Project LOCUS

LOCalization and analytics on-demand embedded in the 5G ecosystem, for Ubiquitous vertical applicationS

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Main info

Budget: 6 M€

Starting date:
1/11/2019

Ending date:
31/10/2022

Duration:
36 months

GA Number:
871249

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LOCUS Partners

Consorzio Nazionale Interuniversitario per le Telecomunicazioni	IT
Ericsson AB	SE
Ericsson S.p.A.	IT
IBM	IE
NEC	DE
Orange	FR
OTE	GR
Samsung	UK
VIAVI	FR
Incelligent	GR
Nextworks	IT
IMDEA Networks	ES
University of Malaga	ES

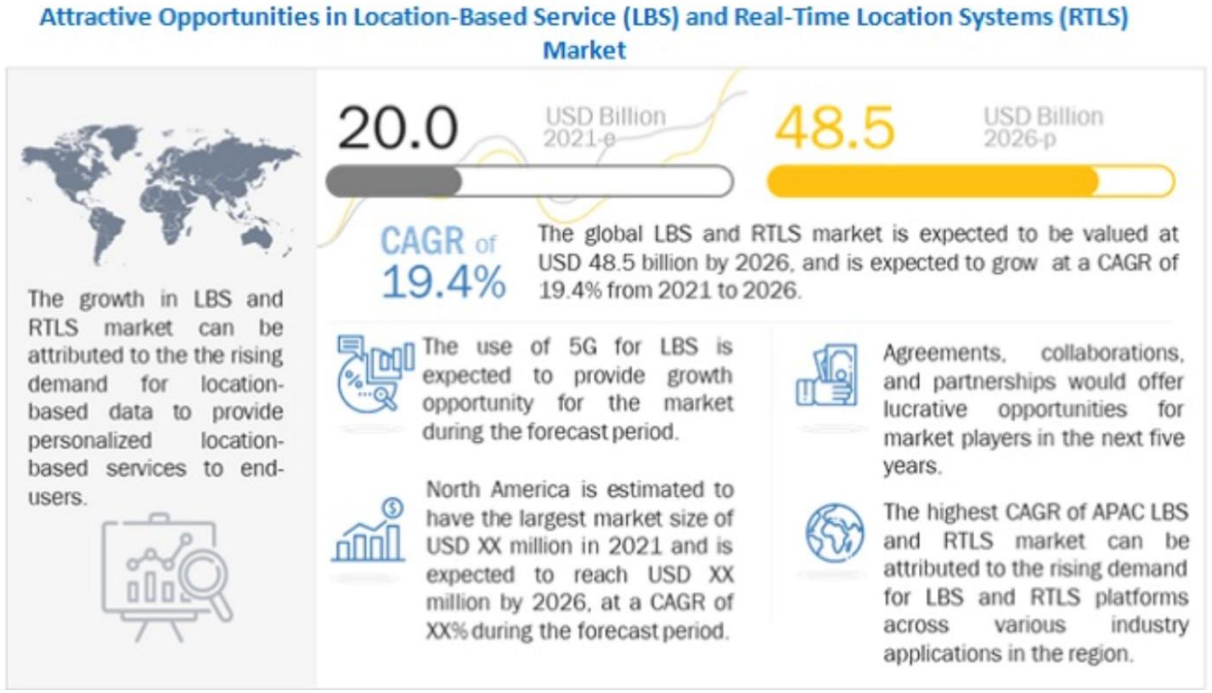
Background

Context-awareness is essential for a variety of existing and emerging applications

Context depends on location information of people and things

Rising need of predictive analytics for businesses and growing use of location-based applications

Network management, risk management, emergency response, customer experience management, remote monitoring, supply chain planning and optimization, etc.



https://www.marketsandmarkets.com/Market-Reports/location-based-service-market-96994431.html

