5G Network Softwarization and Intelligent Resource Orchestration

Data Science Technologies for Tracking Sustainable Development Goals' Indicators

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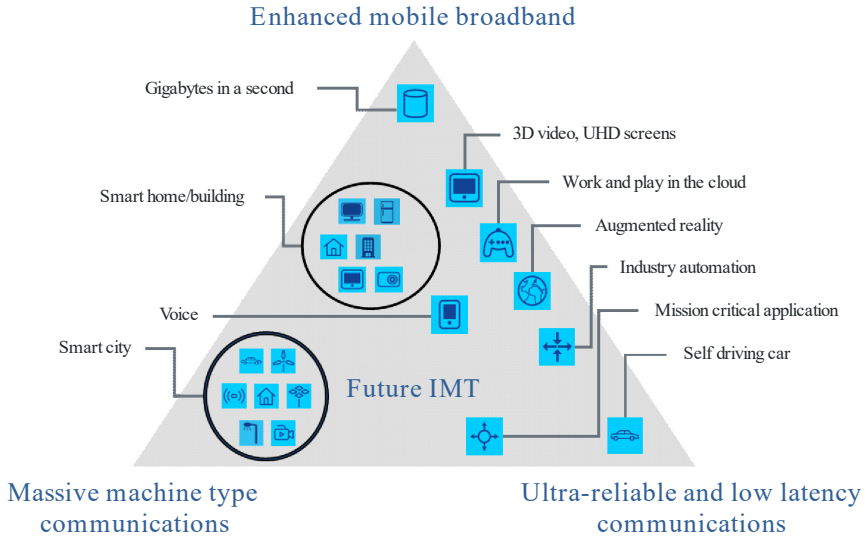
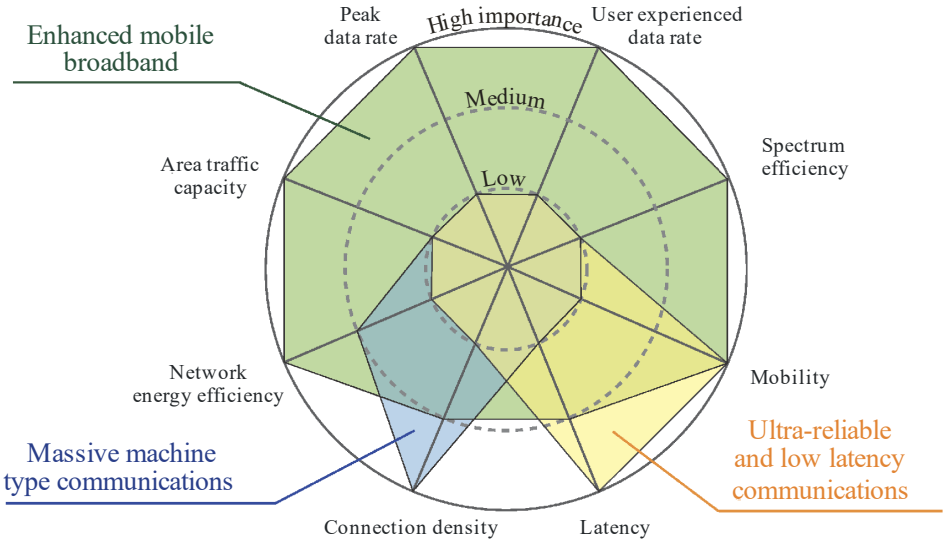
Trends in 5G networks

- Networks evolution to support **three** basic types of communication
- Applications and services for various **vertical industries**
- Support of set of **KPIs** (π.χ. Latency < 1ms, 10-100x higher data rates)
- Need for convergence between network and cloud computing domains

