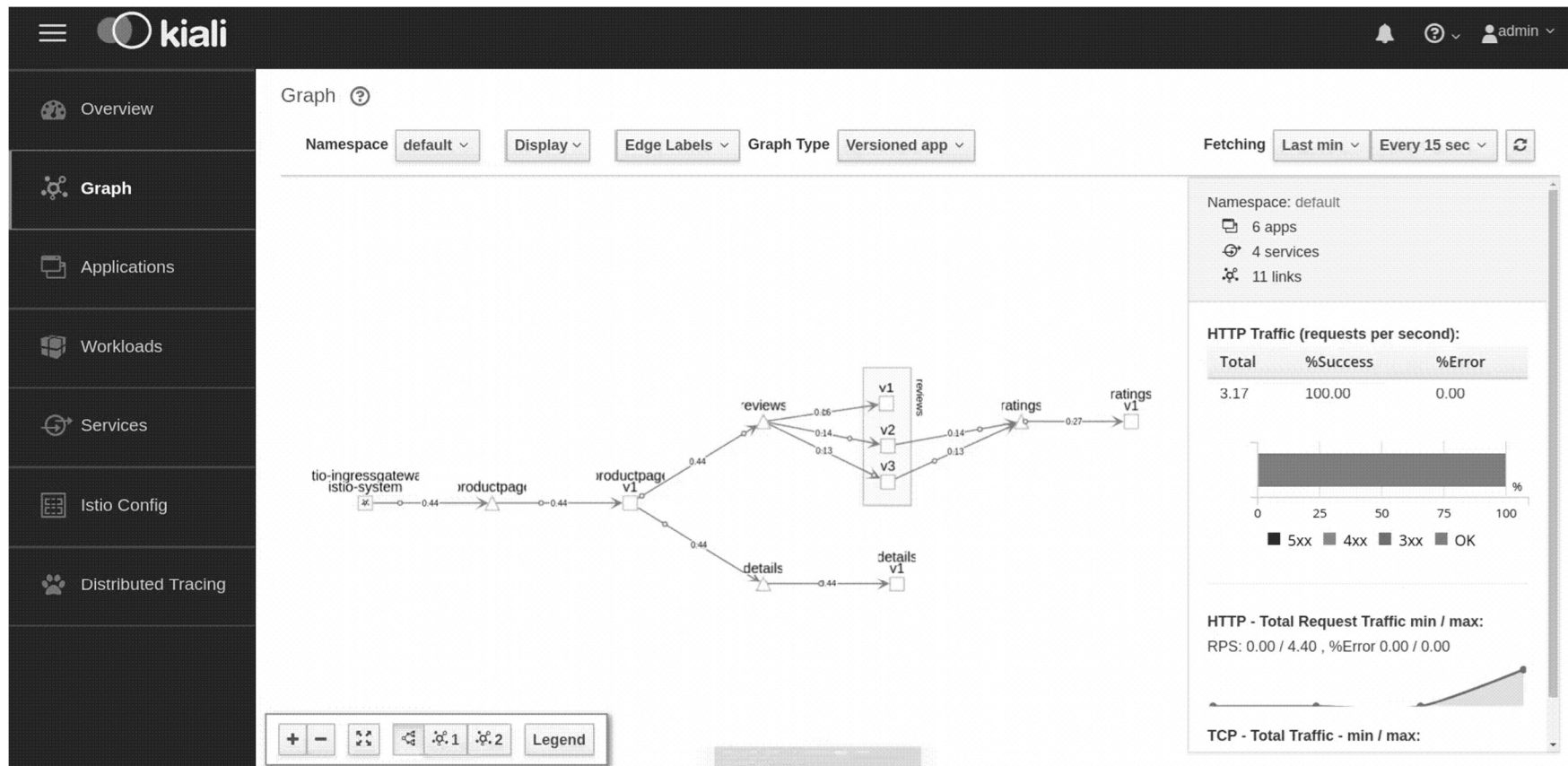
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

272

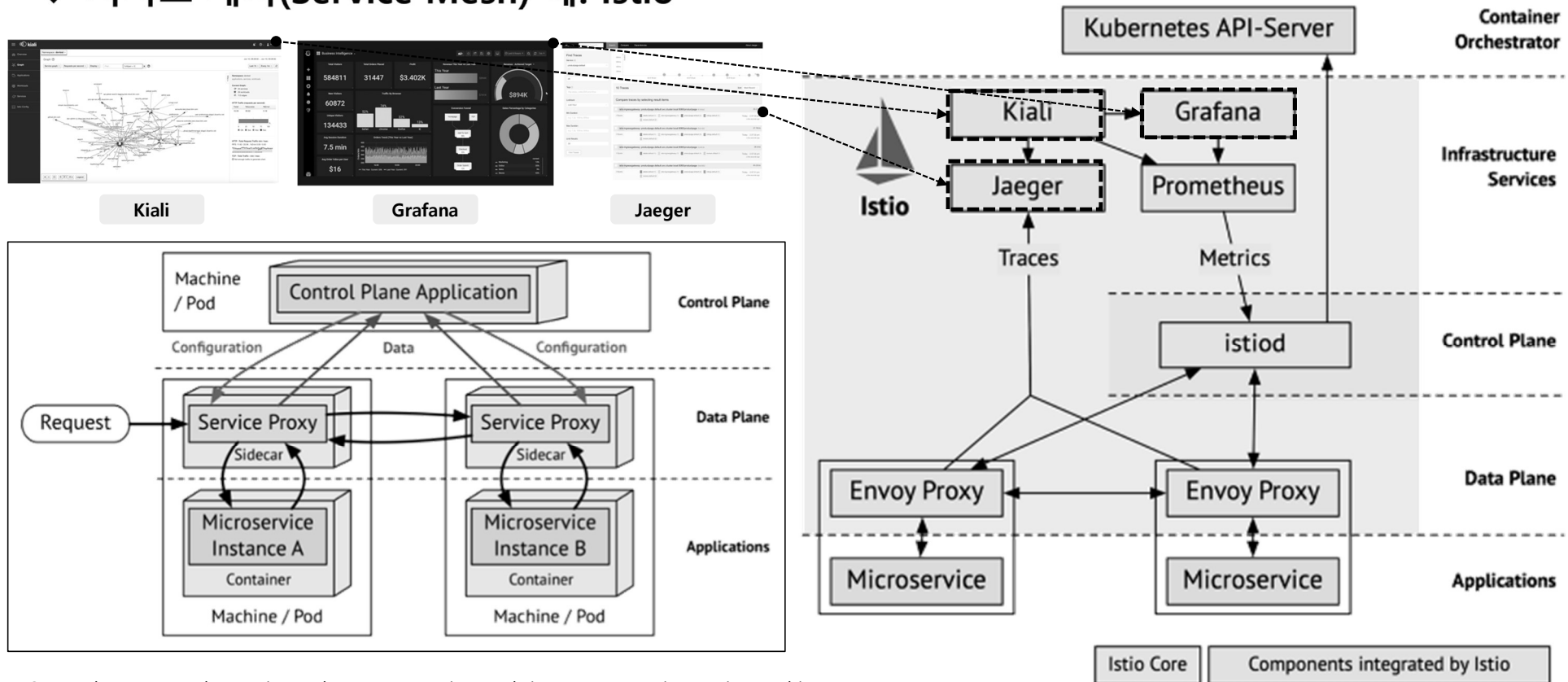
❖ Istio (Service Mesh)



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ 서비스 메시(Service Mesh) 예: Istio



Source: <https://www.dataversity.net/how-can-a-service-mesh-improve-your-microservices-architecture/>

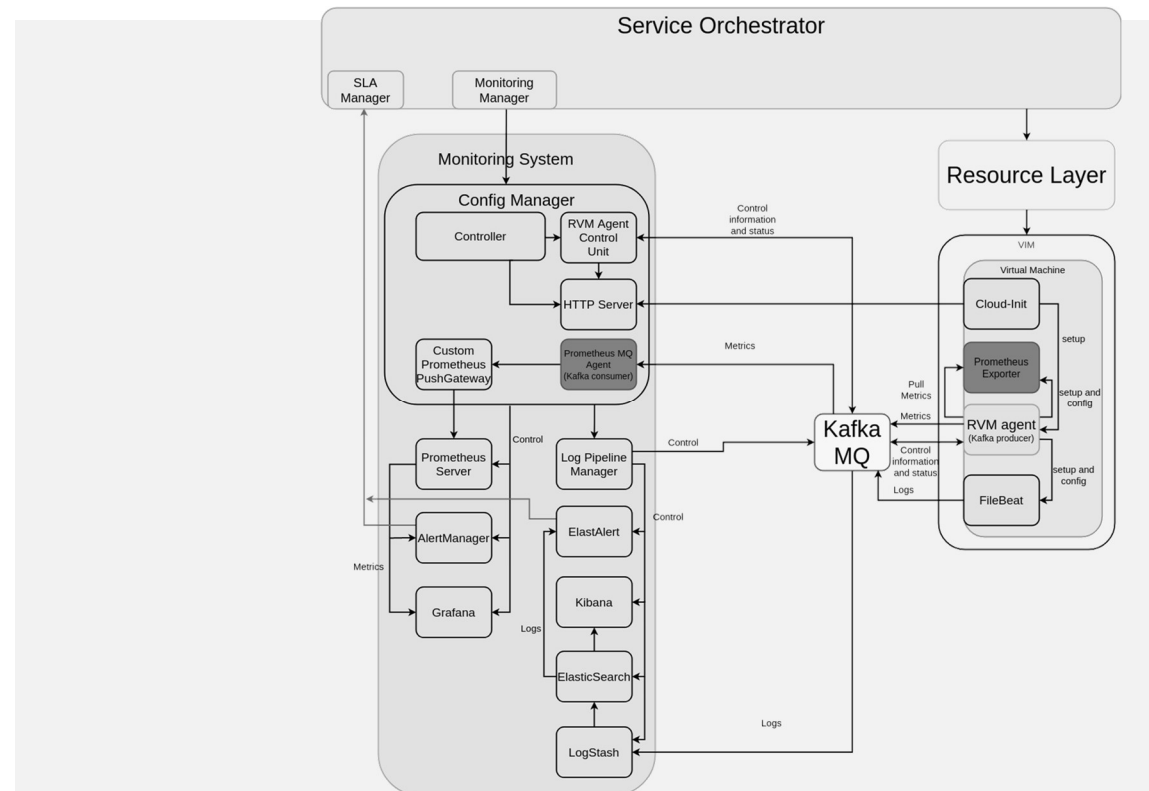


4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

274

❖ Vertical-oriented Monitoring System Architecture

- 서비스 오케스트레이터
- 프로메테우스 (Prometheus)
- 카프카 (Kafka Message Queue)



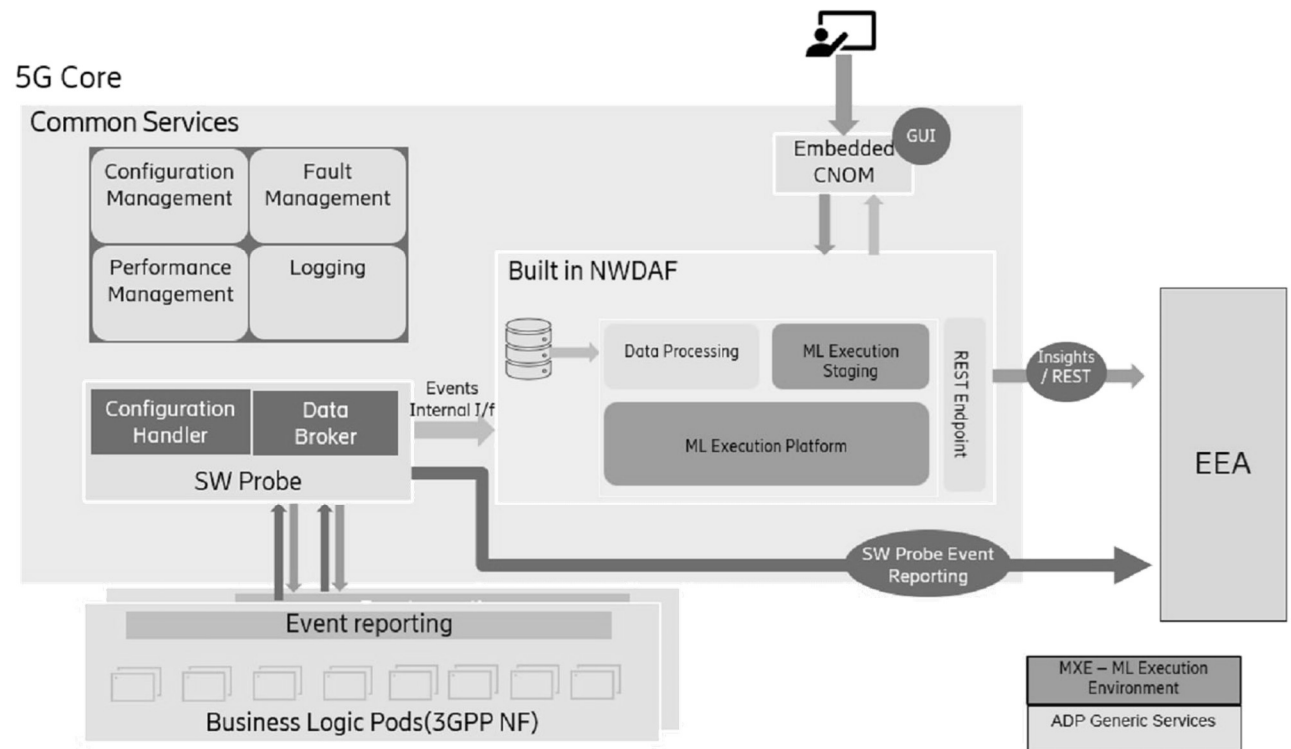
Source: 5GPPP Architecture Working Group, 5G Architecture White Paper



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

275

- ❖ 제조사 (예): Ericsson - To enable ML/AI platform that constitutes the NWDAF
 - What built-in NWDAF looks like in 5G Core



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ Observability for Monitoring, Tracing Lineage in Microservices

• Four Pillars of Observability

- Log aggregation/analytics
- Alerting/visualization
- Distributed systems tracing infrastructure
- Monitoring



Source: https://www.decipherzone.com/blog-detail/observability-monitoring-in-microservices?fbclid=IwAR110yqe7k0mnectfUVUpnYUelcVHOg_tqIf1NpSzUQGR3VfAxldbDNlvaY



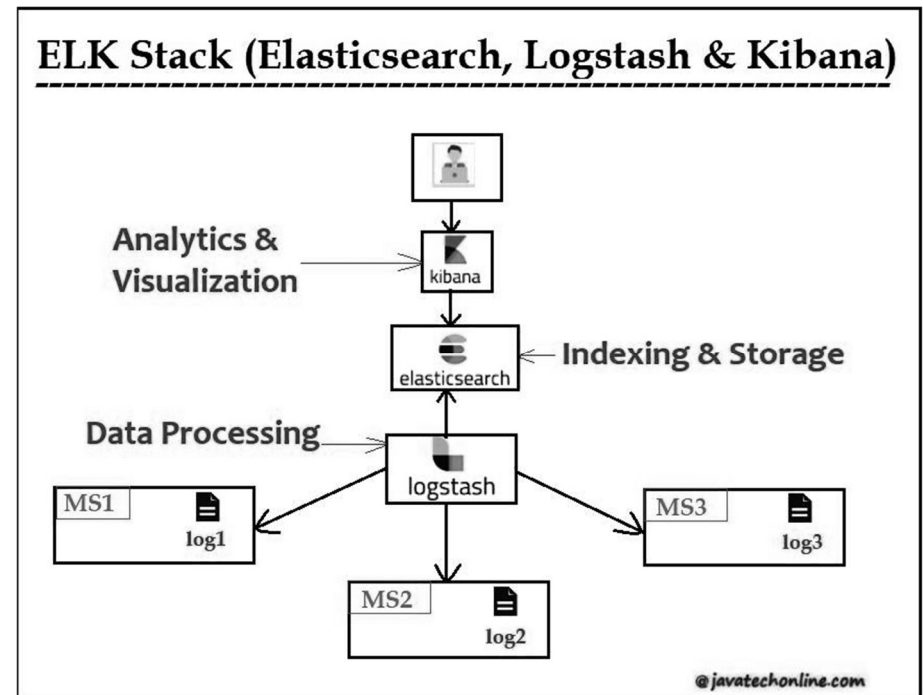
4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

277

❖ Monitor Java Spring Boot Microservices Application Using ELK Stack

• ELK Stack

- Elasticsearch
- Logstash
- Kibana



Source: https://javatechonline.com/how-to-monitor-spring-boot-microservices-using-elk-stack/?fbclid=IwAR2iqeO2oHKovoedVHH2FZP_G87SzXcXUomFtJiAXrrhBb65pB3DTLkA-S4



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

278

❖ Observability Tools

- SigNoz
- Grafana Labs
- Honeycomb
- Instana
- Lightstep
- Dynatrace
- Datadog
- Splunk
- New Relic
- Sentry

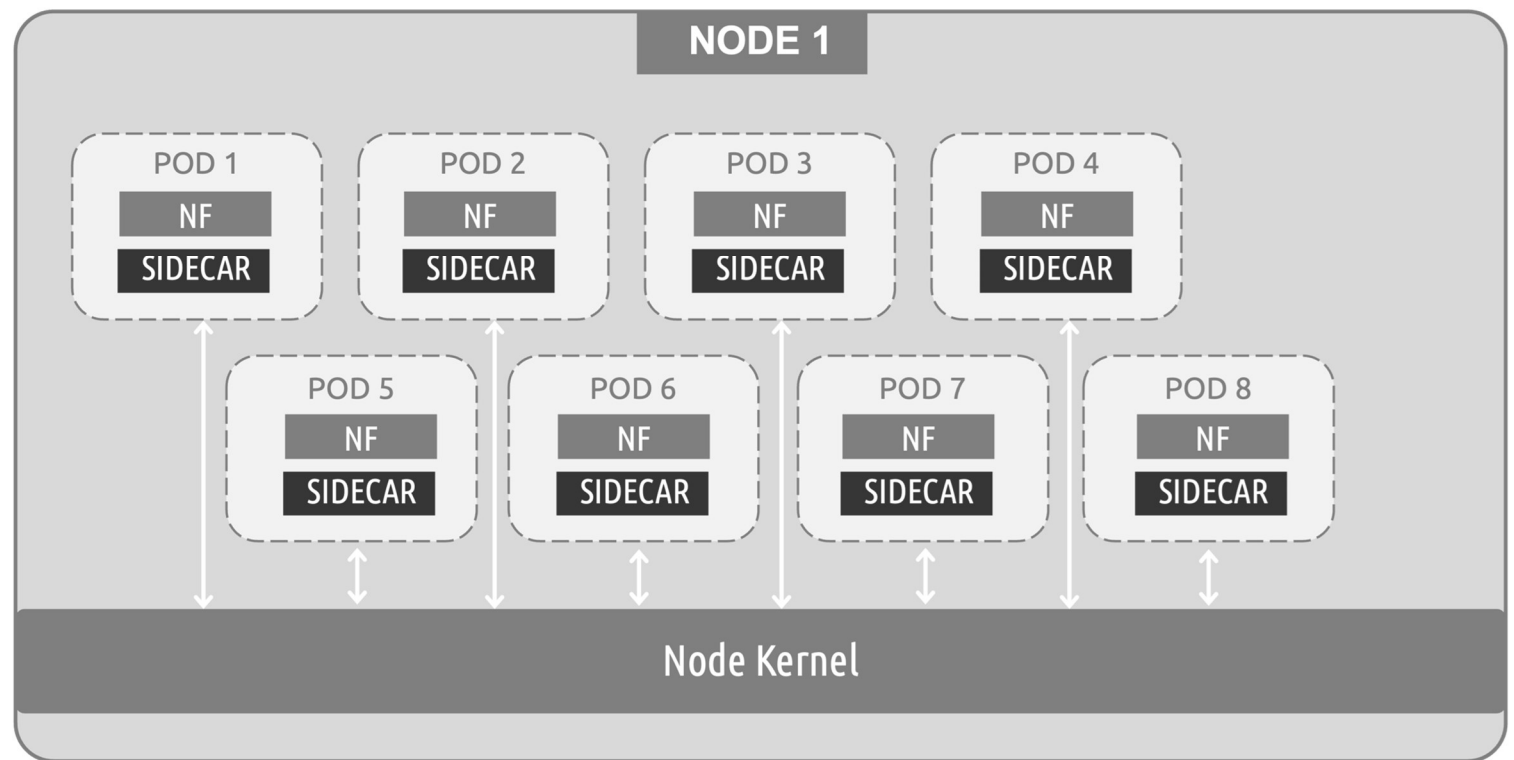
Source: <https://www.mantisnet.com/blog/ebpf-v-sidecar-containers-5g-observability>



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ The sidecar container



Source: <https://www.mantisnet.com/blog/ebpf-v-sidecar-containers-5g-observability>

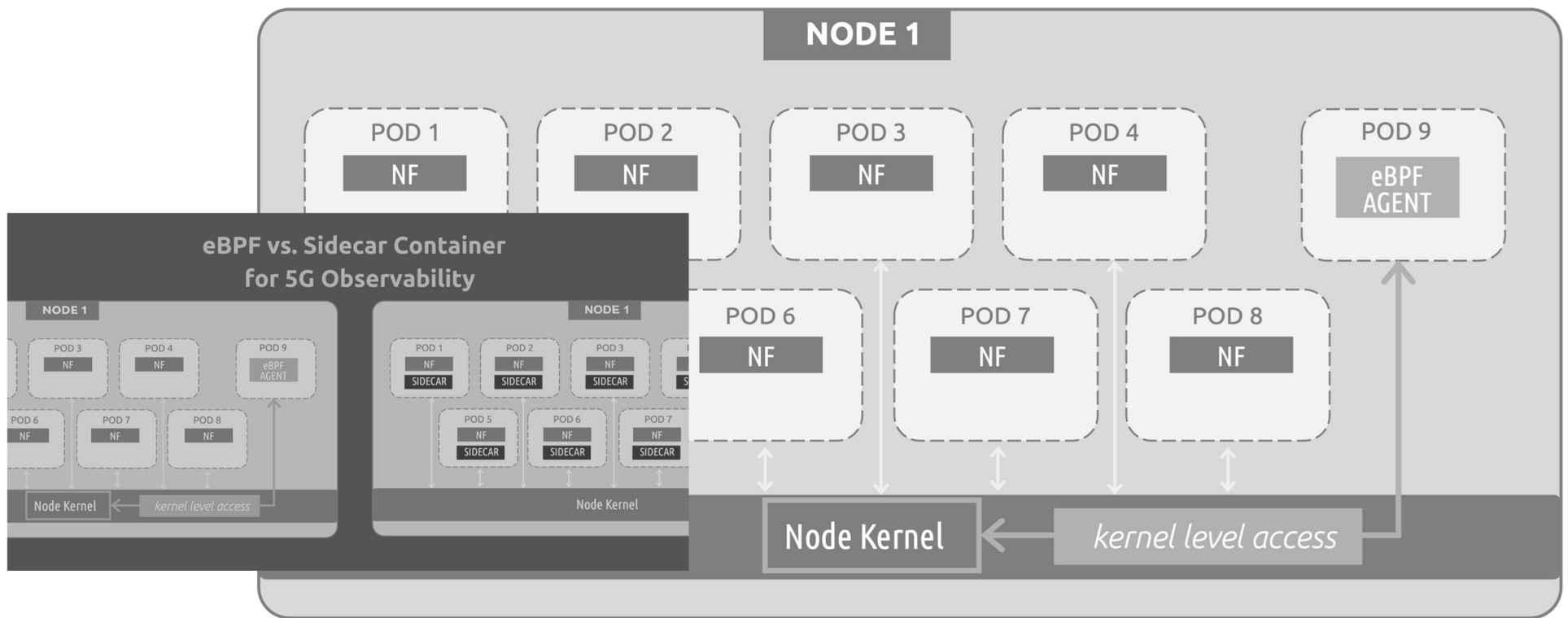


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4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ eBPF technology



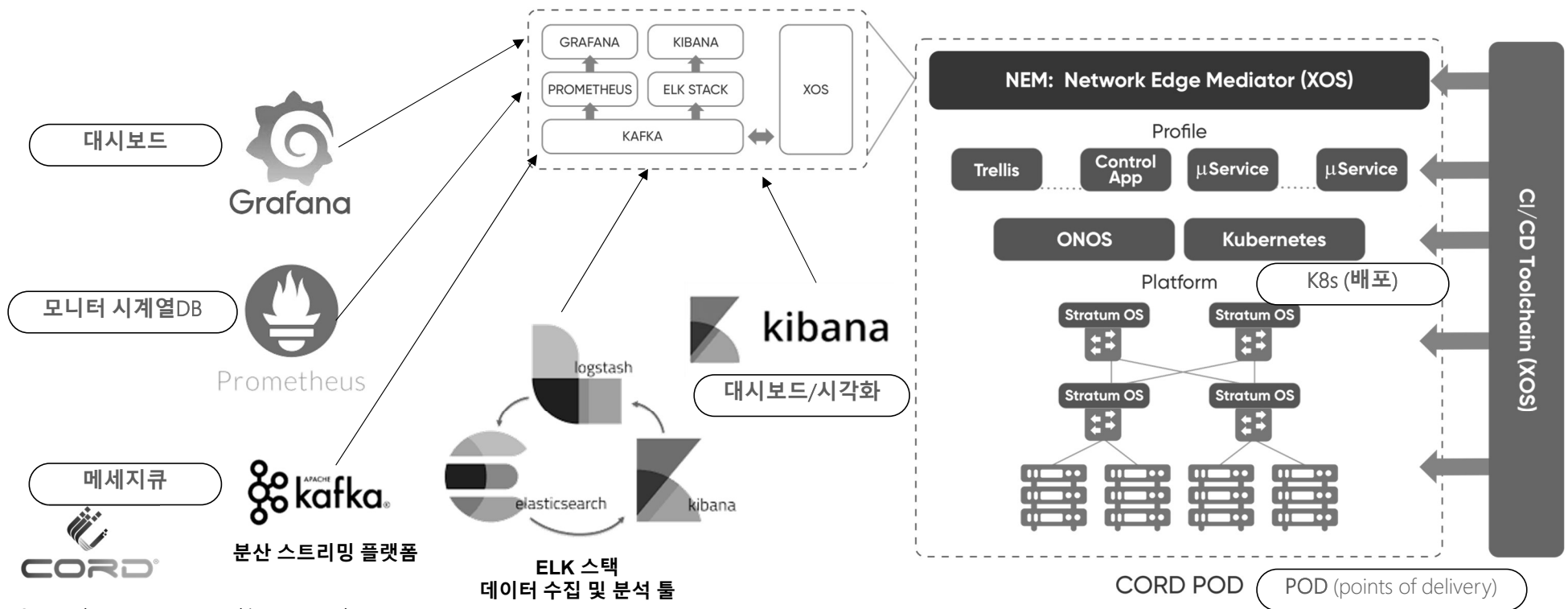
Source: <https://www.mantisnet.com/blog/ebpf-v-sidecar-containers-5g-observability>



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

281

❖ CORD (Central Office Re-architected as a Datacenter)

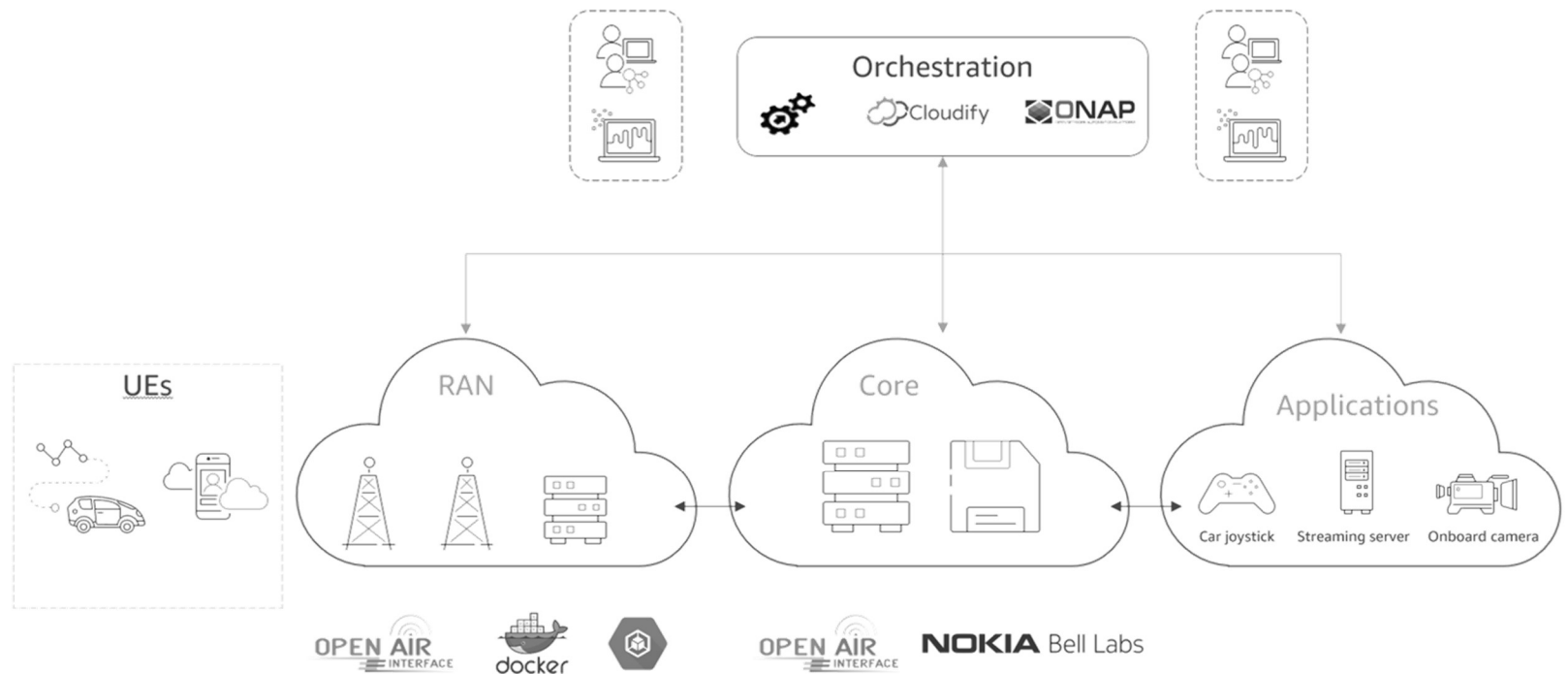


4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

282

❖ Implementing 5G Network Slicing with Cloudify on AWS

- Use of Cloudify with ONAP to deliver full 5G network slicing.



Source: <https://aws.amazon.com/blogs/industries/implementing-5g-network-slicing-with-cloudify-on-aws/>



JS Lab

4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ Configuring a network slice.

The screenshot displays the AWS Cloudify console interface for configuring a network slice blueprint. The main form is titled "Deploy blueprint eMBB_5G-Slice" and includes the following fields:

- Deployment name:** eMBB_5G-Slice_A
- Site name:** AWS_Edge_Location-1
- Deployment inputs:** Includes a "Show Data Types" button and a "Load Values" button.
- Slice_Differentiator:** A dropdown menu with options: QOS 3, Priority 3, Service A (selected), QOS 4, Priority 4, Service B, and QOS 5, Priority 5, Service C.
- Slice_Domain:** A dropdown menu with options: Core_UPF (selected), Core_Full, RAN, Transport_Network, Data_Network(MEC), and Slice_E2E.
- Slice_Location:** A dropdown menu with options: AWS_Edge_Location-1 (selected), AWS_Edge_Location-2, and AWS_Edge_Location-3.
- Slice_Type(SST):** 1

Dotted lines connect the selected values in the dropdown menus to their respective lists of options. The "Slice_Differentiator" dropdown is connected to a list of QoS and Service options. The "Slice_Domain" dropdown is connected to a list of network domain options. The "Slice_Location" dropdown is connected to a list of edge location options.

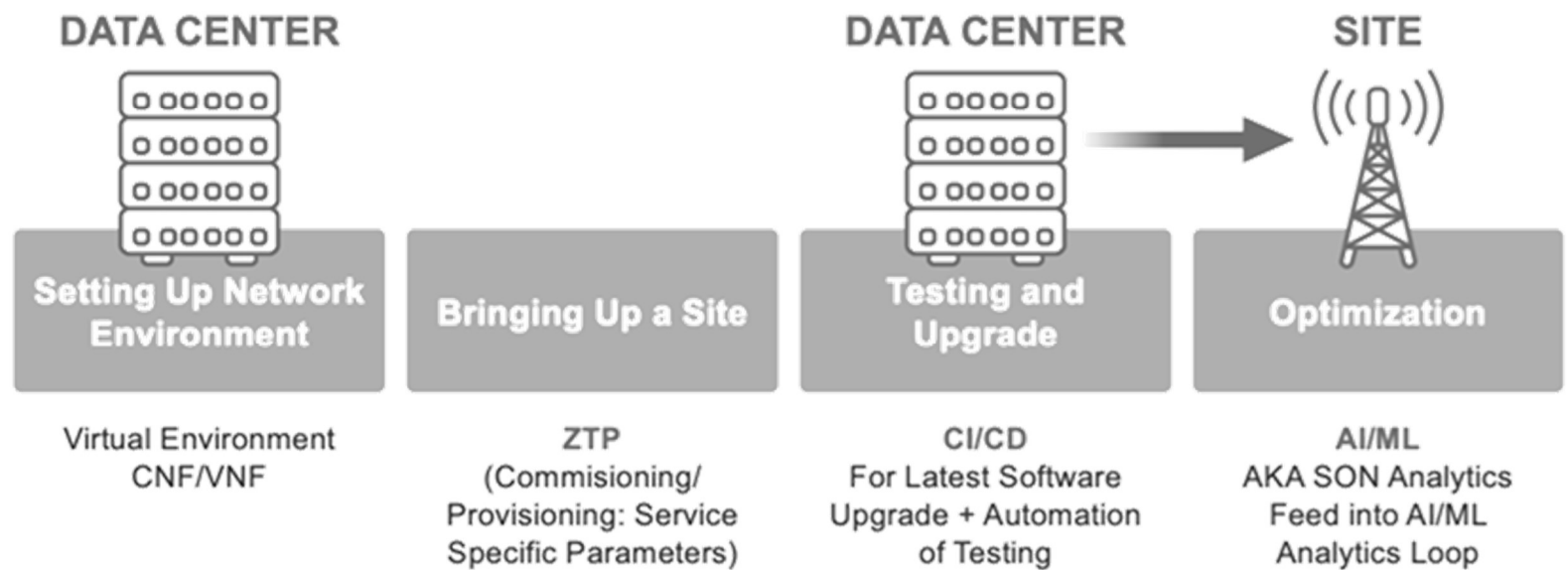
Source: <https://aws.amazon.com/blogs/industries/implementing-5g-network-slicing-with-cloudify-on-aws/>

4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

284

- ❖ 자동화: Network automation uses zero-touch positioning, CI/CD, and AI/ML to bring upgrades to the radio access network.