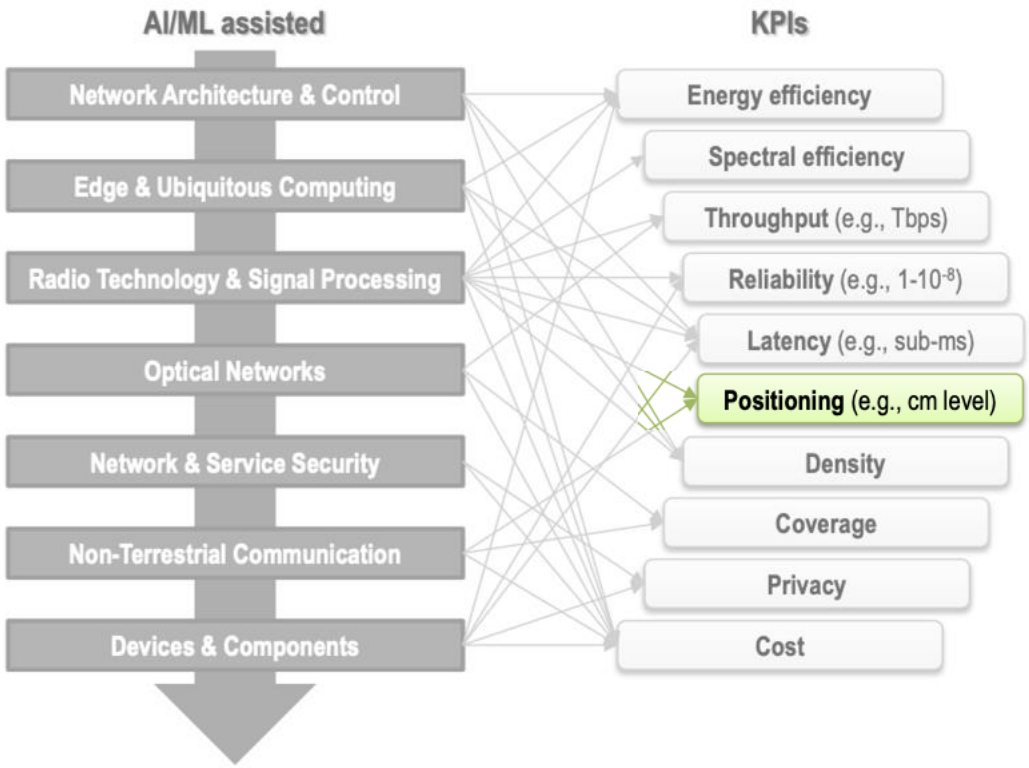
Background: Beyond 5G

Further recent confirmation from 5G-PPP (and 6G-IA)

- 5G IA “Vision and Societal Challenges Work Group” White Paper on: ‘European Vision for the 6G Network Ecosystem’. https://5g-ppp.eu/wp-content/uploads/2021/06/WhitePaper-6G-Europe.pdf

Sign of market needs

- Deployment of small base stations that create very small cells, e.g. in the vicinity of a shop, where there is already a good cellular coverage, with the sole purpose of identifying users and locating them
- Such base stations only require a power plug and provide connectivity to users by connecting themselves to available co-located cellular cells



https://5g-ppp.eu/wp-content/uploads/2021/06/WhitePaper-6G-Europe.pdf

Motivation

However

- current navigation satellite systems work accurately only outdoor
- 4G cellular systems fail to provide high-accuracy (and indoor) localization
- other short-range localization technologies (e.g. WiFi) imply high deployment/maintenance/integration costs
- application developers need to master and integrate several heterogeneous and hardly interoperable “add-on” technologies

Motivation

Lack of a reference context **analytics** infrastructure

- stakeholders need to operate on raw spatiotemporal data
  - consequences not only in terms of work, but also in terms of privacy.

