ITU KALEIDOSCOPE
ONLINE 2021

6-10 December 2021

A review of network slicing in 5G and beyond: Intelligent approaches and challenges

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Session 6: Machine learning for next generation wireless network

Paper S6.2: A review of network slicing in 5G and beyond: Intelligent approaches and challenges

Outline

- 5G Networks
- Network Slicing in 5G
- Slicing Standards
- Artificial Intelligence in 5G networks
- The proposed model
- Conclusion

5G Networks at a glance

5G network:

- Wide range of services and devices
- High speed data transfer
- Existing networks with conventional design

The goal:

- minimizing the total cost of network infrastructure
- maximizing system performance and efficiency

Enabling technologies:

- Software defined network (**SDN**)
- Network function virtualization (**NFV**)

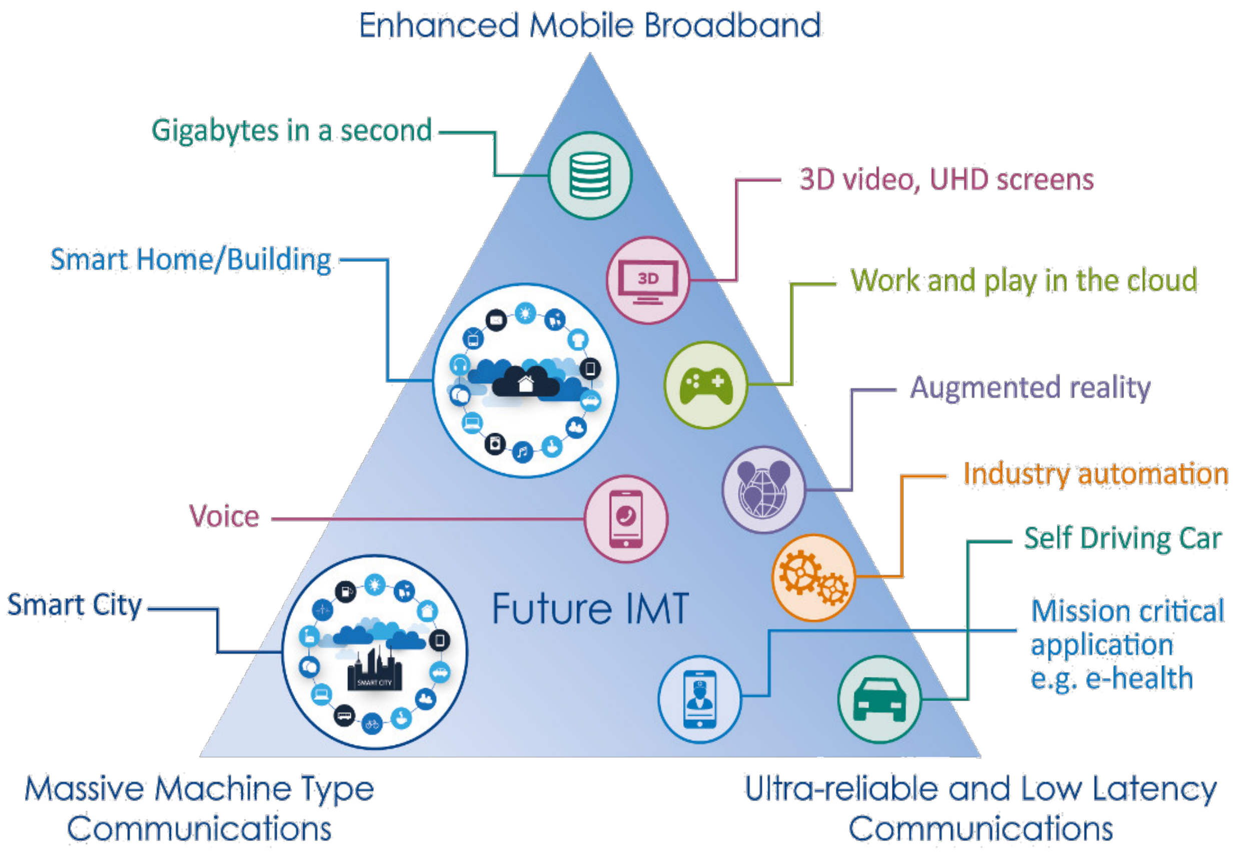
The goal:

- Having are flexible and highly adaptable network
- Handling a variety of services simultaneously

5G Network (Service Categories)

Main applications for 5G networks fall into **three** categories:

- **Massive Machine Type Communication** (mMTC): Smart city, etc.
- **Enhanced mobile broadband** (eMBB):ultra-high definition video, 3D video, etc.
- **Ultra-reliable and low latency Communication** (URLLC): Driverless, industrial automation, etc.



Network Slicing in 5G (Concept and Architecture)

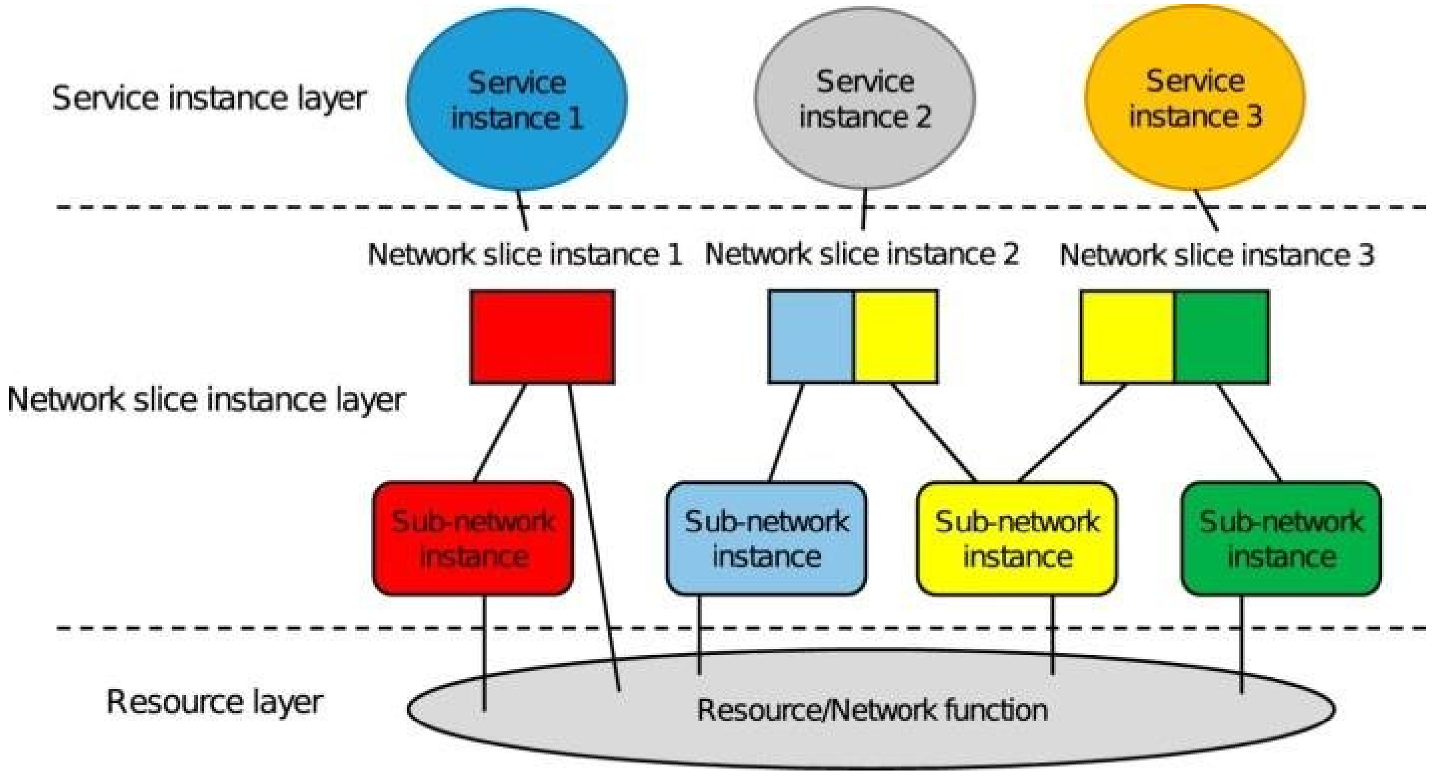
Network Slicing:

An E2E logical subnet including

1. Core Network
2. Radio Access Network
3. Transport Network

Architecture of network Slicing:

1. Service instance layer
2. Network slice instance layer
3. Resource layer



The NGMN 5G White Paper

Network Slicing in 5G (Top companies)

Ericsson and **Deutsche Telekom** share slice of success in 5G on-demand video service trial

Slicing Standards

There are many standards considering **slicing** in different parts of the network. Here we have brought a number of these standards:

Radio Access Network: 3GPP RAN

Release 15:
Present Key principles for supporting network slicing in NG-RAN , enhancement of some implementation dependent features.

Transport Network: ITU-T SG15

The international standards (ITU-T Recommendations) developed by **Study Group 15.**

Mobile Core Network: 3GPP SA

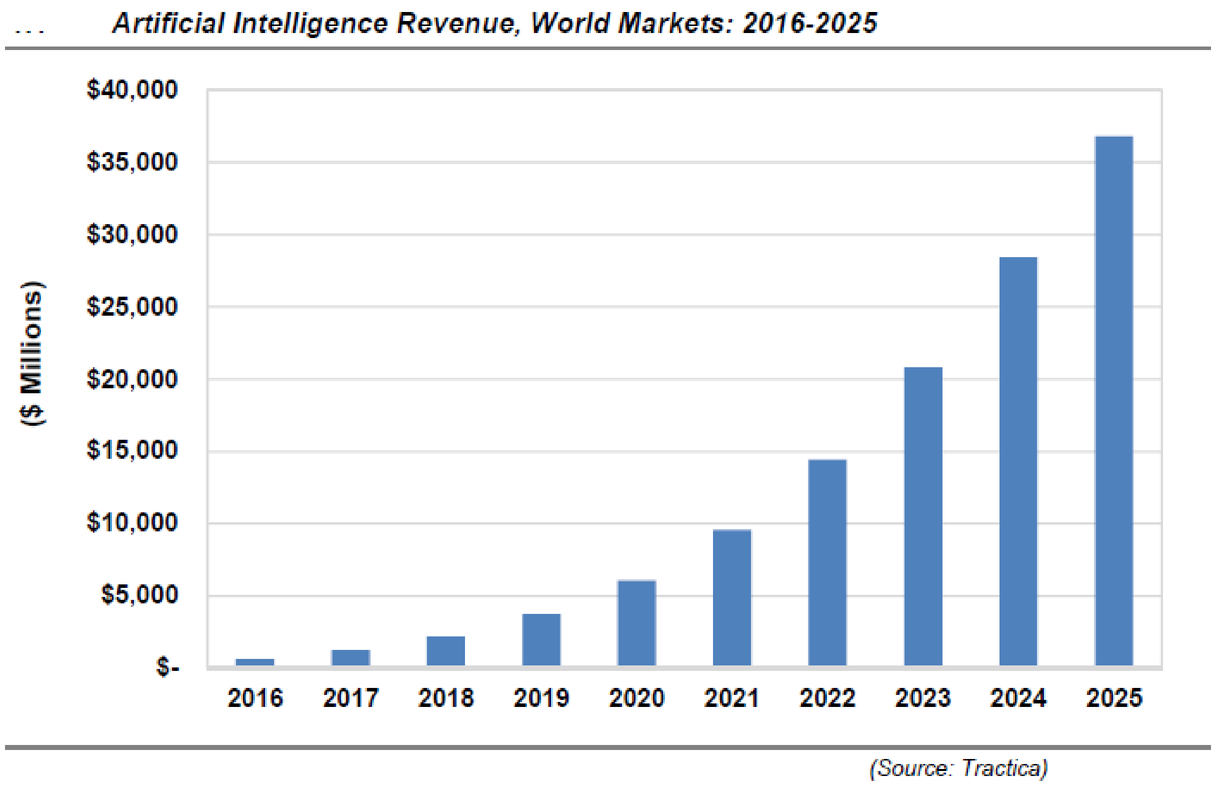
Release 15:
Considering basic network slice features
Release 16:
enhancements of network slicing
enhancements of Service-based Architecture (SBA)
higher flexibility and better modularization
full-scale virtualization
Release 17:
Several parameters of the GST parameters studied in order to keep SLS