STAGES OF NETWORK TO AUTOMATE



CI/CD (Continuous Integration/Continuous Development)

Source: Parallel Wireless.

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

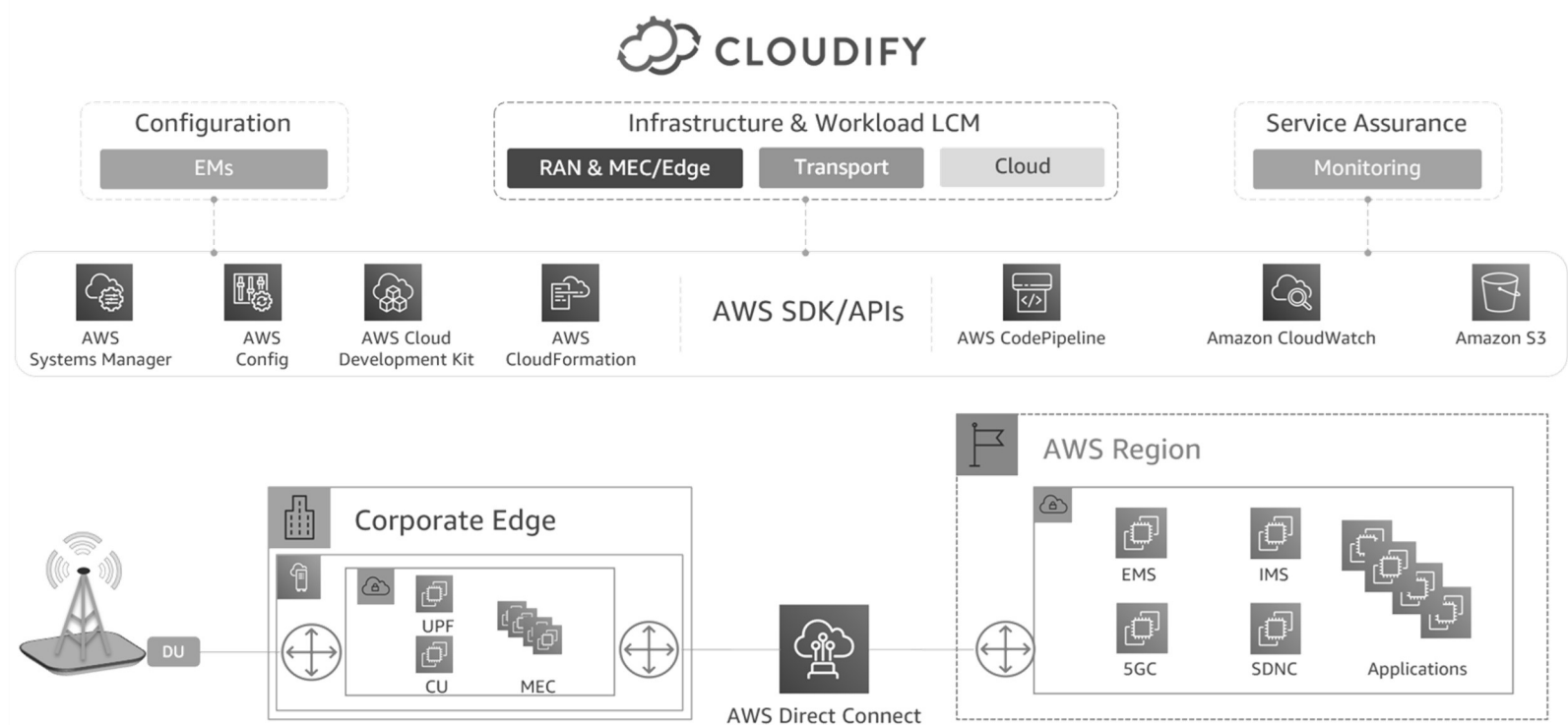


4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

285

❖ Implementing 5G Network Slicing with Cloudify on AWS

- Cloudify architecture on AWS.



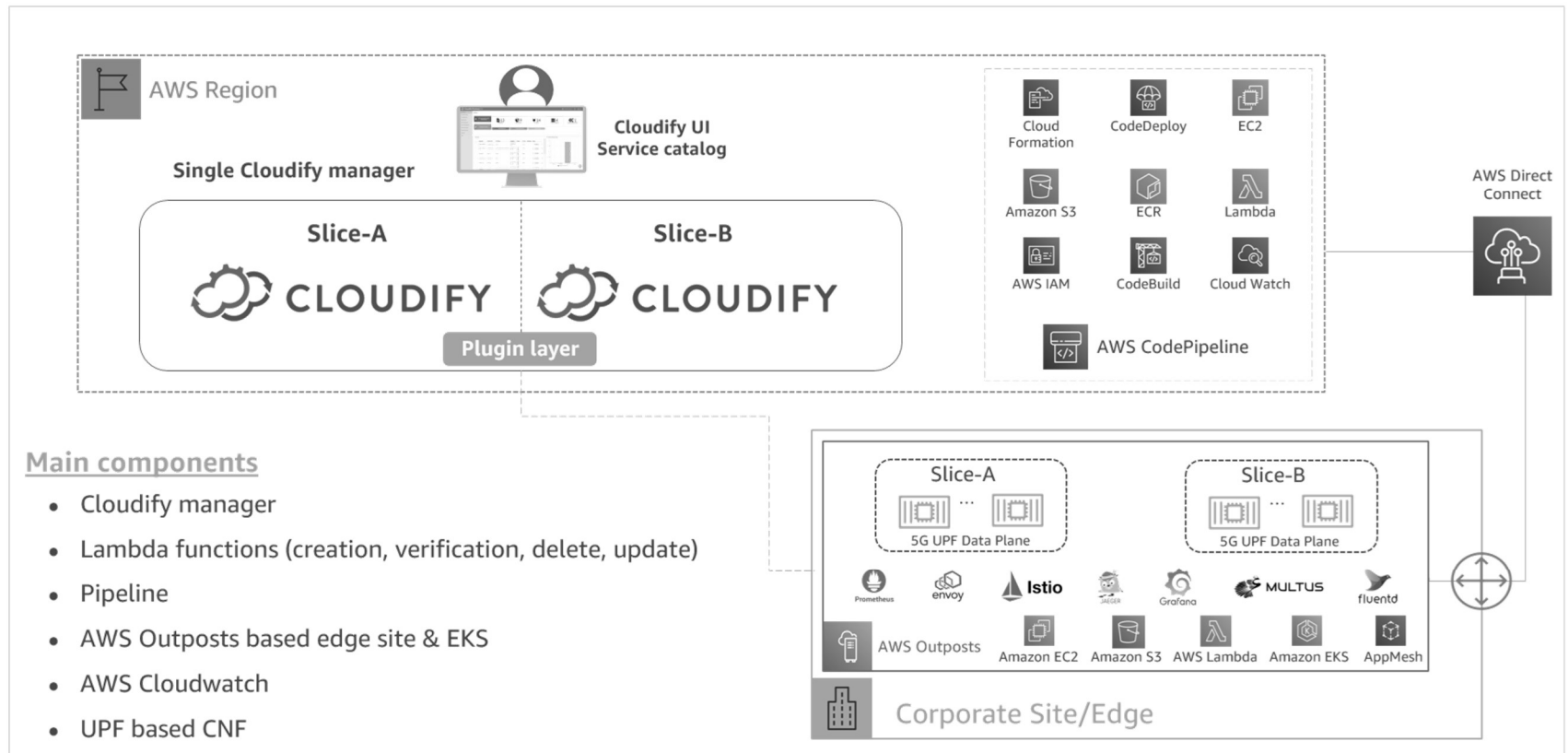
Source: <https://aws.amazon.com/blogs/industries/implementing-5g-network-slicing-with-cloudify-on-aws/>



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ Cloudify on AWS for network slicing



Source: <https://aws.amazon.com/blogs/industries/implementing-5g-network-slicing-with-cloudify-on-aws/>



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ Manage network slices.

The screenshot displays the '5G Slicing portal' interface. On the left is a sidebar with navigation links: 'Dashboard', '5G Blueprints Catalog', 'Deployments', and 'System Resources'. The main content area is titled 'Deployments' and includes a 'Create Deployment' button. Below this is a form with a 'Blueprint' dropdown menu and a 'Site Name' input field. A table lists three deployments: 'uRLLC_5G-Slice', 'mMTC_5G-Slice', and 'eMBB_5G-Slice'. Each row shows the blueprint name, site name, creation time, creator, and node instance counts. Action buttons for each deployment include delete, refresh, check status, and trash.

Deployment	Blueprint	Site Name	Created	Creator	Node Instances (4)
uRLLC_5G-Slice	uRLLC_5G-Slice	AWS_Edge_Location-3	19-11-2020 15:38	admin	0, 0, 4, 0
mMTC_5G-Slice	mMTC_5G-Slice	AWS_Edge_Location-2	19-11-2020 15:37	admin	0, 0, 4, 0
eMBB_5G-Slice	eMBB_5G-Slice	AWS_Edge_Location-1	19-11-2020 14:55	admin	0, 0, 4, 0

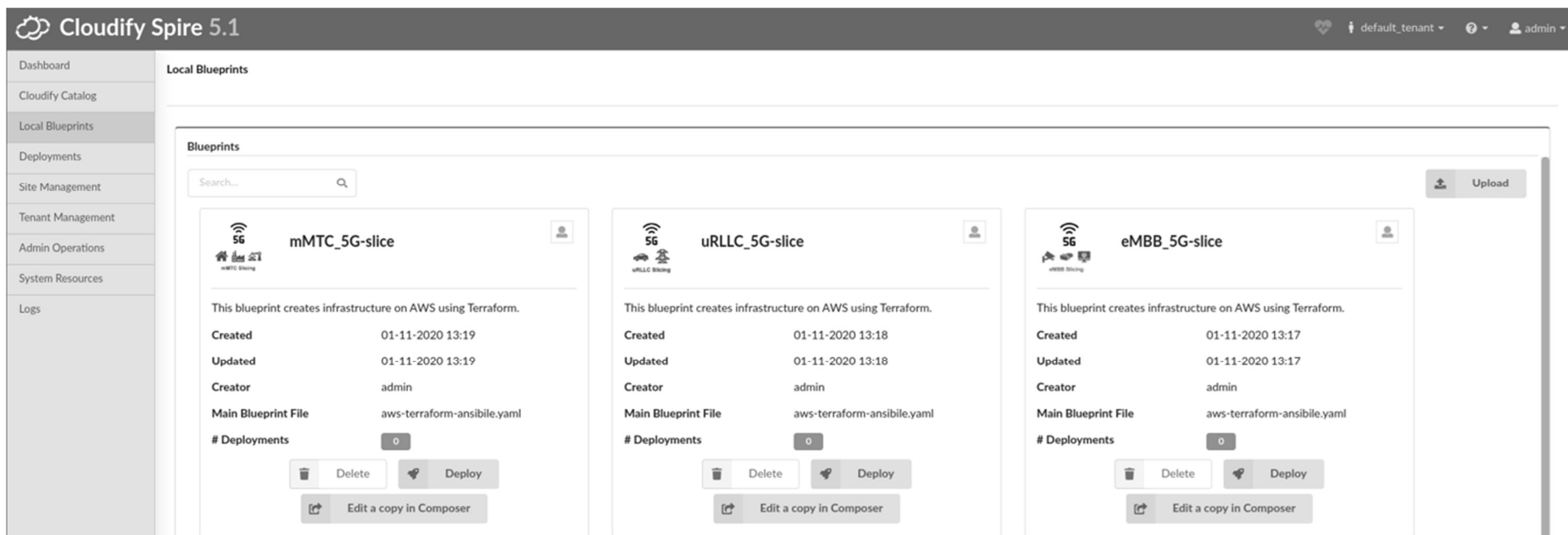
Source: <https://aws.amazon.com/blogs/industries/implementing-5g-network-slicing-with-cloudify-on-aws/>



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

288

- ❖ Providing a simple operator interface using Cloudify catalog service.



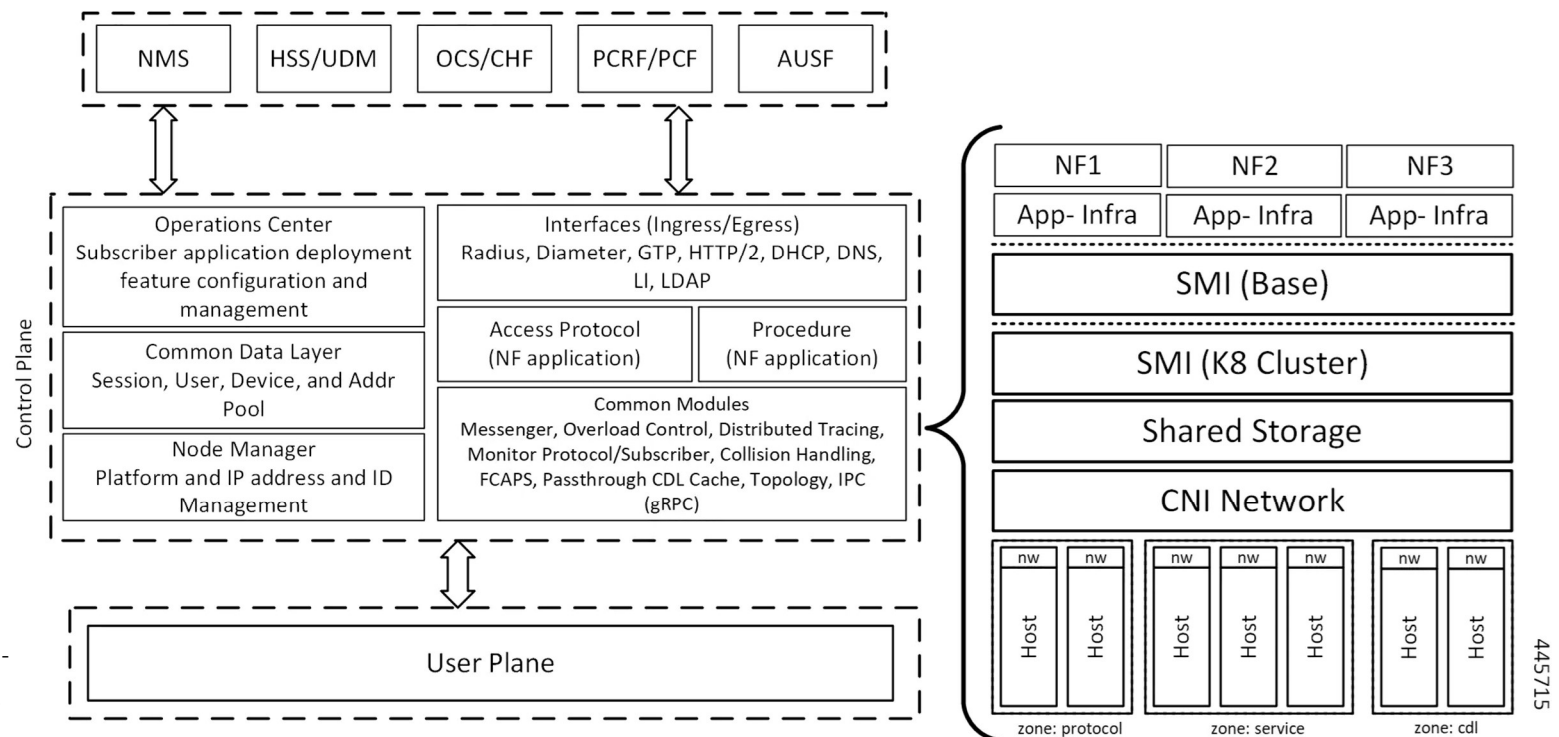
Source: <https://aws.amazon.com/blogs/industries/implementing-5g-network-slicing-with-cloudify-on-aws/>



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ 제조사(예): Cisco - Ultra Cloud Core CP Architectural Components



FCAPS (fault, configuration, accounting, performance, and security)

Cisco Smart Install (SMI) is a "plug-and-play" configuration and image-management feature that provides zero-touch deployment for new (typically access layer) switches.

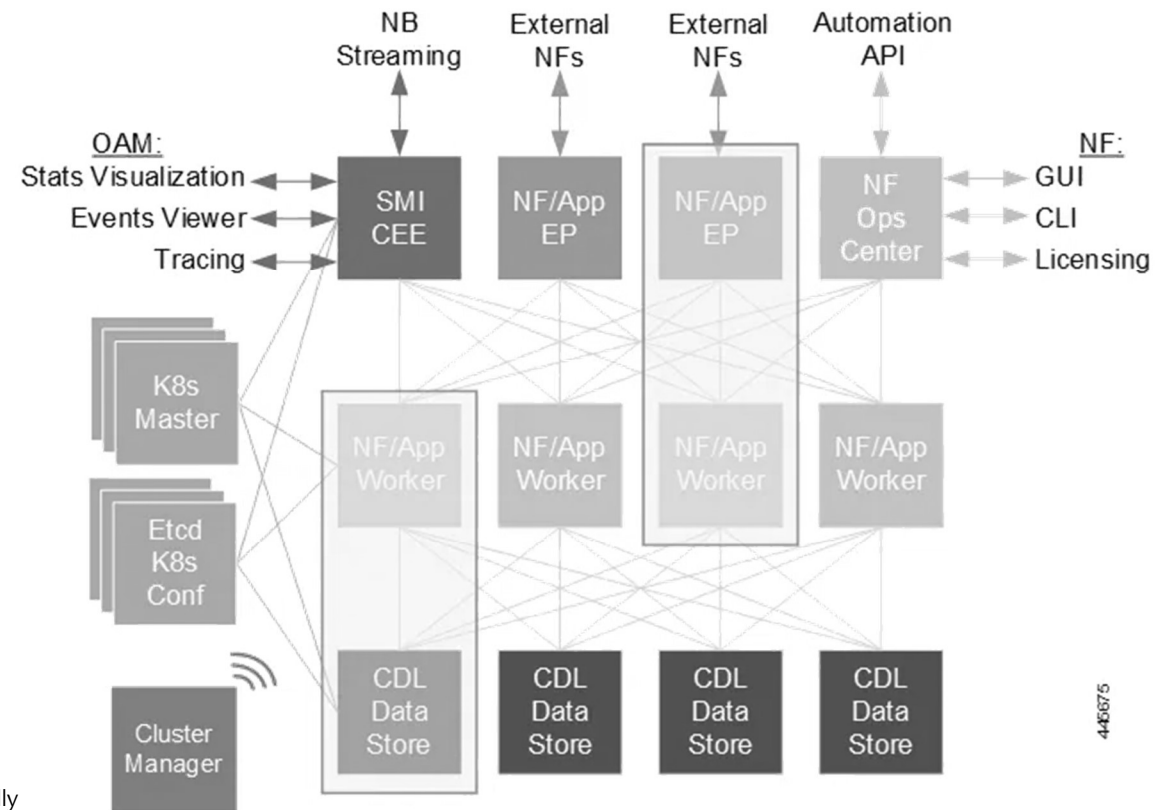
Source: https://www.cisco.com/c/en/us/td/docs/wireless/ucc/upf/2020-03/b_ucc-5g-upf-config-and-admin-guide_2020-03/m_html



4일차 '모니터/제어, 클라우드 네이티브 5G 네트워크'

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❖ SMI Components



Cisco Smart Install (SMI) is a "plug-and-play" configuration and image-management feature that provides zero-touch deployment for new (typically access layer) switches.

Source: https://www.cisco.com/c/en/us/td/docs/wireless/ucc/upf/2020-03/b_ucc-5g-upf-config-and-admin-guide_2020-03/m.html



5일차

‘관리/보안, MSA 시연/실습’

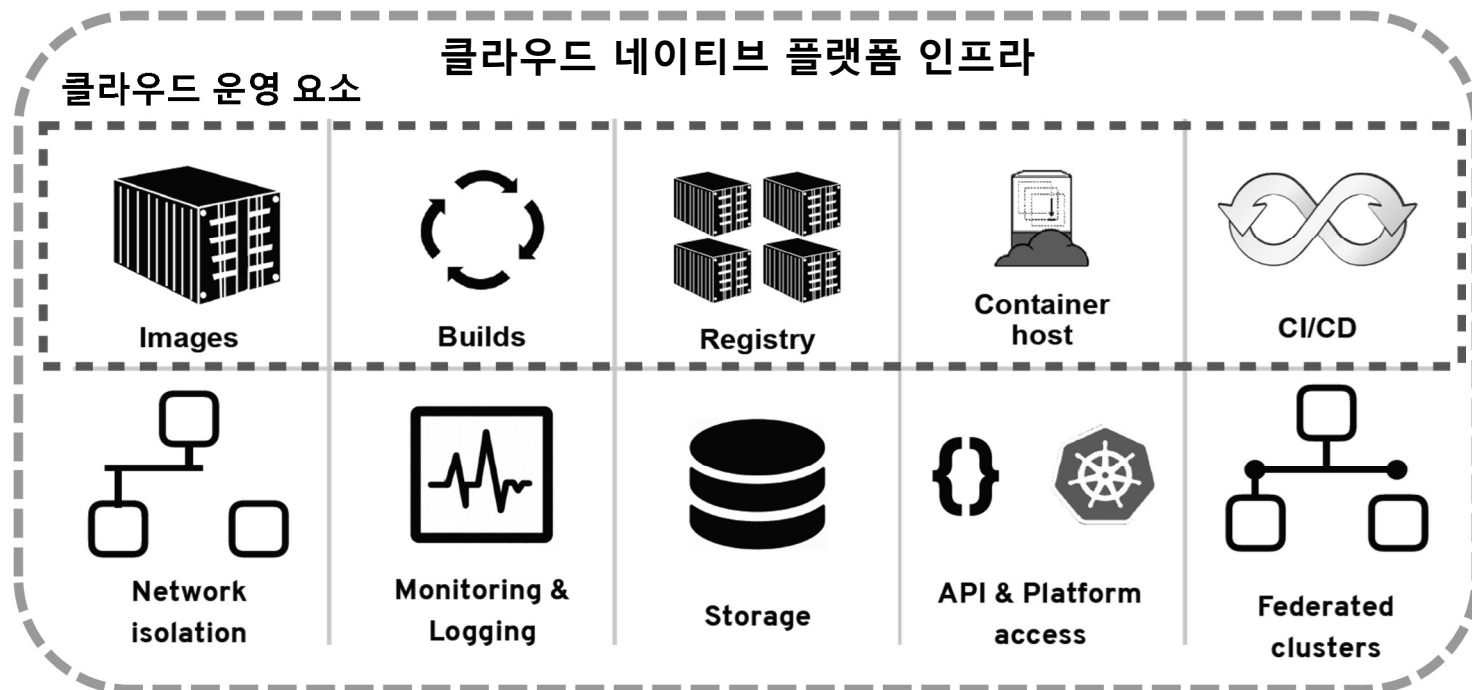
구분	주제	세부 내용
이론	1일차. MSA와 5G 네트워크	<ul style="list-style-type: none"> • MSA(Microservices Architecture) 개요 • 통신 시장의 클라우드 서비스 기술 변화 • 5G 네트워크 서비스의 클라우드화 • Cloud Native Transformation
	2일차. 가상화 (Virtualization) 인프라	<ul style="list-style-type: none"> • 네트워크 가상화 • RAN 가상화 • SDN (Software Defined Networking) • MEC와 하드웨어 가속
	3일차. 클라우드 서비스	<ul style="list-style-type: none"> • 클라우드 5G 서비스 개요 • 컨테이너 기술 • 클라우드 네이티브 인프라 구축 • 서비스 메시
이론/ 실습	4일차. 모니터/제어, 클라우드 네이티브 5G 네트워크 랩 시연/실습	<ul style="list-style-type: none"> • 모니터링 • 네트워크 슬라이싱 • Zero-touch Automation • 5G Networks Lab을 위한 K8s/Helm 설치 (실습) • 쿠버네티스 오퍼레이션 (실습)
	5일차. 관리/보안 MSA 시연/실습	<ul style="list-style-type: none"> • Private 5G Network 인프라 관리 • 통신 보안 • 제조사 솔루션 • Design Pattern • Cloud Native 5G Edge Networks (실습)

랩(Lab)시연/실습 별도교재

5일차 '관리/보안, MSA 시연/실습'

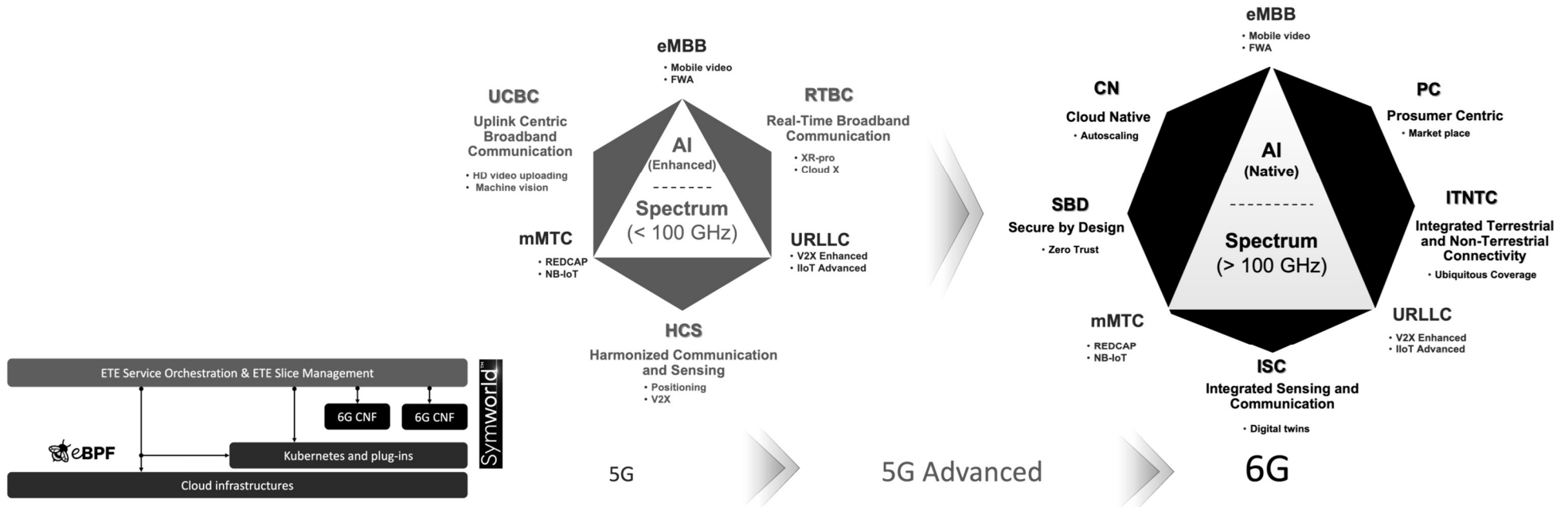
❖ 클라우드 인프라 구성 요소 고려 보안

- SDDC 추상화 운영 요소: 컴퓨팅, 스토리지, 네트워크, 관리, API 접속
- 클라우드 운영 요소: Images, Builds, Registry, Container Host, CI/CD



5일차 '관리/보안, MSA 시연/실습'

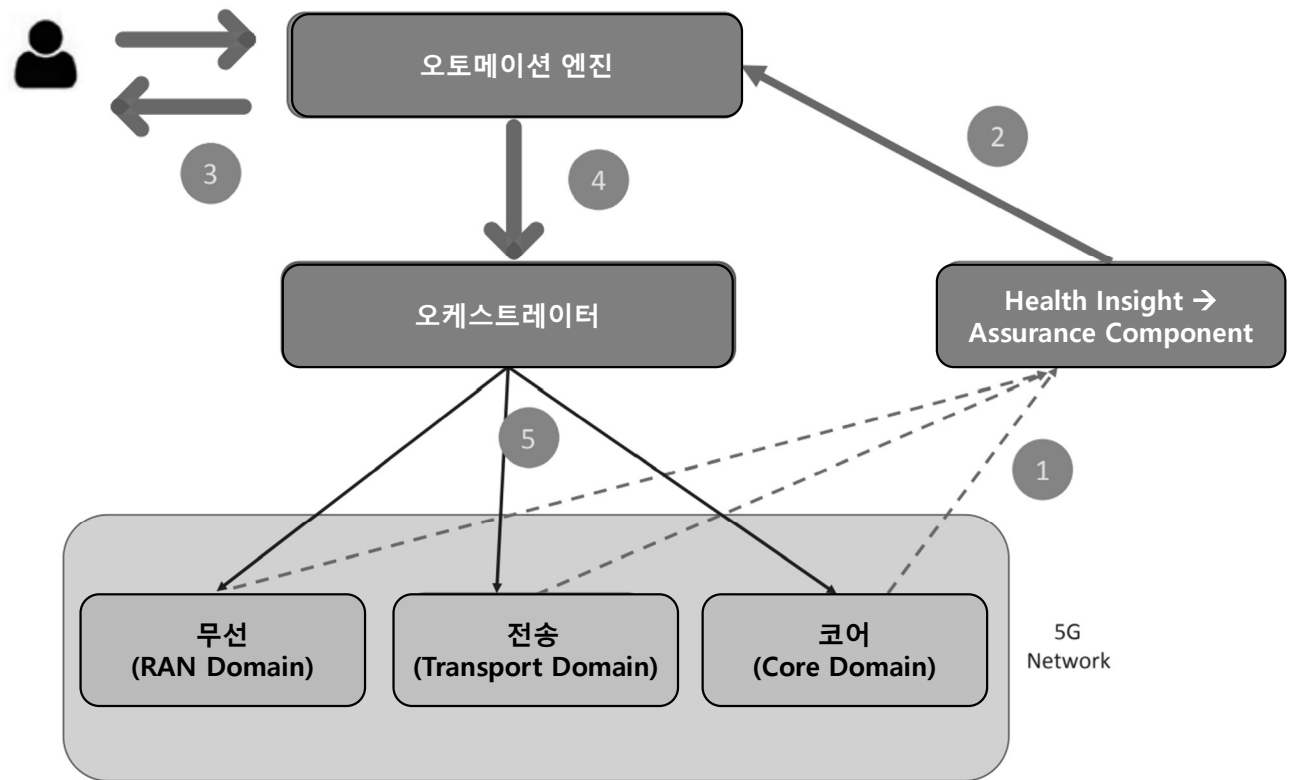
❖ Towards 6G Cloud Native and Secure by Design



5일차 '관리/보안, MSA 시연/실습'

294

❖ Closed-loop automation with the help of service assurance



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

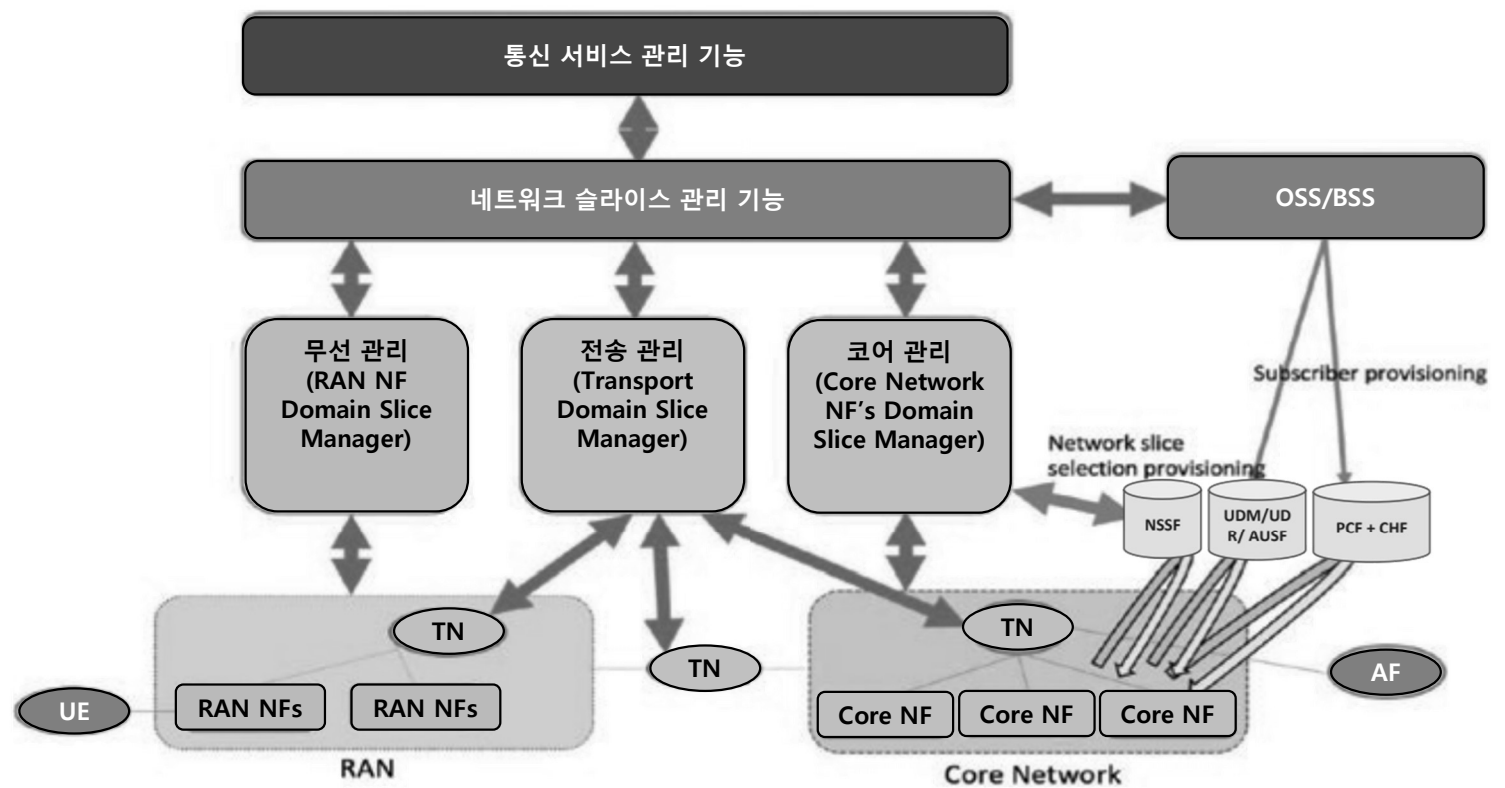


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5일차 '관리/보안, MSA 시연/실습'

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❖ End-to-end slice orchestration overview