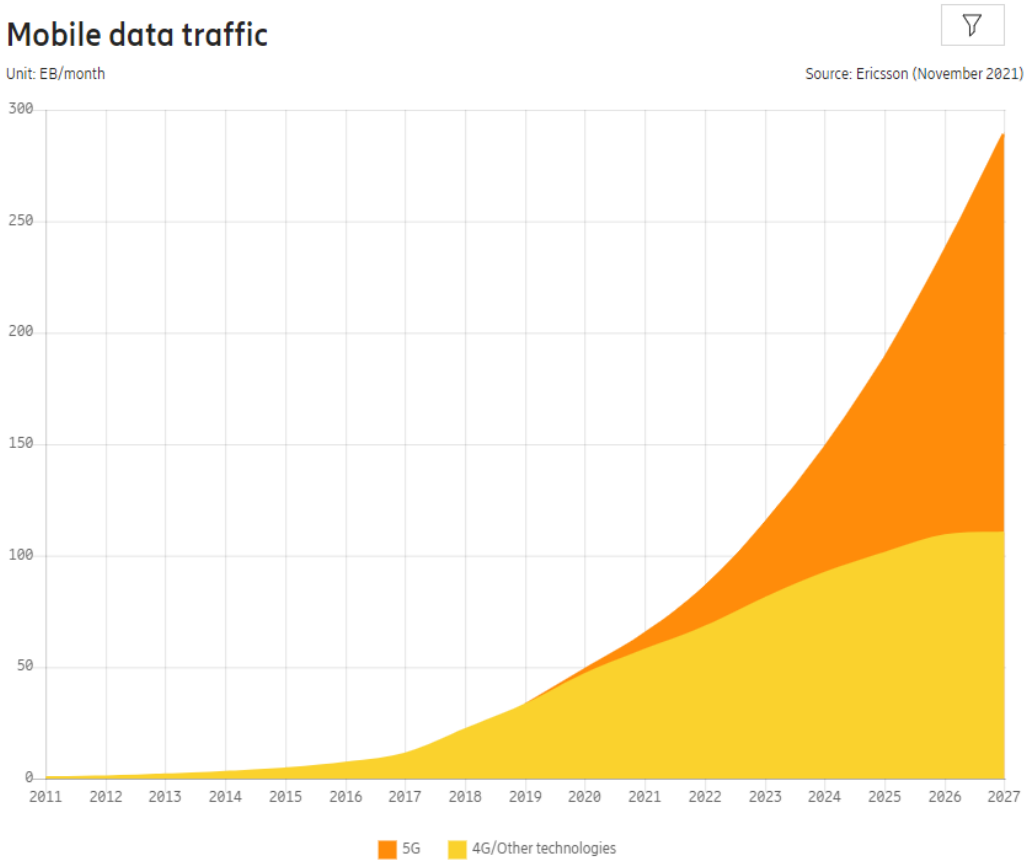


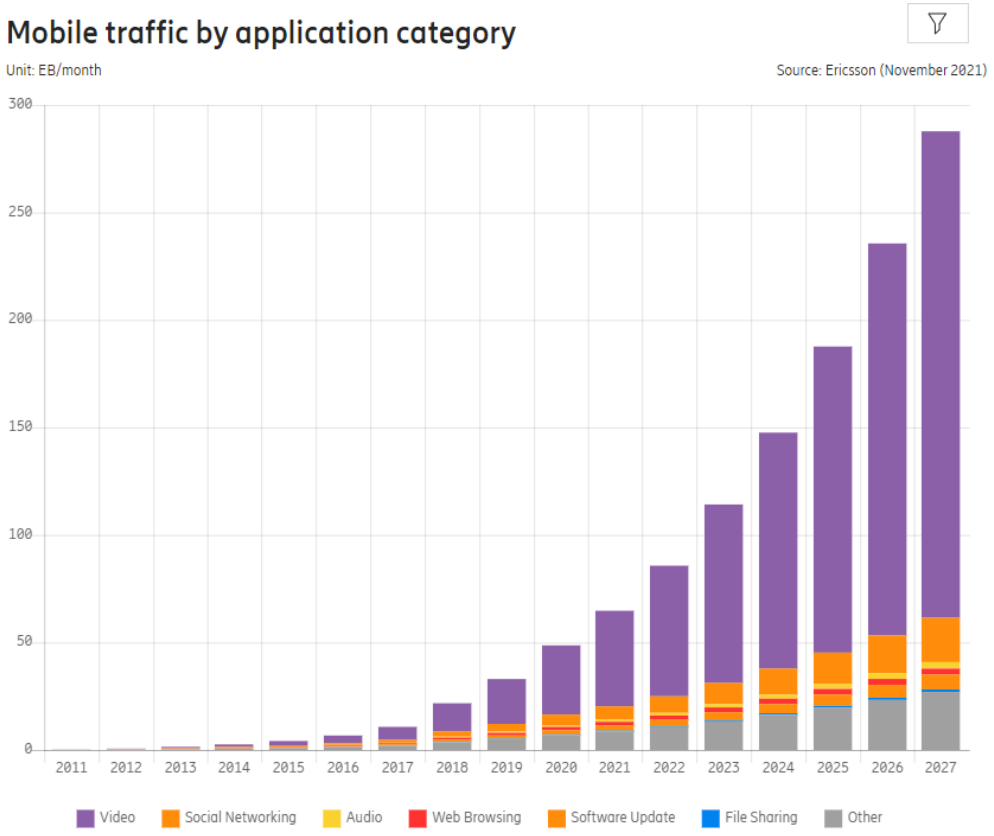
Recommendation ITU-R M.2083-0



Recommendation ITU-R M.2083-0

Statistics and forecasting





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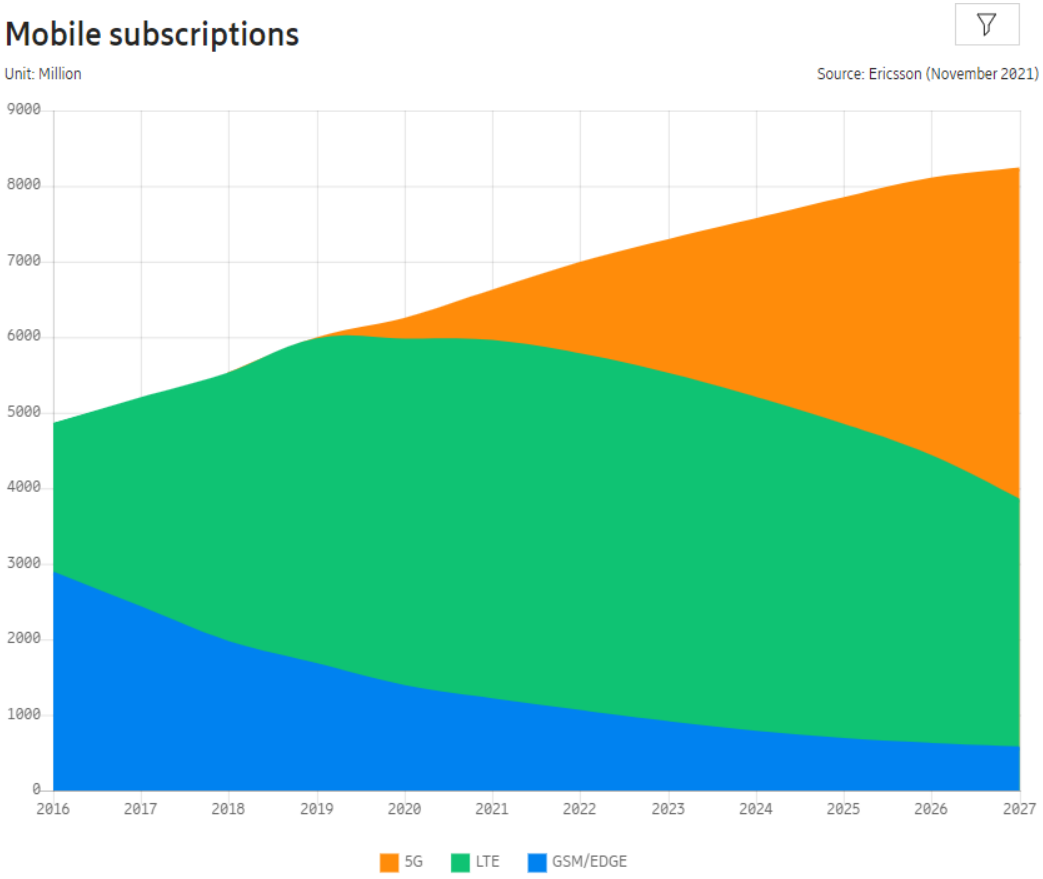
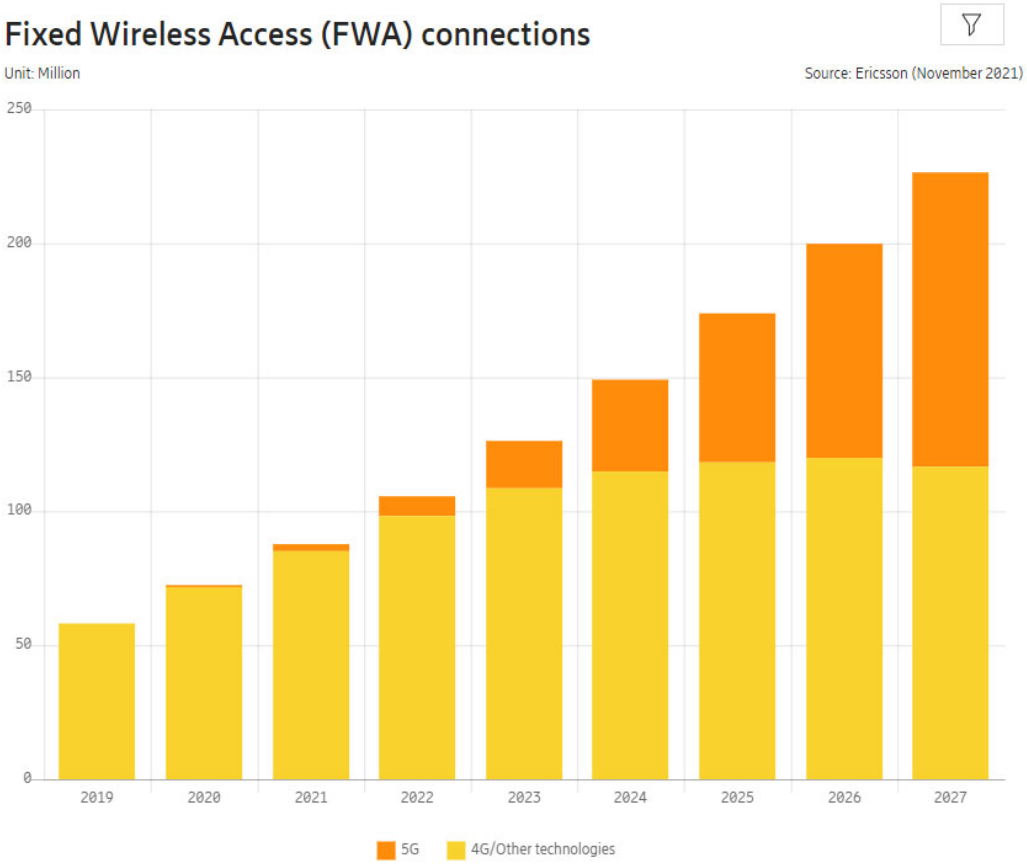
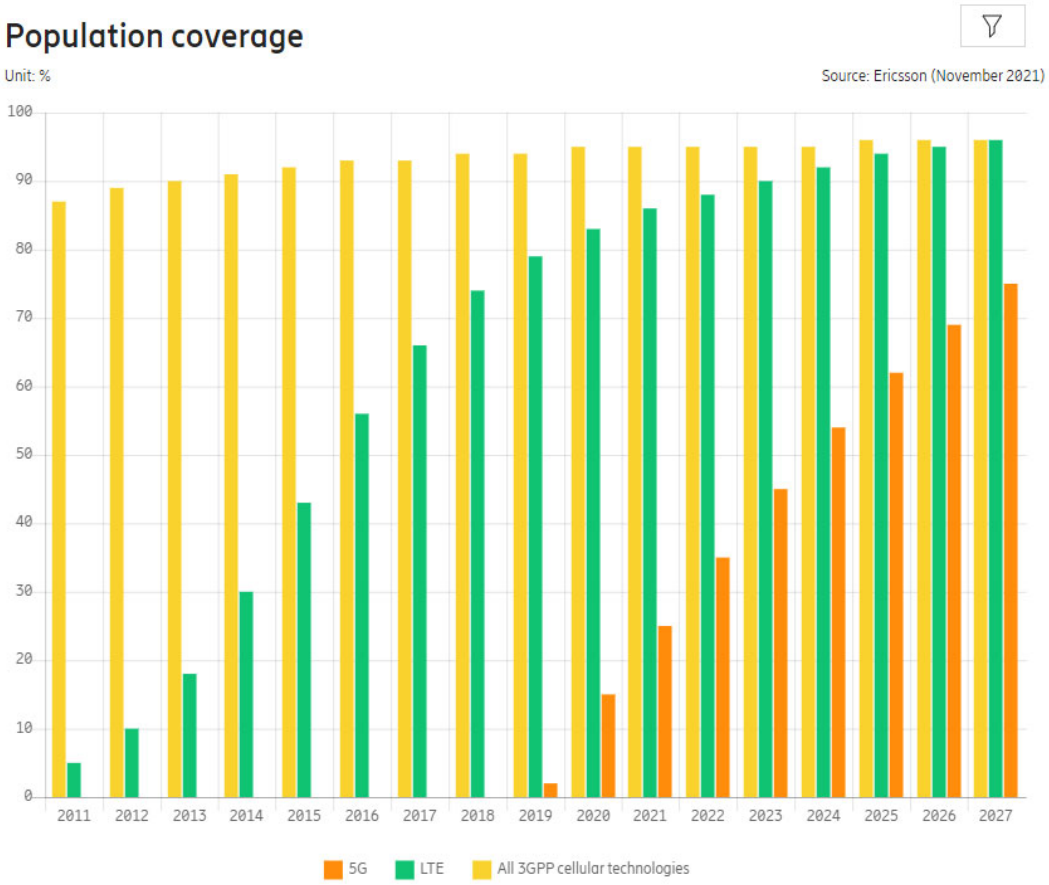
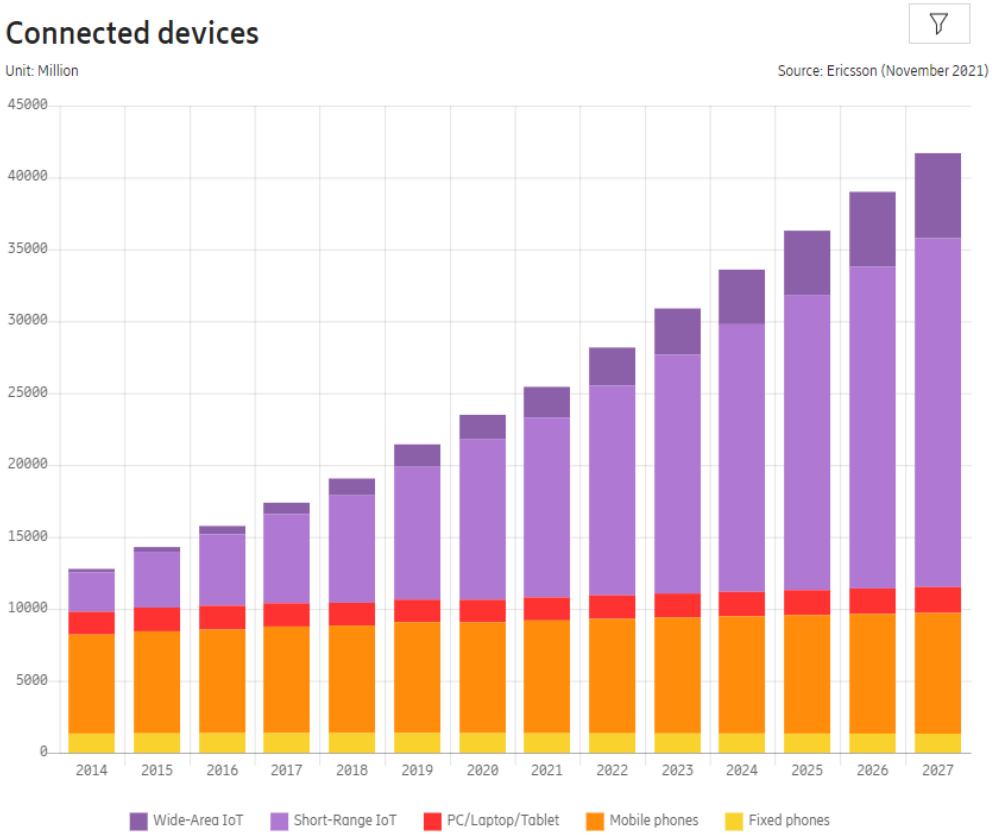