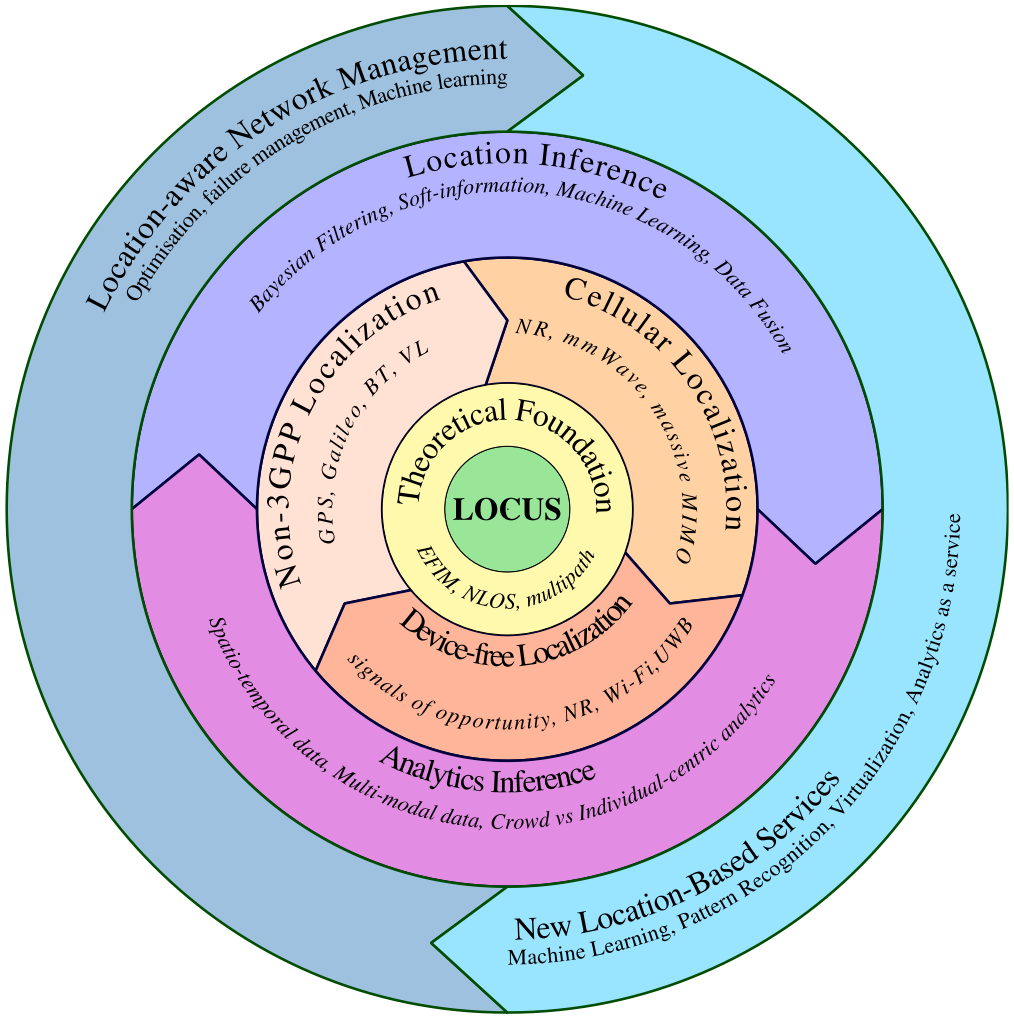
Raw spatiotemporal data should be pre-processed, so as to extract hidden features/behaviours of physical targets to be leveraged for smart service provision

Project concept

Design and develop a location management infrastructure capable of improving localization accuracy and security, and to extend it with physical analytics, and extract value out of it, meanwhile guaranteeing the end users' right to privacy

Make localization and related analytics a first-class citizen in the cellular world: the evolution of 5G, both in the short and in the long term, must address not only communication but also localization functionality

Technical Concept: 7 goals



- System architecture with built-in security and privacy
- 5G Terminal Localization, a cellular-based localization thought of as an evolving functionality in terms of performance
- Integration with non-3GPP localization technologies (GNSS, WIFi, Bluetooth, etc.)
- Device-free localization technologies: solutions to use base stations and other transmitters present in the environment as “illuminators of opportunity” for passive radar, and to localize also passive targets (people and things)
- Analytics, Learning and Inference: analyse the behaviour of devices and targets
- Network management: exploit localization information and advanced data analytics to enhance network management
- Exemplary localization-based services: empower exemplary services