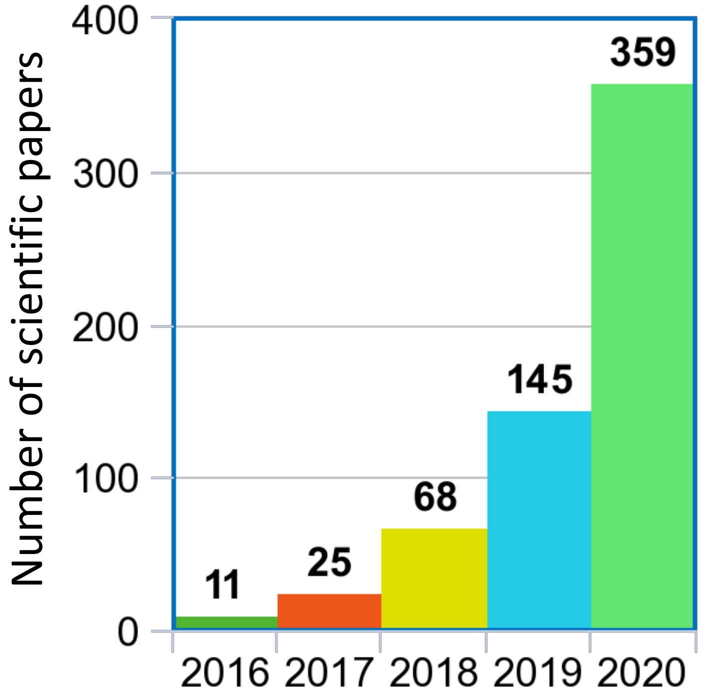
Artificial Intelligence: Special Groups for AI

AI has become so widespread that Standardization Bodies have formed some specific **ICT groups** for **standardization of AI.**
Some of these specific groups are as follows:

FG-ML5G	IEEE SA	ISO/IEC JTC	ETSI ISG ENI

Artificial Intelligence (In Network Slicing)