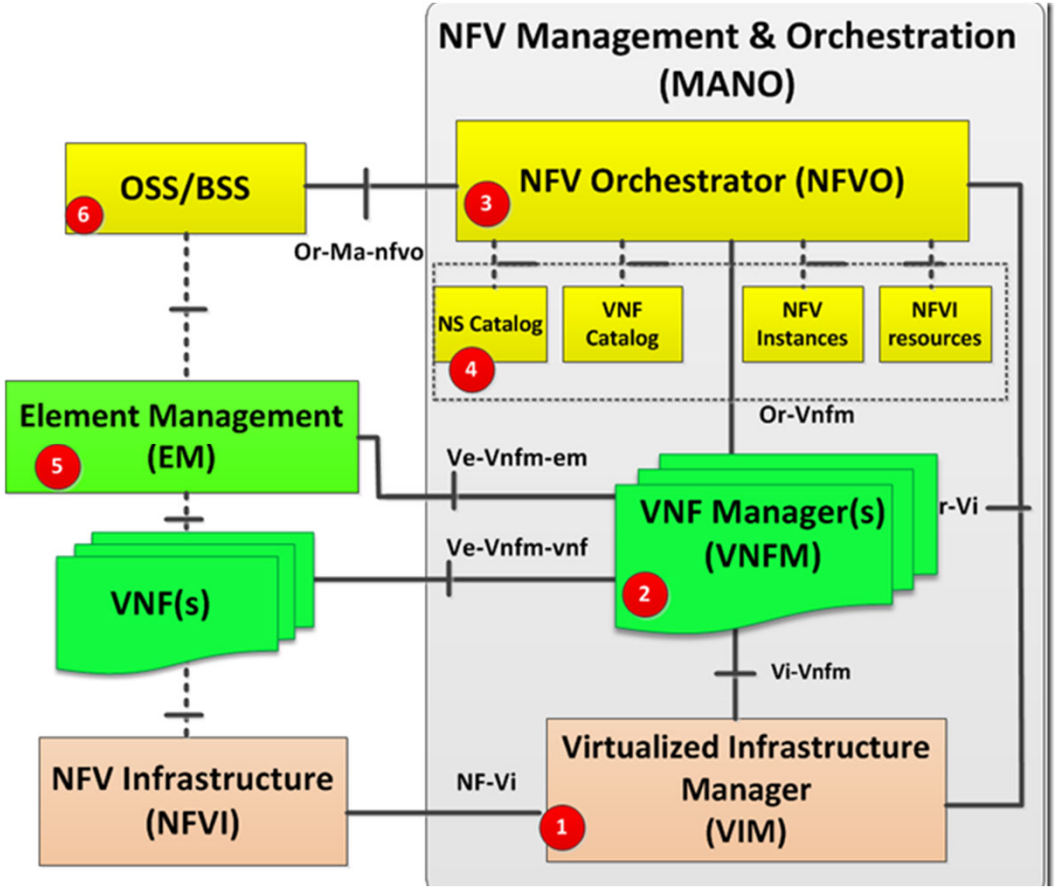
Statistics and forecasting



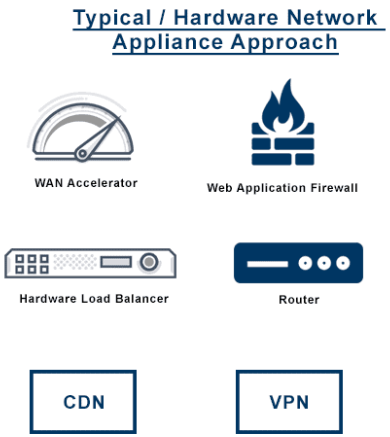


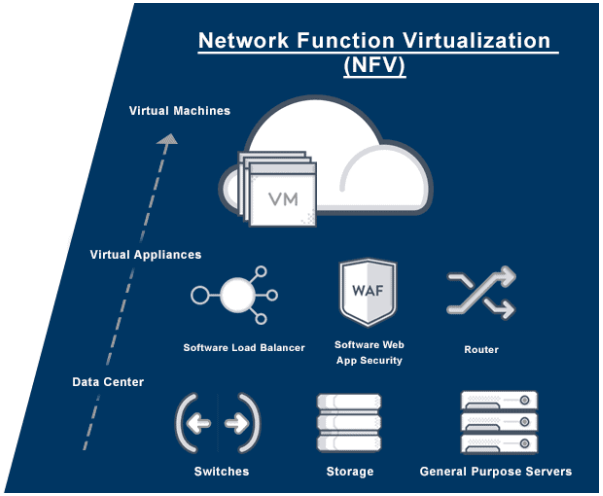
Network softwarization

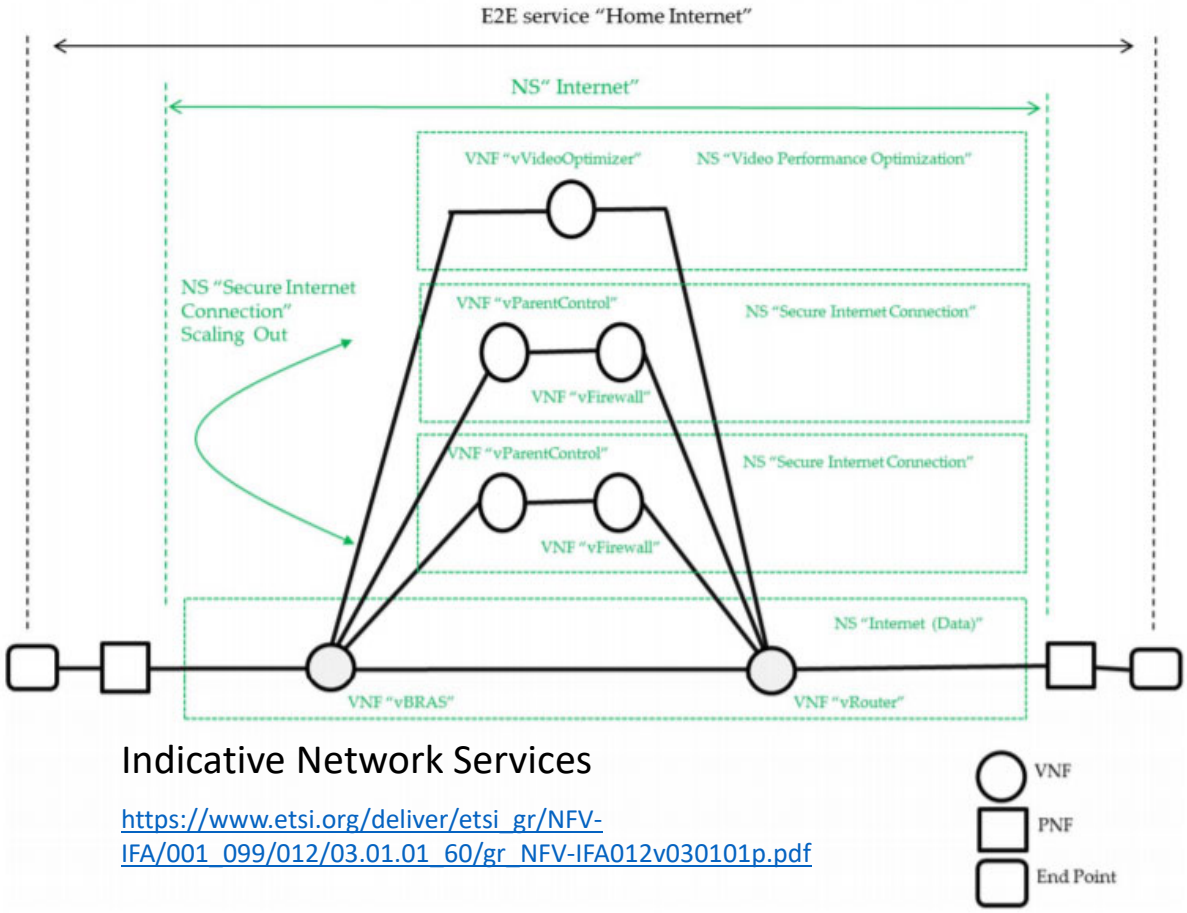
- **Network Function Virtualization (NFV)**
  - Development of Virtual Network Functions (VNFs) and Network Services (NSs)
  - Development of NFV Orchestration Mechanisms
- **Software Defined Networking (SDN)**
  - Development of network/traffic management mechanisms based on software (e.g., OpenFlow)
- Advanced role of the **Operations Support System (OSS)** of a telco provider



Virtual Network Functions





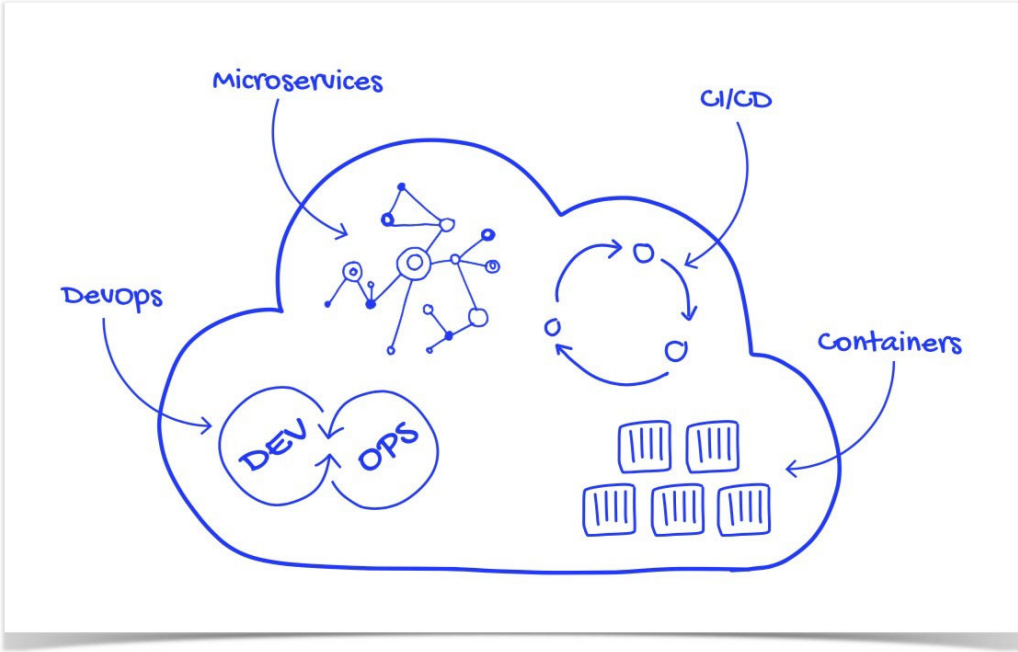


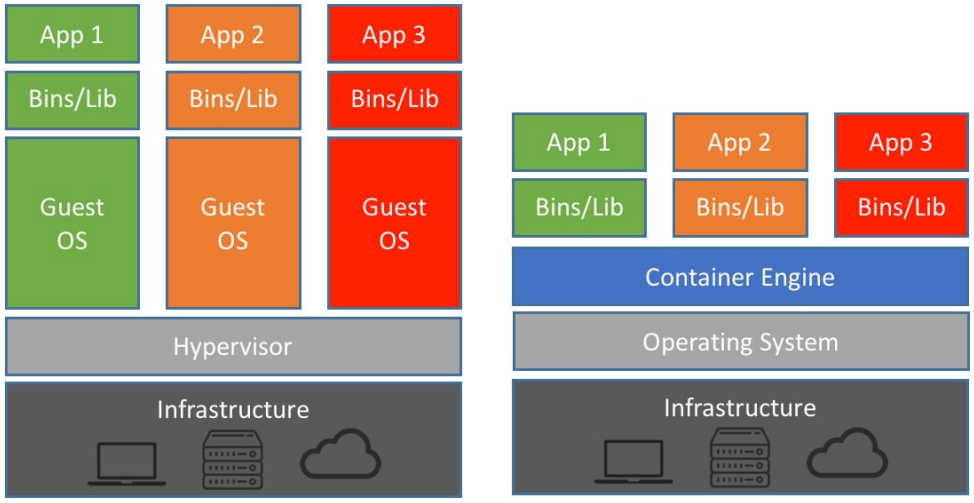
Indicative Network Services

https://www.etsi.org/deliver/etsi_gr/NFV-IFA/001_099/012/03.01.01_60/gr_NFV-IFA012v030101p.pdf

Cloud native technologies

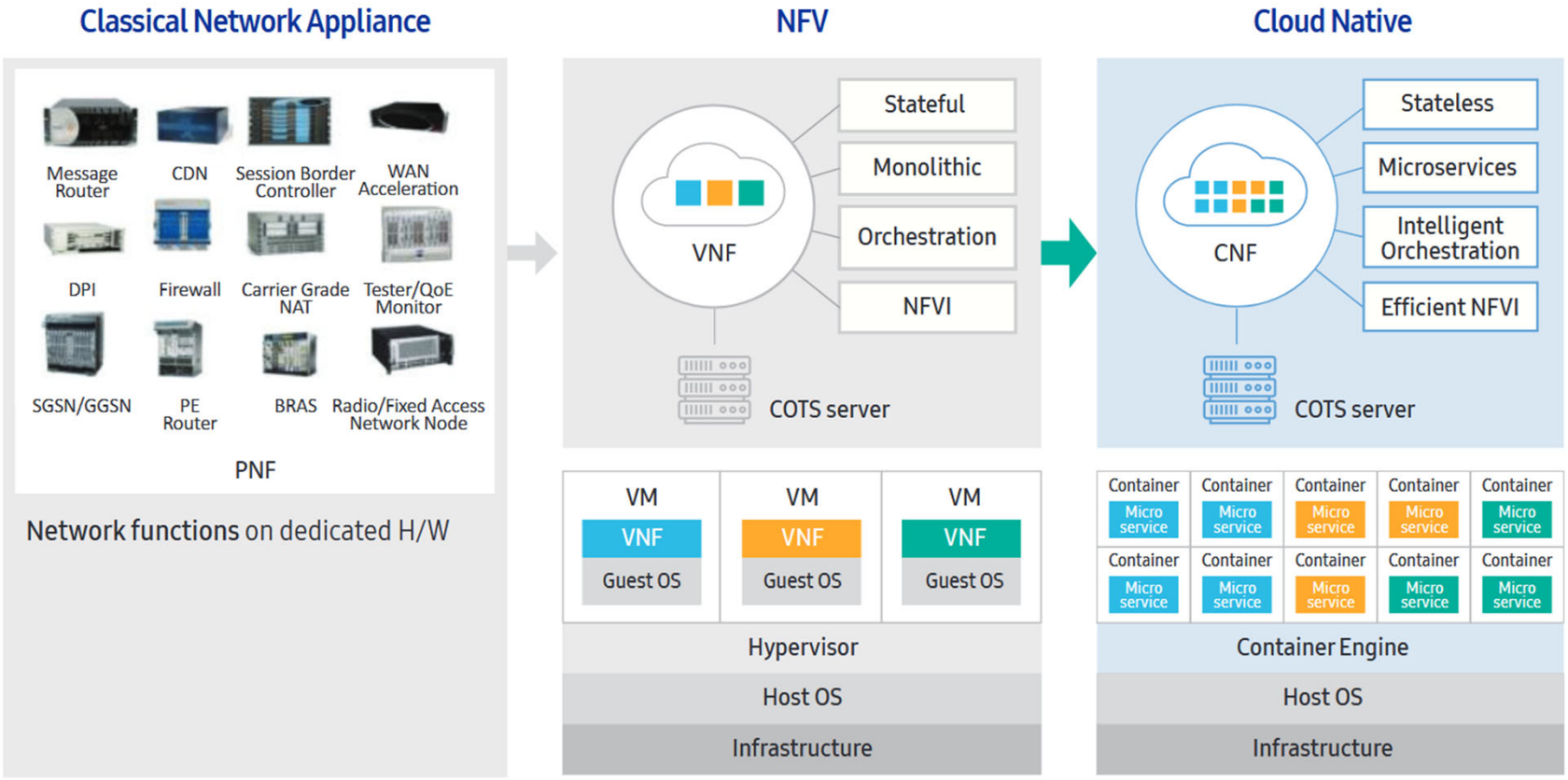
- Application development based on microservices
- Need for specification of open APIs
- Deployment in the form of containers
- Orchestration mechanisms
- Elasticity efficiency – Horizontal scaling