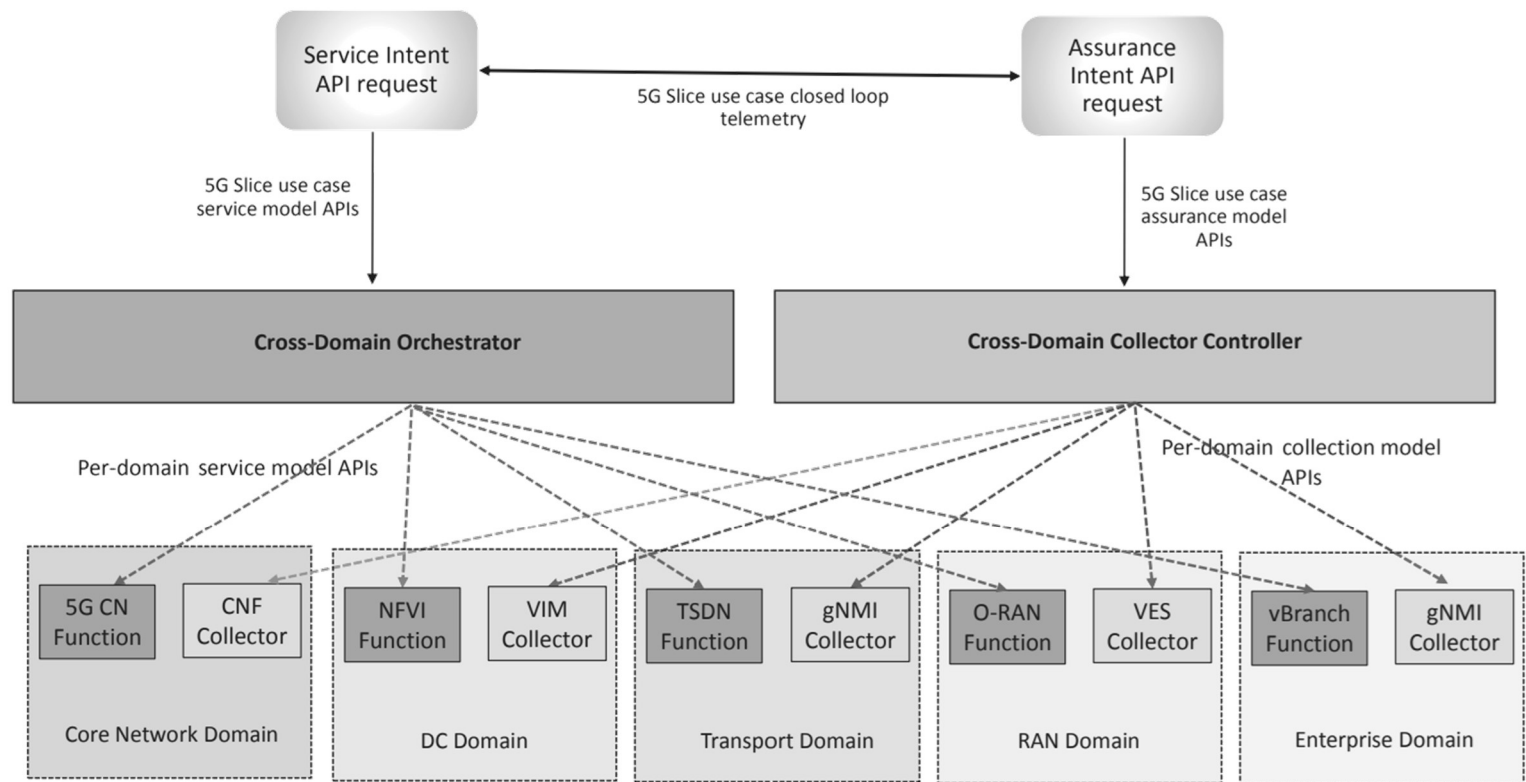


Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

❖ 의도기반 모델링 개념 (Intent-based modeling concept)

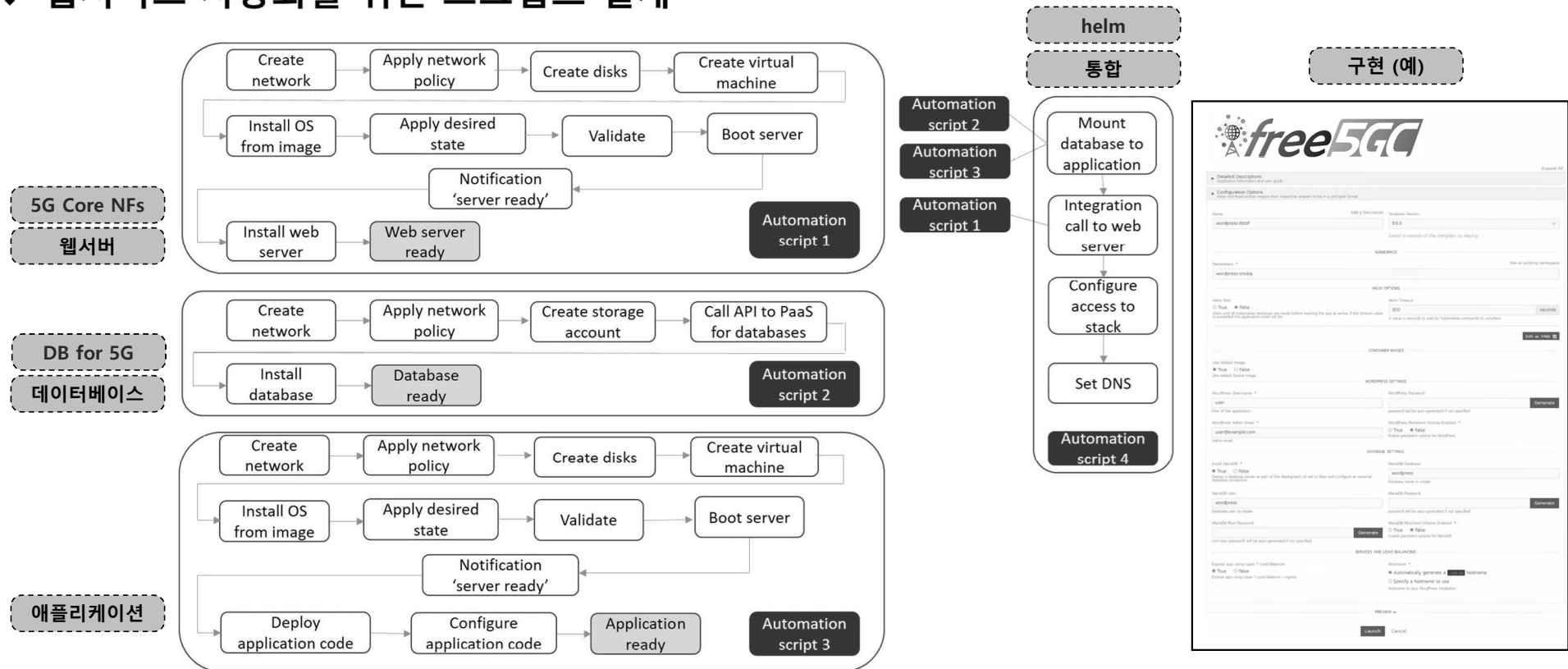


Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

❖ 웹서비스 자동화를 위한 스크립트 설계

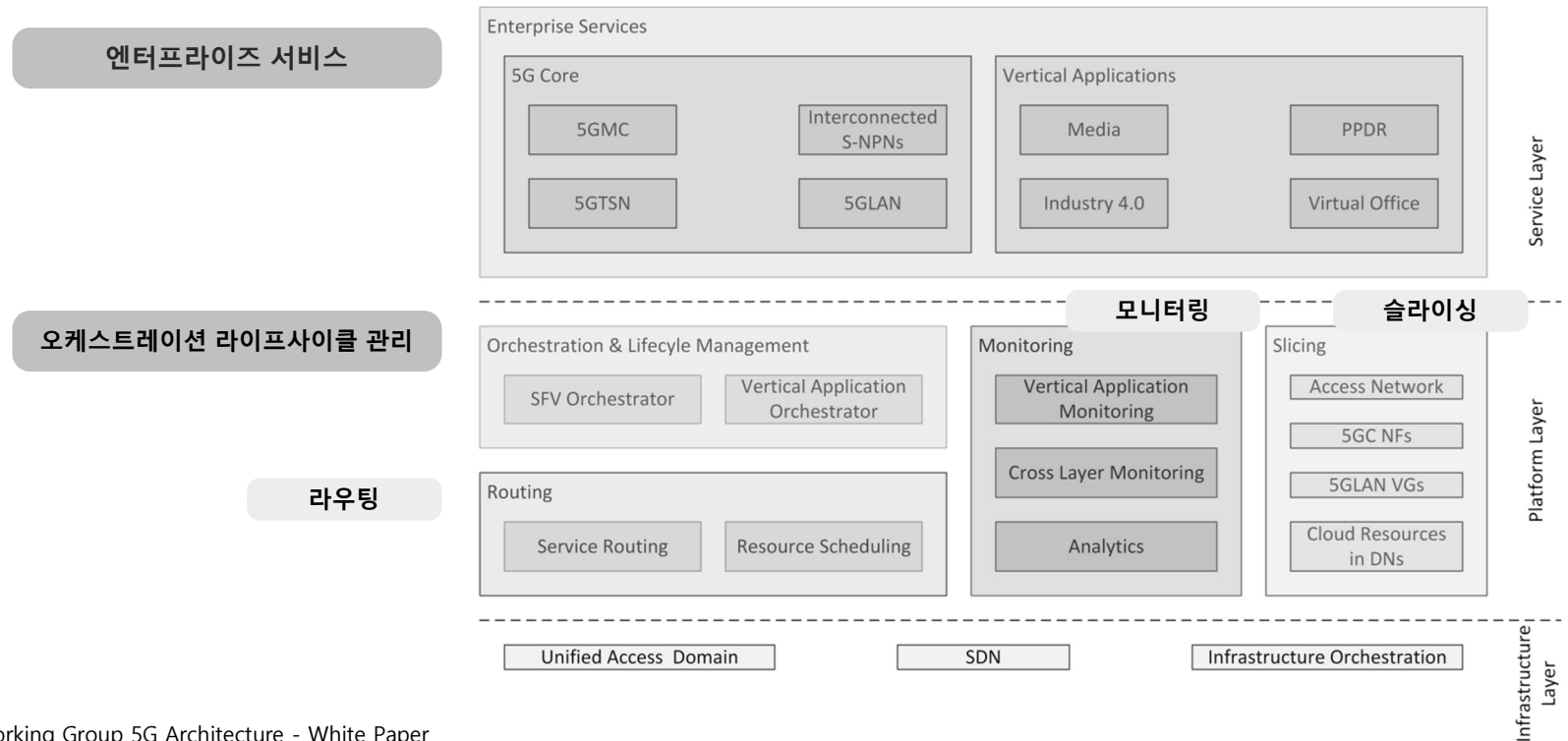


Source: Mulder, Jeroen. Multi-Cloud Architecture and Governance: Leverage Azure, AWS, GCP, and VMware vSphere to build effective multi-cloud solutions. Packet Publishing.

5일차 '관리/보안, MSA 시연/실습'

❖ 엔터프라이즈 서비스 고려

- High level system component overview of a disintegrated private network architecture

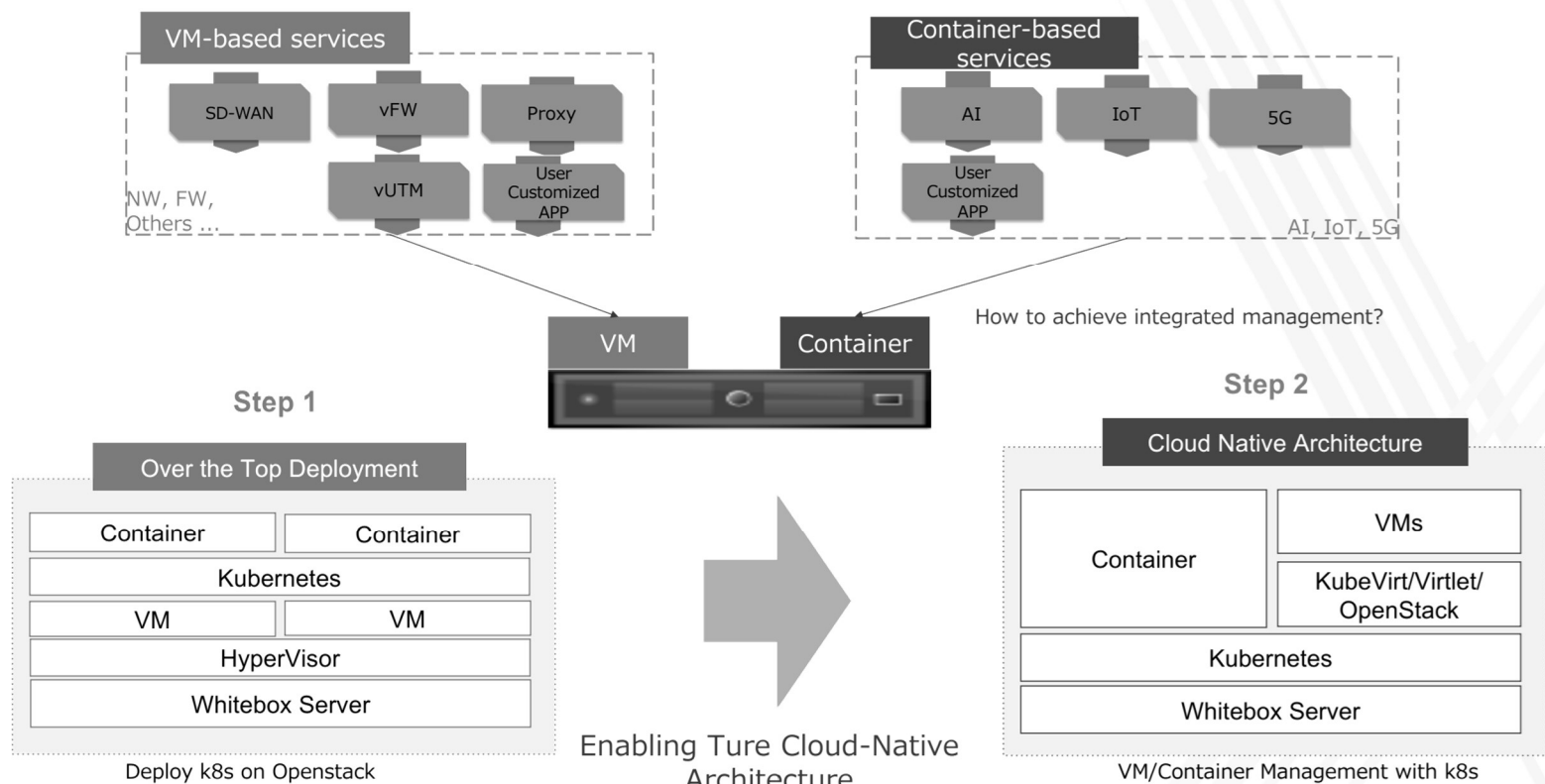


Source: 5GPPP Architecture Working Group 5G Architecture - White Paper

5일차 '관리/보안, MSA 시연/실습'

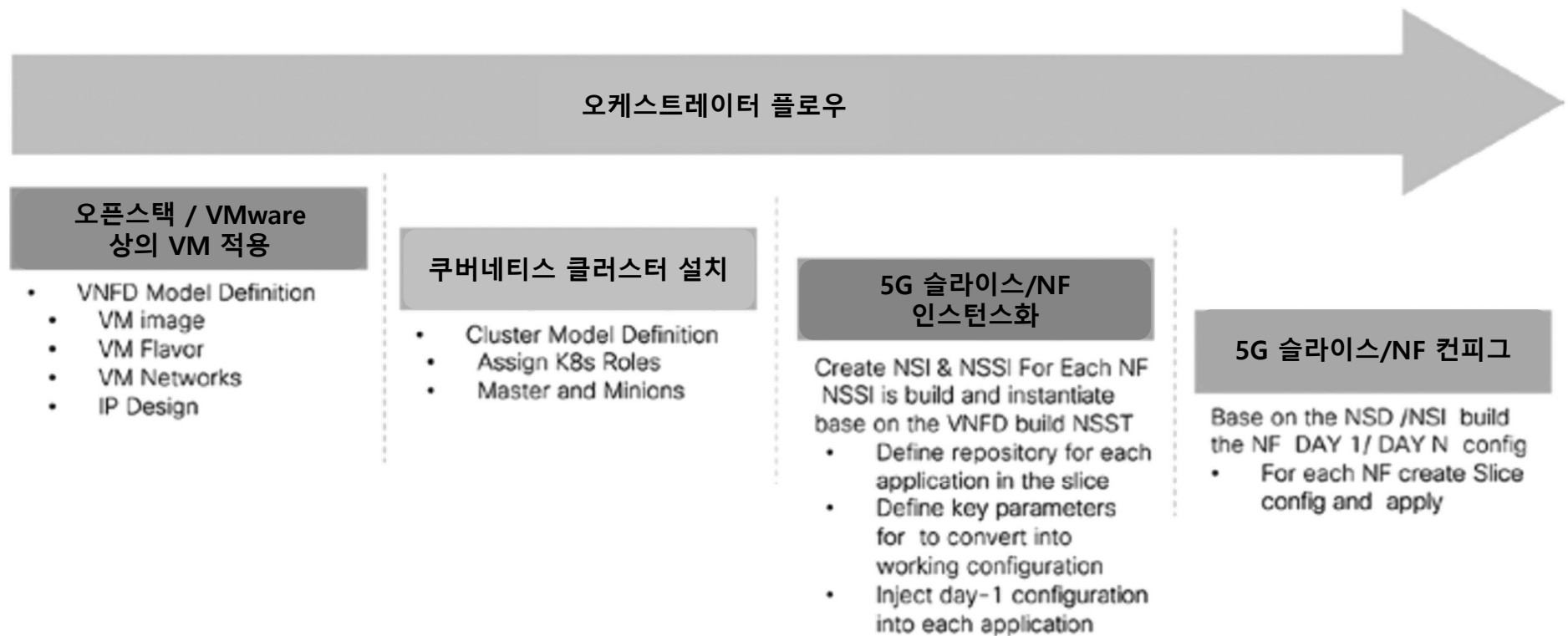
299

❖ Cloud Native Platform Architecture (예: NTT Communications Corporation)



5일차 '관리/보안, MSA 시연/실습'

❖ 5G core NF and slice creation



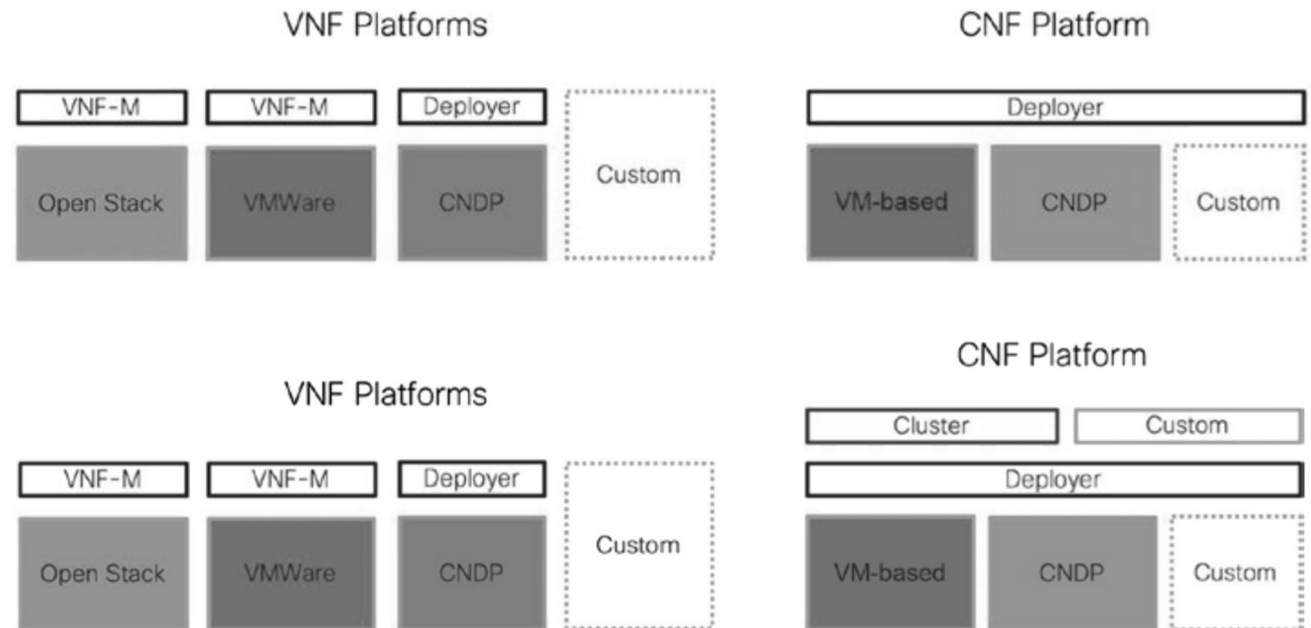
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

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- ❖ Hybrid infrastructure with different platforms
- ❖ Deployment layer automations



critical node detection problem (CNDP)

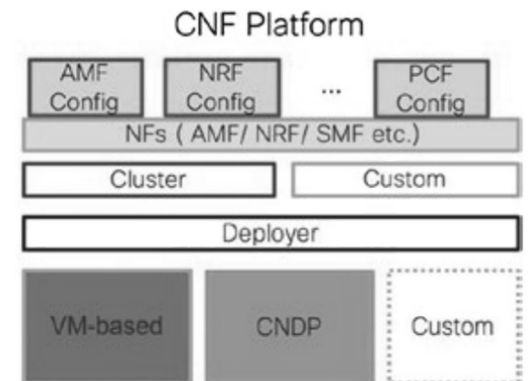
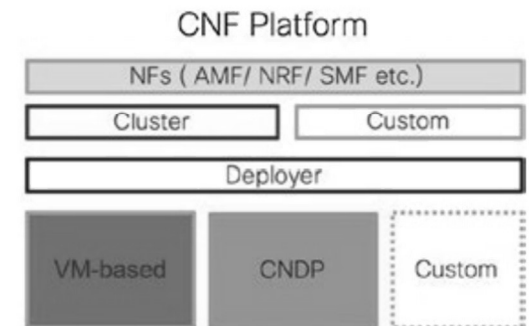
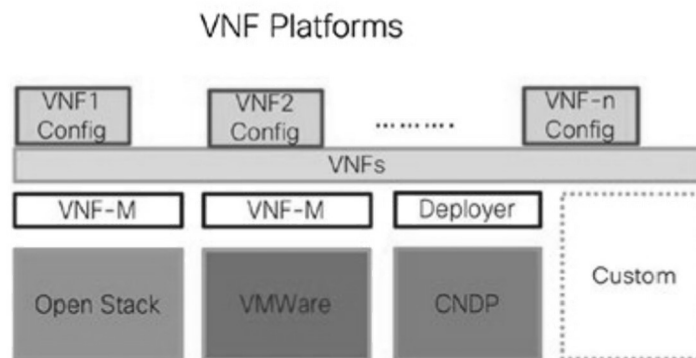
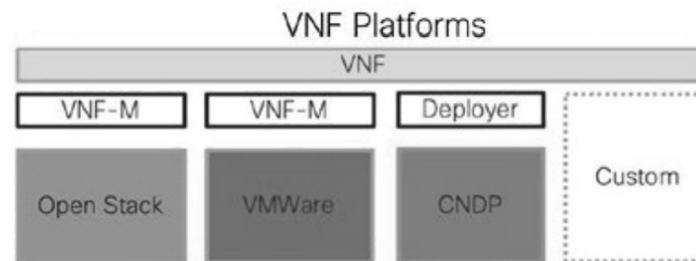
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

302

- ❖ Function layer automation
- ❖ Configuration layer automation



critical node detection problem (CNDP)

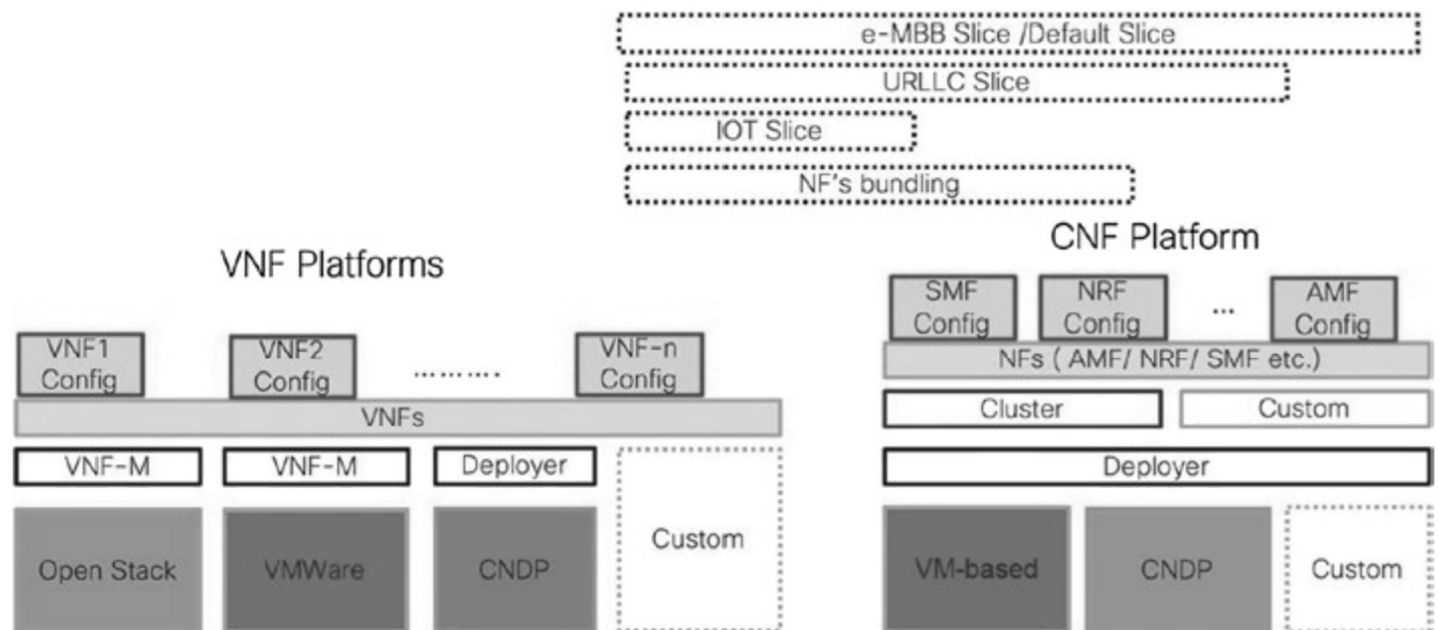
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

303

❖ 5G abstraction



critical node detection problem (**CNDP**)

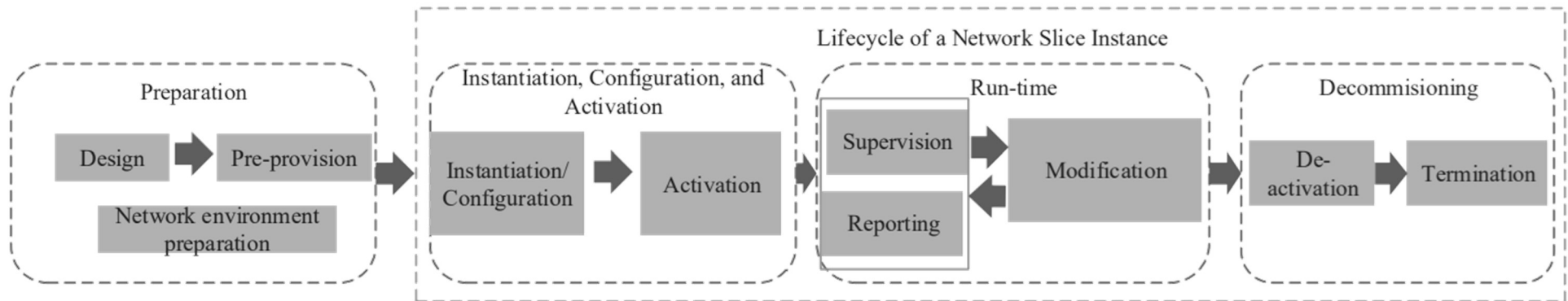
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

❖ 네트워크 슬라이스의 라이프사이클 관리: Lifecycle phases of a NSI > 3GPP spec 23.801

- **Preparation**
- **Lifecycle of a Network Slice Instance**
 - Instantiation, Configuration, and Activation
 - Run-time
 - Decommisioning



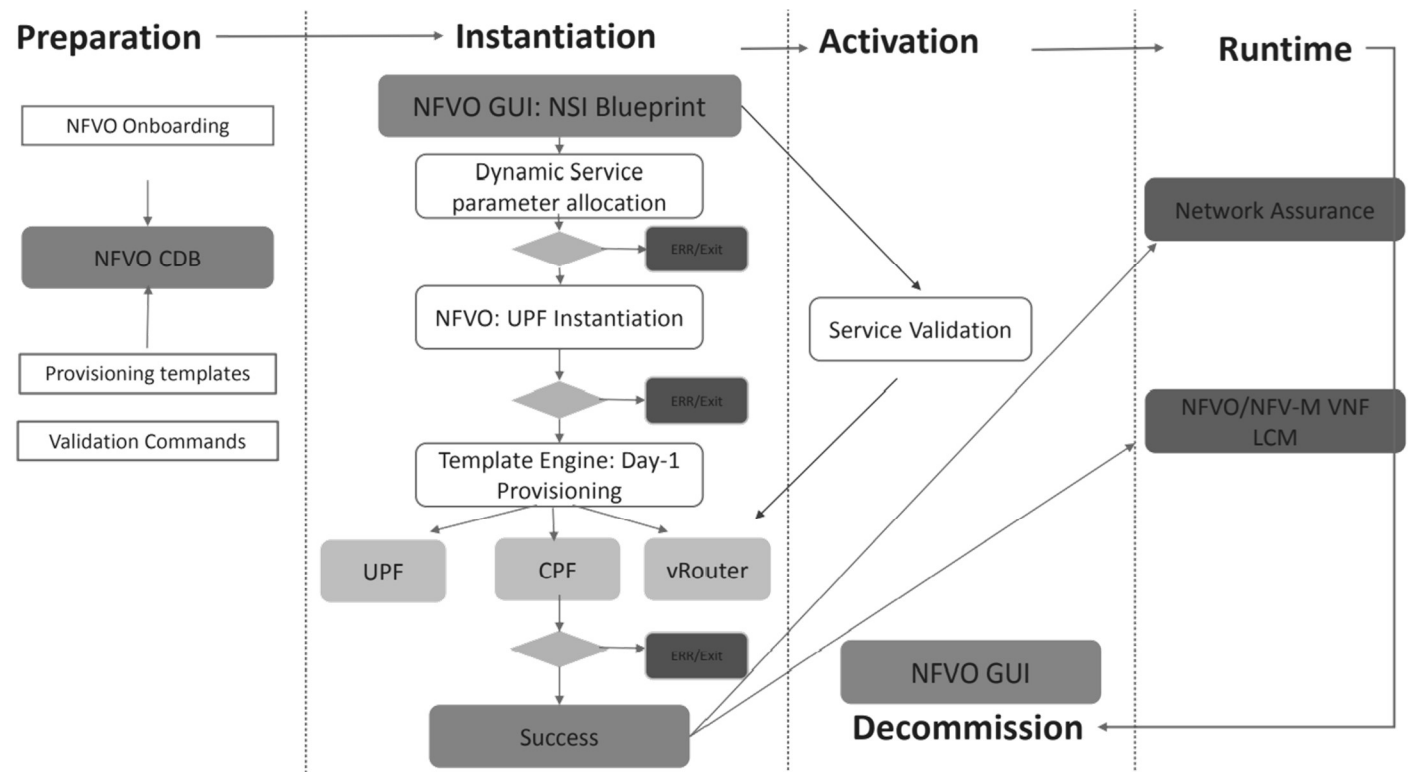
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

305

❖ UPF 슬라이스 라이프사이클: UPF slice lifecycle with core network domain slice orchestrator



critical node detection problem (CNDP)

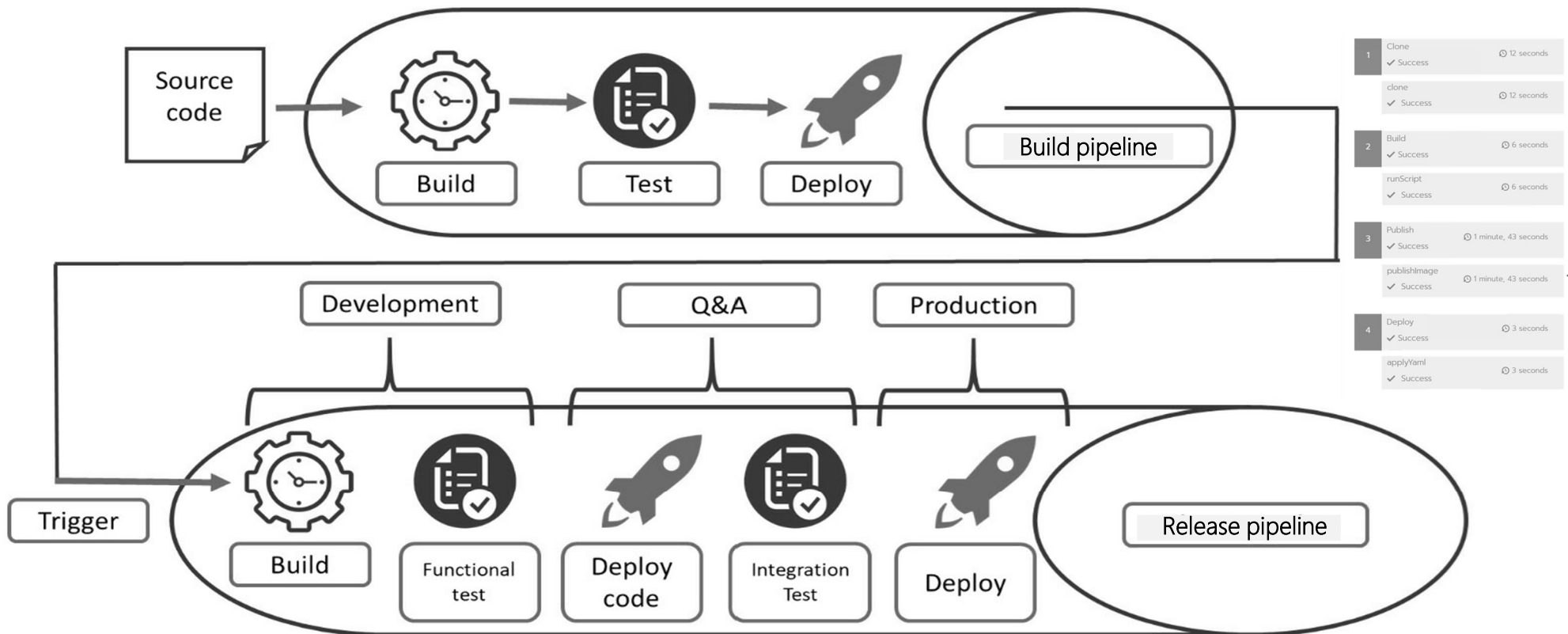
Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress



5일차 '관리/보안, MSA 시연/실습'