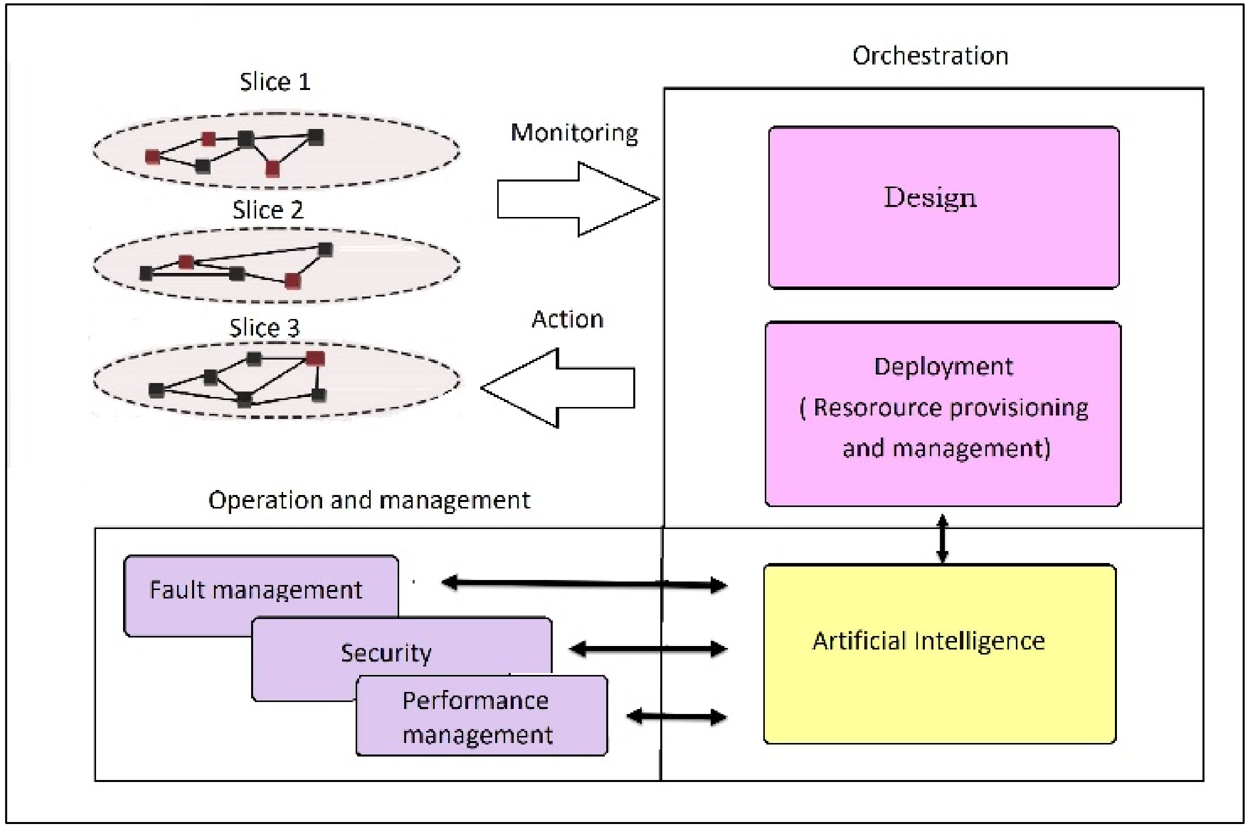




AI and network slicing in recent years

The Proposed Model

Slicing Functionalities		
F.1. Design		
F.2. Deployment		
F3. Operation and management		
F3.1. Performance management	F3.2. Fault management	F3.3. Security



F.1. Design

- The first step to have an efficient network
- Answering distinct service needs defined in 5G network
- Processing vast amount of data includes User needs and requirements, working environment and service goals

F.2. Deployment

Network **resource provisioning and allocation**:

- Under Provisioning: violating Service Level Agreement (SLA)
- Over Provisioning: Wasting resources

2 types of approaches:

- Policy-based
- Auction-based

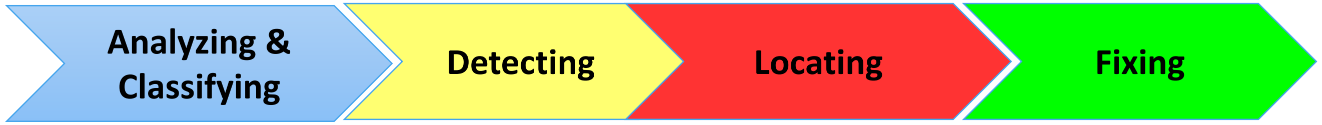
F.3. Operation and Management

F.3.1. Performance management:

- Admission control: whether network can **accept** or **reject** the upcoming slice request
- A wide resource sharing
- A limited resource sharing

F.3.2. Fault management:

- Analyzing the System activities, classifying as normal and flawed
- Recognizing usual and unusual user behavior and traffic
- Locating the precise location of error
- Trying to fix the flaws