Scenarios and Proofs of Concept

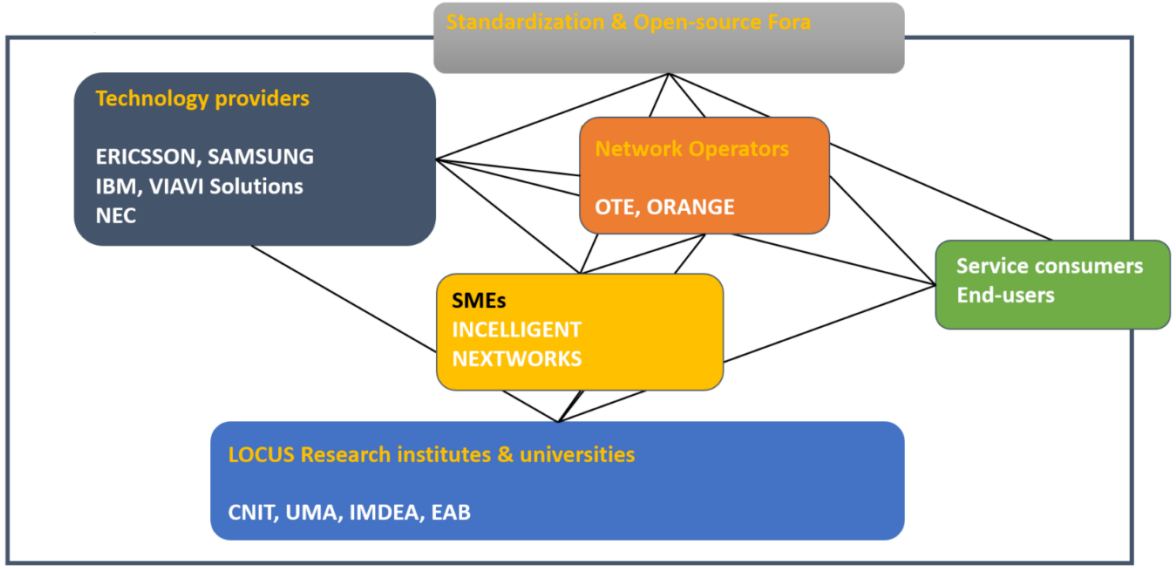
Smart network management based on 5G equipment localization

Network-assisted self-driving objects

People mobility & flow monitoring

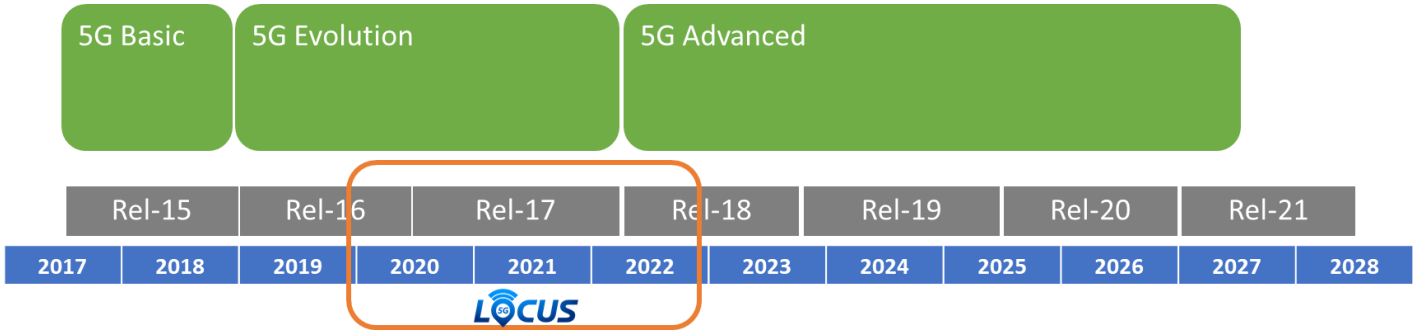
LOCUS Stakeholders

- Technology providers: products in the new segments defined by LOCUS and incorporating LOCUS concepts
- Network operators: enhanced network planning and operations, maximization of network utilization, reduction of operational expense and enhancement of service portfolio
- Research institutes and universities: research themes and background, consultancies, as well as spin-off business initiatives
- Standardization fora: project findings for standardization to be exploited and adopted in all standard-based devices and networks globally
- Open-Source fora: exploitation of the software and algorithms development within the project
- Service consumers/end-users many use-cases identified within LOCUS including smart retail, autonomous vehicles, smart manufacturing, logistics, etc.



Feasibility and Impact

- Freedom to act on the cellular system specification and availability of software network paradigms make it possible to radically improve the future 5G network by endowing it with on-demand localization and dedicated analytics



Some basic positioning support based on LTE reference signals became supported in New Radio (NR) Rel-15, however the main 5G positioning was introduced in Rel-16 and enhanced in Rel-17. The 5G RAN standardization time plan is in line with the duration of LOCUS project

- The timeliness with respect to the 3GPP standardization work for 5G localization, together with the participation of partners directly involved in such standardization process, eases the exploitation of LOCUS results within the 3GPP

Feasibility and Impact

Enabler of new/improved applications for the 5G ecosystem, boosting EU vertical industries, e.g. smart manufacturing, automotive and V2X, logistics, smart retail, etc.