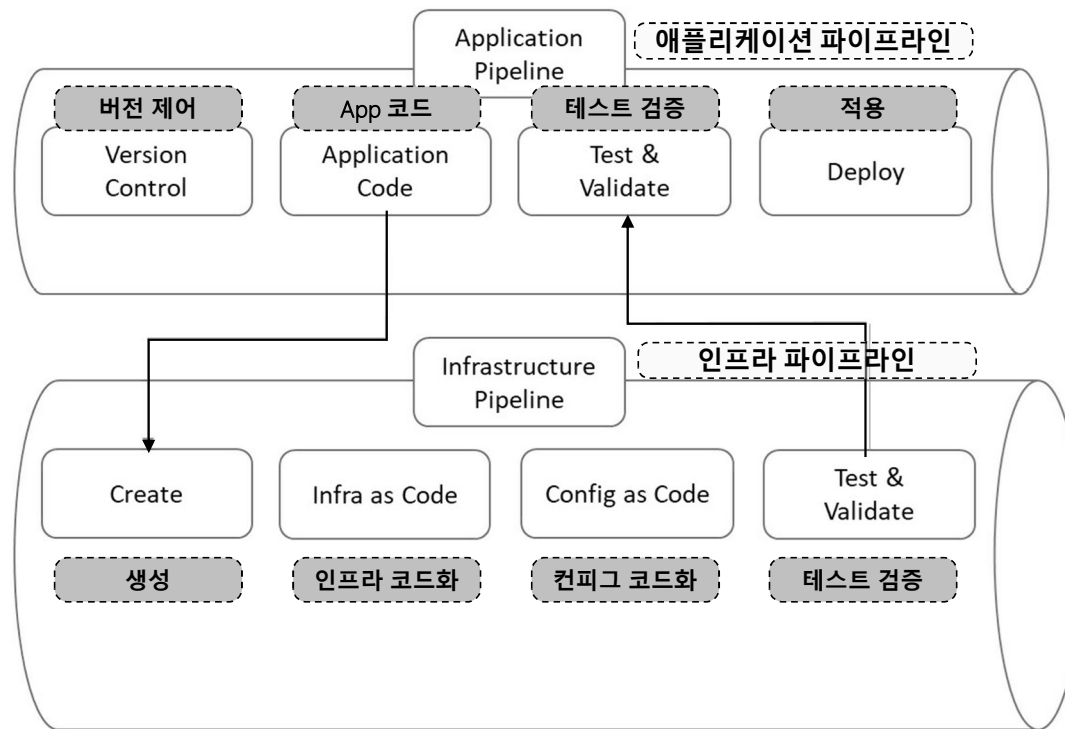
306

❖ Build / Release pipeline (구분)



5일차 '관리/보안, MSA 시연/실습'

❖ 애플리케이션/인프라 (구분) - CI/CD 하이레벨 개념



구현 (예)

1	Clone	✓ Success	⌚ 12 seconds
	clone	✓ Success	⌚ 12 seconds
2	Build	✓ Success	⌚ 6 seconds
	runScript	✓ Success	⌚ 6 seconds
3	Publish	✓ Success	⌚ 1 minute, 43 seconds
	publishImage	✓ Success	⌚ 1 minute, 43 seconds
4	Deploy	✓ Success	⌚ 3 seconds
	applyYaml	✓ Success	⌚ 3 seconds

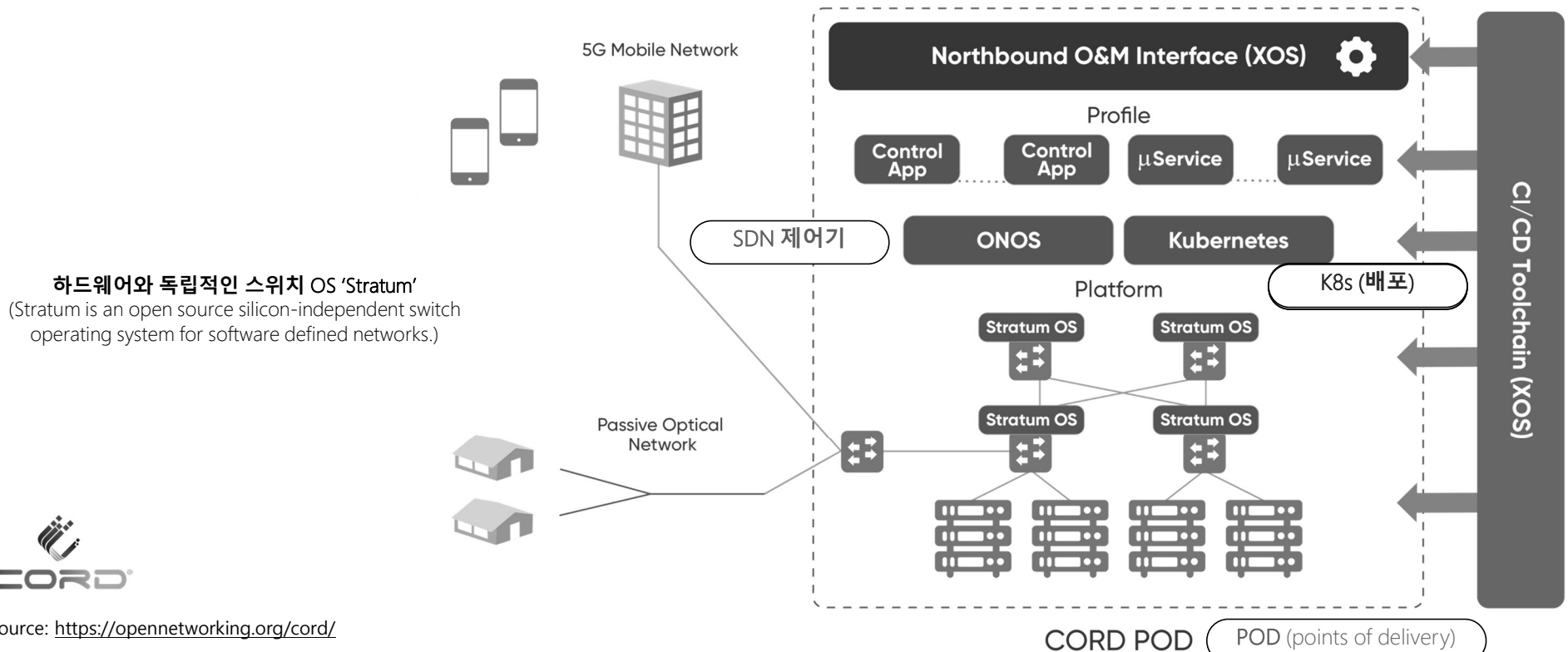
Source: Mulder, Jeroen. Multi-Cloud Architecture and Governance: Leverage Azure, AWS, GCP, and VMware vSphere to build effective multi-cloud solutions. Packt Publishing.



5일차 '관리/보안, MSA 시연/실습'

308

❖ CORD (Central Office Re-architected as a Datacenter)

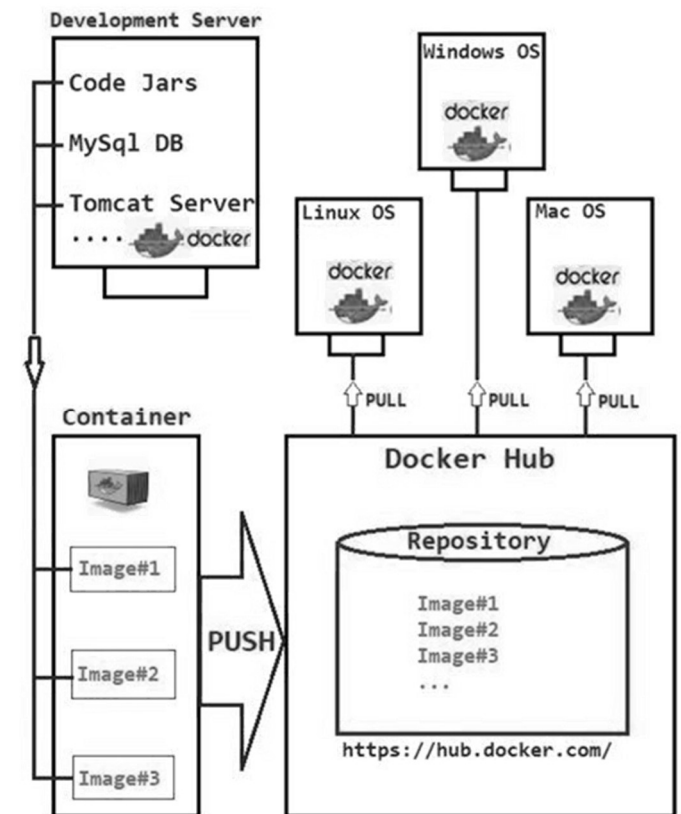


5일차 '관리/보안, MSA 시연/실습'

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❖ Docker Image Creation Flow

- Docker Image Creation Flow



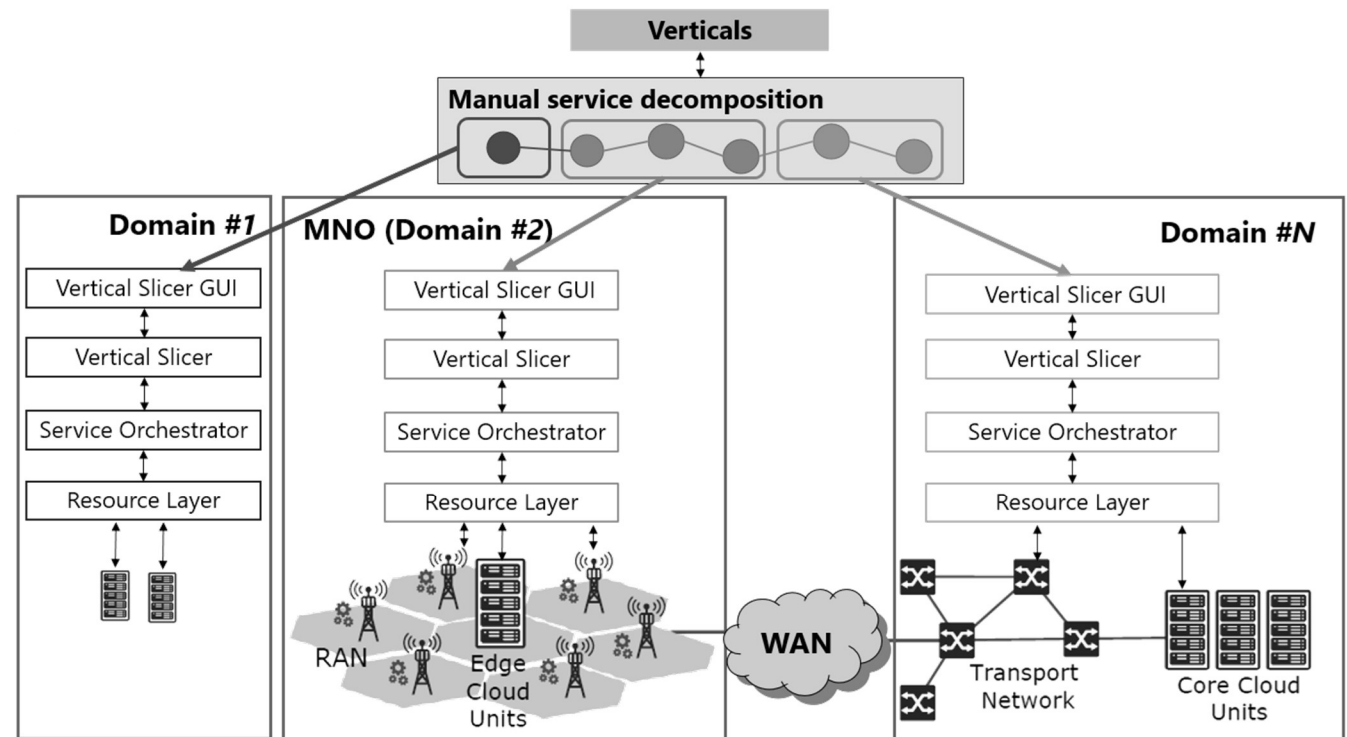
Source: https://javatechonline.com/how-to-deploy-spring-boot-application-in-docker/?fbclid=IwAR3ee4oHG1zTMkpi0khXj_r-nPIWfvDvl8tUcsGawNIJeXMXtLRdb5hvstK



5일차 '관리/보안, MSA 시연/실습'

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❖ Manual Vertical Service Decomposition

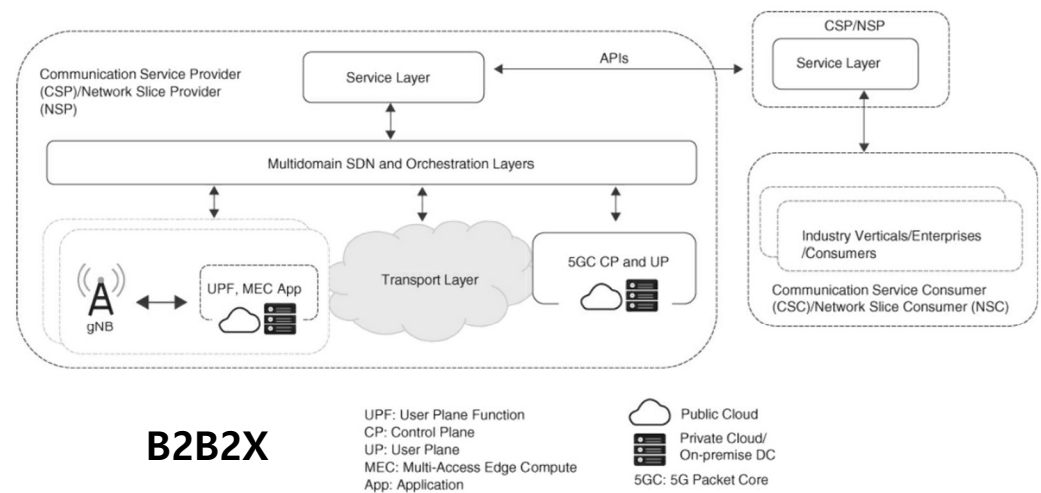
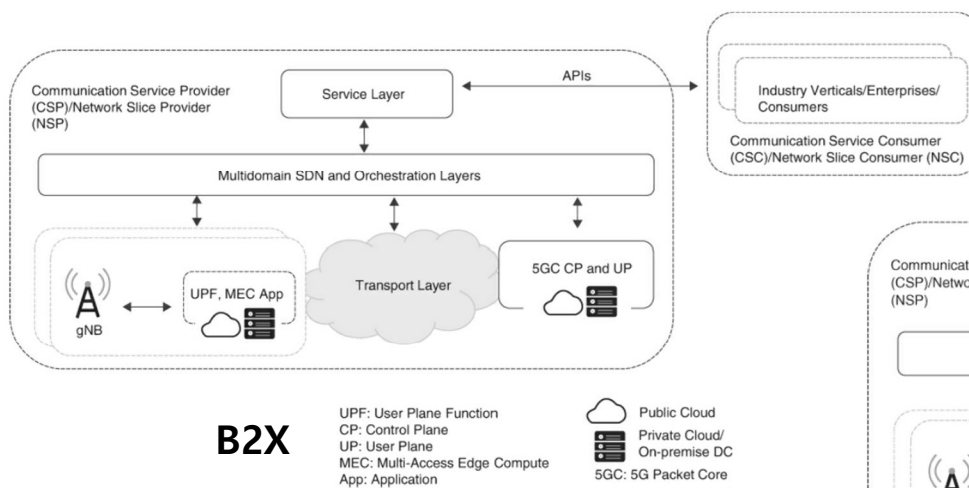


Source: 5GPPP Architecture Working Group, 5G Architecture White Paper

5일차 '관리/보안, MSA 시연/실습'

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- ❖ NSaaS Deployment Method for B2X Offering
- ❖ NSaaS Deployment Method for B2B2X Offering



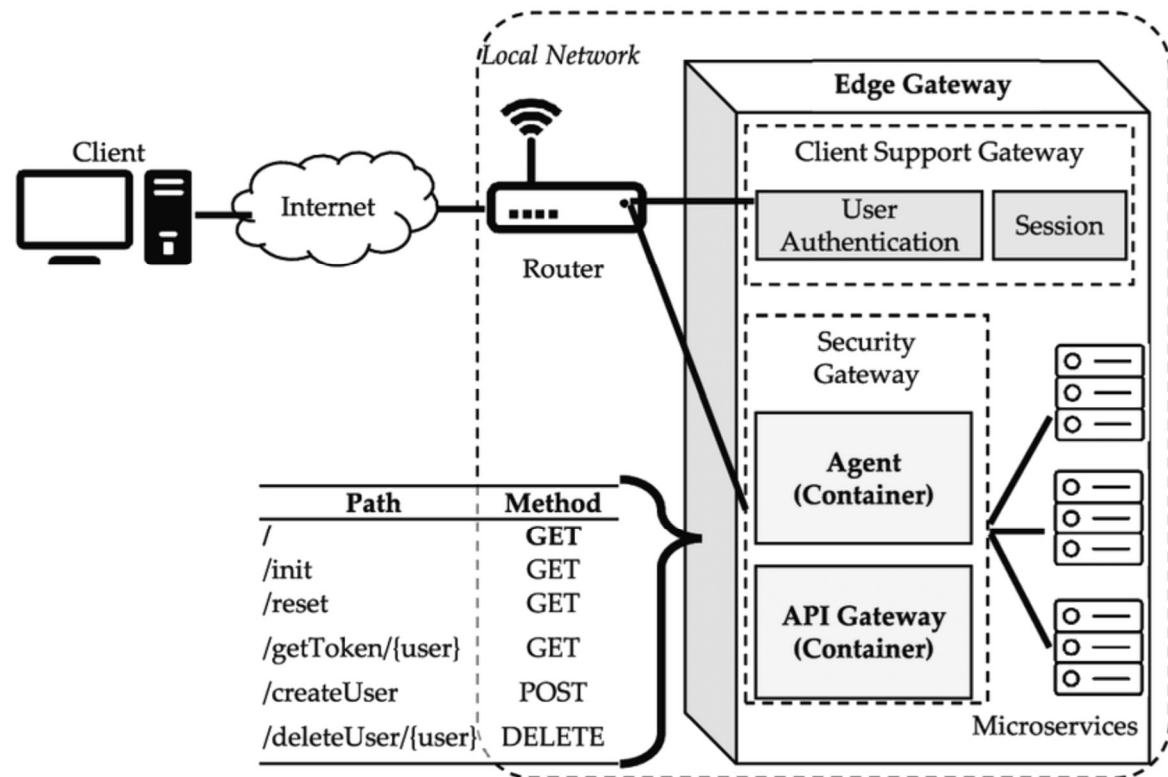
Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.



5일차 '관리/보안, MSA 시연/실습'

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- ❖ edge computing network architecture based on secure microservices.



Source: https://www.researchgate.net/figure/Proposed-edge-computing-network-architecture-based-on-secure-microservices_fig3_347267910

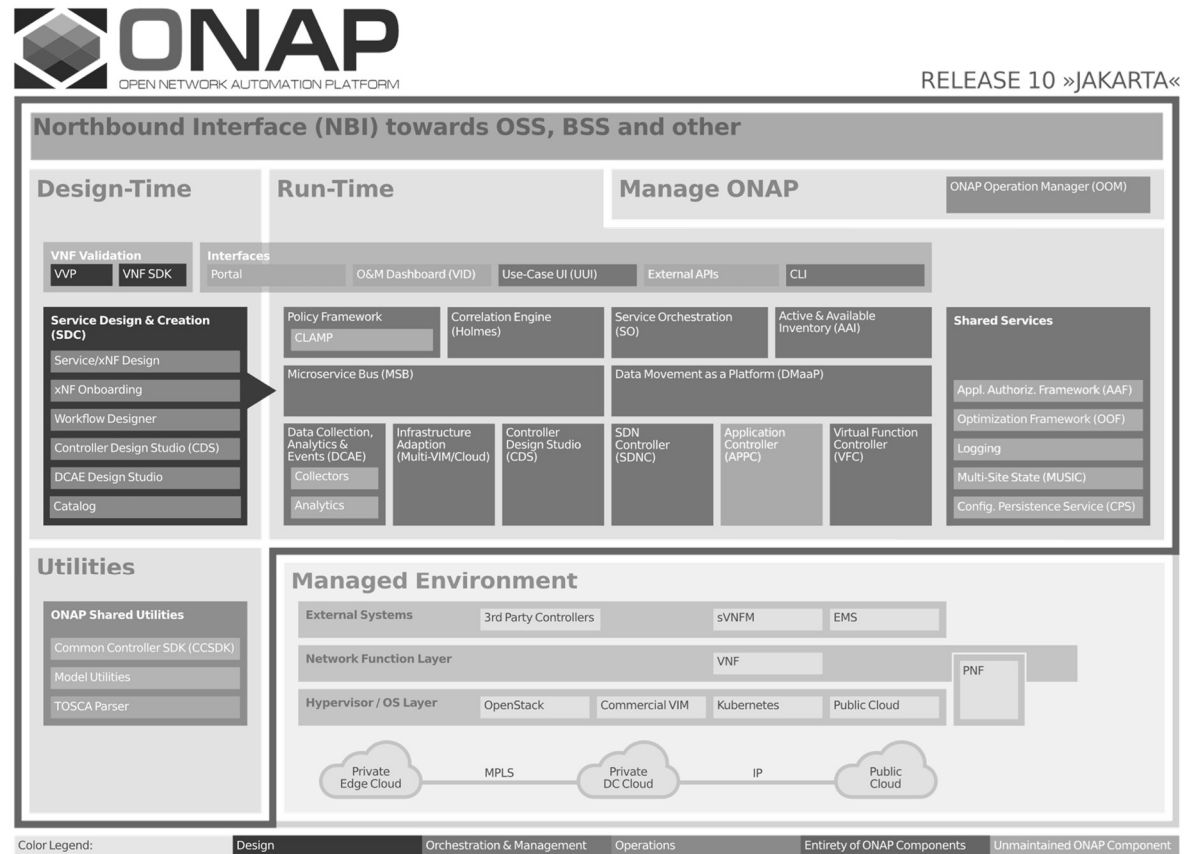


5일차 '관리/보안, MSA 시연/실습'

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❖ ONAP architecture

- high-level view of the ONAP architecture with its microservices-based platform components.



Source: <https://docs.onap.org/en/jakarta/guides/onap-developer/architecture/onap-architecture.html#architecture-overview>

5일차 '관리/보안, MSA 시연/실습'

❖ 리눅스재단(LF): LFN 5G Super Blueprints

CONFIGURATION & SECURITY MANAGEMENT

- Enable uniform and platform-level Service-Mesh Pattern Security
- Leverage open source projects including Istio, Envoy, K8S Ingress and Egress, Keycloak
- Allow security extensibilities with configurations/policies
- Support integration/deployment flexibilities with external IdAM and IdP



보안 관리

CONTAINERIZATION

- Container-based ONAP components support private, public and hybrid cloud infrastructures
- Manage complete lifecycle of ONAP components with OOM leveraging K8 ecosystem



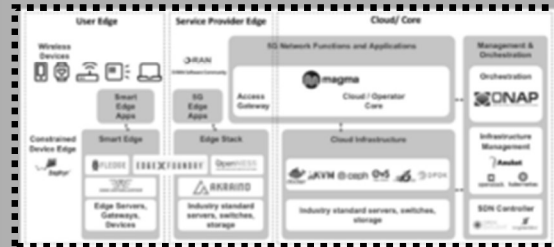
컨테이너화

CROSS-COMMUNITY & SDO COLLABORATION



커뮤니티 협력

LFN 5G SUPER BLUEPRINTS



ONBOARDING & DESIGN

- Support VNF/CNF/PNF onboarding
- Conform to industry standard modeling and packaging



온보딩/설계

ORCHESTRATION

- Support hybrid services CNF/VNF/PNF
- Provide ETSI-aligned and Cloud Native Orchestration
- Manage 3GPP compliant 5G slicing use cases



오케스트레이션

OBSERVABILITY & ANALYSIS

App - Log Generation → fluentbit → fluentd → elastic → Kibana

Support open Source & Standard-based Logging Architecture

- Decouple log generation from collection / aggregation / analysis processes
- Enable pick-and-choose solutions for monitoring, aggregating, storing and visualization
- Provide logging reference implementation

가시화/분석

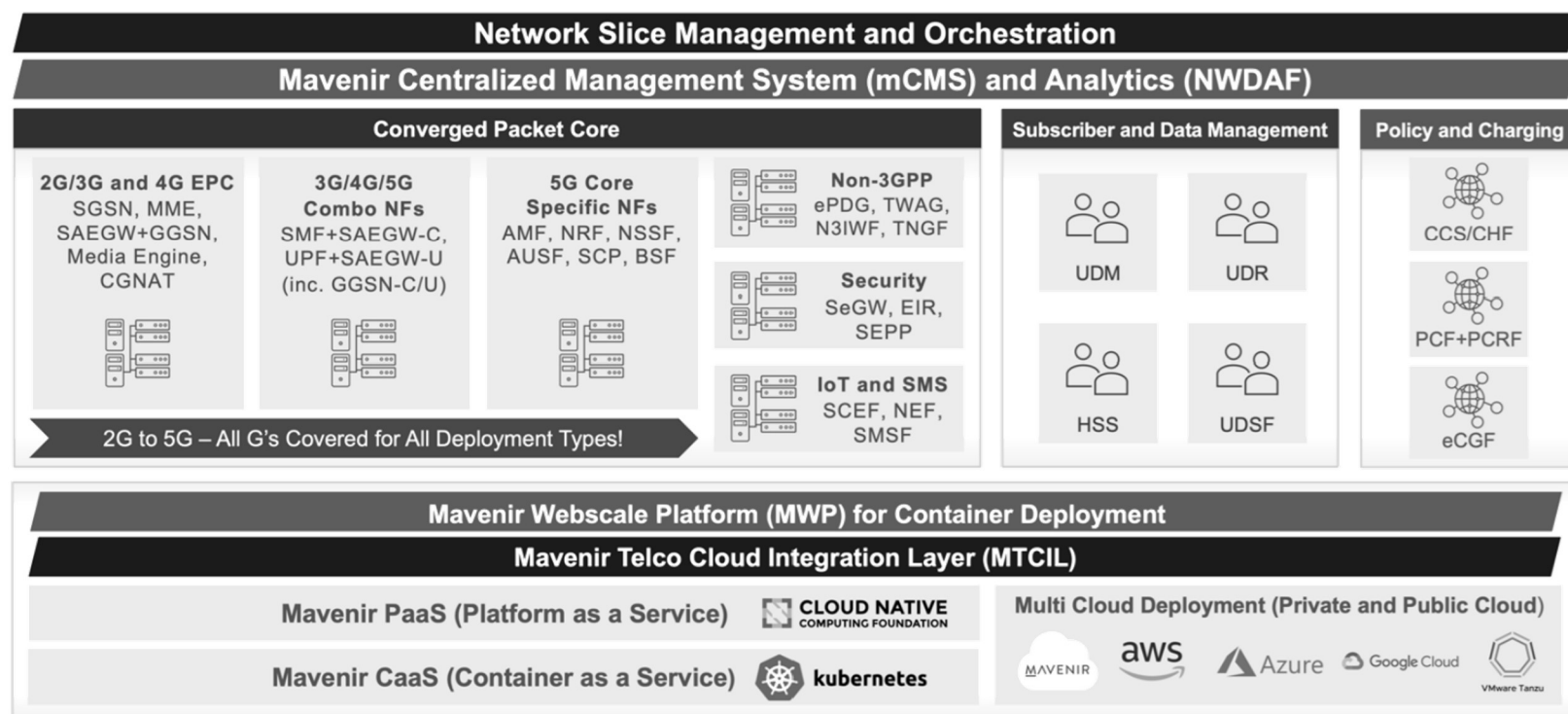
Source: <https://www.onap.org/software>

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5일차 '관리/보안, MSA 시연/실습'

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❖ Mavenir Converged Packet Core Solution Components



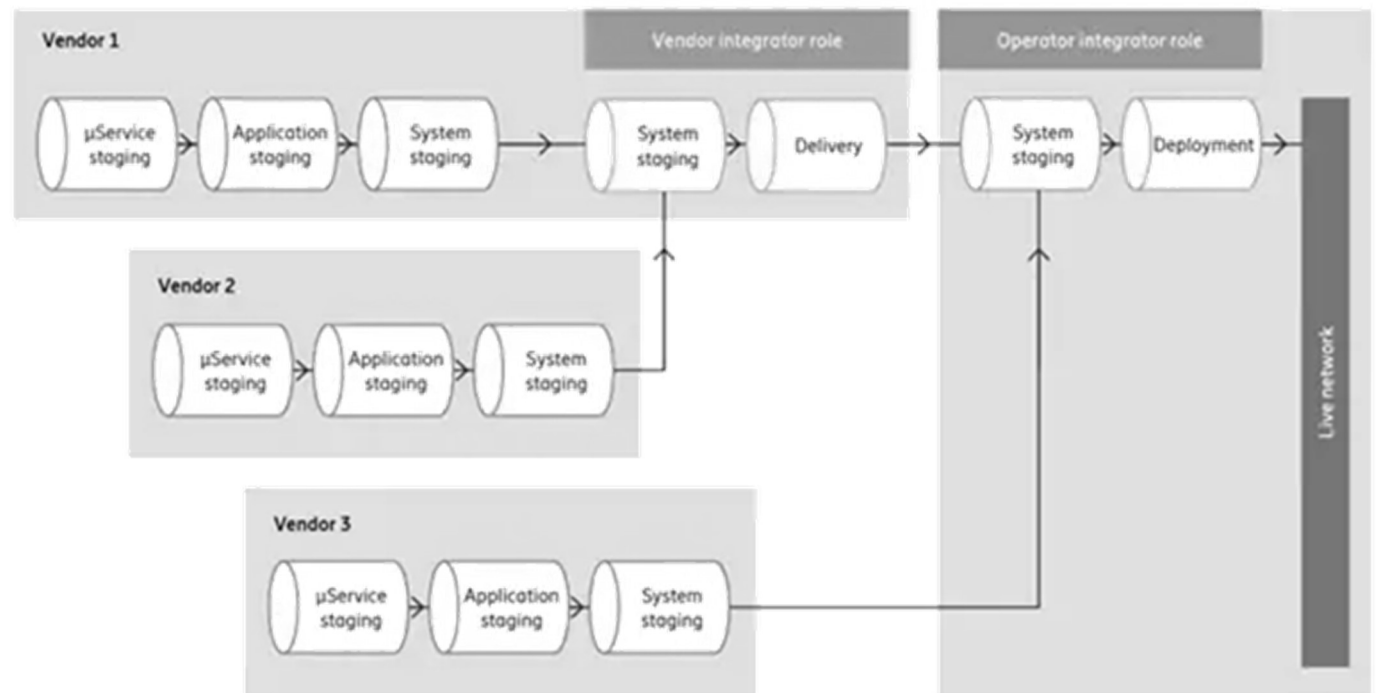
Source: https://www.mavenir.com/wp-content/uploads/2022/02/CPC_Solution-Brief_020222_final.pdf

5일차 '관리/보안, MSA 시연/실습'

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❖ 제조사 CI/CD (예): OSS/BSS in the Clouds

- Telecom phasing of software pipelines (CI/CD) and merging multiple vendors

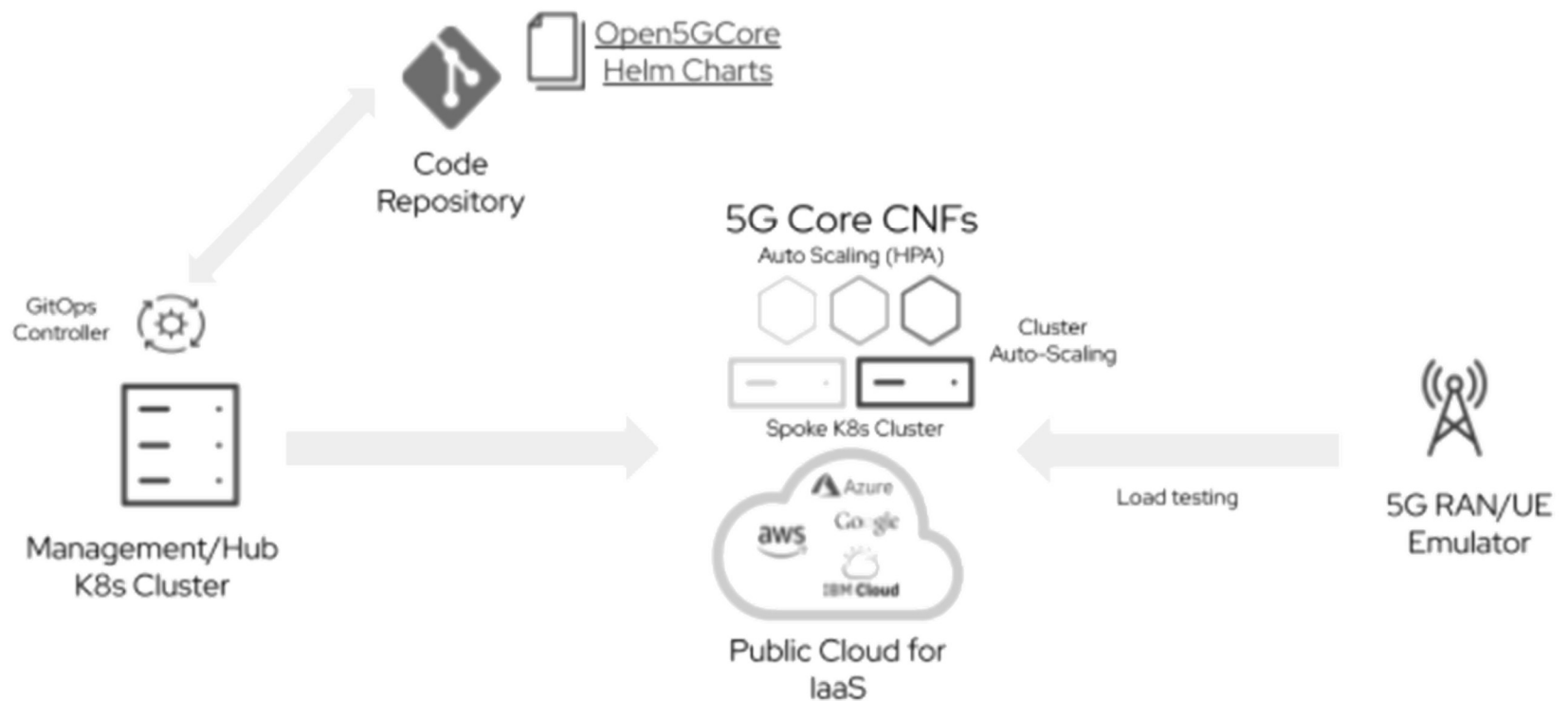


Source: <https://www.ericsson.com/en/blog/2020/10/guide-to-building-cloudnative-infrastructure>



5일차 '관리/보안, MSA 시연/실습'