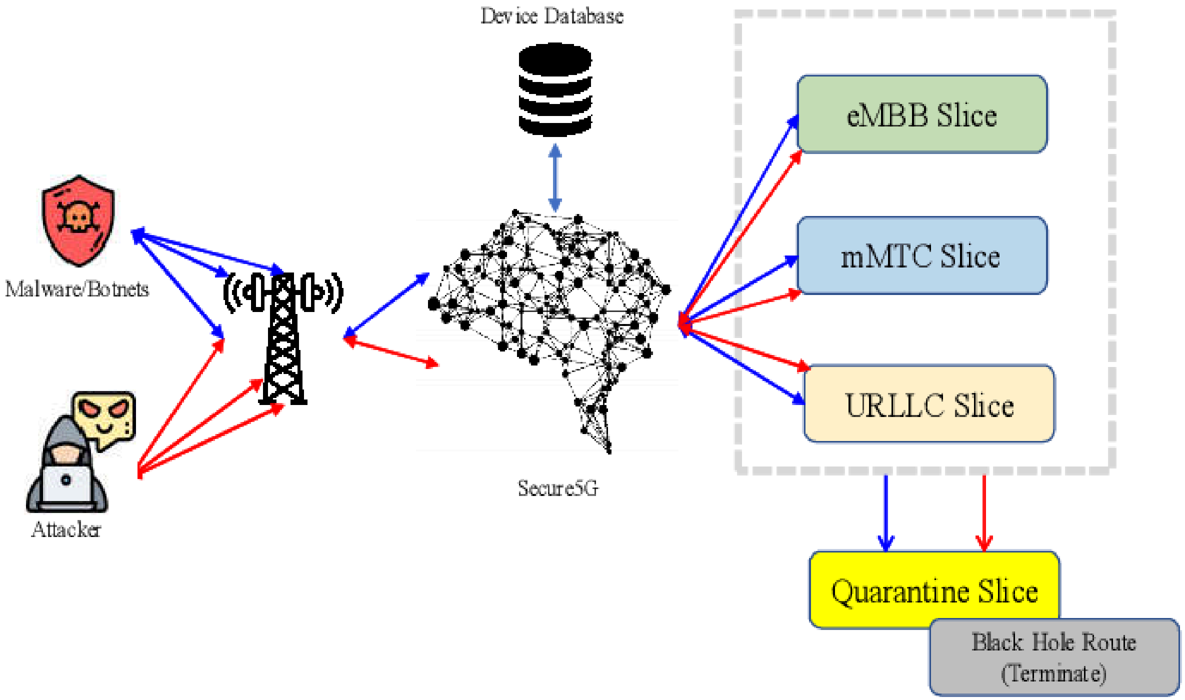
F.3. Operation and Management

F.3.3. Security:

- ❑ Analyzing the traffic, service requests and status of slice
- ❑ Spotting security vulnerabilities and detecting attacks in the slice
- ❑ Taking the proper action against threats and attacks

An effective action against attacks:

- ❑ Quarantining the contaminated slice to restrict the attack and it's following damage to other slices



Artificial Intelligence (AI) Algorithms

Supervised Learning (A1)	Unsupervised Learning (A2)	Reinforcement Learning (A3)
Nearest Neighbor Naive Bayes Decision Trees Support Vector Machines Neural Networks Linear Regression Logistical Regression Random Forest Gradient Boosted Trees	k-means clustering Association Rules t-Distributed Stochastic Neighbor Embedding Association rule	Q-Learning Temporal Difference Deep Adversarial Networks Monte-Carlo Tree Search Asynchronous Actor-Critic Agents

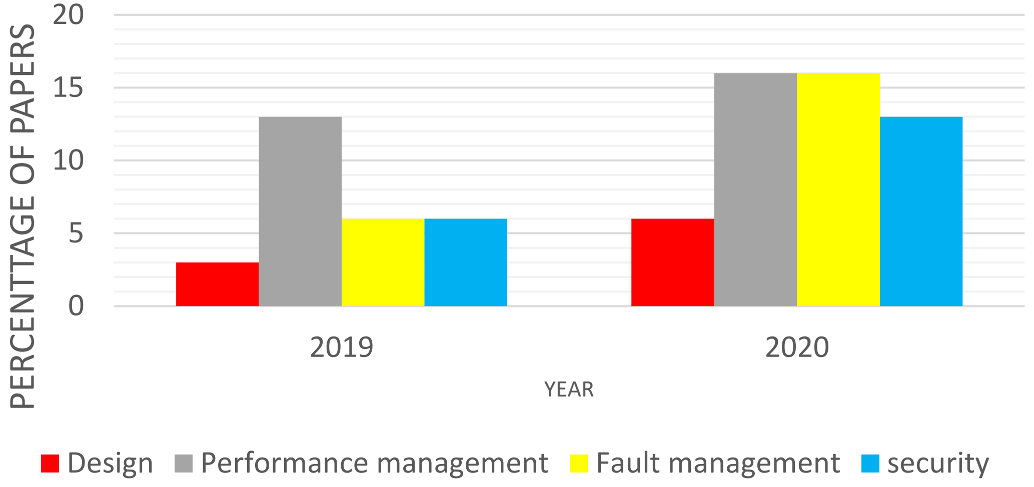
AI Algorithms (Applied in different functionalities)