Machine Virtualization Containers

Network Softwarization



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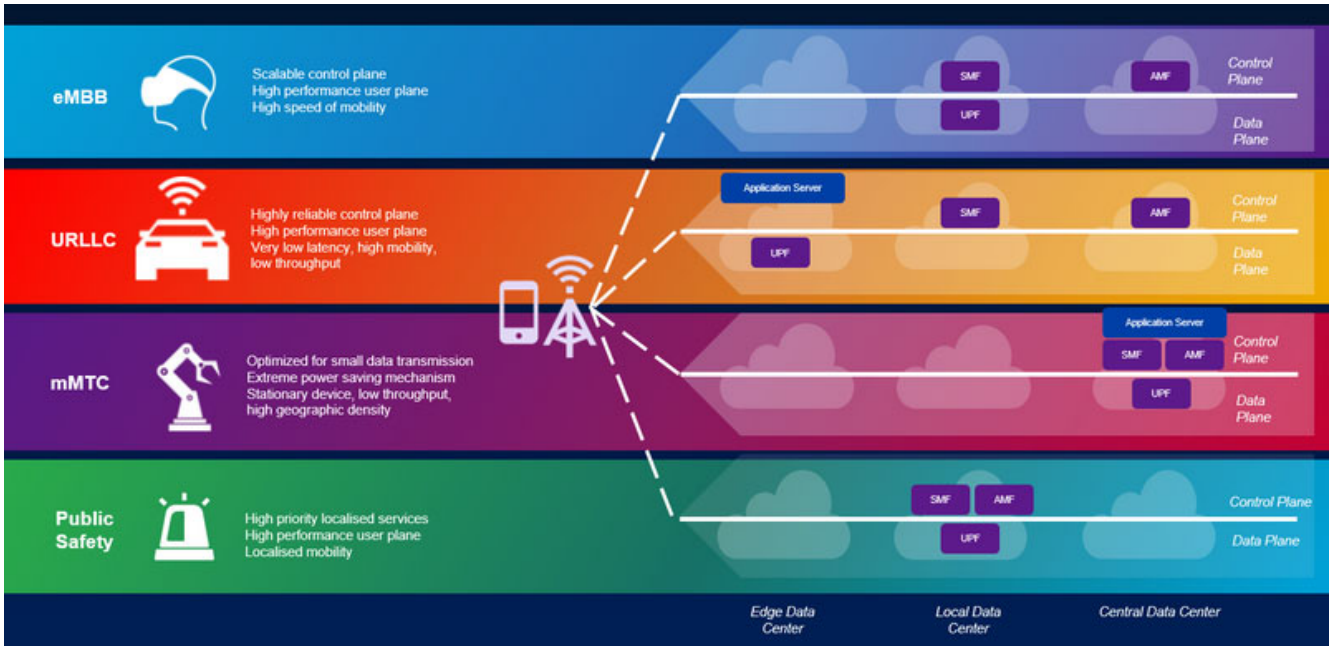
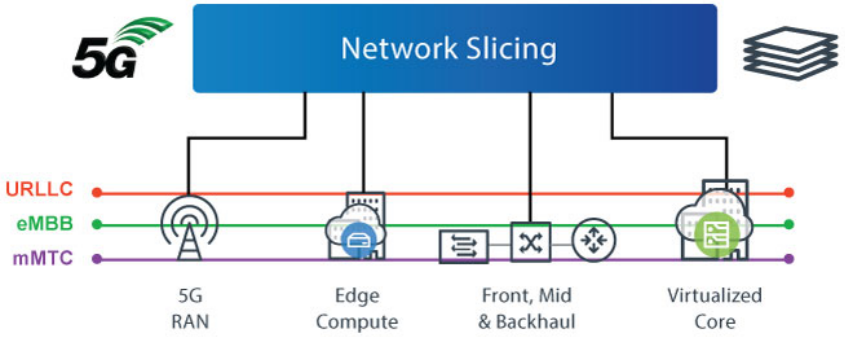
Network Slice Specification

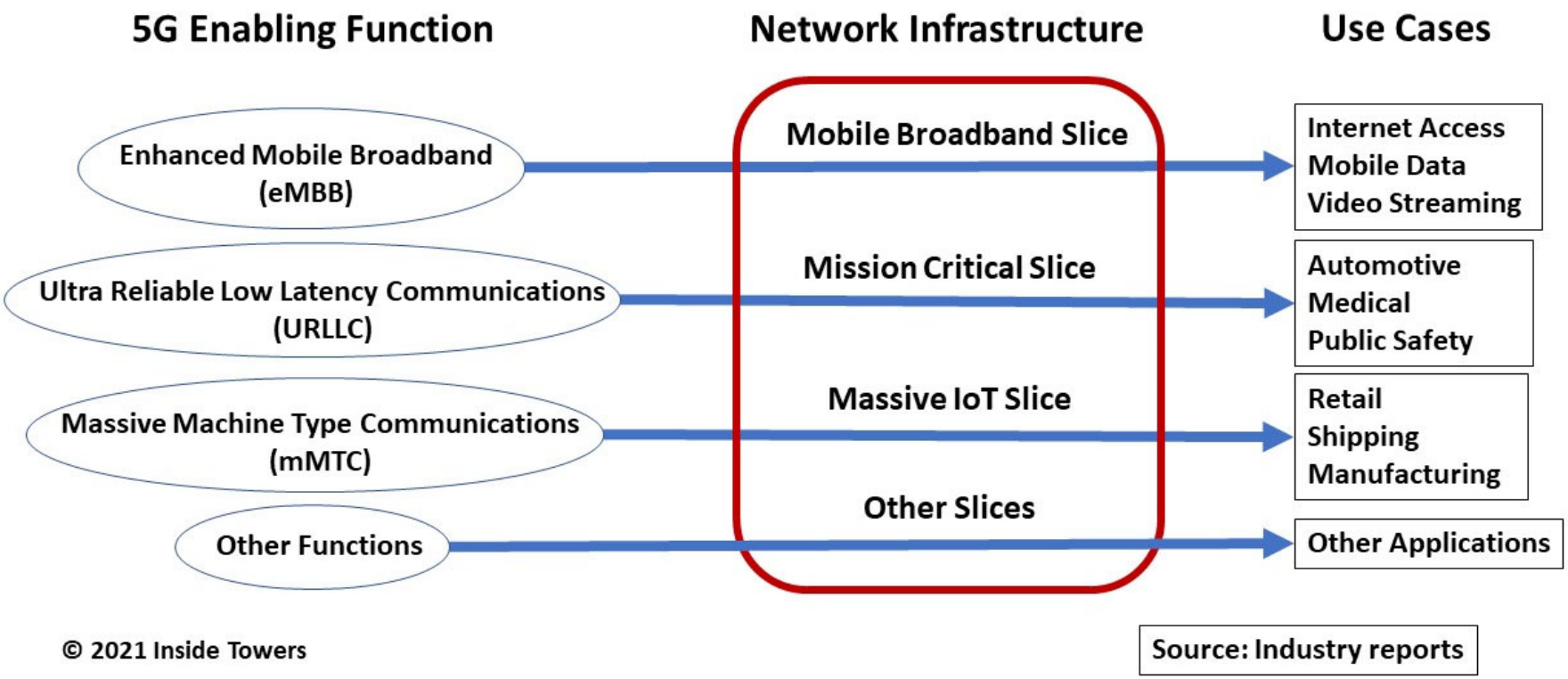


https://www.viavisolutions.com/en-us/5g-network-slicing



https://www.blueplanet.com/resources/what-is-network-slicing.html

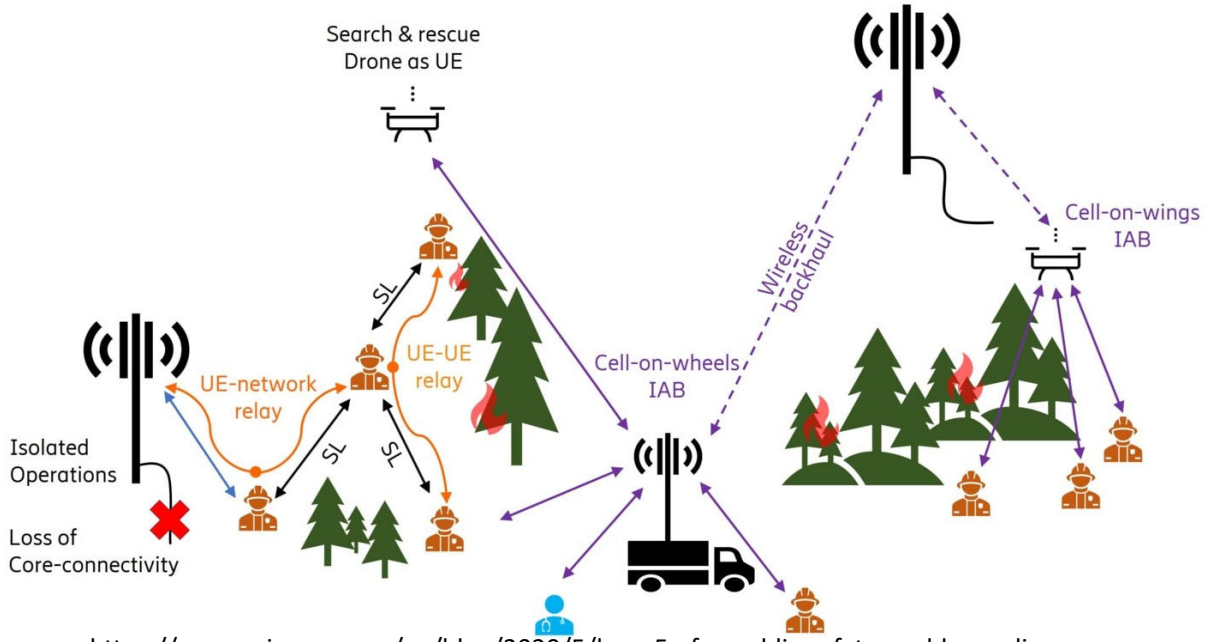
Network Slice Specification



https://insidetowers.com/cell-tower-news-do-you-want-that-network-slice-to-go/

Private 5G networks

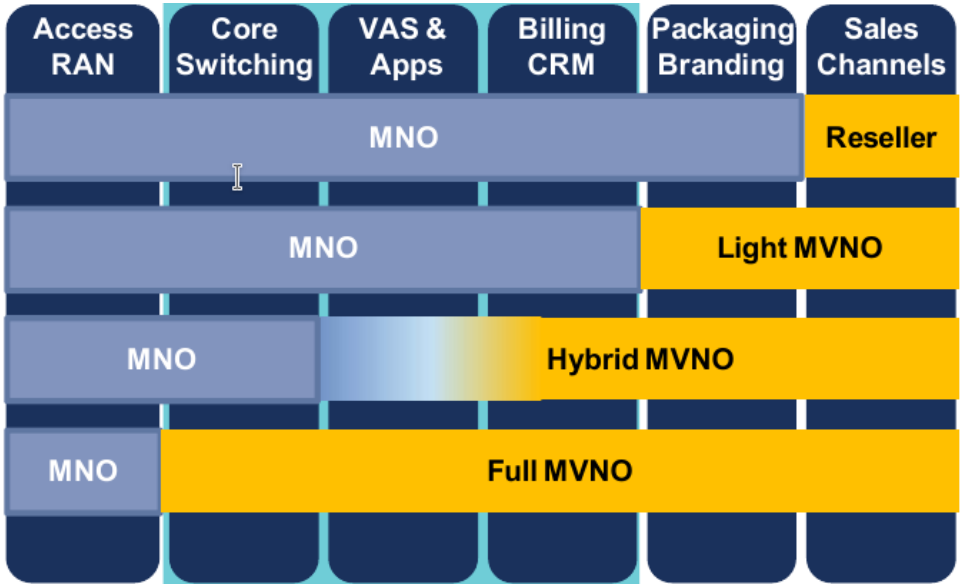
- Provision of priorities to end users in specific frequency zones
- Definition of list of terminals that can be connected to a 5G network
- Routing and network access policies
- Quality of service assurance