❖ 제조사 (예): Red Hat - Scaling a 5G platform

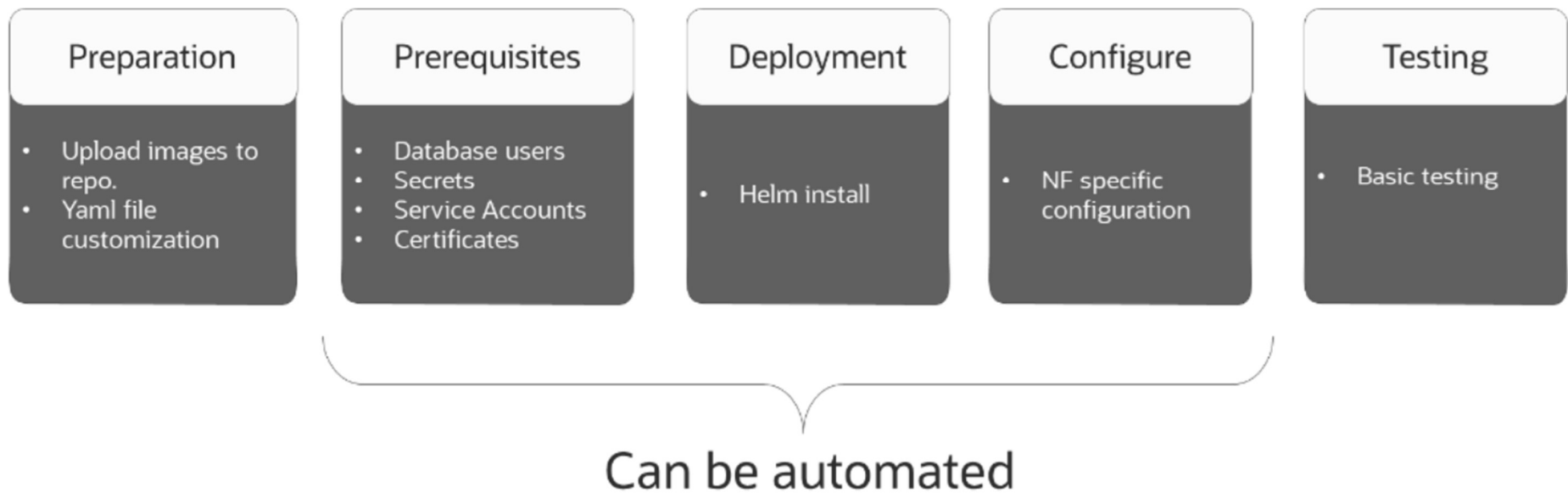


Source: Anca Pavel, Fatih E. Nar, Federico Rossi, and Mathias Bogebrant, CC BY-SA 4.0
 Source: <https://www.redhat.com/architect/autoscale-5g-core>

5일차 '관리/보안, MSA 시연/실습'

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- ❖ NF deployment on the cloud infrastructure
 - NF life cycle management



Source: <https://infohub.delltechnologies.com/l/dell-technologies-5g-core-validated-design-with-oracle-and-vmware-reference-architecture-guide-1/nf-deployment-on-the-cloud-infrastructure-1>



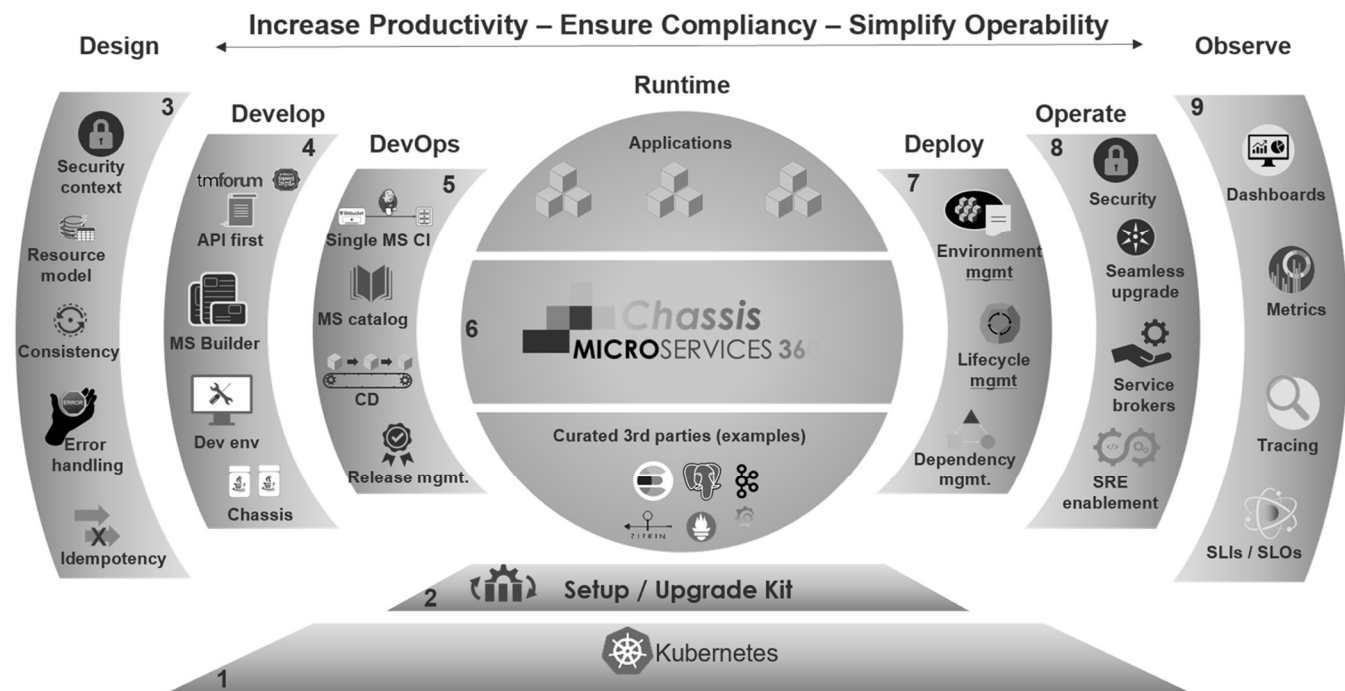
5일차 '관리/보안, MSA 시연/실습'

319

❖ 제조사 OSS/BSS Modernization (예): Red Hat and Intel

• Amdocs MS360 Cloud Native Development Platform

1. Kubernetes
2. Setup / Upgrade
3. Design
4. Develop
5. DevOps
6. Runtime
7. Deploy
8. Operate
9. Observe

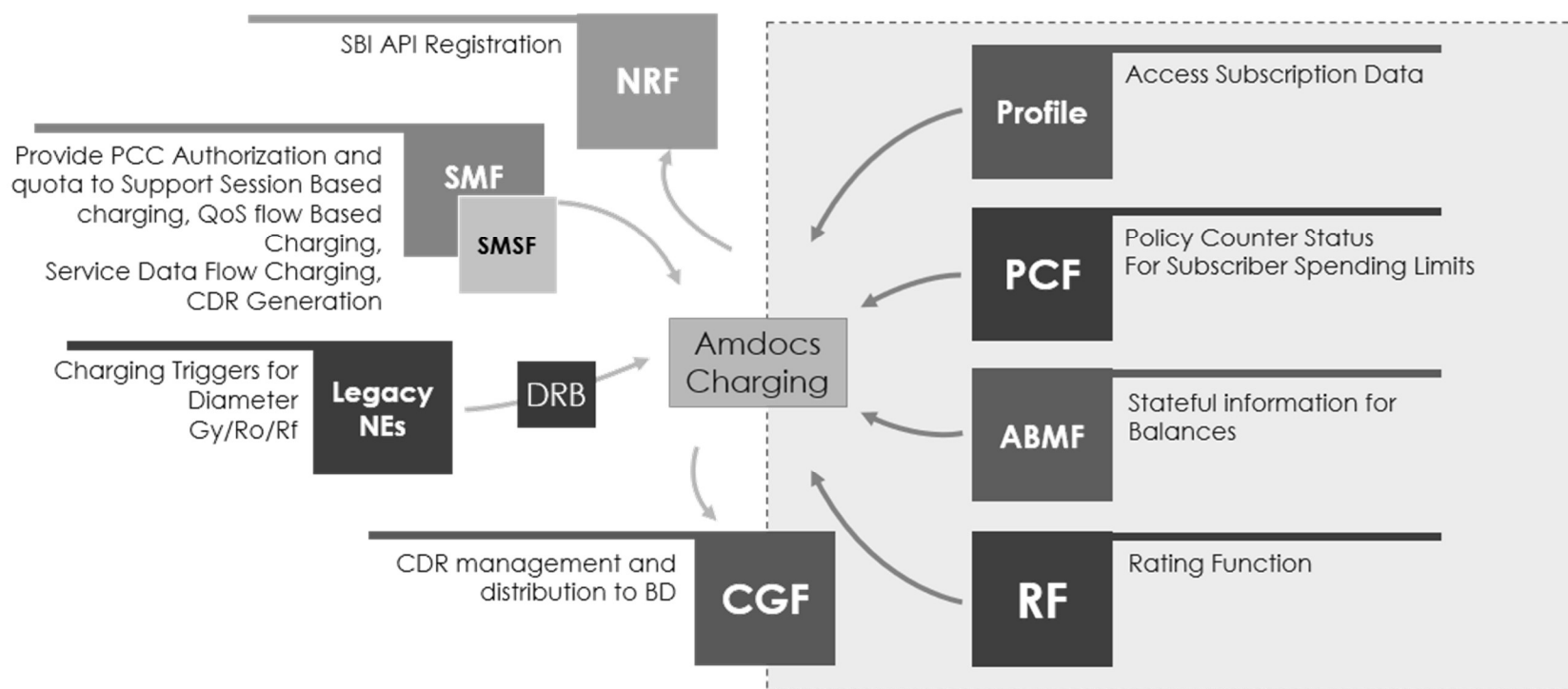


Source: <https://telecoms.com/intelligence/oss-bss-modernization-amdocs-m360-cloud-native-development-platform/>

5일차 '관리/보안, MSA 시연/실습'

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❖ Overview of Amdoc's converged charging system



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>



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5일차 '관리/보안, MSA 시연/실습'

❖ Open standards tools used for the development of each microservice

- **UAA** (User Account and Authentication)
- **API Gateway**
- **Cache**
- **Continuous Delivery**
- **Containers**
- **Cloud Platform**

UAA	okta	Apache DS	gluu	AWS IAM			
API Gateway	WSO2	TreeGateway	AWS API Gateway				
Cache	redis	HBASE	AWS Elastic Cache				
Continuous Delivery	git	+	Gradle	+	Jenkins	+	AWS Elastic Beanstalk
Containers	docker	kubernetes	MESOS				
Cloud Platform	openstack	IBM Bluemix	Microsoft Azure	amazon web services			

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



5일차 '관리/보안, MSA 시연/실습'

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❖ Frameworks for web services for MSA

- Spring Boot
- Eclipse Vert.X
- Oracle Helidon
- GoMicro
- Molecular

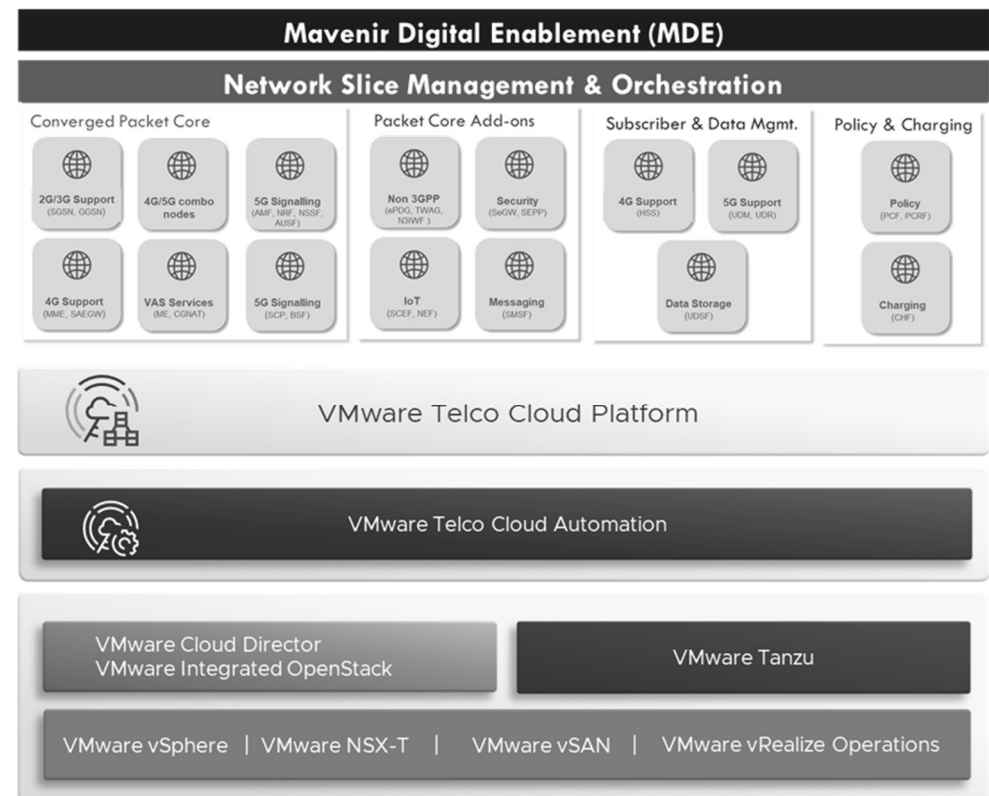
Source: <https://www.mantisnet.com/blog/ebpf-v-sidecar-containers-5g-observability>



5일차 '관리/보안, MSA 시연/실습'

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❖ Mavenir's Converged Packet Core on VMware Telco Cloud Platform. (VMware)



Source: <https://blogs.vmware.com/telco/mavenir-mwc-amer/>

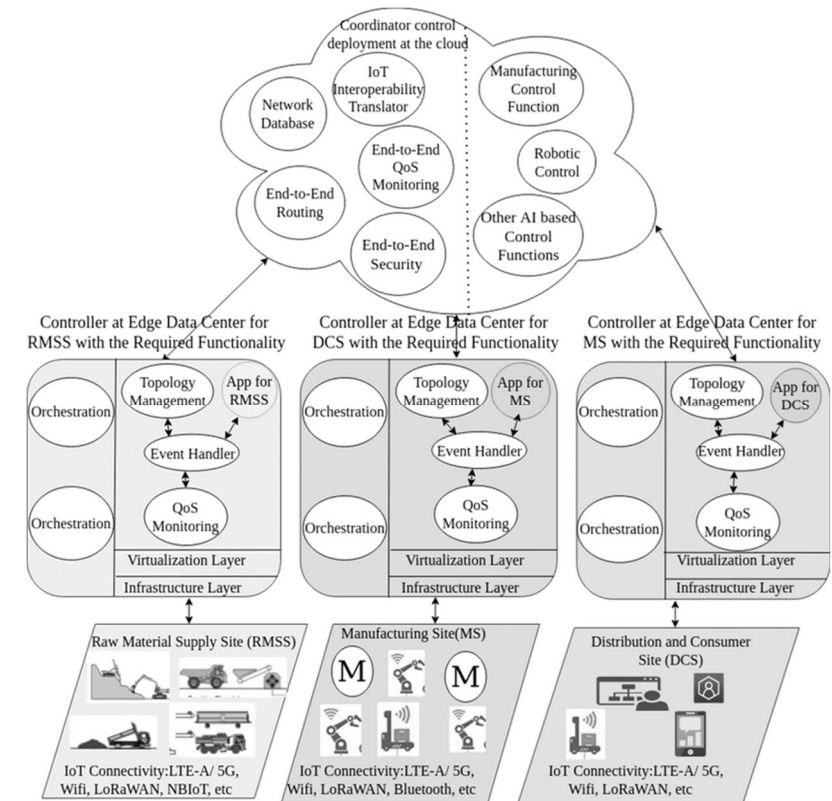


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5일차 '관리/보안, MSA 시연/실습'

324

❖ Microservices-based SDN deployment blueprint in IIoT Scenarios



산업용 사물 인터넷(Industrial Internet of Things)

Source: https://www.researchgate.net/figure/Microservices-based-SDN-deployment-blueprint-in-IIoT-Scenarios_fig4_355473965

5일차 '관리/보안, MSA 시연/실습'

❖ IaaS (예): Terraform

- AWS 랜딩존

Name	서브...	IPv4 CIDR
<input checked="" type="checkbox"/> 101subnet-1	subnet...	10.0.0.0/23
<input type="checkbox"/> 101subnet-2	subnet...	10.0.2.0/23
<input type="checkbox"/> 101subnet-private-1	subnet...	10.0.4.0/23
<input type="checkbox"/> 101subnet-private-2	subnet...	10.0.6.0/23
<input type="checkbox"/> 101subnet-pri-db1	subnet...	10.0.8.0/23
<input type="checkbox"/> 101subnet-pri-db2	subnet...	10.0.10.0/23

subnet-068809cf055800fd9 / 101subnet-1

세부 정보 | 플로우 로그 | 라우팅 테이블 | 네트워크 ACL | CIDR 예약 | 공유 중

이제 Reachability Analyzer를 사용하여 네트워크 연결을 확인할 수 있습니다.

라우팅 테이블: rtb-031409dbff2ac9047 / main-default

라우팅 (2)

Q 라우팅 필터링

대상	대상
0.0.0.0/0	igw-0f9e147f6bf1f7d0e
10.0.0.0/20	local
0.0.0.0/0	igw-0f9e147f6bf1f7d0e

rtb-031409dbff2ac9047 / main-default

세부 정보 | 라우팅 | 서브넷 연결 | 엣지 연결 | 라우팅 전략 | 태그

라우팅 (2)

Q 라우팅 필터링

대상	대상
0.0.0.0/0	igw-0f9e147f6bf1f7d0e
10.0.0.0/20	local

subnet-05614a12e0d8f391d / 101subnet-private-1

세부 정보 | 플로우 로그 | 라우팅 테이블 | 네트워크 ACL | CIDR 예약 | 공유 중

이제 Reachability Analyzer를 사용하여 네트워크 연결을 확인할 수 있습니다.

라우팅 테이블: rtb-05bbd4b9256665277 / main-private-1

라우팅 (2)

Q 라우팅 필터링

대상	대상
10.0.0.0/20	local
0.0.0.0/0	nat-008d078b94ef8337c

subnet-0aca3809503682944 / 101subnet-pri-db1

세부 정보 | 플로우 로그 | 라우팅 테이블 | 네트워크 ACL | CIDR

이제 Reachability Analyzer를 사용하여 네트워크 연결을 확인할 수 있습니다.

라우팅 테이블: rtb-08c6ead87d7f3cf4f / main-private-db1

라우팅 (1)

Q 라우팅 필터링

라우팅 테이블 (1/6) 정보

Q 라우팅 테이블 필터링

Name	라우팅 테이블 ID	명시적 서브넷 연결
-	rtb-04b5e2c2efcd71b4	-
<input checked="" type="checkbox"/> main-default	rtb-031409dbff2ac9047	2 서브넷
<input type="checkbox"/> main-private-1	rtb-05bbd4b9256665277	subnet-05614a12e0d8f...
<input type="checkbox"/> main-private-2	rtb-09a329033ea947b1d	subnet-06edbcddfd24f5e...
<input type="checkbox"/> main-private-db1	rtb-08c6ead87d7f3cf4f	subnet-0aca380950368...
<input type="checkbox"/> main-private-db2	rtb-0d625bf4da05d7c18	subnet-091e3fbbad3b9...

```
# pub1, pri1, nat 2 -> pub2, pri2, public2, nat2
# nat
resource "aws_vpc" "nat_1" {
  cidr_block = "10.0.0.0/20"
  enable_dns_hostnames = true
  tags = {
    Name = "nat-1"
  }
}

resource "aws_subnet" "pub1" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-1"
  }
}

resource "aws_subnet" "pub2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-2"
  }
}

resource "aws_internet_gateway" "igw" {
  vpc_id = aws_vpc.nat_1.id
  tags = {
    Name = "nat-igw"
  }
}

# private route table add
resource "aws_route_table" "public_private_1" {
  vpc_id = aws_vpc.nat_1.id
  tags = {
    Name = "main-private-1"
  }
}

resource "aws_route_table_association" "public_association_1" {
  subnet_id = aws_subnet.pub1.id
  route_table_id = aws_route_table.public_private_1.id
}

resource "aws_route_table_association" "public_association_2" {
  subnet_id = aws_subnet.pub2.id
  route_table_id = aws_route_table.public_private_1.id
}

resource "aws_route_table" "private_nat_1" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-private-1"
  }
}

resource "aws_subnet" "pri1" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-private-1"
  }
}

resource "aws_subnet" "pri2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-private-2"
  }
}

resource "aws_route_table" "public_private_db1" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "main-private-db1"
  }
}

resource "aws_subnet" "pri-db1" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-private-db1"
  }
}

resource "aws_subnet" "pri-db2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-private-db2"
  }
}

resource "aws_route_table" "public_private_db2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "main-private-db2"
  }
}

resource "aws_route_table_association" "public_association_db1" {
  subnet_id = aws_subnet.pri-db1.id
  route_table_id = aws_route_table.public_private_db1.id
}

resource "aws_route_table_association" "public_association_db2" {
  subnet_id = aws_subnet.pri-db2.id
  route_table_id = aws_route_table.public_private_db2.id
}

resource "aws_route_table" "private_nat_1" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "main-private-nat-1"
  }
}

resource "aws_subnet" "nat_1" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "nat-1"
  }
}

resource "aws_internet_gateway" "igw" {
  vpc_id = aws_vpc.nat_1.id
  tags = {
    Name = "nat-igw"
  }
}

# private route table add
resource "aws_route_table" "public_private_2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "main-private-2"
  }
}

resource "aws_route_table_association" "public_association_2" {
  subnet_id = aws_subnet.pub2.id
  route_table_id = aws_route_table.public_private_2.id
}

resource "aws_route_table_association" "public_association_3" {
  subnet_id = aws_subnet.pub1.id
  route_table_id = aws_route_table.public_private_2.id
}

resource "aws_route_table" "private_nat_2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "main-private-nat-2"
  }
}

resource "aws_subnet" "nat_2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "nat-2"
  }
}

resource "aws_internet_gateway" "igw2" {
  vpc_id = aws_vpc.nat_1.id
  tags = {
    Name = "nat-igw2"
  }
}

# private route table add
resource "aws_route_table" "public_private_db2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "main-private-db2"
  }
}

resource "aws_subnet" "pri-db2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "101subnet-private-db2"
  }
}

resource "aws_route_table_association" "public_association_db2" {
  subnet_id = aws_subnet.pri-db2.id
  route_table_id = aws_route_table.public_private_db2.id
}

resource "aws_route_table" "private_nat_2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "main-private-nat-2"
  }
}

resource "aws_subnet" "nat_2" {
  vpc_id = aws_vpc.nat_1.id
  cidr_block = "10.0.0.0/24"
  availability_zone = "ap-northeast-2"
  tags = {
    Name = "nat-2"
  }
}

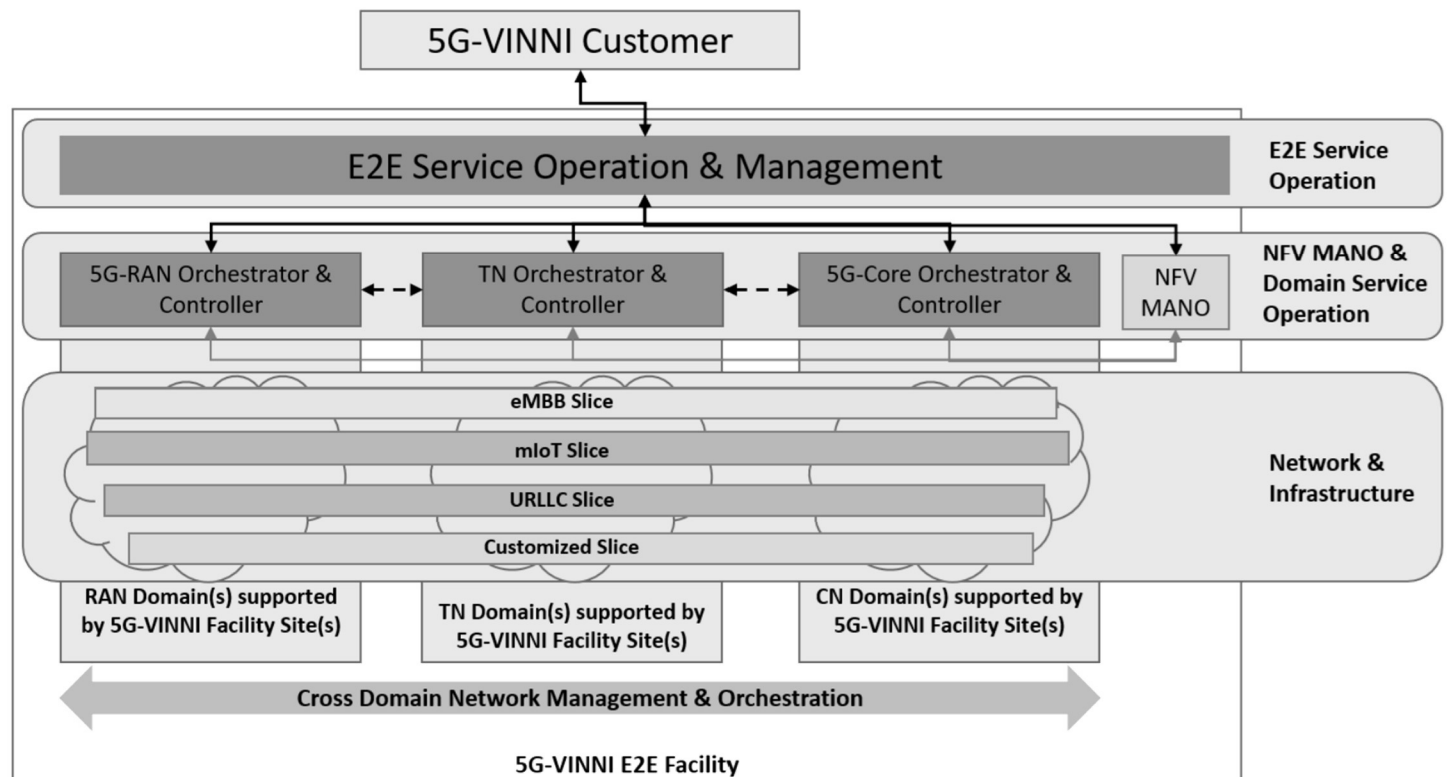
resource "aws_internet_gateway" "igw2" {
  vpc_id = aws_vpc.nat_1.id
  tags = {
    Name = "nat-igw2"
  }
}
```

Source: <https://brunch.co.kr/@topasvga/279/>

5일차 '관리/보안, MSA 시연/실습'

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❖ elastic MEC-enabled E2E slices



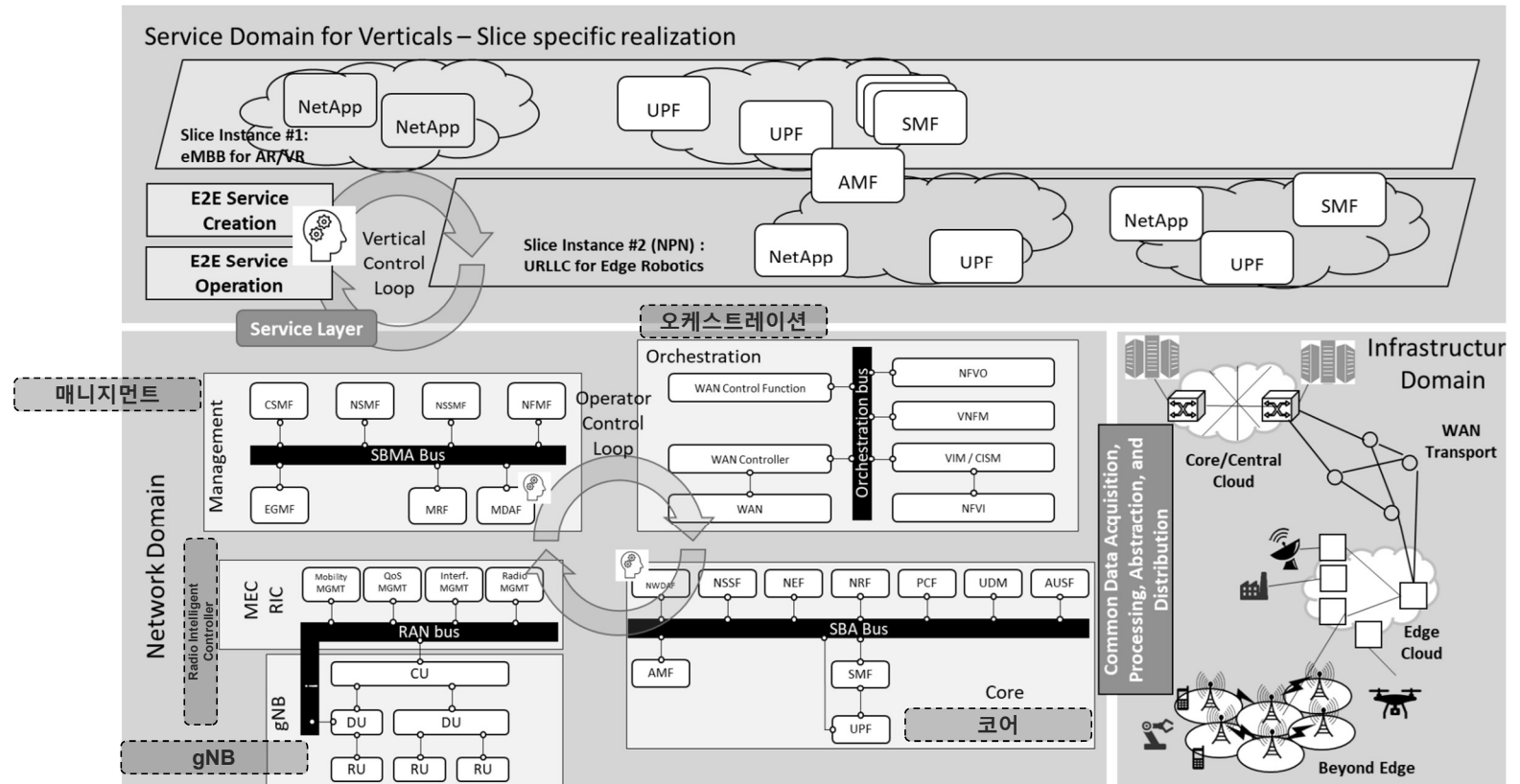
Source: 5GPPP Architecture Working Group 5G Architecture - White Paper



5일차 '관리/보안, MSA 시연/실습'

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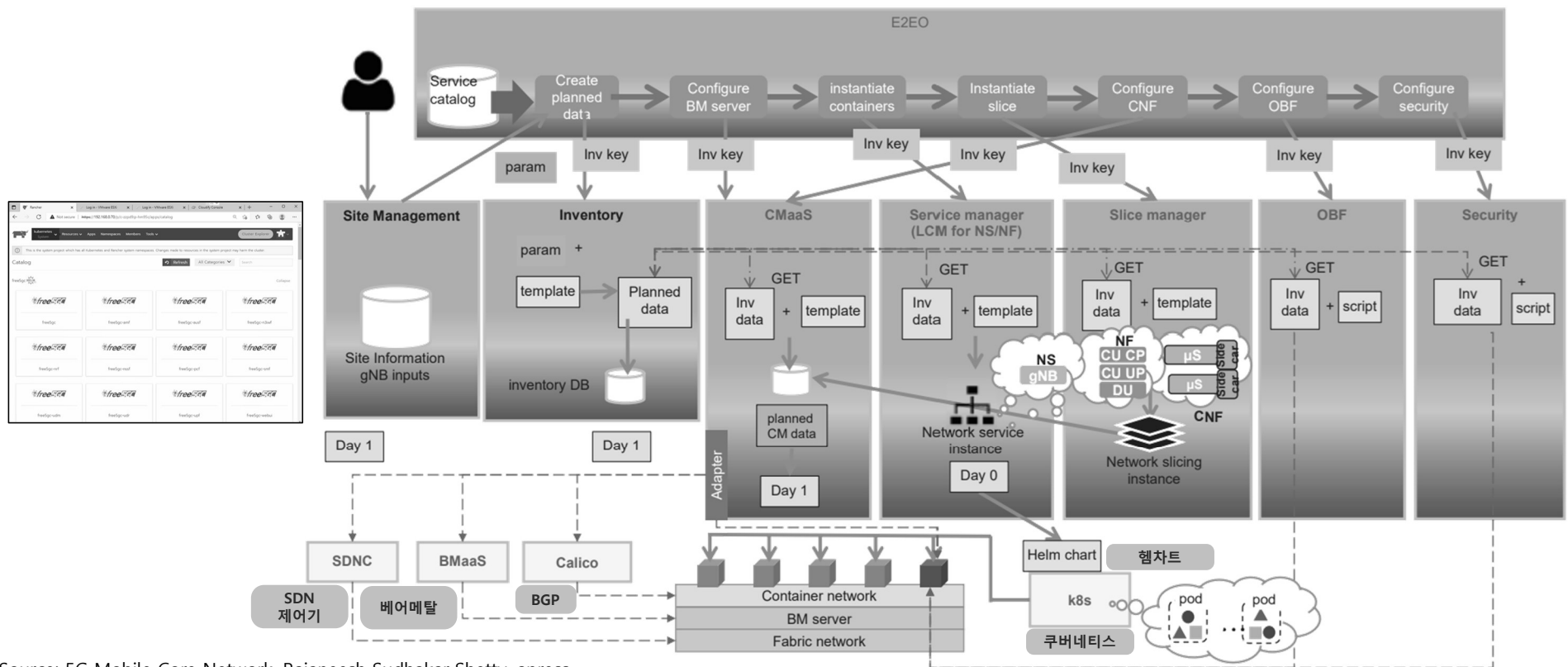
❖ 5GPPP: Overall 5G architecture



5일차 '관리/보안, MSA 시연/실습'