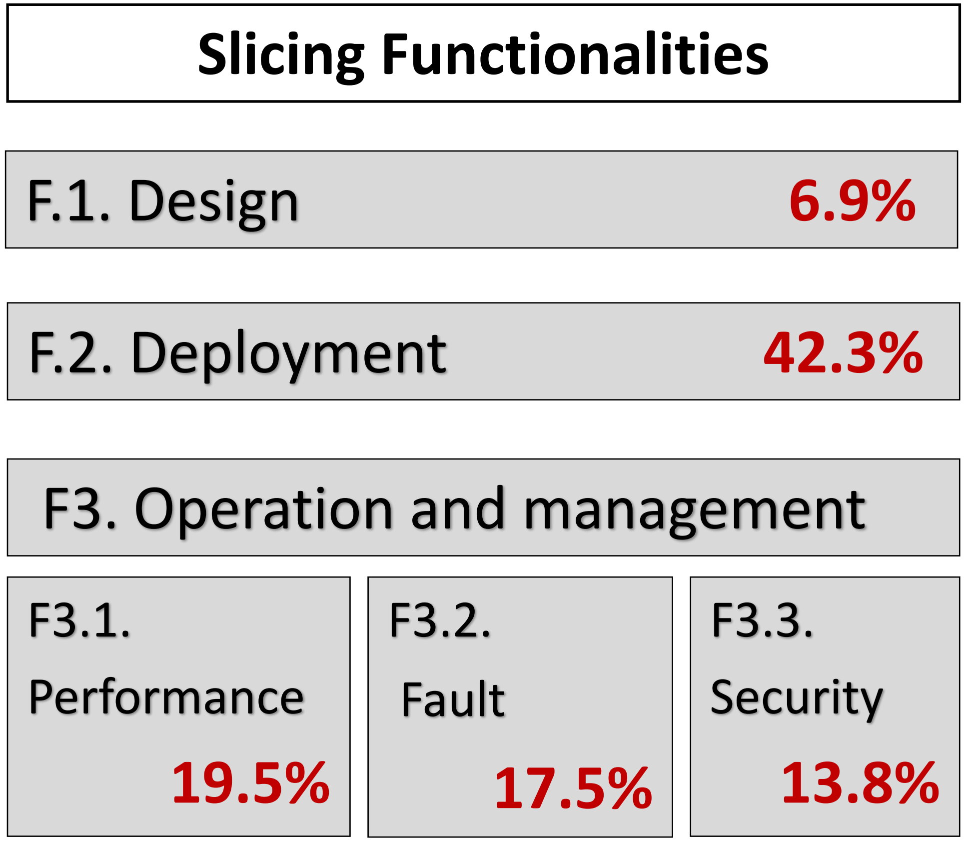
	A1. Supervised	A2. Unsupervised	A3. Reinforcement Learning
F1. Design	60%	20%	20%
F2. Deployment	21.7%	4.1%	74.1%
F3. Operation & Management	41%	16%	41%

Conclusion

We found about half of the papers in this subject have studied AI algorithms in the **F.2.Deployment**. This might be due to high AI applicability in **resource provisioning and allocation** which are the main functions of deployment.

The further comparison between other functionalities is depicted in the figure below.





Percentage of researchers focus on applying AI in different functionalities

Conclusion

In the paper we did the following items which some of the important ones have been described in this presentation.

- Reviewing 5G network, network slicing concepts, service categories and architecture
- Highlighting the specific working groups for AI in the ICTs standardization bodies
- Investigating Critical role of AI techniques in network slicing automation
- Proposing a functionalities model for AI-based network slicing
- Exploring the researchers focus on applied AI in network slicing functionalities

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Thank you!