https://www.ericsson.com/en/blog/2020/5/how-5g-for-public-safety-could-save-lives

Mobile Virtual Network Operator

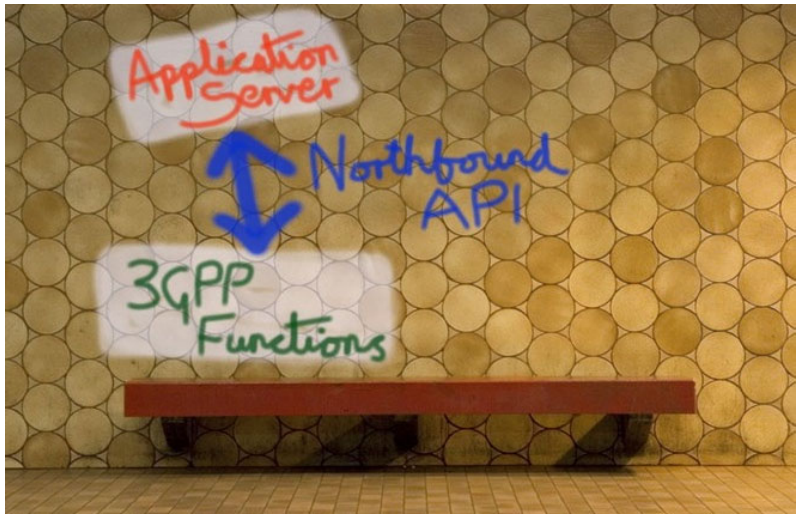
- Hybrid model for usage of the infrastructure based on leasing of resources from telco providers
- Network services and applications orchestration mechanisms
- Service provision to end users



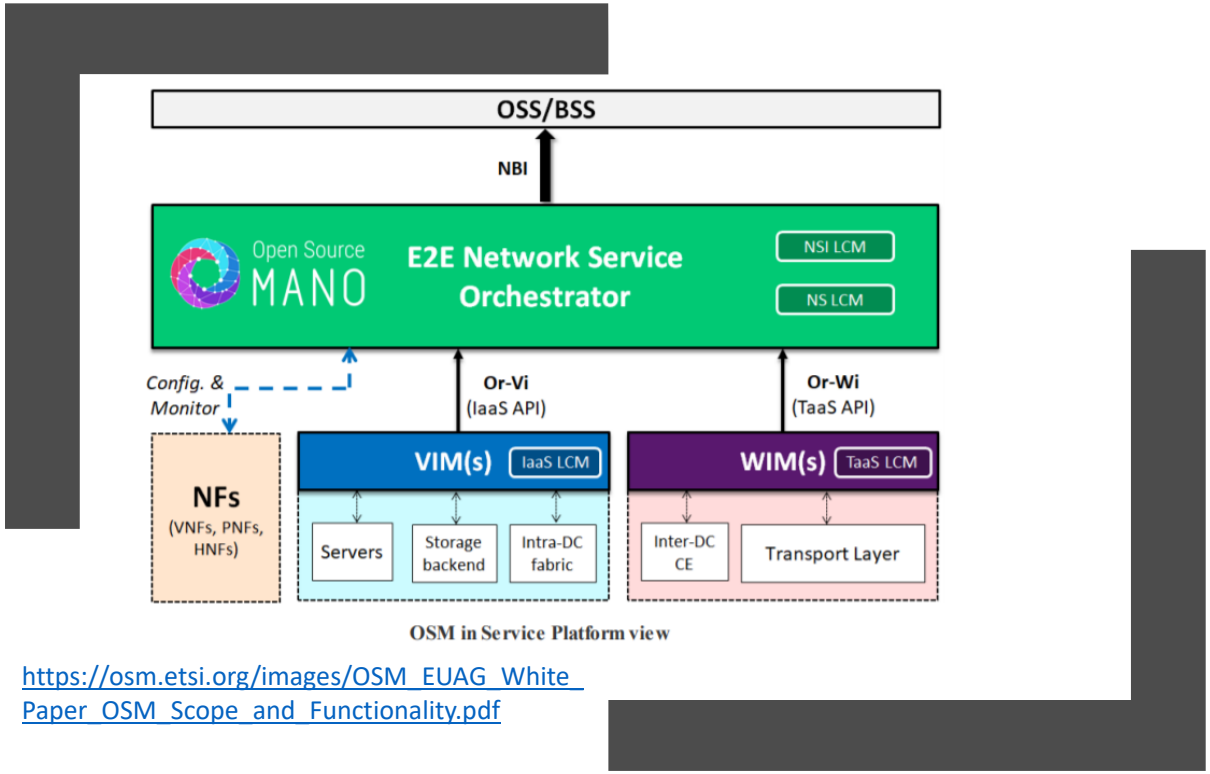
https://www.utilitycons.com/mobile-virtual-network-operator-for-utilities/

5G, Cloud and Edge Computing Technologies Convergence

- Need for exploitation of 5G functionalities by cloud computing applications
- Need for specification of open APIs



Network Services Orchestration Mechanisms



OSM in Service Platform view

https://osm.etsi.org/images/OSM_EUAG_White_Paper_OSM_Scope_and_Functionality.pdf

Κύριοι NFV Orchestrators

- Open Source MANO (OSM) NFVO
- SONATA
- ONAP
- Openbaton

Elasticity Efficiency

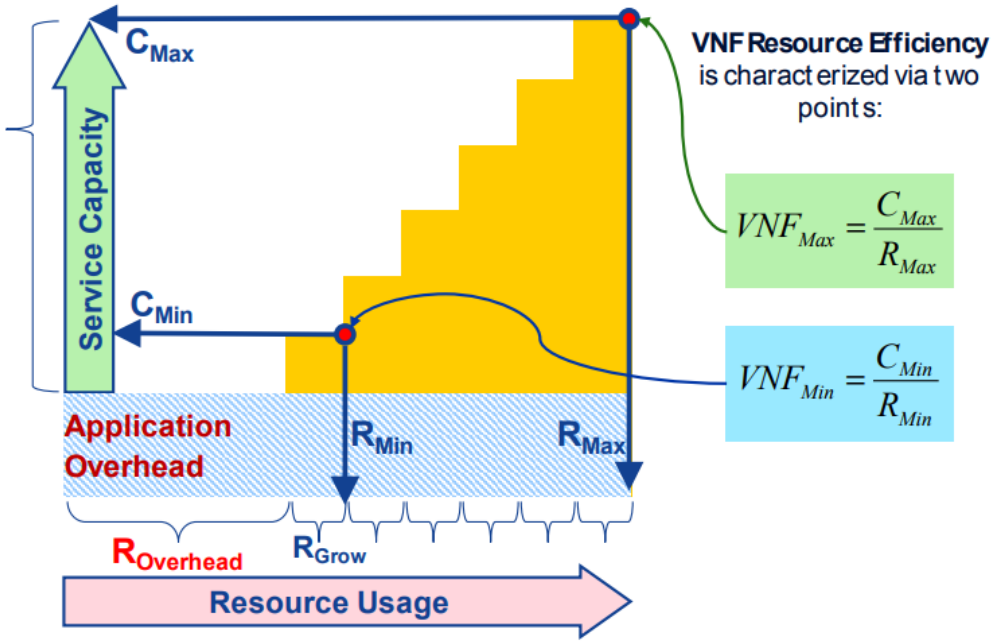


Figure 7-1 VNF Resource Efficiency Measurements

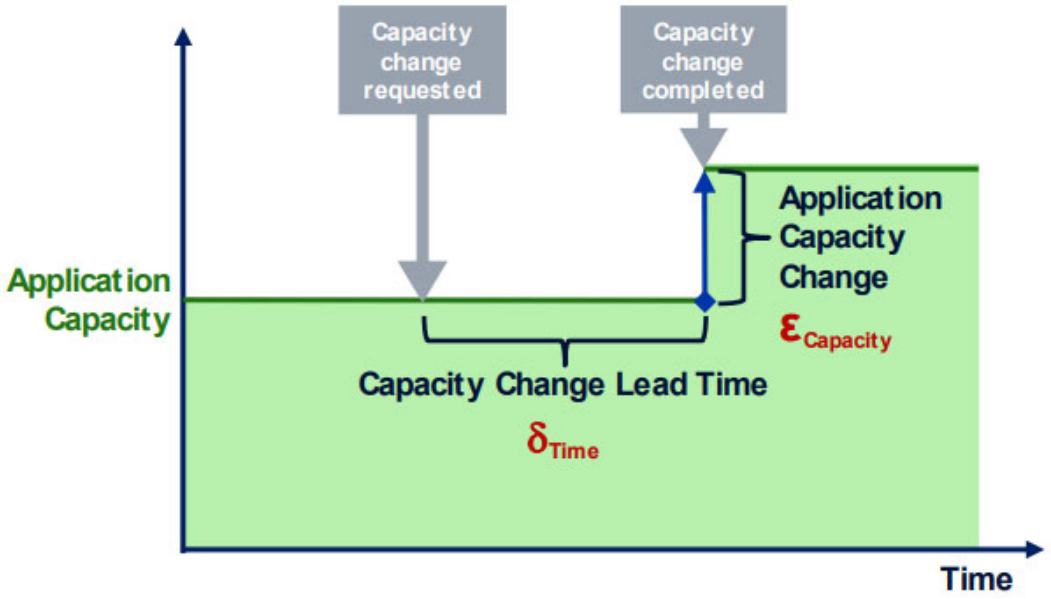
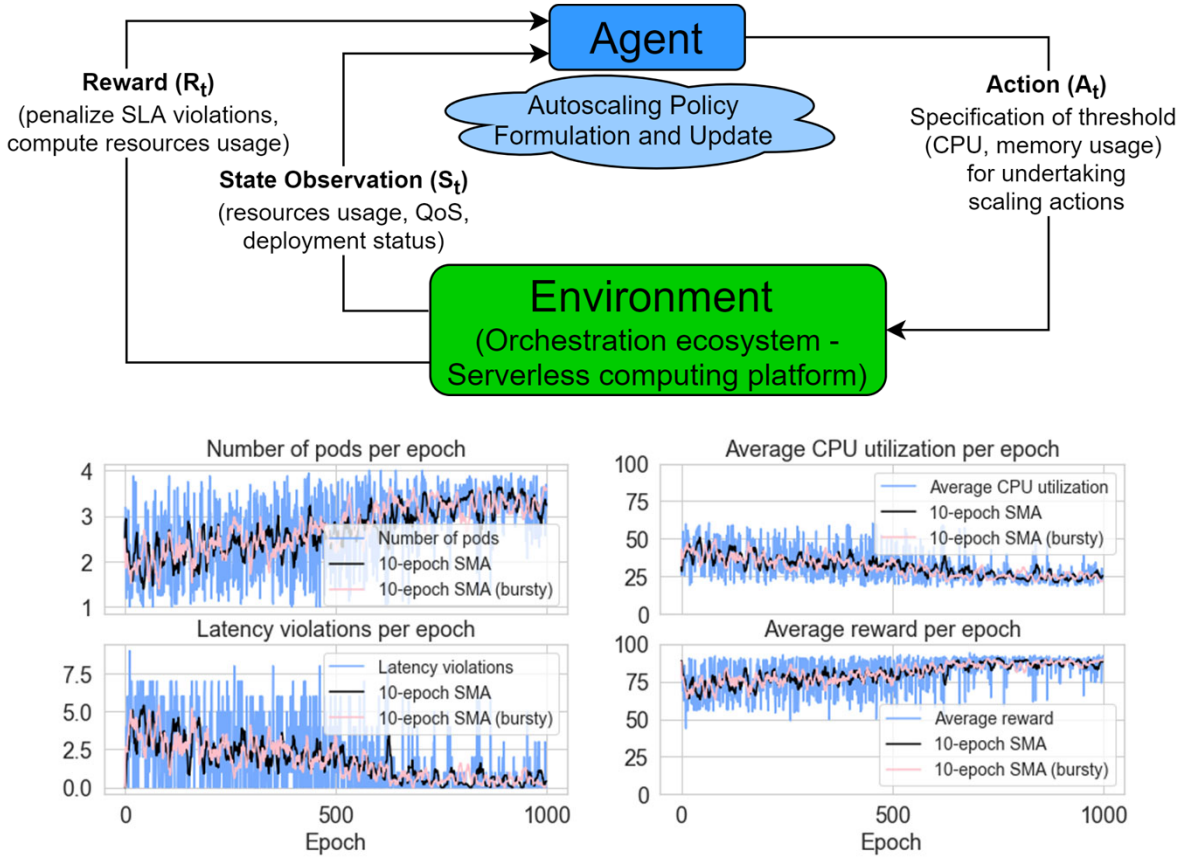