328

❖ 종단간 오케스트레이션: End-to-end orchestration functionalities

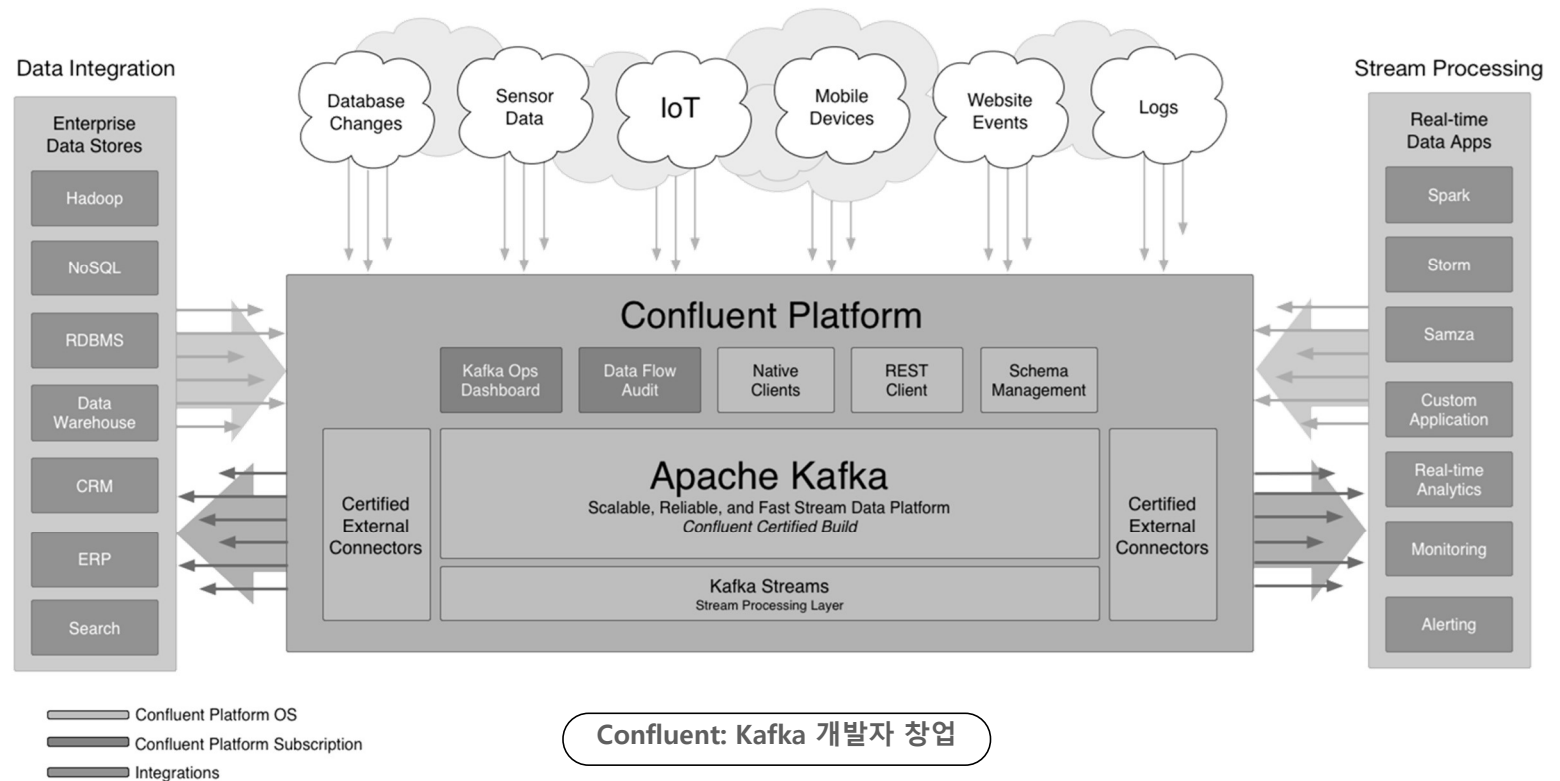


Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apress

5일차 '관리/보안, MSA 시연/실습'

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❖ Stream Processing (예: Confluent Platform)

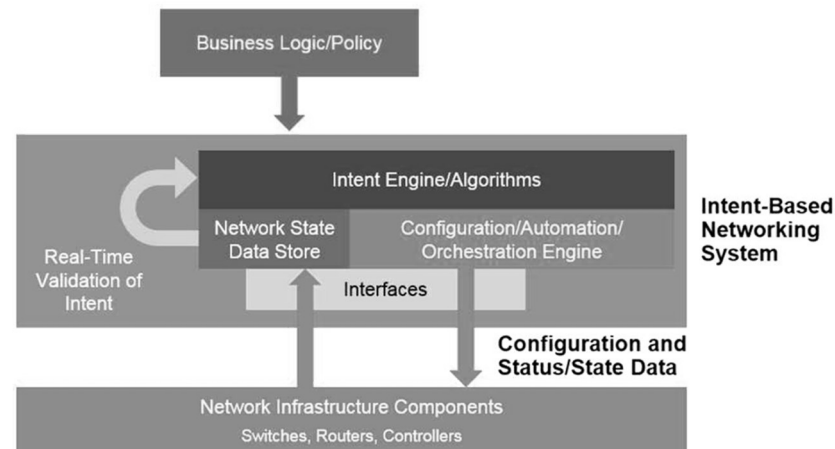


Source: <https://docs.confluent.io/2.0.0/platform.html>

5일차 '관리/보안, MSA 시연/실습'

❖ 인텐트 기반 네트워킹(IBN)

- 네트워크 사용자의 의도(Intent)에 맞는 네트워크 서비스를 효율적으로 제공하고자 하는 개념
- AI 기술과 결합 되면서 네트워크 제어 및 관리 분야에서 자동화 네트워크를 구현
- 기능 요소: 인텐트를 해석, 네트워크 자원 배정을 배정, 폐쇄 제어 루프
- IETF에서는 통신 분야의 IBN과 관련된 용어/개념/기본 구조를 제시하는 RFC 9315 표준 제시
- 오픈소스 (예): Linux Foundation의 ONAP 플랫폼

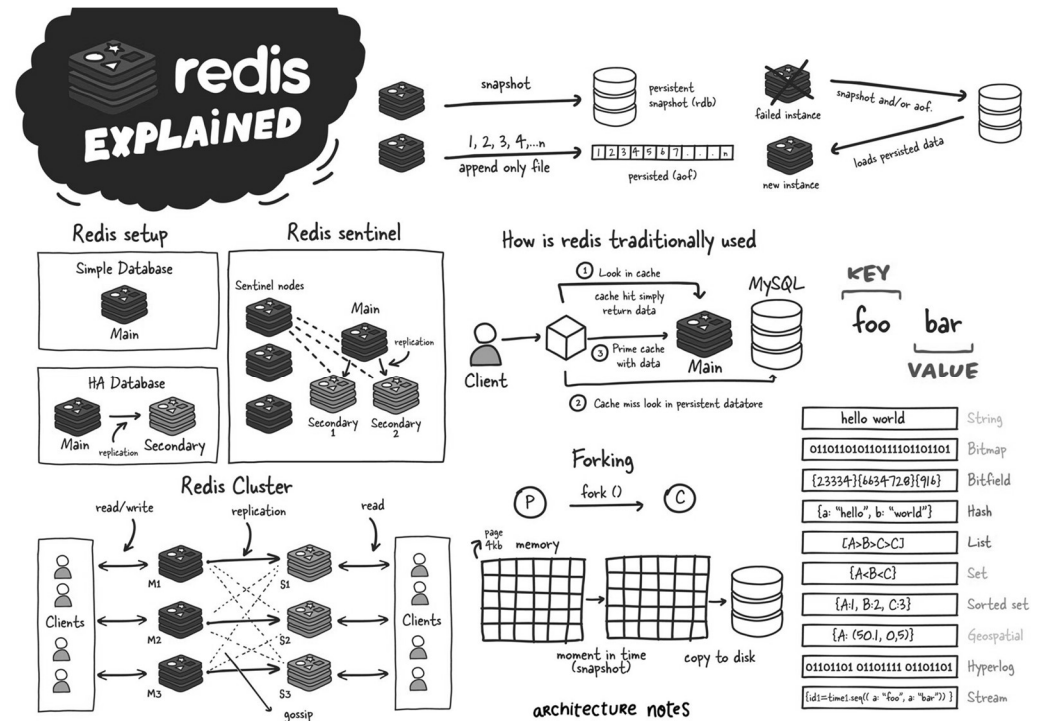


Source: 네트워크 자동화 오픈 플랫폼 동향: IETF IBN & LF ONAP, NIA, 경남대학교 석승준교수

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5일차 '관리/보안, MSA 시연/실습'

- ❖ Open and Standards-based
- ❖ The Pathway to Software Control and Automation

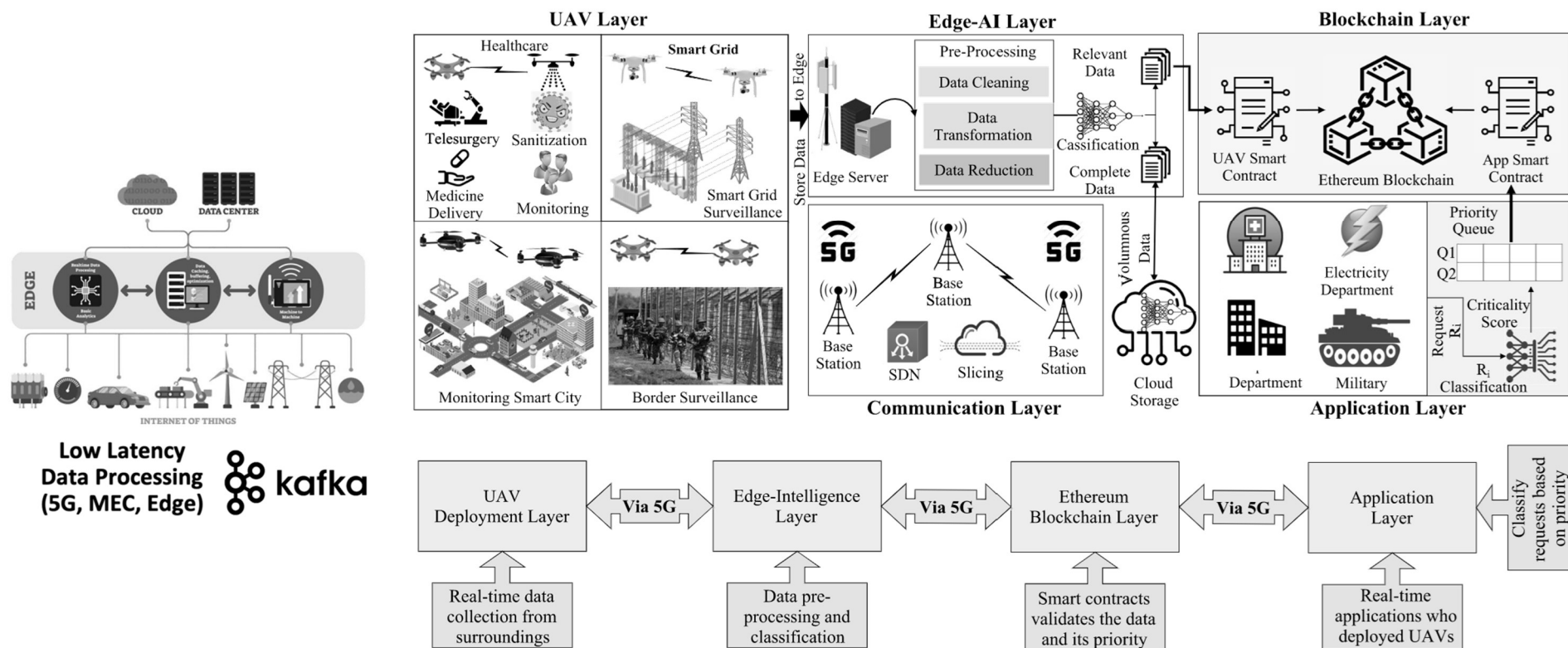


Source: <https://www.ecosmob.com/key-microservices-trends-for-2022/>

5일차 '관리/보안, MSA 시연/실습'

332

❖ Loosely coupled applications

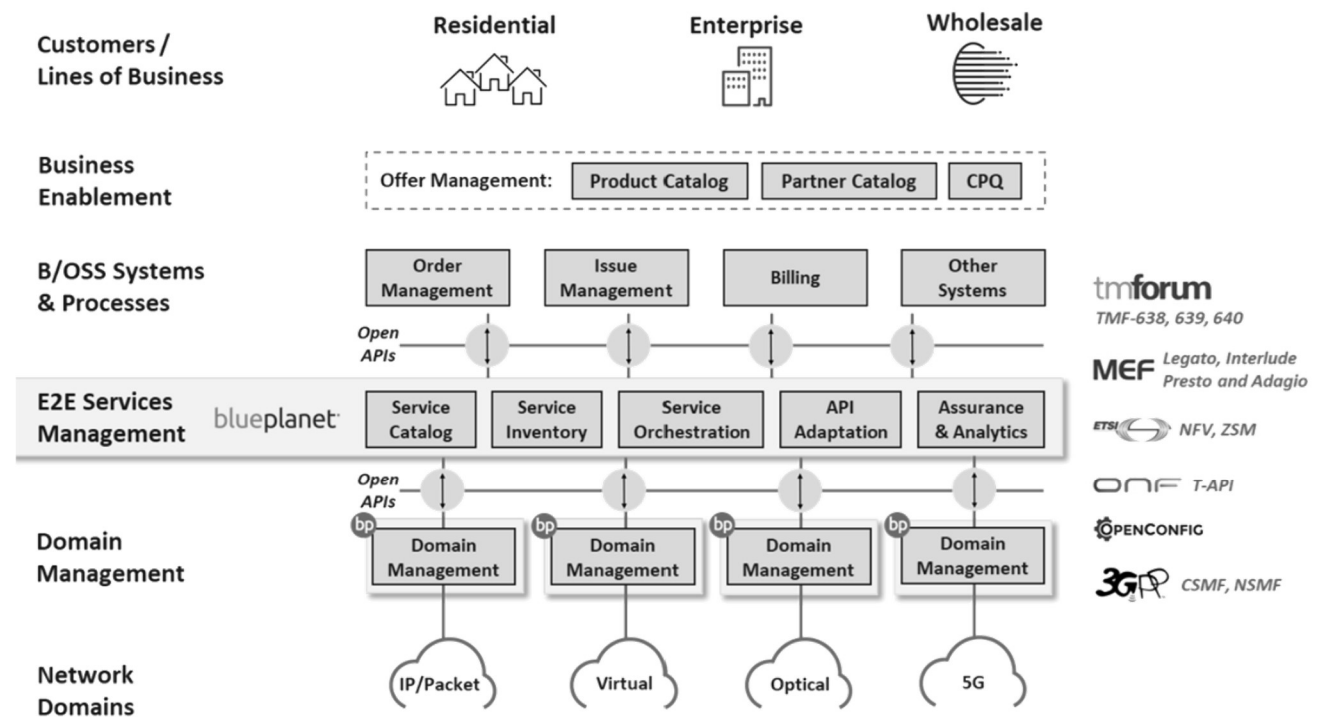


Source: <https://onlinelibrary.wiley.com/doi/epdf/10.1002/ett.4176>

5일차 '관리/보안, MSA 시연/실습'

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❖ Open and Standards-based - The Pathway to Software Control and Automation

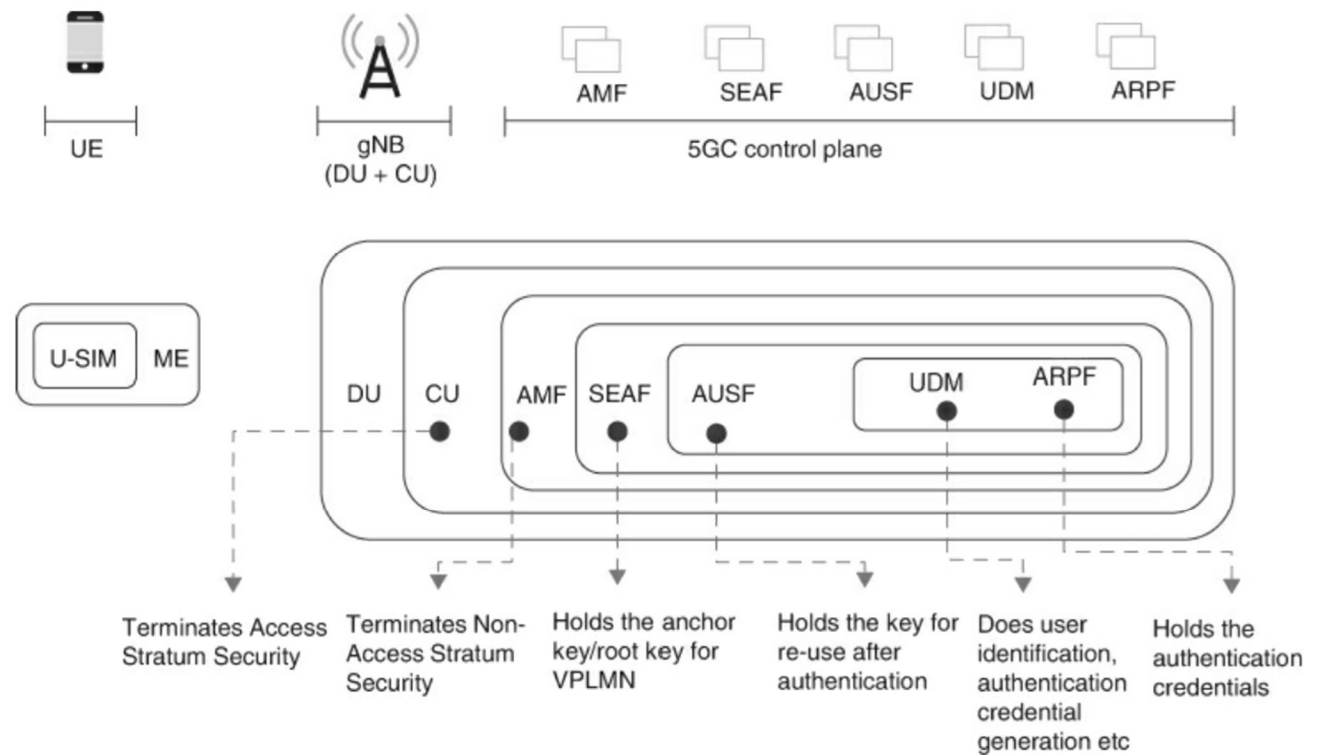


Source: <https://www.ecosmob.com/key-microservices-trends-for-2022/>

5일차 '관리/보안, MSA 시연/실습'

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❖ Trust Model for 5G Non-Roaming Architecture



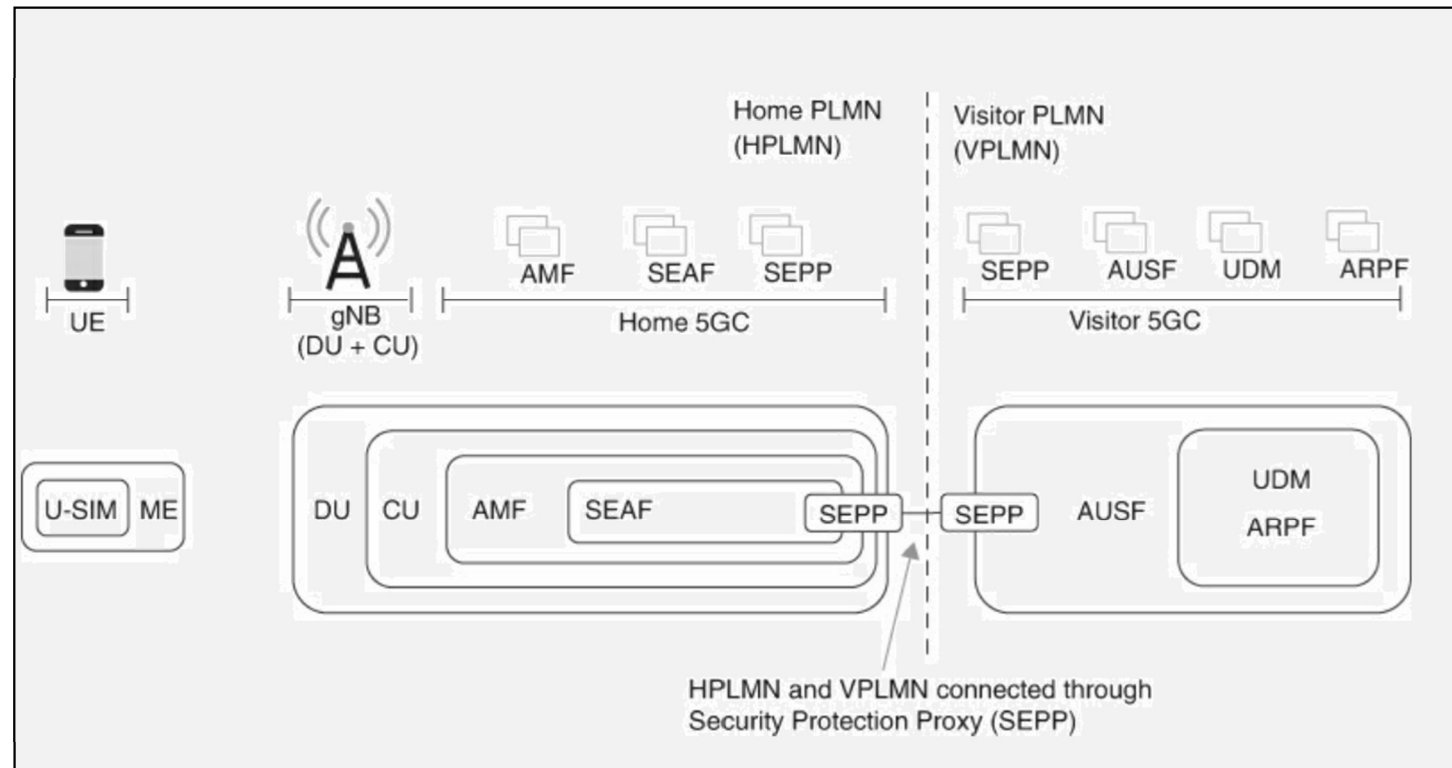
Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.



5일차 '관리/보안, MSA 시연/실습'

335

❖ Trust Model for 5G Roaming Architecture

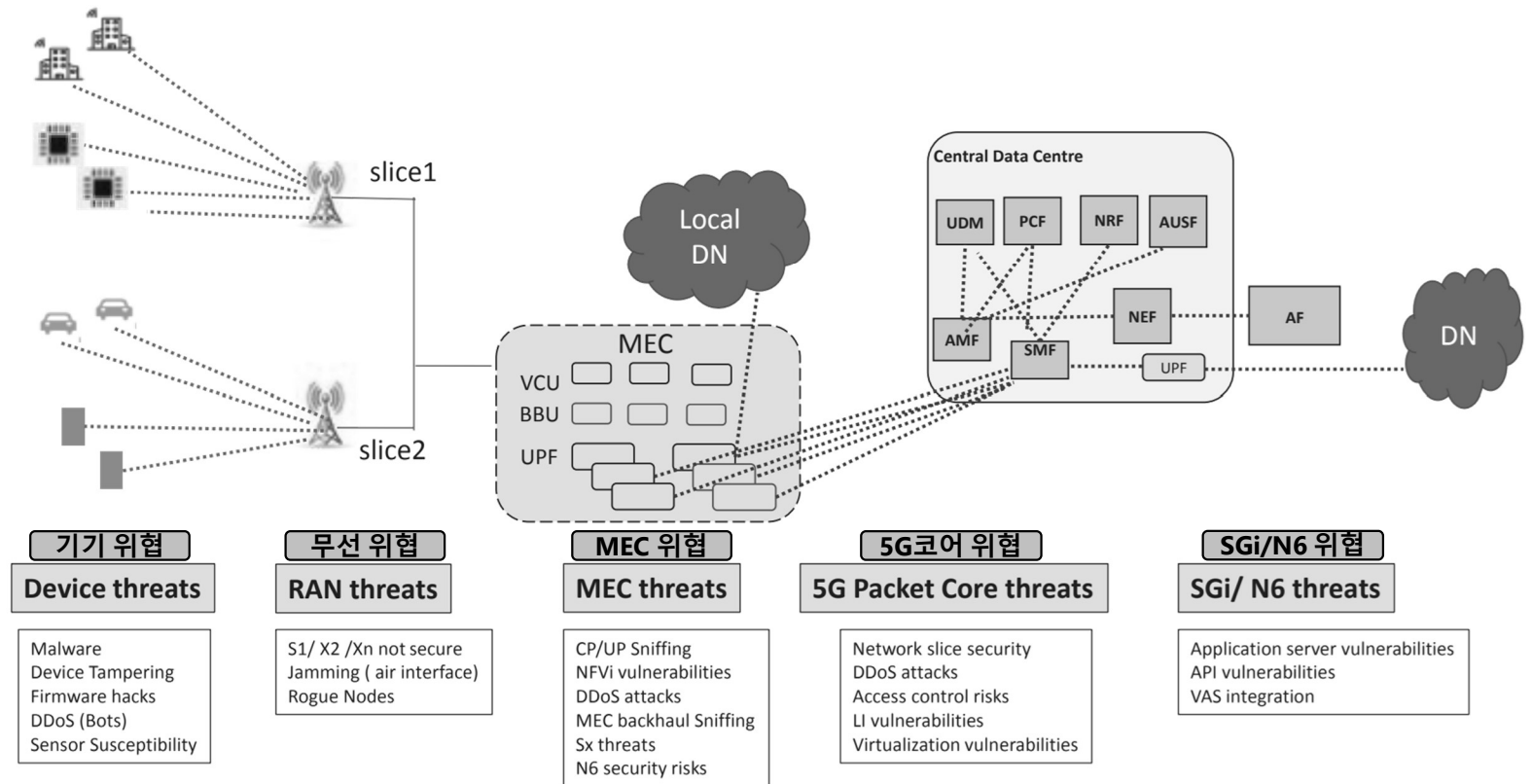


Source: Nair, Pramod (2021-12-06T22:58:59.000). Securing 5G and Evolving Architectures . Pearson Education. Kindle Edition.



5일차 '관리/보안, MSA 시연/실습'

❖ 5G 보안 위협 (Security threats in 5G)

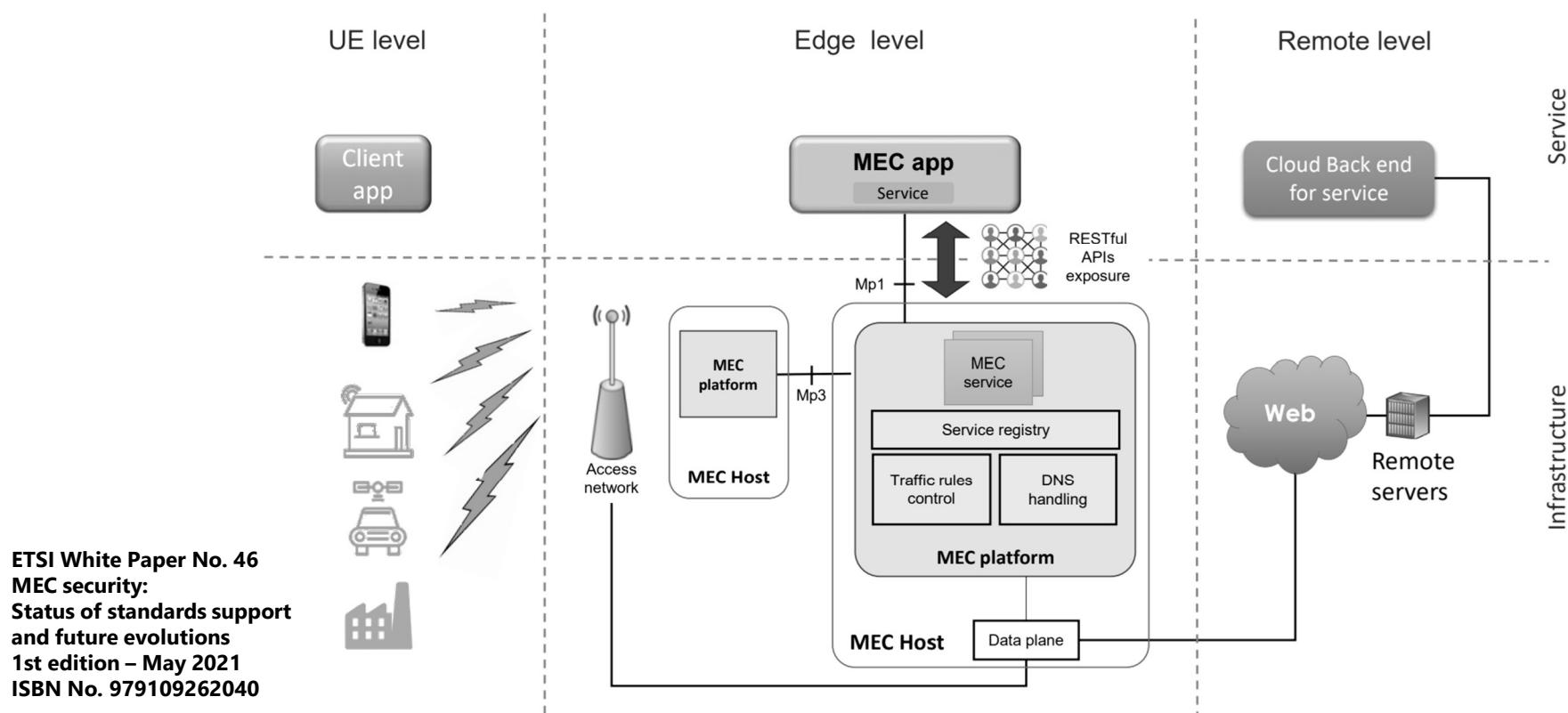


Source: 5G Mobile Core Network, Rajaneesh Sudhakar Shetty, apres

5일차 '관리/보안, MSA 시연/실습'

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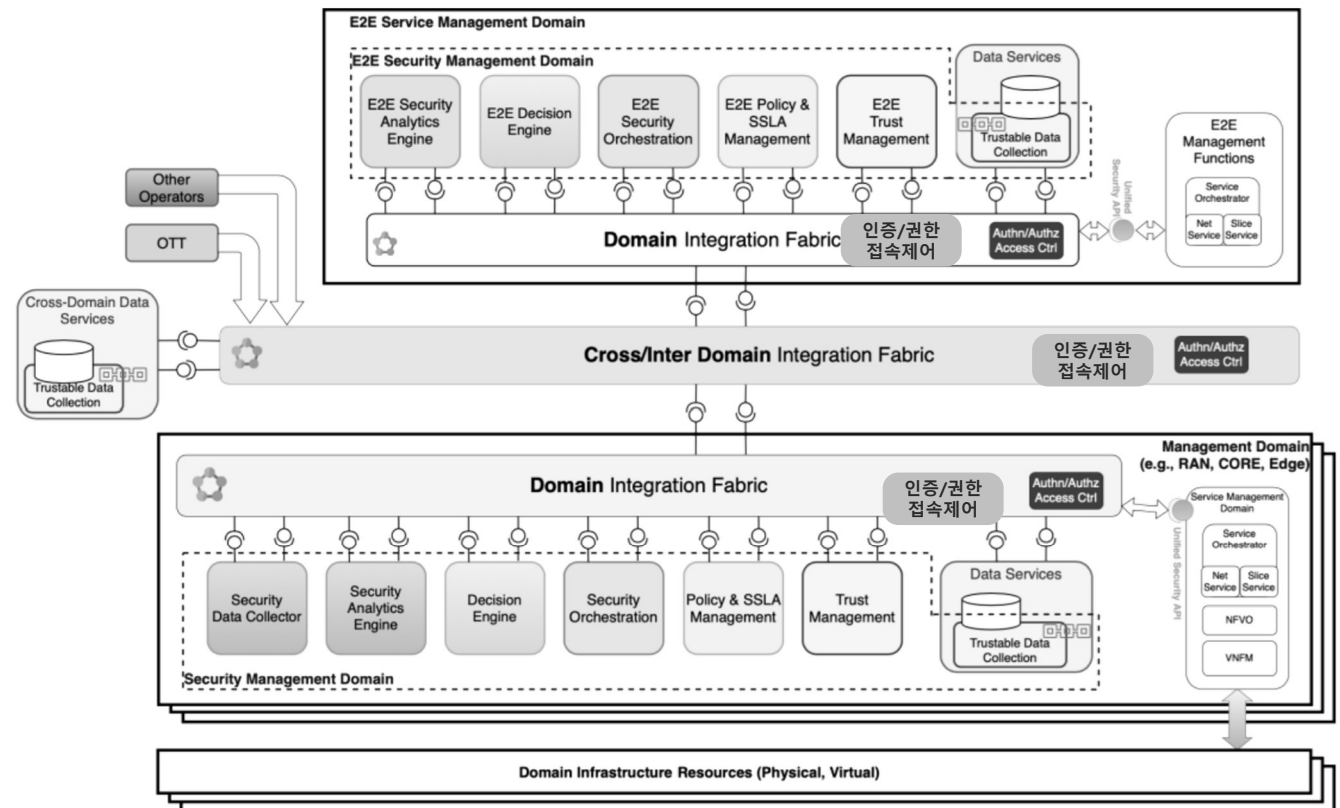
❖ ETSI의 MEC 보안: MEC applications, interaction and service exposure



5일차 '관리/보안, MSA 시연/실습'

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❖ Security Framework High-Level Architecture



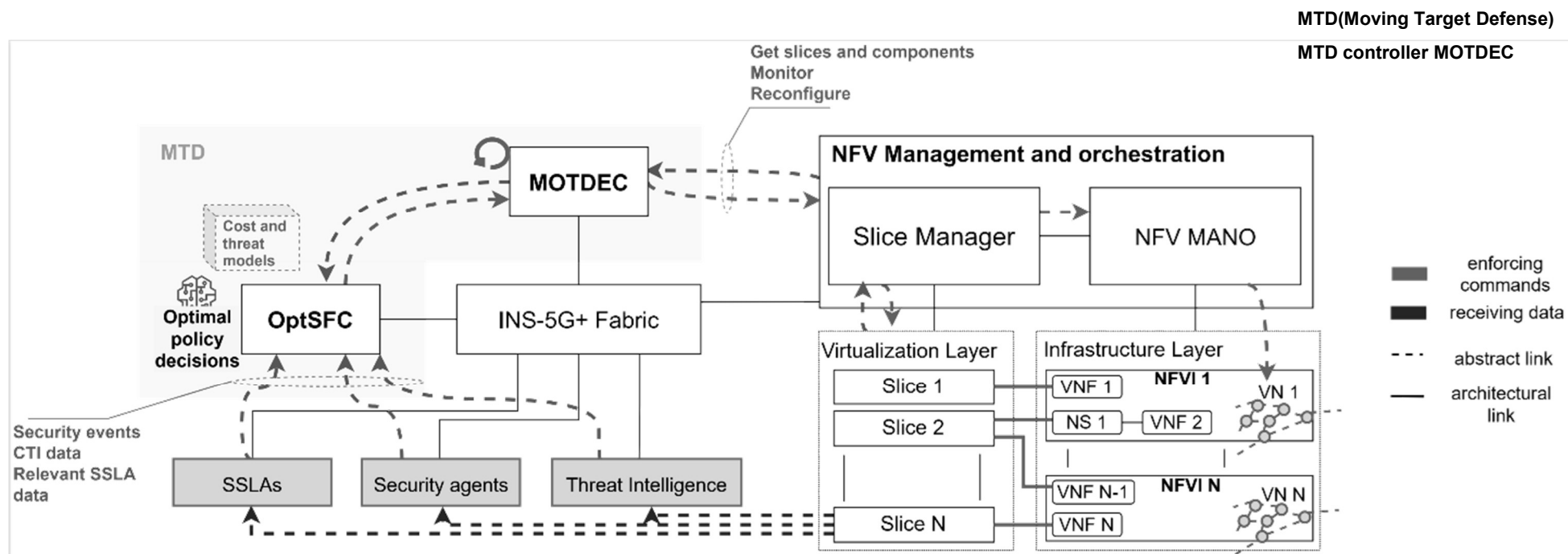
Source: 5GPPP Architecture Working Group 5G Architecture - White Paper

5일차 '관리/보안, MSA 시연/실습'

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❖ Security (보안)

- MTD for network slice protection



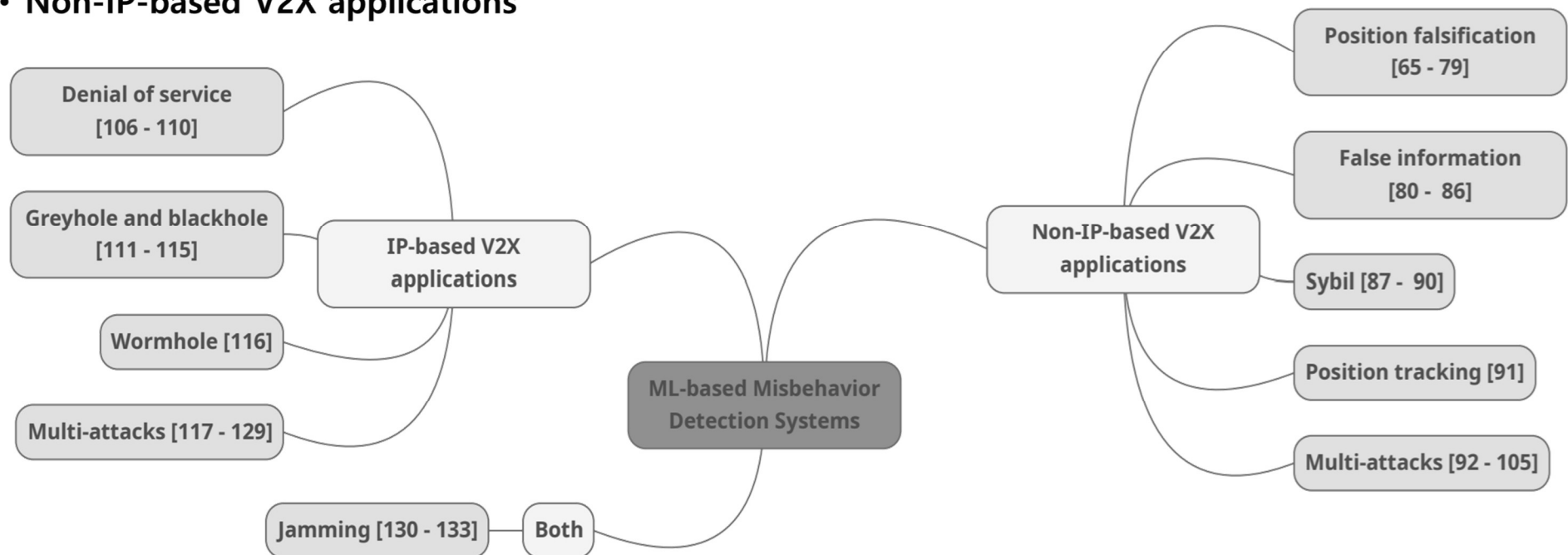
Source: AI and ML – Enablers for Beyond 5G Networks' (URL <http://doi.org/10.5281/zenodo.4299895>) , 5G PPP Technology Board, 2021-05-11

5일차 '관리/보안, MSA 시연/실습'

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❖ Taxonomy of ML-based Misbehavior Detection Systems

- IP-based V2X applications
- Non-IP-based V2X applications



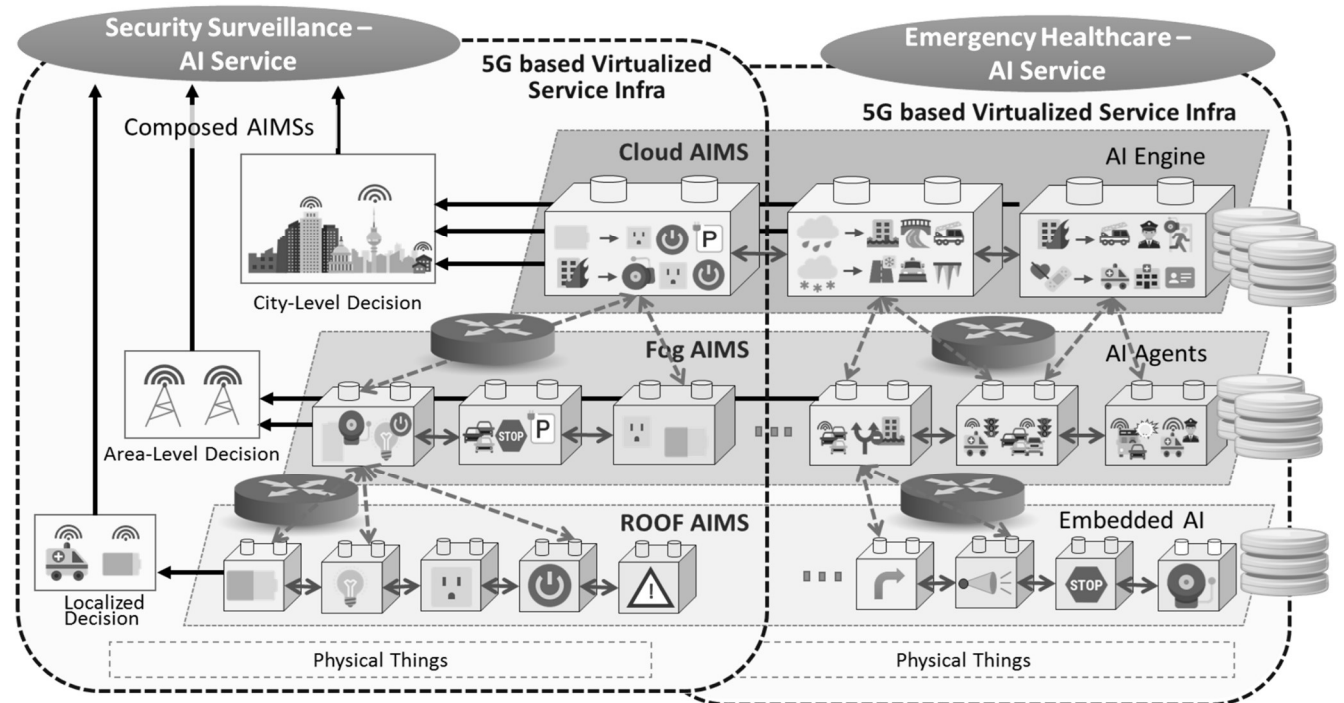
Source: A Survey on Machine Learning-base Misbehavior Detection Systems for 5G and Beyond Vehicular Network, Abdelwahab Boualouache, Member, IEEE and Thomas Engel, Member, IEEE



5일차 '관리/보안, MSA 시연/실습'

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❖ AIMS Use Cases

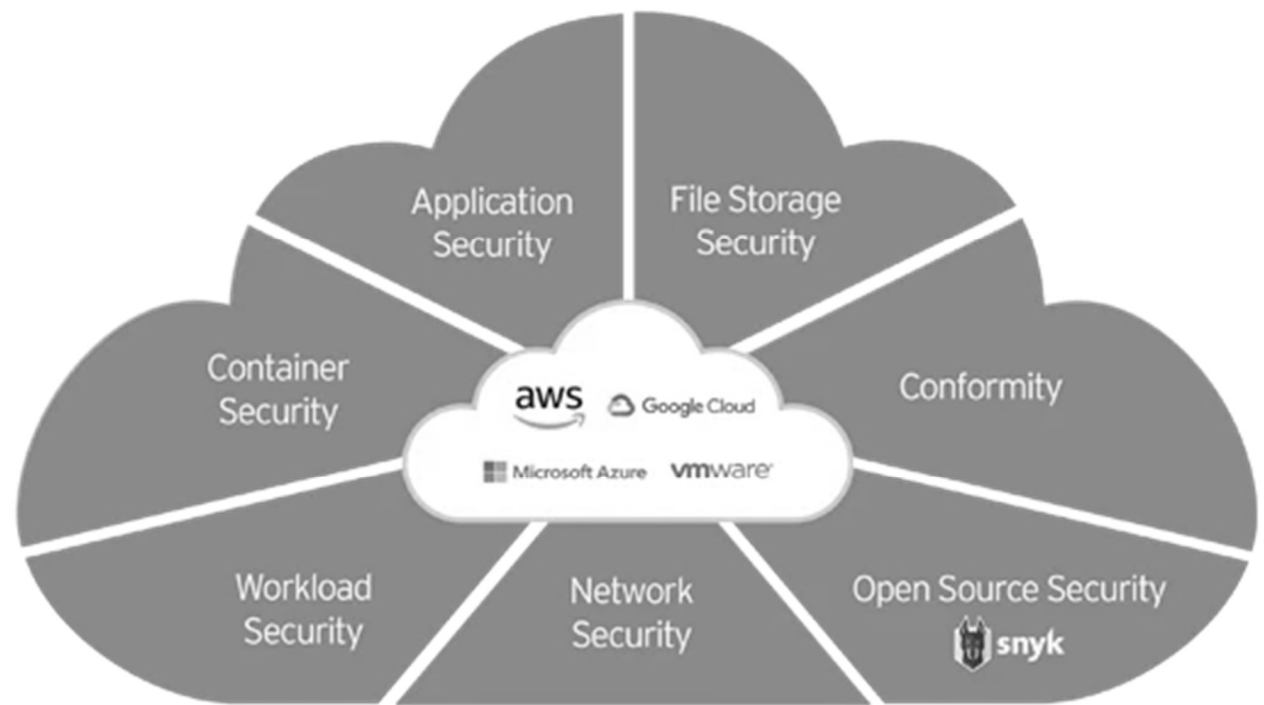


Source: https://www.itu.int/en/ITU-T/academia/kaleidoscope/2018/Documents/Presentations/S2.2_AI%20as%20a%20Microservice_UM.pdf



5일차 '관리/보안, MSA 시연/실습'

❖ 제조사 (예): Trend Micro - Cloud One Open Source Security



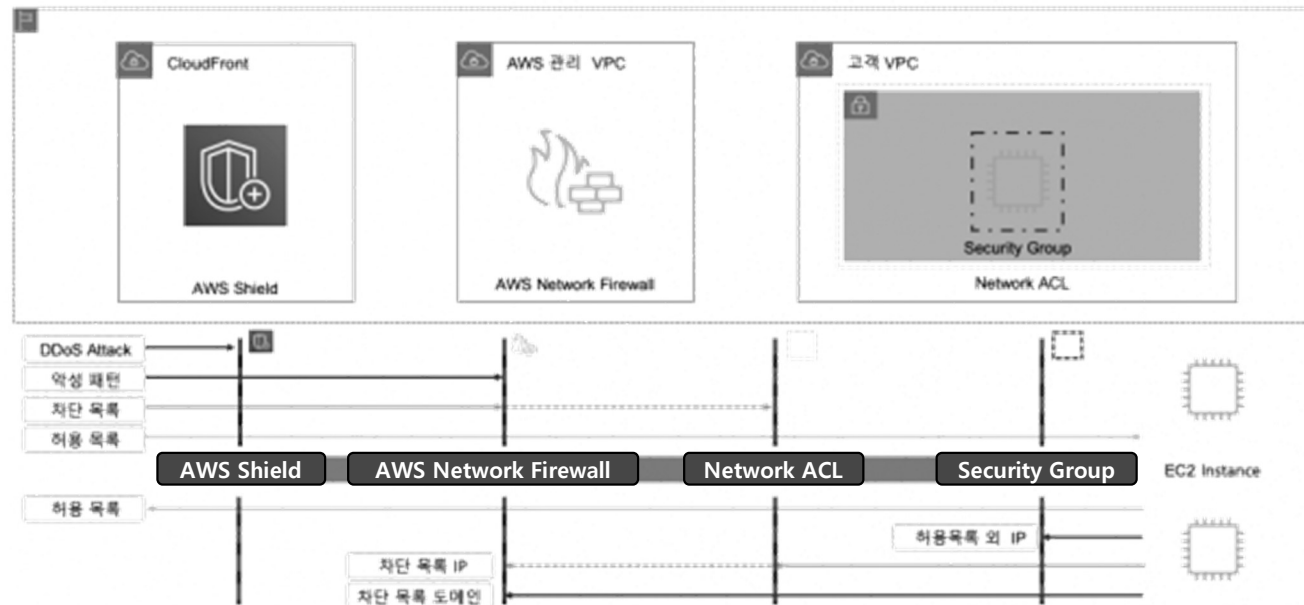
Source: https://www.trendmicro.com/en_nz/business/products/hybrid-cloud/cloud-one-open-source-security-by-snyk.html



5일차 '관리/보안, MSA 시연/실습'

❖ AWS 가상네트워크(VPC) 인프라 보안: AWS 서비스 보안

- AWS 실드(AWS Shield)
- AWS 네트워크 파이어월(AWS Network Firewall)
- NACL(Network Access Control List)
- 보안 그룹(Security Group)
- 데이터 암호화



Source: <http://www.datanet.co.kr/news/articleView.html?idxno=178057>

5일차 '관리/보안, MSA 시연/실습'

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❖ NSX Dashboard

- Home
- Networking
- Security
- Inventory
- Plan & Troubleshoot
- System

Home Networking **Security** Inventory Plan & Troubleshoot System

Security Overview

Threat Detection & Response Configuration Capacity

Campaigns IDS/IPS FQDN Analysis URL Filtering

TLS Inspection

To get started with Threat Detection and Response, you need to configure the NSX Application Platform. [GO TO DEPLOY NSX](#) [LEARN MORE ABOUT](#)

Security

From the Security tab, you can configure features to protect your network and workloads.

NEW The Campaigns, Malware Prevention, and Suspicious Network Activity features can help protect your environment.

☐ Don't show this again

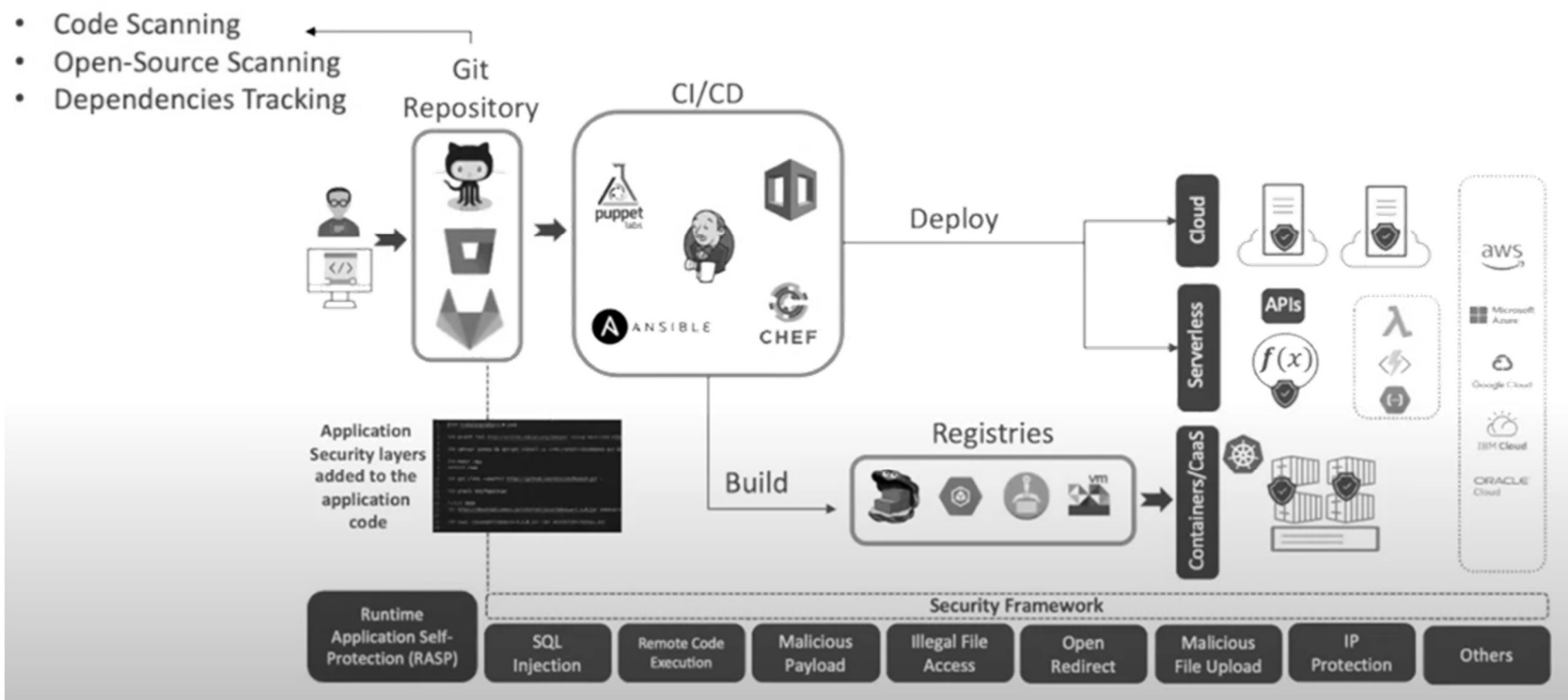
SKIP PREVIOUS NEXT



5일차 '관리/보안, MSA 시연/실습'

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❖ 제조사 (예): Trend Micro - Embedding Microservices Security



Source: https://www.trendmicro.com/en_dk/devops/22/a/microservice-security-how-to-proactively-protect-apps.html



JS Lab

5일차 '관리/보안, MSA 시연/실습'

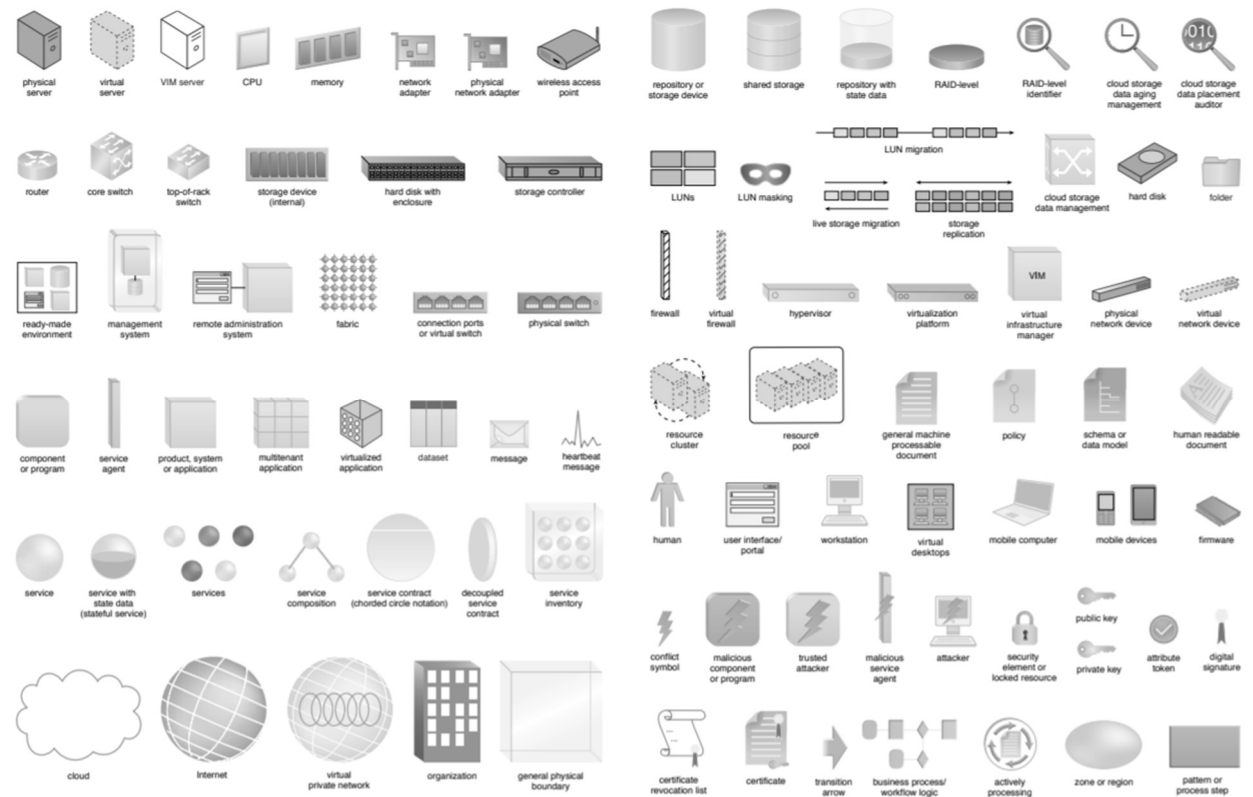
❖ 클라우드 디자인 패턴

- 디자인 패턴은 클라우드에서 안정적이고 확장성 있는 안전한 애플리케이션을 빌드하는데 유용
- 각 패턴은 패턴이 해결하는 문제, 패턴을 적용하기 위한 고려
- 클라우드 플랫폼에 호스팅, 분산 시스템과 관련
 - 가용성
 - 데이터 관리
 - 디자인 및 구현
 - 메시징
 - 관리 및 모니터링
 - 성능 및 확장성
 - 복원력
 - 보안



5일차 '관리/보안, MSA 시연/실습'

❖ 클라우드 디자인 패턴 구성 (2015)

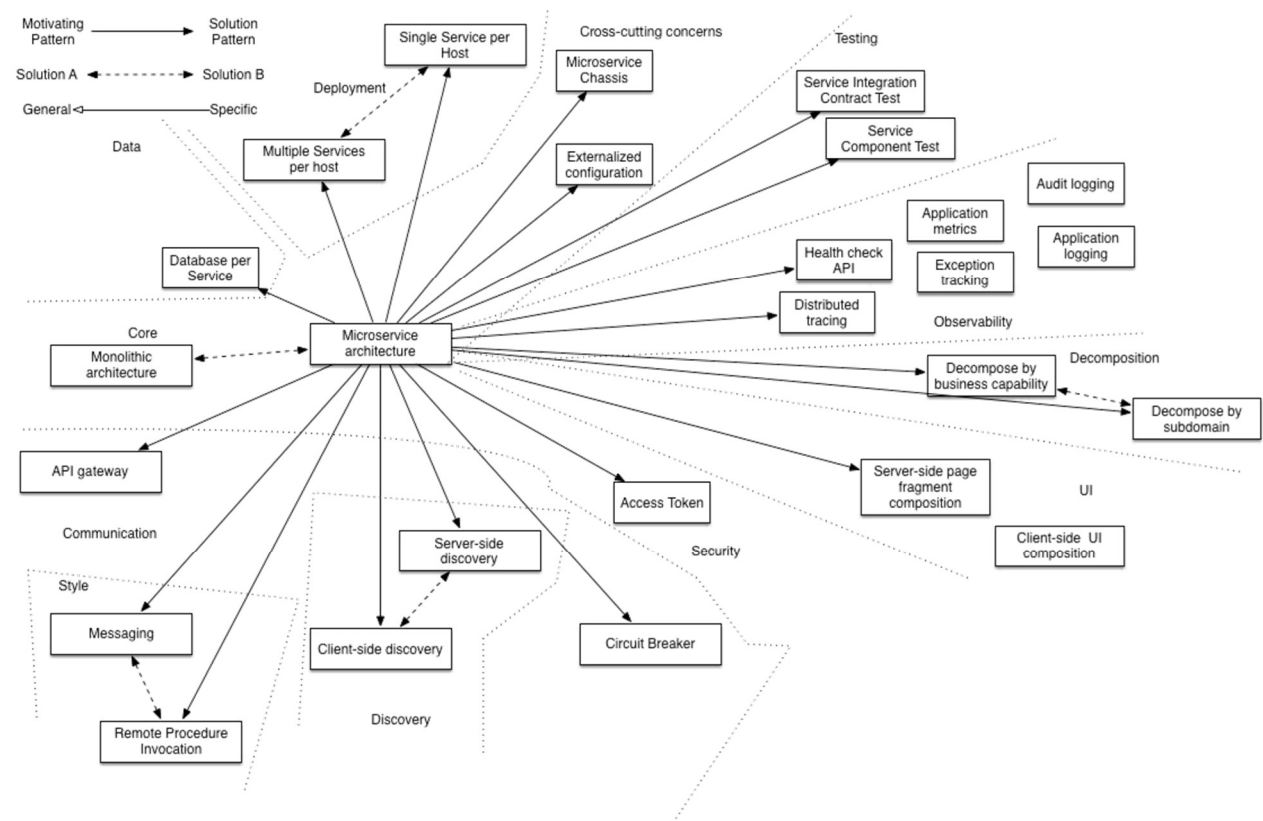


Source: Erl, Thomas. Cloud Computing Design Patterns (The Prentice Hall Service Technology Series from Thomas Erl) . Pearson Education.

5일차 '관리/보안, MSA 시연/실습'

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❖ Pattern: Microservice Architecture



Source: <https://microservices.io/patterns/microservices.html>

5일차 '관리/보안, MSA 시연/실습'

❖ 패턴 카탈로그 (MS Azure 예)

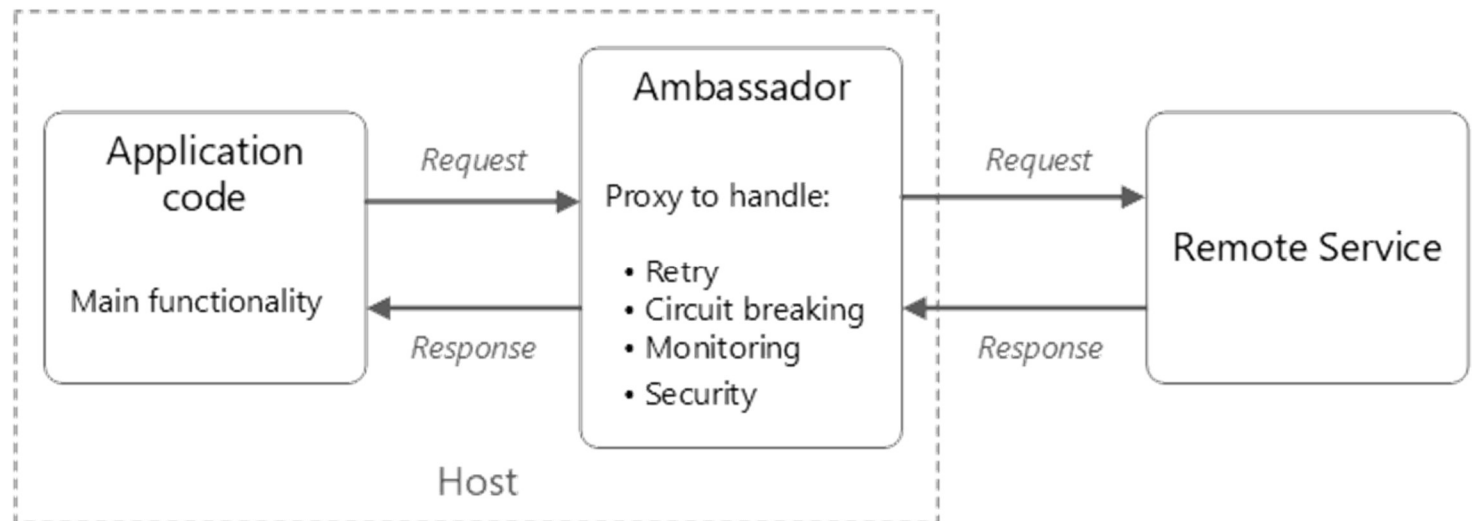
특사	소비자 서비스 또는 애플리케이션을 대신하여 네트워크 요청을 전송하는 도우미 서비스를 만듭니다.
손상 방지 레이어	현대식 애플리케이션과 레거시 시스템 사이에 외관 또는 어댑터 레이어를 구현합니다.
프런트 엔드에 대한 백 엔드	특정 프런트 엔드 애플리케이션 또는 인터페이스에서 사용할 별도의 백 엔드 서비스를 만듭니다.
격벽	하나가 고장 나더라도 나머지는 정상적으로 작동하도록 애플리케이션의 요소를 여러 풀에 격리합니다.
Cache-Aside	필요할 때 데이터를 데이터 저장소에서 캐시로 로드
연출	중앙 오케스트레이터에 의존하는 대신 각 서비스에서 비즈니스 작업이 처리되는 시기와 방법을 결정하도록 합니다.
회로 차단기	원격 서비스 또는 리소스에 연결할 때 해결하는 데 걸리는 시간이 유동적인 오류를 처리합니다.
클레임 검사	큰 메시지를 클레임 검사 및 페이로드로 분할하면 메시지 버스의 과부하를 피할 수 있습니다.
보정 트랜잭션	여러 단계로 나뉘어 있지만 결국에는 일관적인 작업을 정의하는 일련의 단계에서 수행한 작업을 실행 취소합니다.
경쟁 소비자	여러 동시 소비자가 동일한 메시징 채널에 수신된 메시지를 처리할 수 있게 해 줍니다.
컴퓨팅 리소스 통합	여러 작업을 단일 계산 단위로 통합합니다.
CQRS	별도의 인터페이스를 사용하여 데이터를 업데이트하는 작업과 데이터를 읽는 작업을 분리합니다.
이벤트 소싱	추가 전용 저장소를 사용하여 도메인의 데이터에 대해 수행된 작업을 설명하는 일련의 이벤트 전체를 기록합니다.
외부 구성 저장소	구성 정보를 애플리케이션 배포 패키지에서 중앙 위치로 이동합니다.
페더레이션 ID	외부 ID 공급자에게 인증을 위임합니다.
게이트 키퍼	클라이언트와 애플리케이션 또는 서비스 간 브로커 역할을 하며, 요청을 검사 및 정리하고, 요청 및 데이터를 전달하는 전용 호스트 인스턴스를 사용하여 애플리케이션 및 서비스를 보호합니다.
게이트웨이 집계	게이트웨이를 사용하여 여러 개별 요청을 단일 요청으로 집계합니다.
게이트웨이 오프로딩	공유 또는 특수 서비스 기능을 게이트웨이 프록시에 오프로드합니다.
게이트웨이 라우팅	단일 엔드포인트를 사용하여 요청을 여러 서비스에 라우팅합니다.
상태 엔드포인트 모니터링	외부 도구가 노출된 엔드포인트를 통해 주기적으로 액세스할 수 있는 기능 검사를 애플리케이션 내부에 구현합니다.
인덱스 테이블	쿼리에서 자주 참조하는 데이터 저장소의 필드에 대한 인덱스를 만듭니다.
리더 선택	인스턴스 중 하나를 다른 인스턴스를 관리하는 리더로 선택하여 분산된 애플리케이션의 공동 작업 인스턴스 컬렉션이 수행하는 작업을 조정합니다.
구체화된 뷰	데이터가 필요한 쿼리 작업에 대해 이상적으로 포맷되지 않은 경우 하나 이상의 데이터 저장소에 있는 데이터에 대한 미리 채워진 뷰를 생성합니다.
파이프 및 필터	복잡한 처리를 수행하는 작업을 재사용 가능한 일련의 별도 요소로 분류합니다.
우선 순위 큐	우선 순위가 높은 요청을 우선 순위가 낮은 요청보다 먼저 받아서 처리하도록 서비스로 전송된 요청의 우선 순위를 지정합니다.
게시자/구독자	애플리케이션이 발신자와 수신자를 연결하지 않고 여러 관심 있는 소비자에게 이벤트를 비동기적으로 알릴 수 있습니다.
큐 기반 부하 평준화	작업 그리고 그 작업이 일시적인 높은 부하를 부드럽게 처리하기 위해 호출하는 서비스 사이에서 버퍼 역할을 하는 큐를 사용합니다.
다시 시도	이전에 실패한 작업을 투명하게 다시 시도하여 서비스 또는 네트워크 리소스에 연결하려 할 때 애플리케이션을 사용하여 예상된 일시적 오류를 처리합니다.
Scheduler 에이전트 감독자	서비스 및 기타 원격 리소스의 분산된 집합에서 일련의 작업을 조정합니다.
분할	데이터 저장소를 수평 파티션 또는 분할 집합으로 나눕니다.
사이드카	격리 및 캡슐화를 제공하는 별도의 프로세스 또는 컨테이너에 애플리케이션 구성 요소를 배포합니다.
정적 콘텐츠 호스팅	정적 콘텐츠를 클라이언트에 직접 제공할 수 있는 클라우드 기반 스토리지 서비스에 배포합니다.
스트랭글러	특정 기능을 새로운 애플리케이션 및 서비스로 점진적으로 교체하여 레거시 시스템을 단계적으로 마이그레이션합니다.
제한	애플리케이션 인스턴스, 개별 테넌트 또는 서비스 전체의 리소스 사용량을 제어합니다.
발레 키	클라이언트에 특정 리소스 또는 서비스에 대한 제한된 직접 액세스를 제공하는 토큰 또는 키를 사용합니다.

Source: <https://docs.microsoft.com/ko-kr/azure/architecture/patterns/>

5일차 '관리/보안, MSA 시연/실습'

350

❖ 특사(Ambassador) 패턴



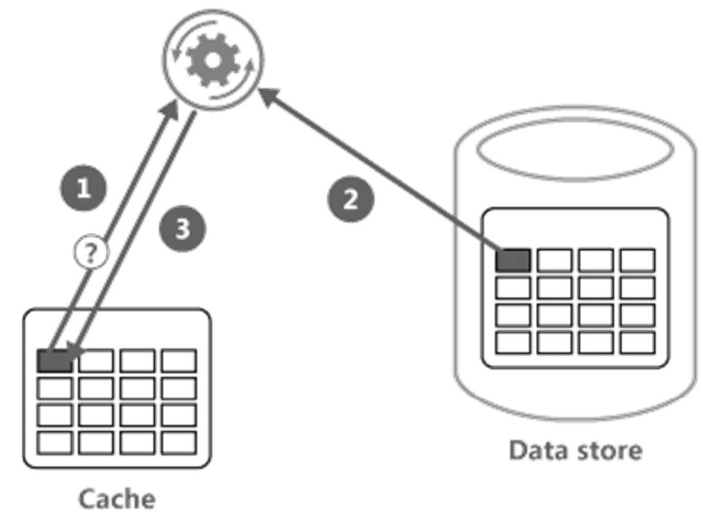
Source: <https://docs.microsoft.com/ko-kr/azure/architecture/patterns/>



5일차 '관리/보안, MSA 시연/실습'

351

❖ Cache-Aside pattern



- 1: Determine whether the item is currently held in the cache.
- 2: If the item is not currently in the cache, read the item from the data store.
- 3: Store a copy of the item in the cache.