Figure 7-3 Dynamic Operational Efficiency of Cloud-Based Applications

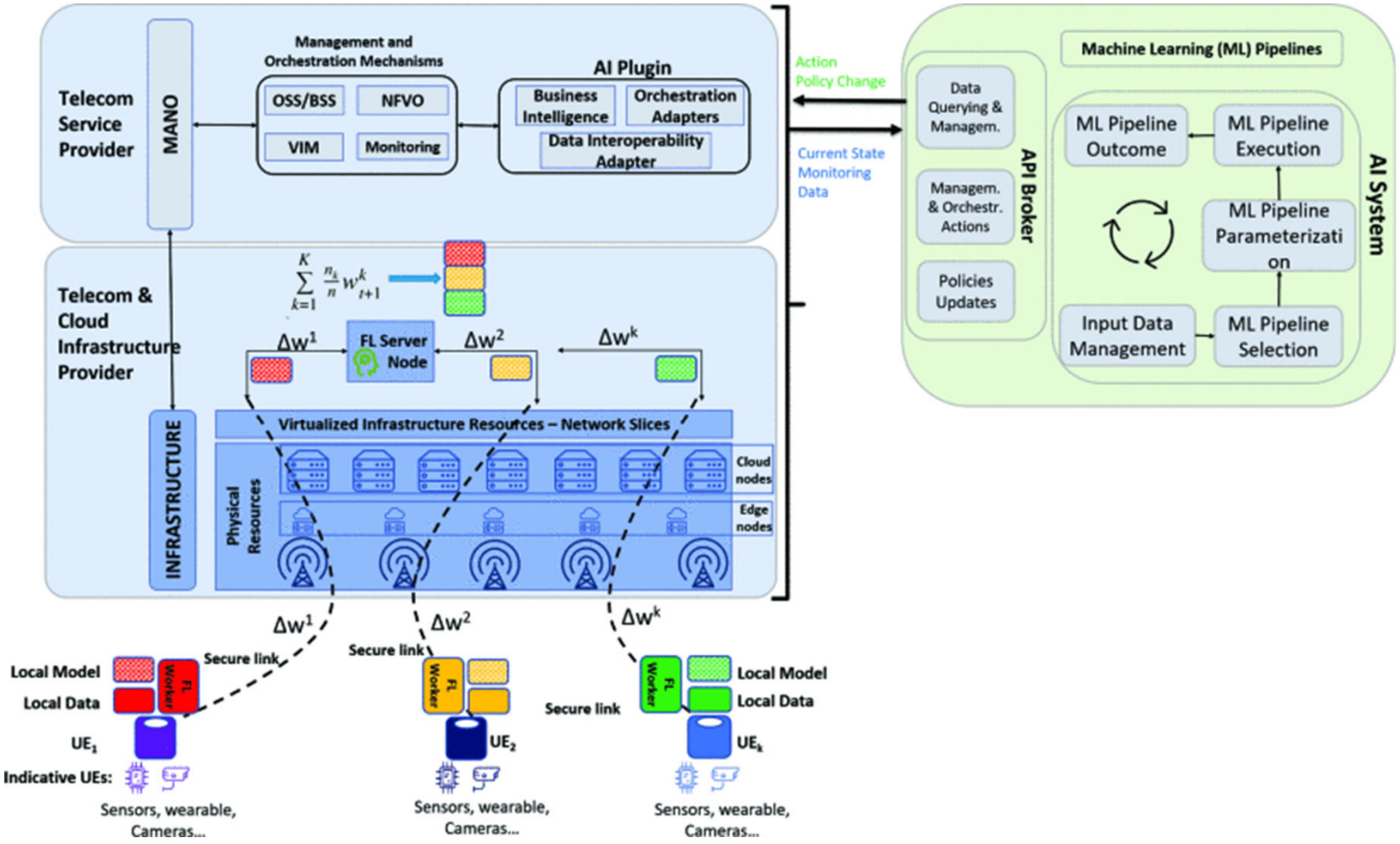
NFV Workload Efficiency Whitepaper,
https://tl9000.org/resources/documents/NFV%20Workload%20Efficiency%20Whitepaper.pdf

Automated scaling based on ML

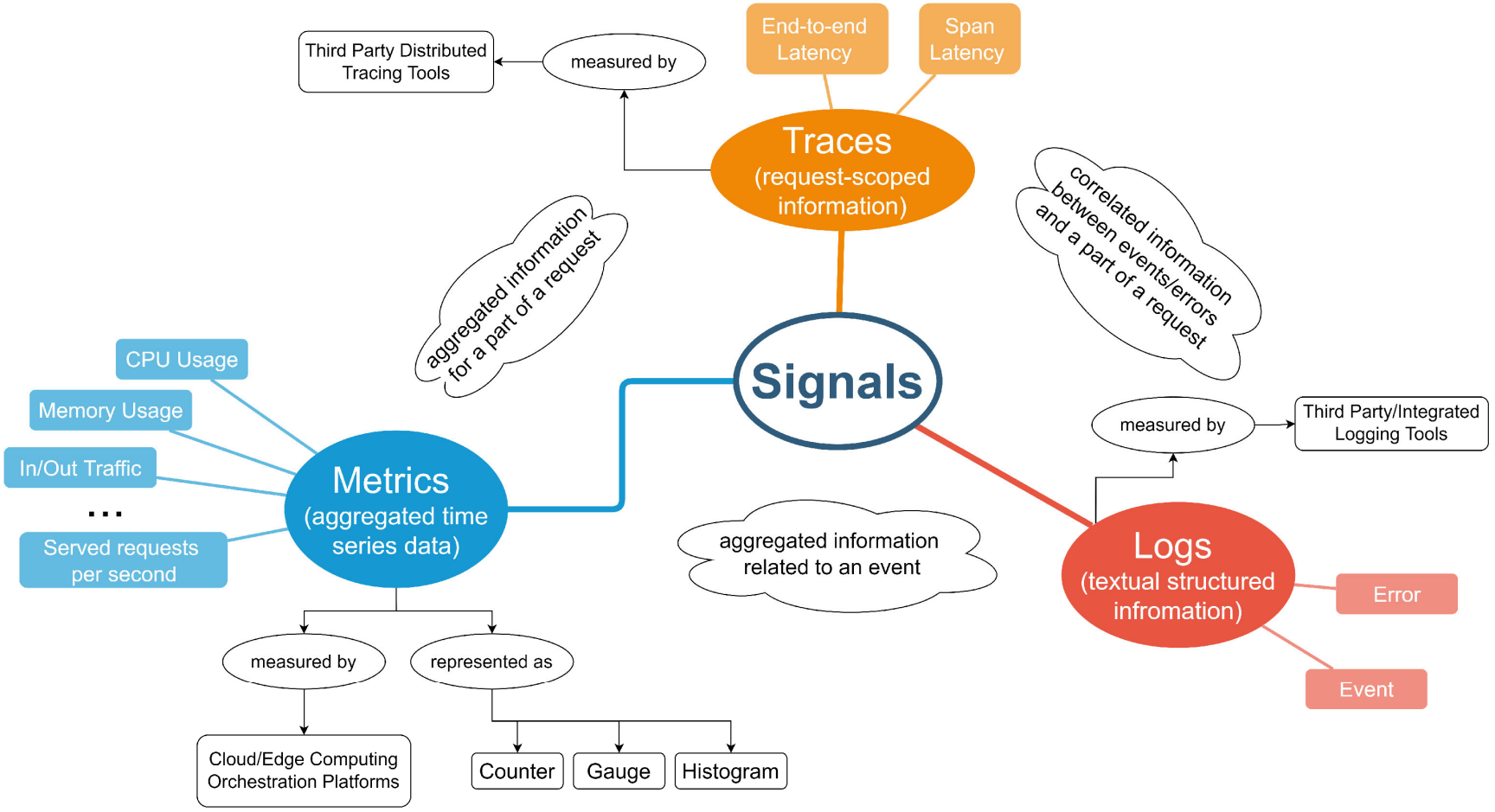
- Reinforcement Learning techniques
  - Q-learning, DynaQ+, DQN
- Federated learning
- Automated thresholds specification for horizontal scaling
- Optimal usage of resources under a given SLA
- Microservices-based apps, serverless computing



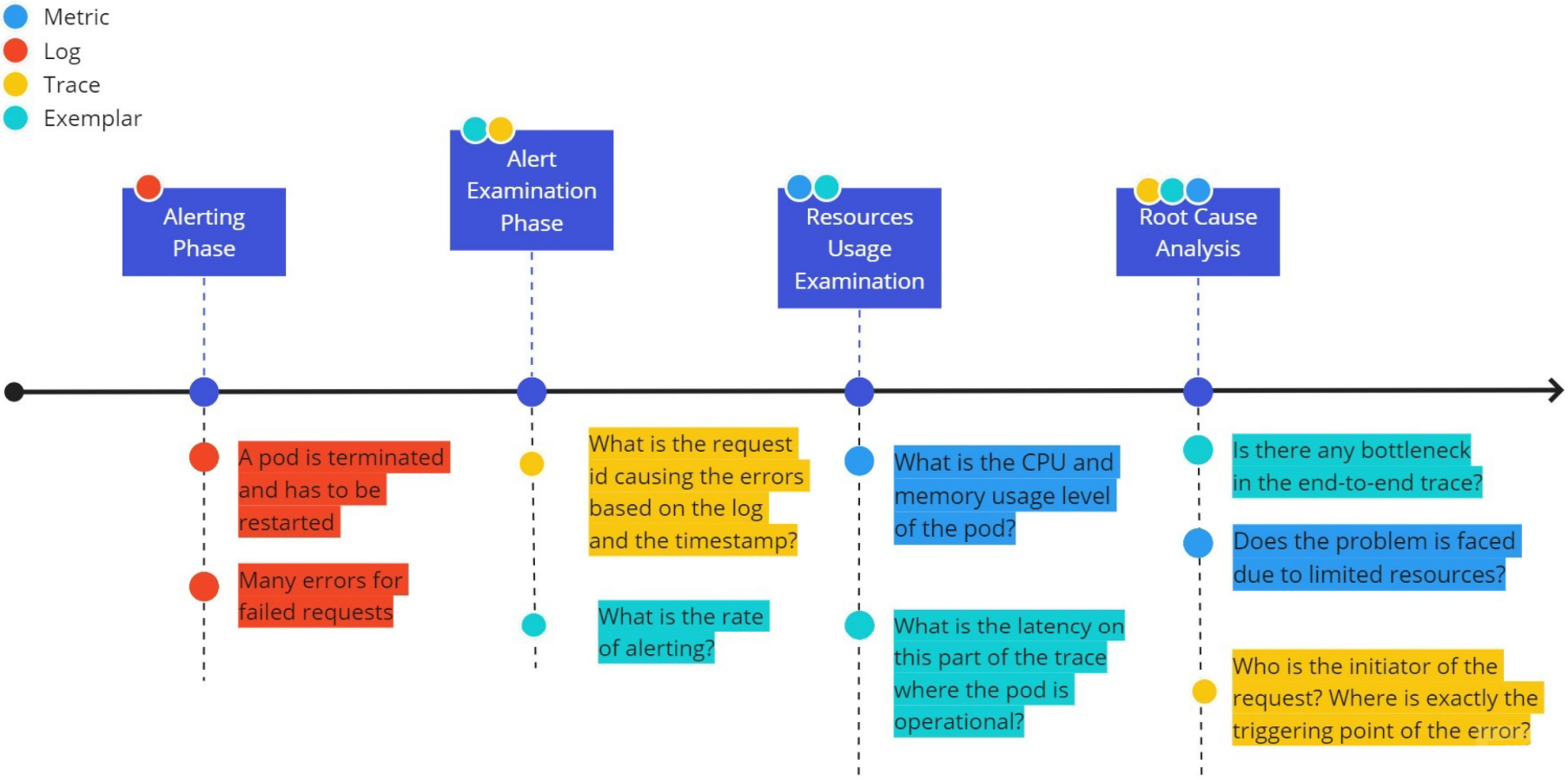
Intelligent orchestration based on data analytics



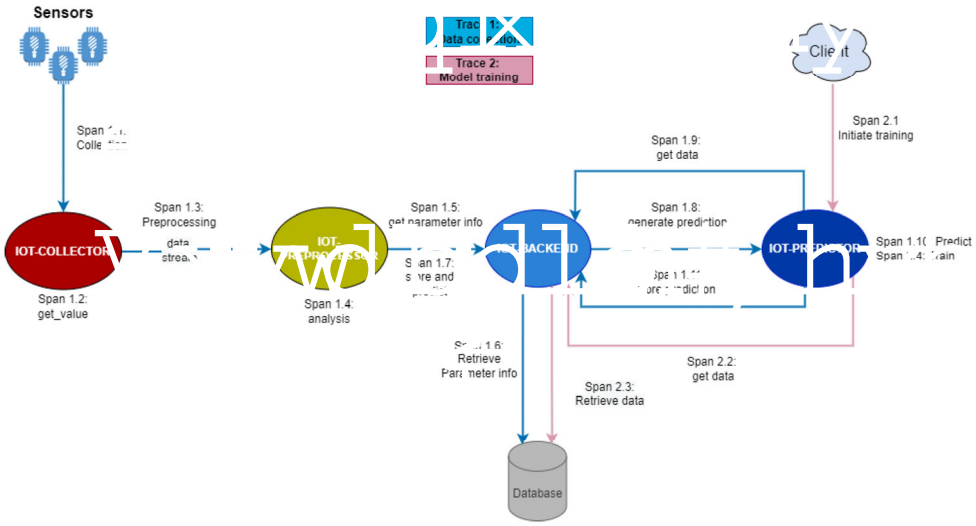
Data fusion techniques

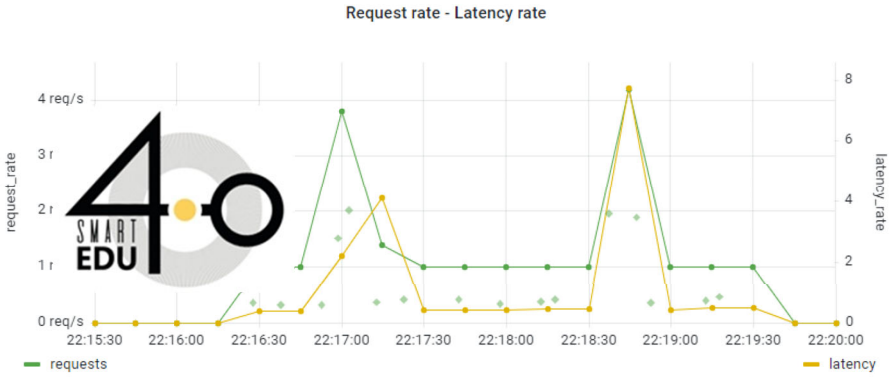


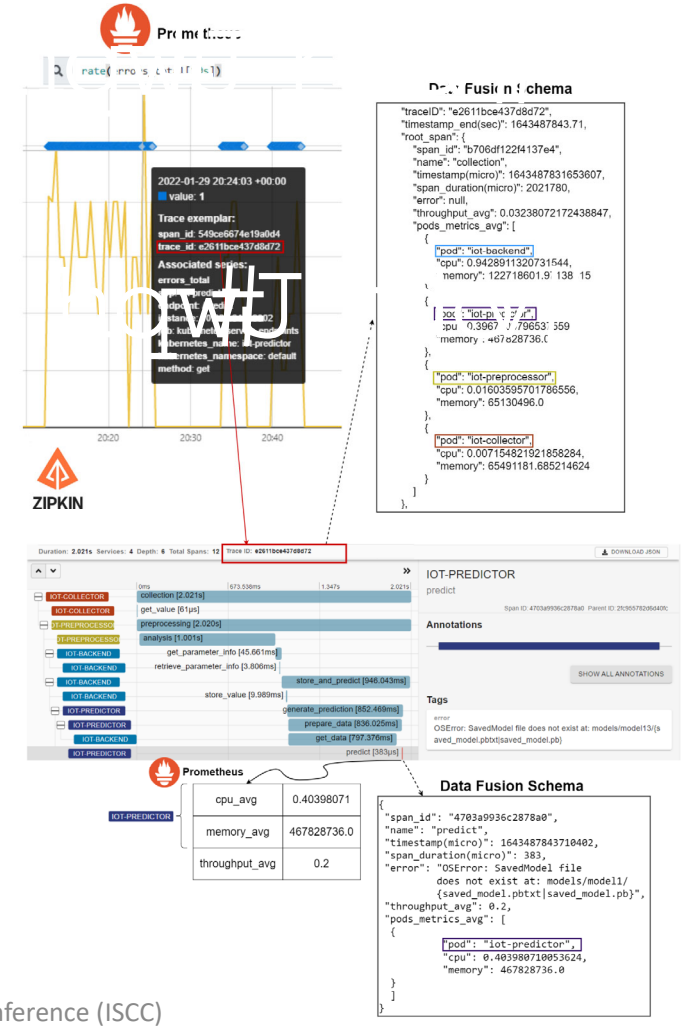
Data fusion techniques



Data fusion techniques







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MDGs Results

The number of people that live on less than $1.25 per day has dropped more than half!

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Still there are lots to do…..

Over 800.000.000 people live with less than $1.25 per day

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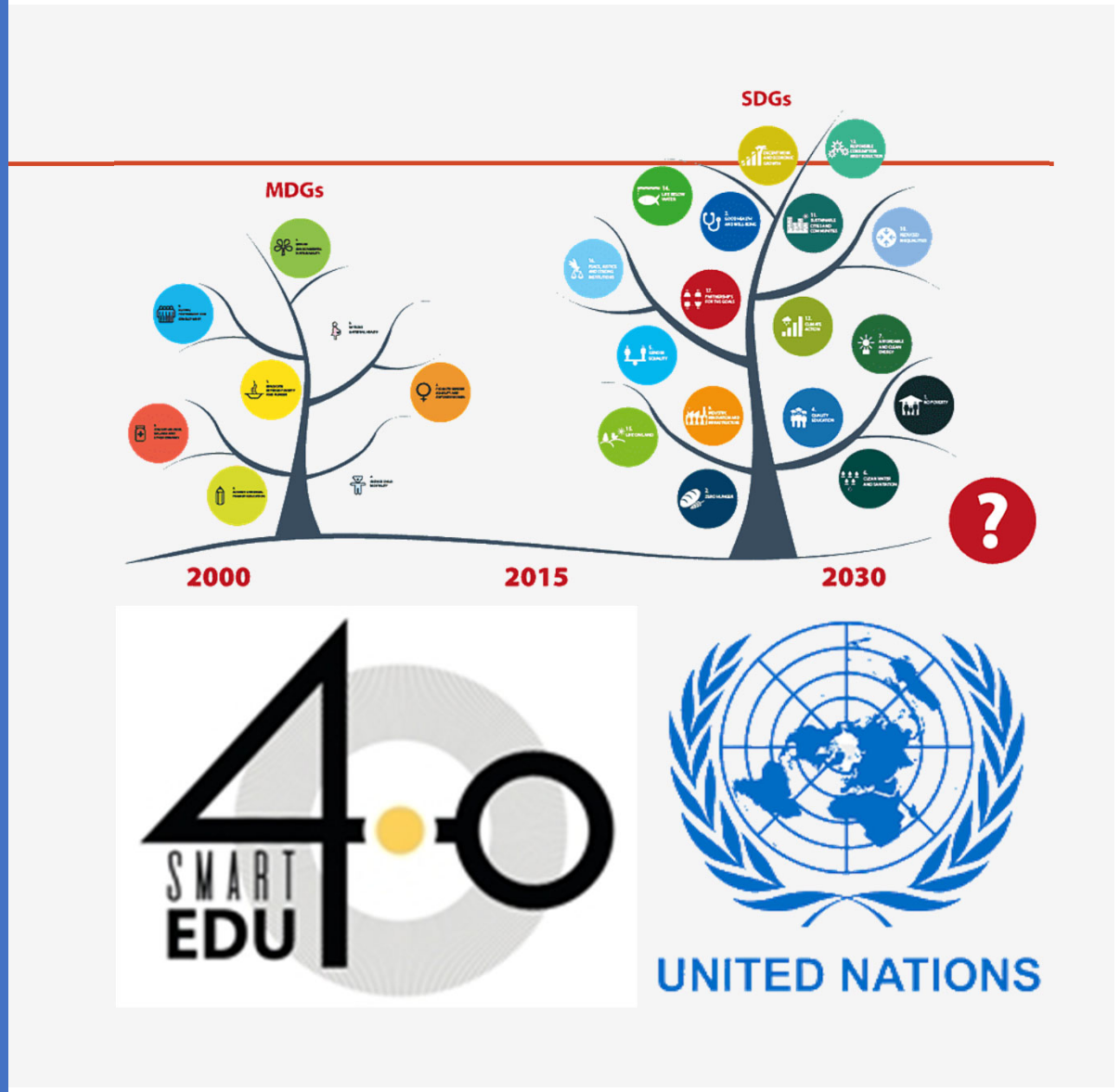
MDGs to SDGs