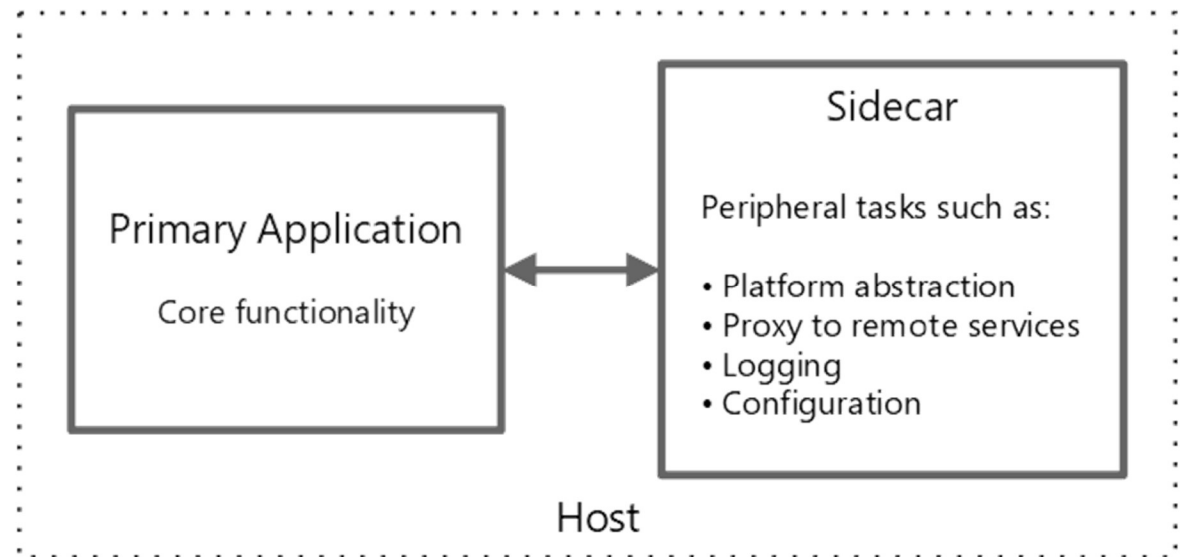
Source: <https://docs.microsoft.com/ko-kr/azure/architecture/patterns/>



5일차 '관리/보안, MSA 시연/실습'

352

❖ 사이드카(Sidecar) 패턴



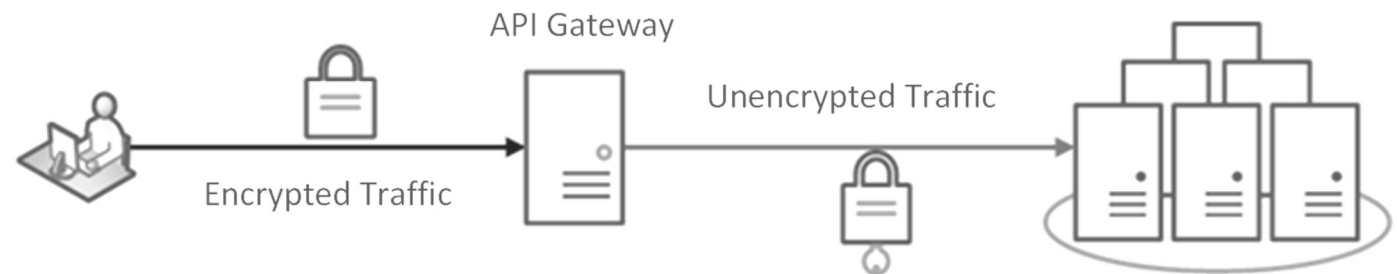
Source: <https://docs.microsoft.com/ko-kr/azure/architecture/patterns/>



5일차 '관리/보안, MSA 시연/실습'

353

❖ 게이트웨이 오프로딩 패턴



Source: <https://docs.microsoft.com/ko-kr/azure/architecture/patterns/>

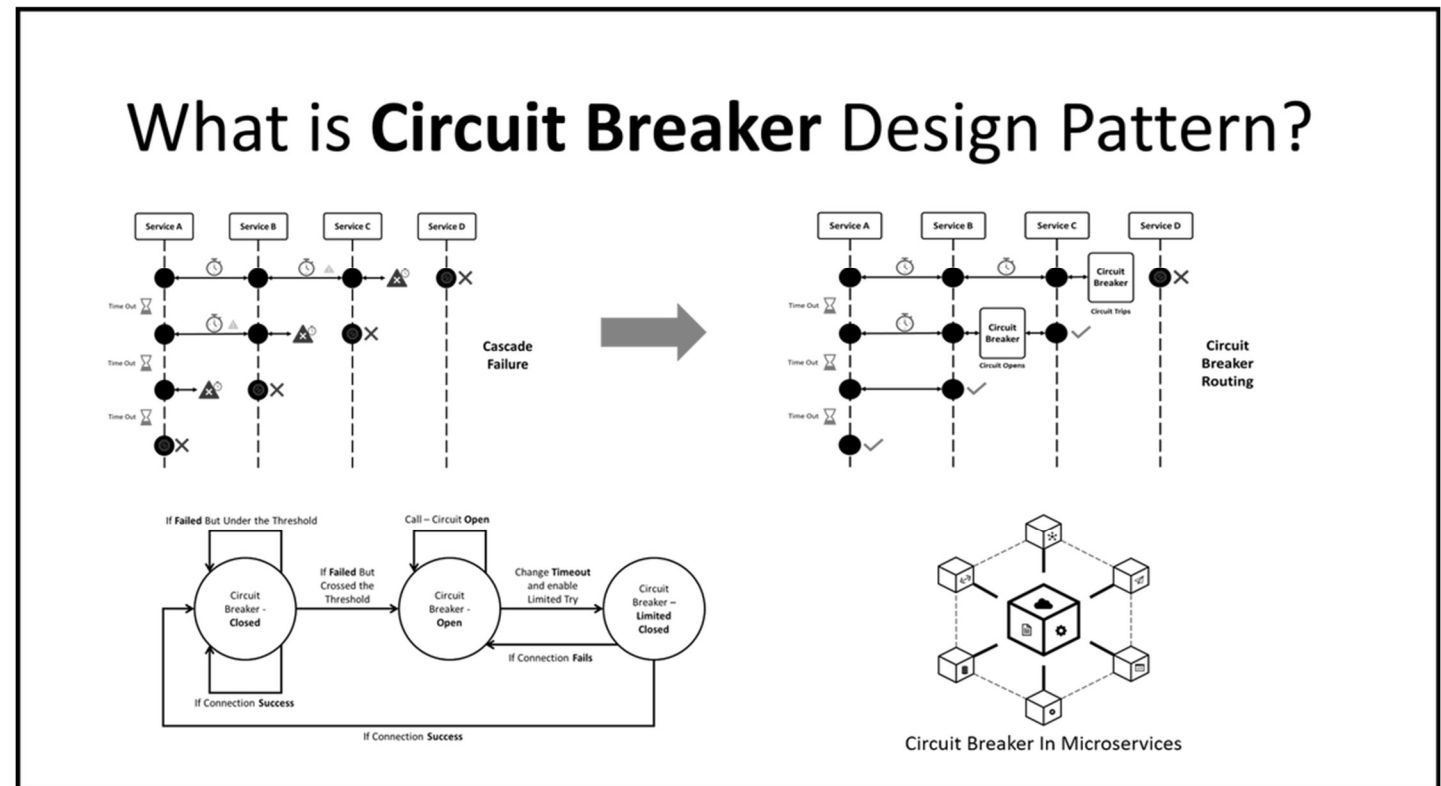


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5일차 '관리/보안, MSA 시연/실습'

354

❖ What is Circuit Breaker Design Pattern?

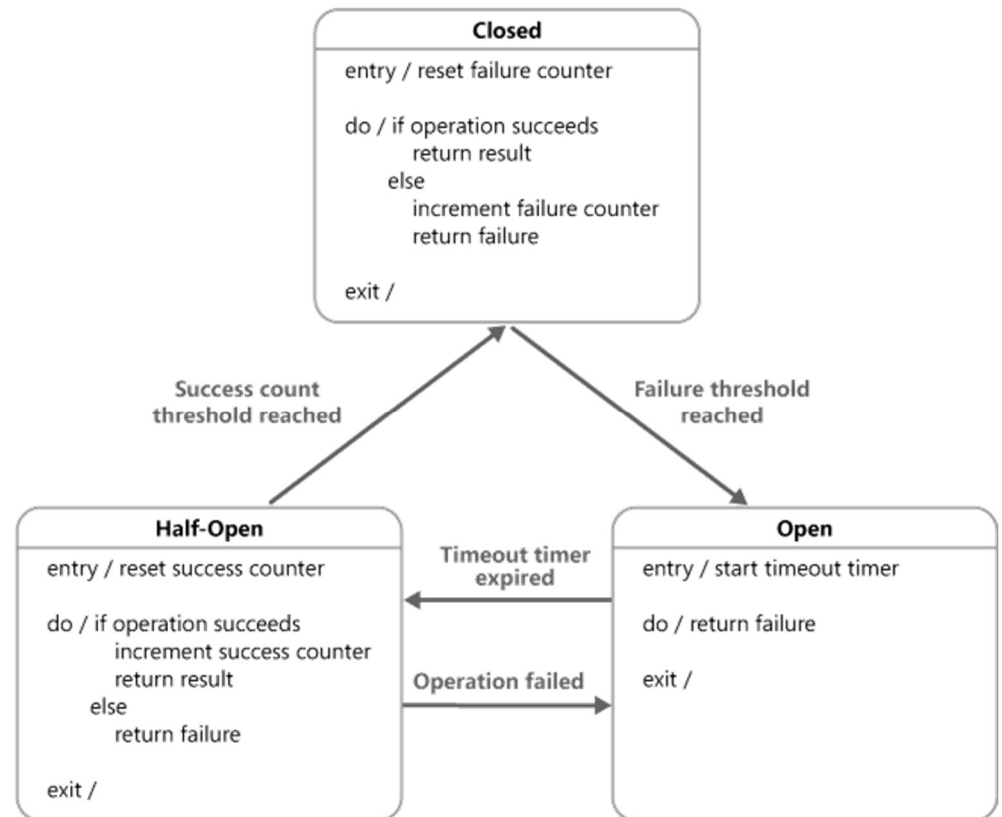


Source: https://digitalvays.com/what-is-circuit-breaker-design-pattern/?fbclid=IwAR1uukaeNh-vJZXeLhQP2MZvpeq7NVeNVKHmjNEPubzrH8vISlwr_Dedph8

5일차 '관리/보안, MSA 시연/실습'

355

❖ 회로 차단기 패턴



Source: <https://docs.microsoft.com/ko-kr/azure/architecture/patterns/>





부록1. OPENSTACK (1 OF 3)

357

❖ 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.

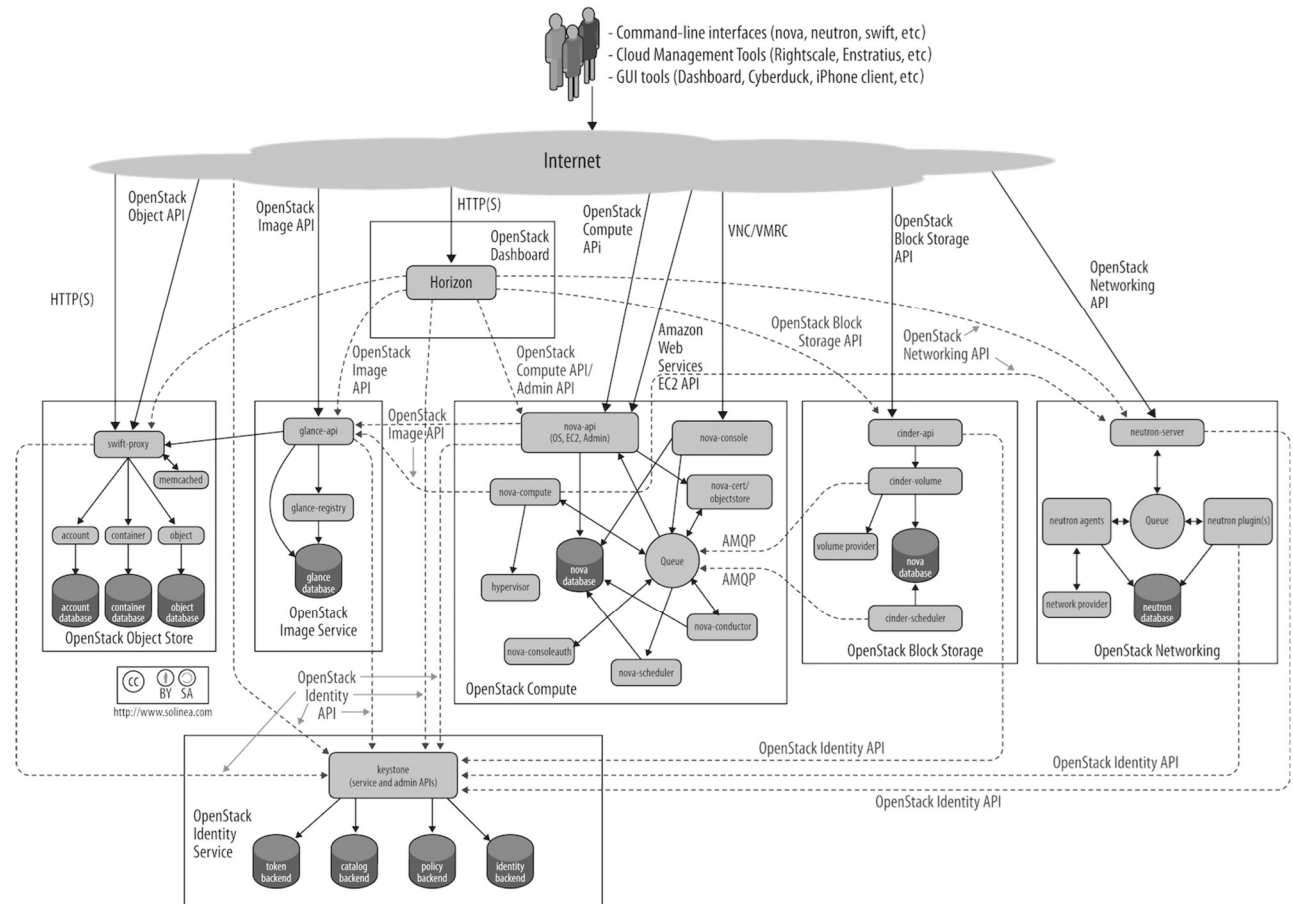
OpenStack components use	Default ports
Application Catalog (murano)	8082
Backup Service (Freezer)	9090
Big Data Processing Framework (sahara)	8386
Block Storage (cinder)	8776
Clustering (senlin)	8777
Compute (nova) endpoints	8774
Compute ports for access to virtual machine consoles	5900-5999
Compute VNC proxy for browsers (openstack-nova-novncproxy)	6080
Compute VNC proxy for traditional VNC clients (openstack-nova-xvncproxy)	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)

358

❖ OpenStack Design



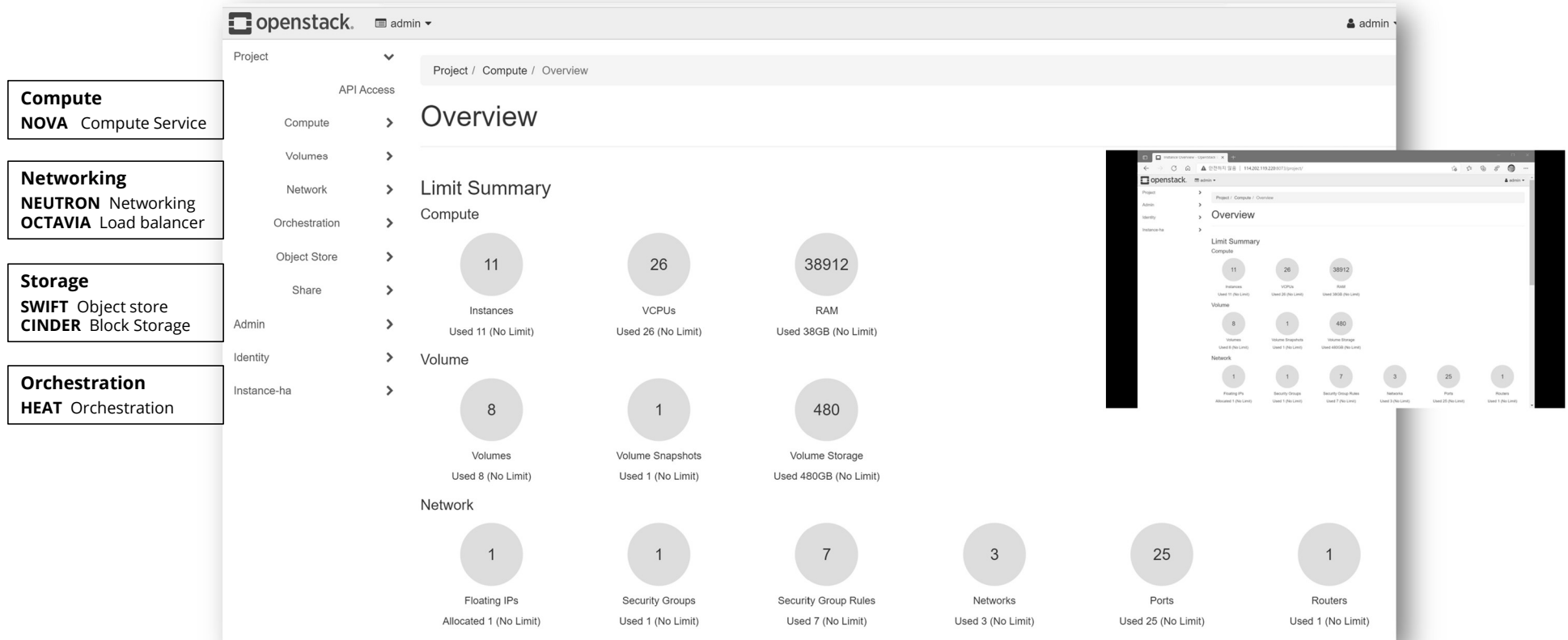
Return: 1일차. 'MSA와 5G 네트워크'



부록1. OPENSTACK (3 OF 3)

359

❖ OpenStack Horizon (Web Frontend)



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

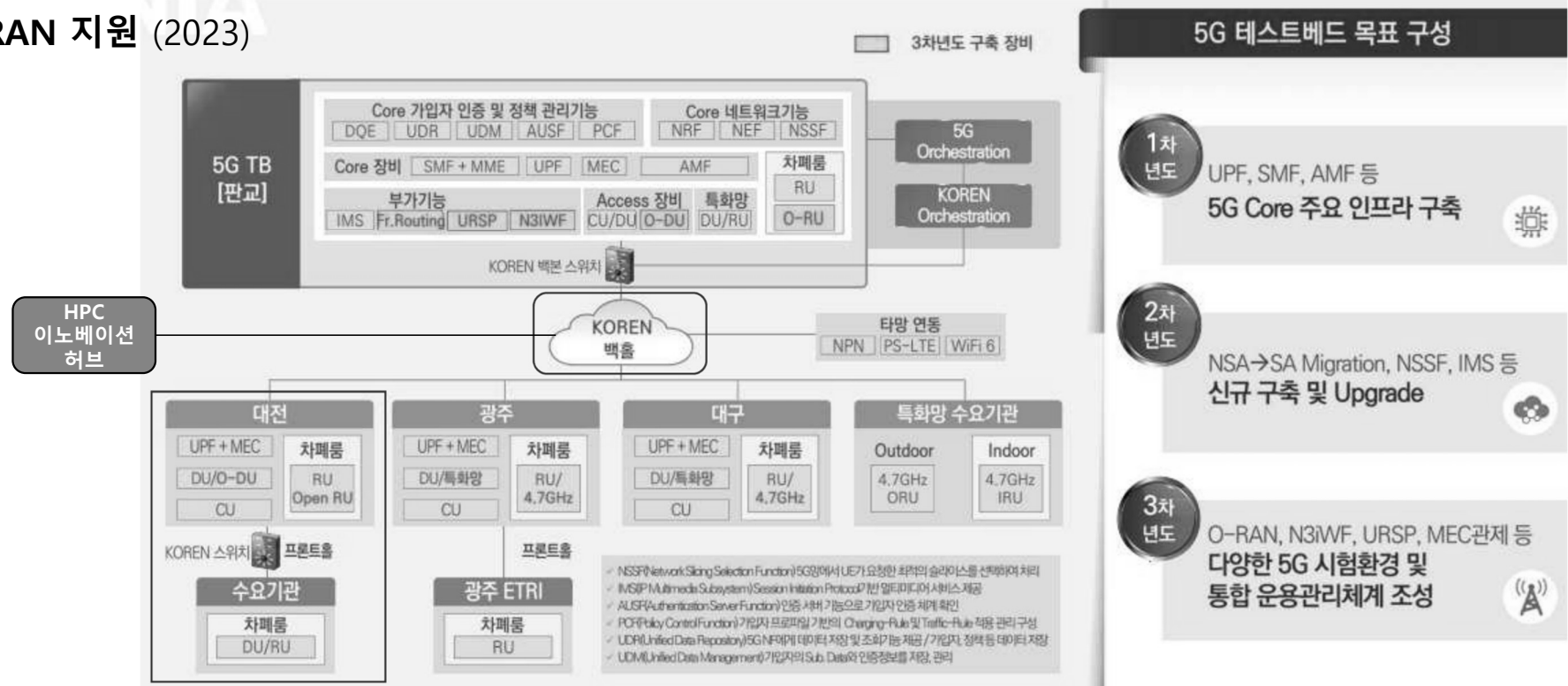


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부록2. 5G 융합서비스 테스트베드 (1 OF 2)

❖ 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)

361

❖ 5G 융합서비스 테스트베드 (@KOREN)

- 대전 거점 (ETRI)



Return: [Slide 21](#)



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부록3. SPRING CLOUD (1 OF 2)

362

❖ 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

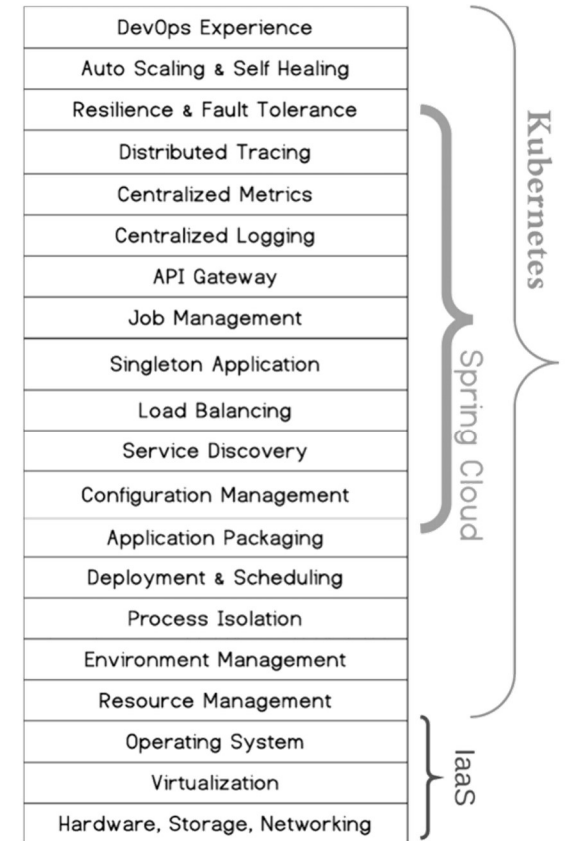
Share: <https://velog.io/@formin/Spring-Cloud%EB%A5%BC-%ED%99%9C%EC%9A%A9%ED%95%9C-MSA-%EC%84%A4%EC%B9%98-%EB%B0%8F-%EA%B5%AC%EC%84%B1>



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부록3. SPRING CLOUD (2 OF 2)

❖ Spring cloud vs Kubernetes



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

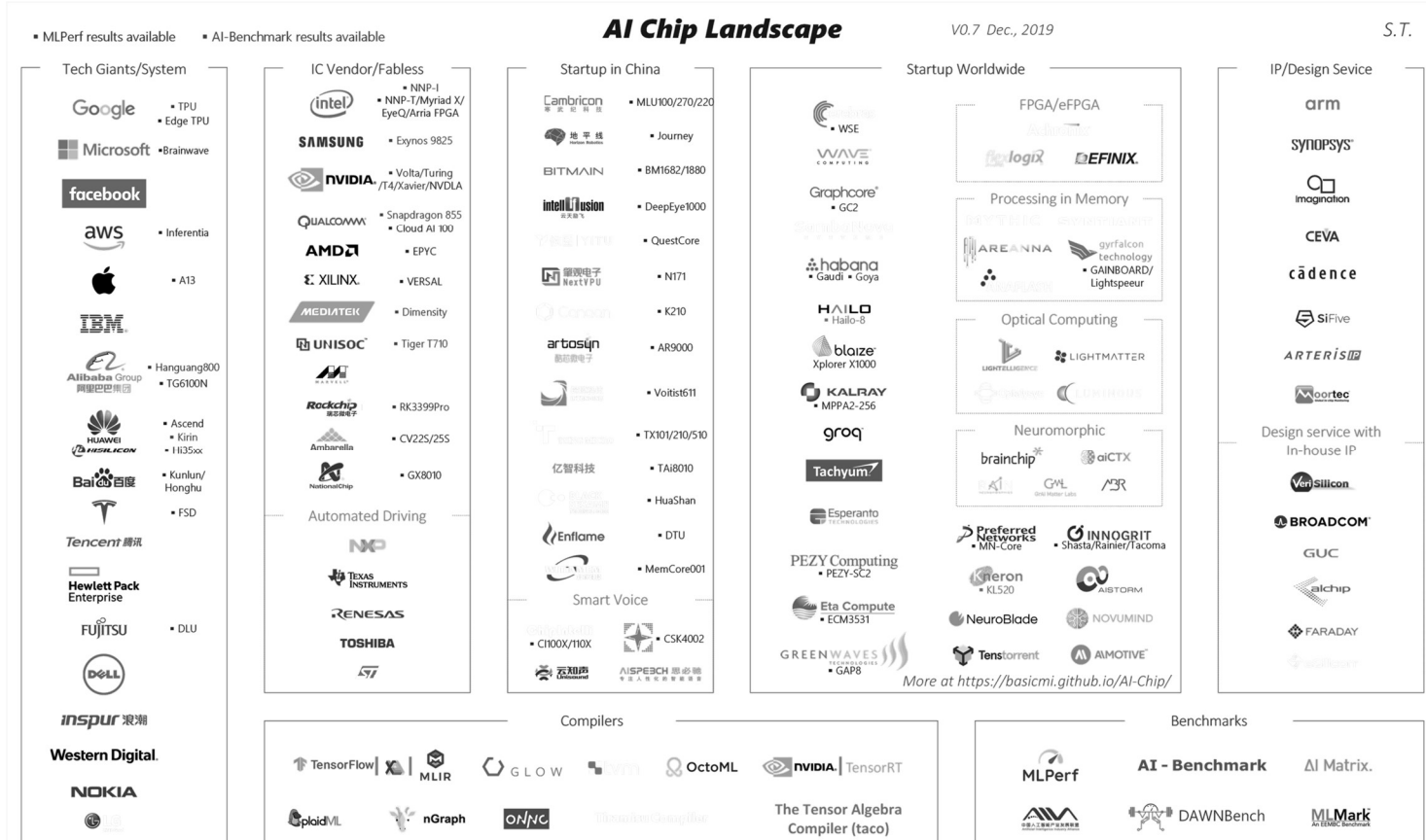
Share: <https://www.steemcoinpan.com/hive-101145/@wonsama/msa>



부록4. AI CHIP LANDSCAPE

❖ AI Chip Landscape

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

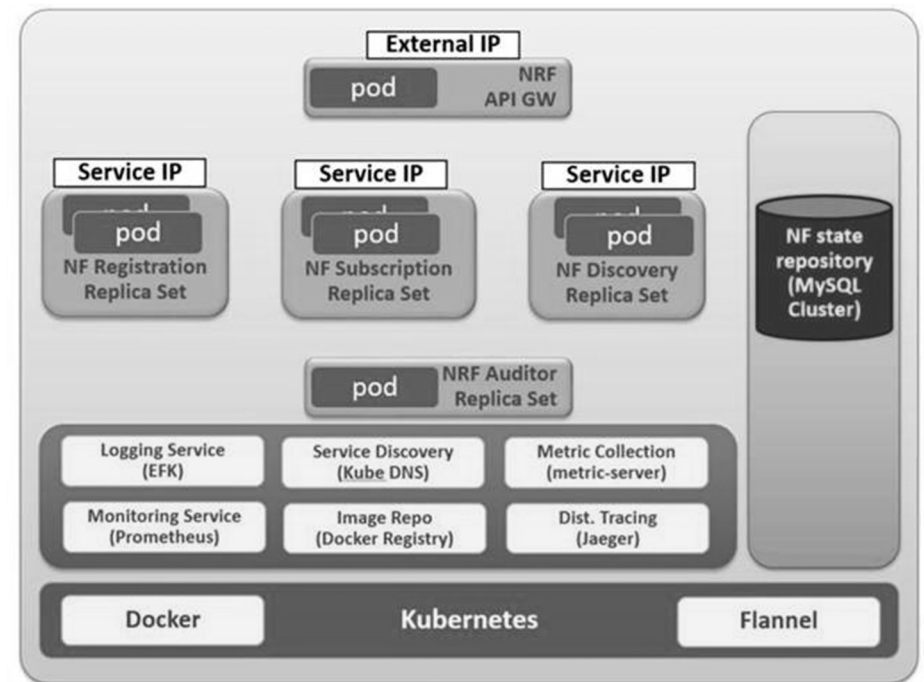
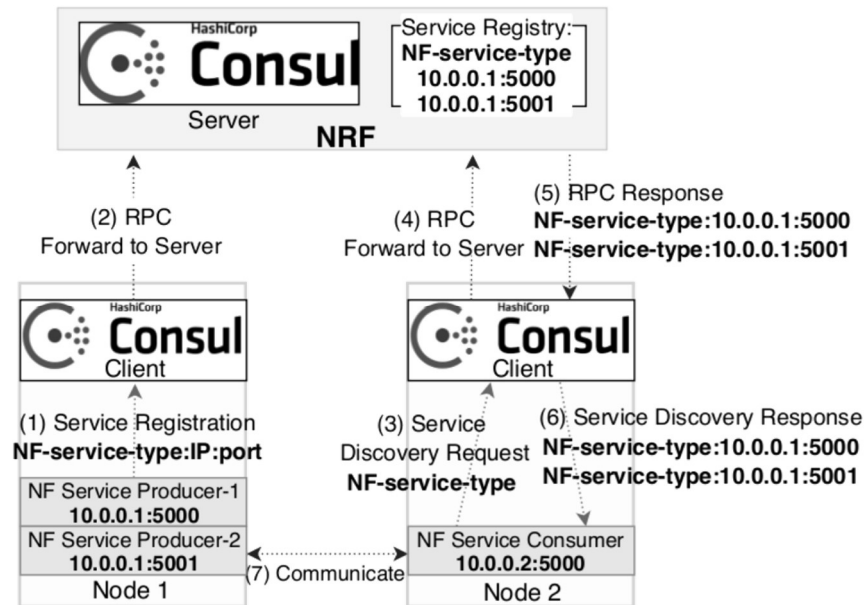


Return: 2일차 '가상화 (Virtualization) 인프라'

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



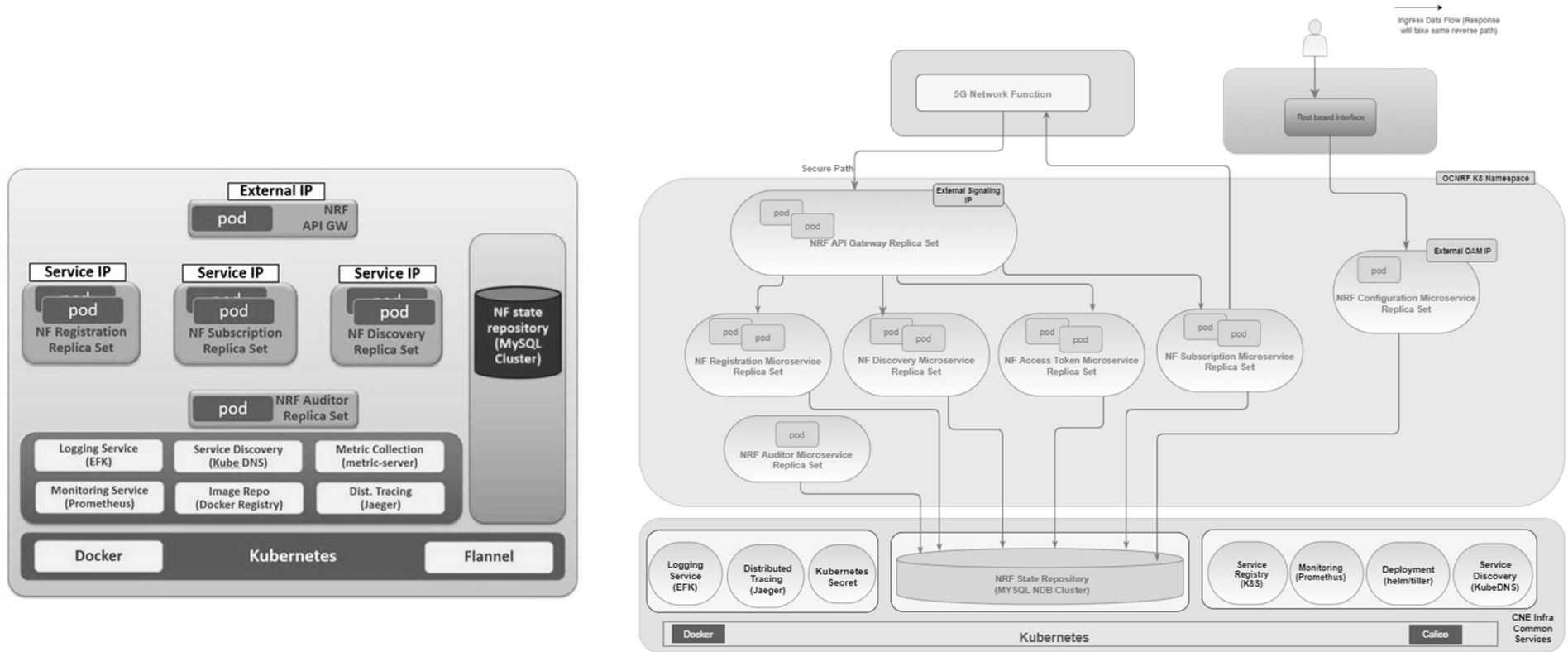
Source: <https://pdfs.semanticscholar.org/52f6/001a27f827d3c724a8718e6768cd35ceb178.pdf>

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)

366

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



Return: Slide 199 , Slide 228

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

367

❖ 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

Return: [Slide 240](#)

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