SUSTAINABLE DEVELOPMENT GOALS

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Social, Economic, Environmental

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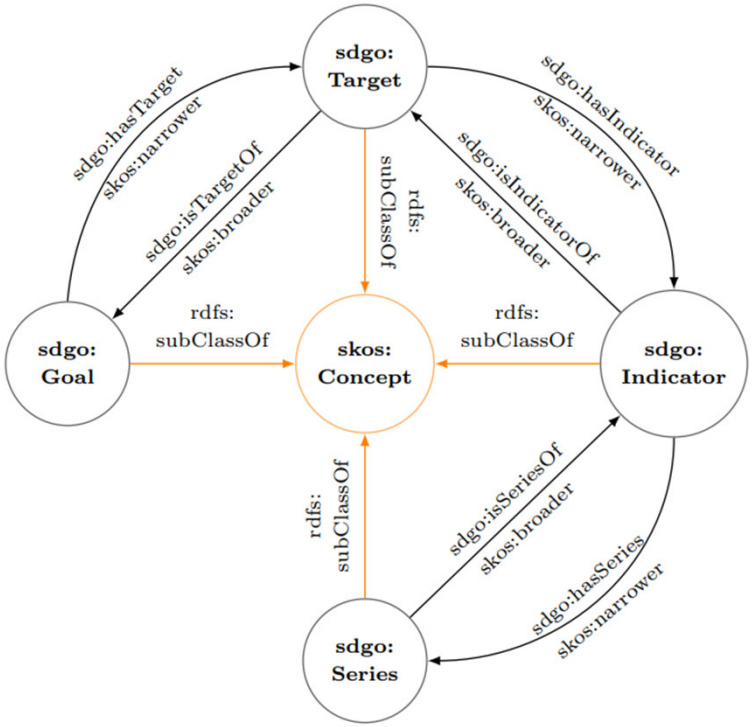
Adapted in 2000 and should be accomplished until 2015	Adapted in 2015 and should be accomplished until 2030
Concern developing countries	Concern ! >> countries
8 goals, 18 targets, 48 indicators	17 goals, 169 targets, 230 indicators

Collective Environmental Intelligence Knowledge Graph

Tracking Sustainable Development Goals (SDGs) indicators at national and regional level

- Sustainable Development Goals (SDGs) Taxonomy and Ontology
- EU SDG Indicators
- European Green Deal (EGD) (Ambition and Policy Areas)
- SDSN Six Transformations (Transformation, Intervention and Outputs)
- Country Specific Recommendations (CSRs)
- Nationally Determined Contributions (NDCs) - linkage between SDG targets and national targets, key hazards considered per country
- Smart Sustainable Cities (UN4SCC)

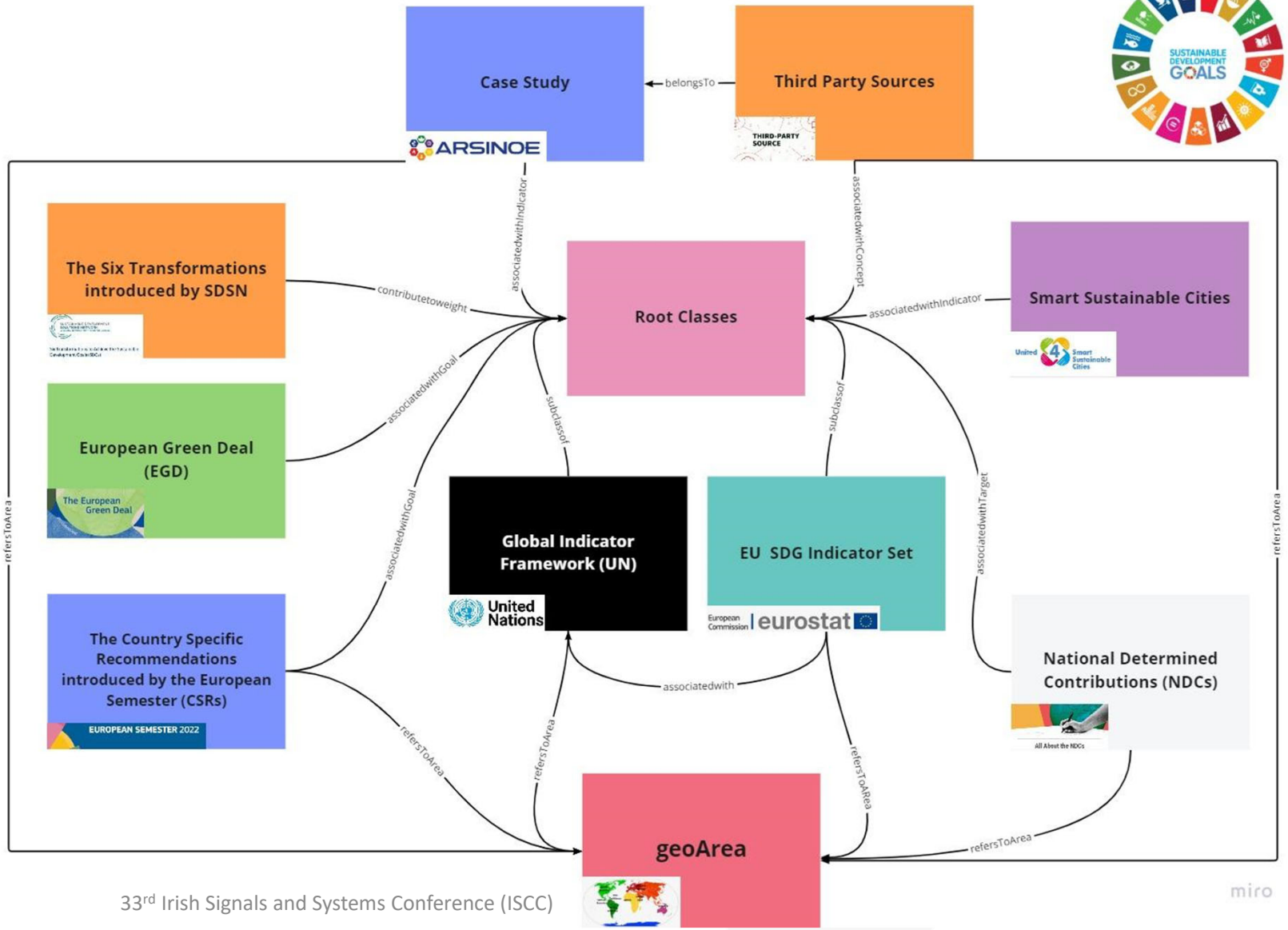


Collective Environmental Intelligence Knowledge Graph

Next steps in conceptualization

- Interlinking with case studies
  - Main monitoring metrics
  - Relationship with SDGs
  - Stakeholders
  - Hazards indices
  - Innovations from Climate Innovation Window
- Behavioural aspects (community)
  - Environmental intelligence concepts
- Third party data series

Case Study #1 Athens Metropolitan Area															
	1.1.1	1.2.1	1.2.2	1.3.1yellow	1.4.1	1.4.2	1.5.1	1.5.2	1.5.3	1.5.4 yellow	1.a.1	1.a.2	1.b.1	
	2.1.1	2.1.2	2.2.1	2.2.2	2.2.3	2.3.1	2.3.2	2.4.1	2.5.1	2.5.2	2.a.1	2.a.2	2.b.1	2.c.1
	3.1.1	3.1.2	3.2.1	3.2.2	3.3.1	3.3.2	3.3.3	3.3.4	3.3.5	3.4.1 yellow	3.4.2	3.5.1	3.5.2	3.6.1
	4.1.1	4.1.2	4.2.1	4.2.2	4.3.1	4.4.1	4.5.1	4.6.1	4.7.1 green	4.a.1	4.b.1	4.c.1yellow		
	5.1.1	5.2.1	5.2.2	5.3.1	5.3.2	5.4.1	5.5.1	5.5.2	5.6.1	5.6.2	5.a.1	5.a.2	5.b.1	5.c.1
	6.1.1	6.2.1	6.3.1	6.3.2	6.4.1	6.4.2	6.5.1	6.5.2	6.6.1green	6.a.1	6.b.1green			
	7.1.1	7.1.2	7.2.1	7.3.1	7.a.1	7.b.1								
	8.1.1	8.2.1	8.3.1	8.4.1	8.4.2	8.5.1	8.5.2yellow	8.6.1	8.7.1	8.8.1	8.8.2	8.9.1	8.10.1	8.10.2
	9.1.1	9.1.2	9.2.1	9.2.2	9.3.1	9.3.2	9.4.1 yellow	9.5.1	9.5.2 green	9.a.1	9.b.1	9.c.1 yellow		
	10.1.1	10.2.1	10.3.1	10.4.1	10.4.2	10.5.1	10.6.1	10.7.1	10.7.2	10.7.3	10.7.4	10.a.1	10.b.1	10.c.1
	11.1.1	11.2.1	11.3.1	11.3.2 yellow	11.4.1 yellow	11.5.1green	11.5.2	11.6.1	11.6.2 green	11.7.1 green	11.7.2	11.a.1	11.b.1	11.b.2 yellow
	12.1.1	12.2.1	12.2.2	12.3.1	12.4.1	12.4.2	12.5.1	12.6.1	12.7.1	12.8.1 green	12.a.1	12.b.1	12.c.1	
	13.1.1 green	13.1.2	13.1.3 yellow	13.2.1	13.2.2 yellow	13.3.1 green	13.a.1	13.b.1						
	14.1.1	14.2.1	14.3.1	14.4.1	14.5.1	14.6.1	14.7.1	14.a.1	14.b.1	14.c.1				
	15.1.1 green	15.1.2 green	15.2.1 yellow	15.3.1 yellow	15.4.1 green	15.4.2	15.5.1	15.6.1	15.7.1	15.8.1	15.9.1 yellow	15.a.1 yellow	15.b.1	15.c.1


Case Study
belongsTo
Third Party Sources
ARSINOE
THIRD-PARTY SOURCE
associatedwithIndicator
associatedwithConcept
The Six Transformations introduced by SDSN
contributetoweight
Root Classes
associatedwithIndicator
Smart Sustainable Cities
associatedwithGoal
subclassof
subclassof
European Green Deal (EGD)
The European Green Deal
refersToArea
associatedwithGoal
Global Indicator Framework (UN)
United Nations
EU SDG Indicator Set
European Commission eurostat
associatedwithTarget
refersToArea
The Country Specific Recommendations introduced by the European Semester (CSRs)
EUROPEAN SEMESTER 2022
National Determined Contributions (NDCs)
All About the NDCs
associatedwith
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Natural Language Processing for SDGs

How do social media (e.g., Twitter) reflect the emphasis given to Sustainable Development Goals?

Bidirectional Encoder Representations from Transformers (**BERT**) is a transformer-based machine learning technique for natural language processing (NLP) pre-training

text2sdg

,m-$Iyvstier$Yrmsr$Eggsyrxw>

- Iyvstier$Tevqeq irx
- IY$Gsyrgmp
- IY$Gsqqmwmsr
- Xli$Gsyrgmp$sj$Iyvsti
- IY$Gpmqexi$Egxmsr
- IY$Irzmsrq irx

,m-YWEEggsyrxw>

- Xli$[lmi$Lsywi
- YWE$Wxexi$Hitevxq irx
- YWE$Kszivq irx
- TviwmirxsjXli$Yrmih$ Wxexiw$gywirxp}$Nsi$ Fmir-

,mm-RKSEggsyrxw>

- YRMGIJ
- [[J
- Qihigmrw$werw$ Jvsrxiviw$QWJ-
- EgxsrEm$IY

,mz-$Mrxivrexmsrep$ Svkerm-exmsrw>

- Yrmih$Rexmsrw
- YRIWGS
- Kpsfe$Ksepw
- SIGH

Natural Language Processing for SDGs

How do social media (e.g., Twitter) reflect the emphasis given to Sustainable Development Goals?