The LOCUS platform can offer **service providers and telco operators** innovative, complementary and added-value localization and analytics services

Automated deployment of localization and analytics services to ease the management of exposure of high-level and easy-to-consume localization and analytics services and data outputs, which hides to the service consumer the complexity of data management, processing and pipelines

LOCUS: Overview of the Main Results

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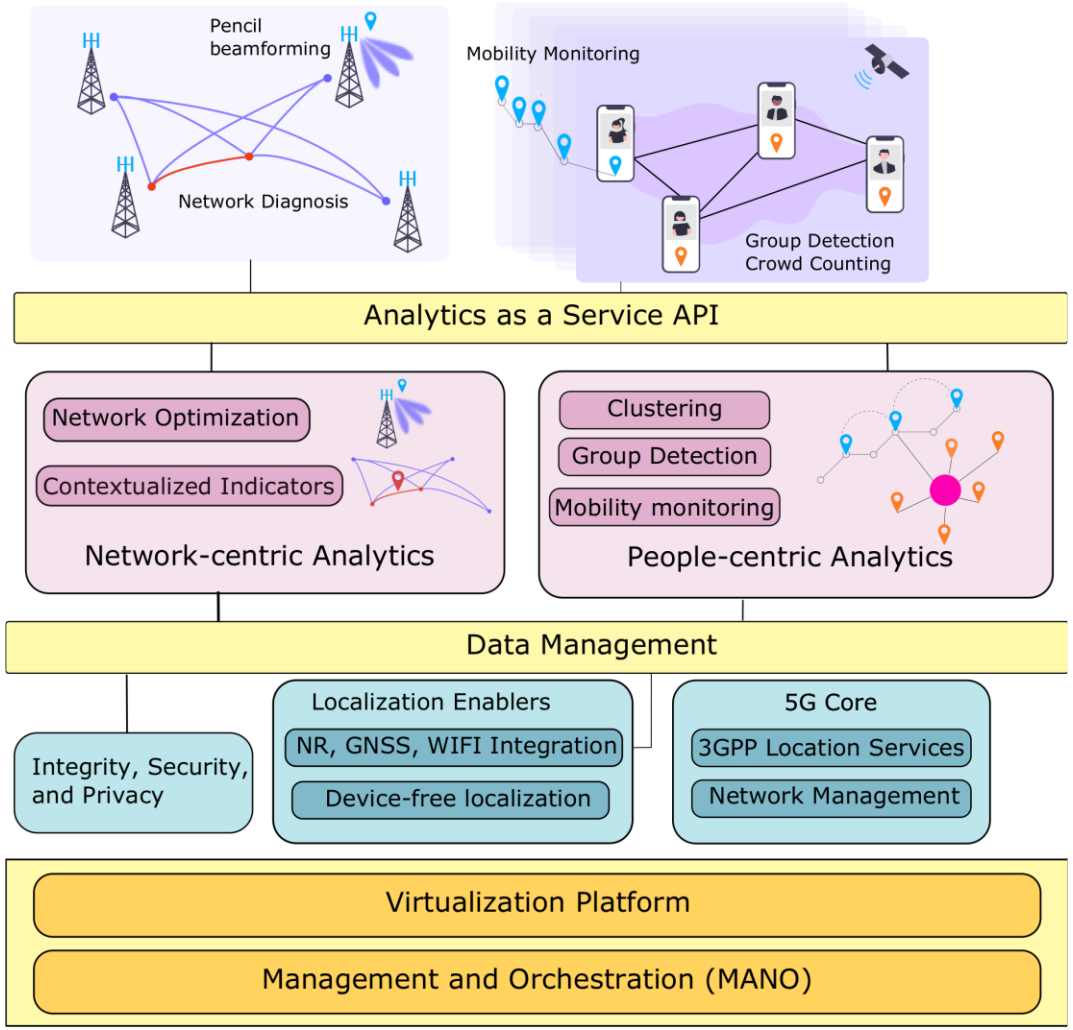
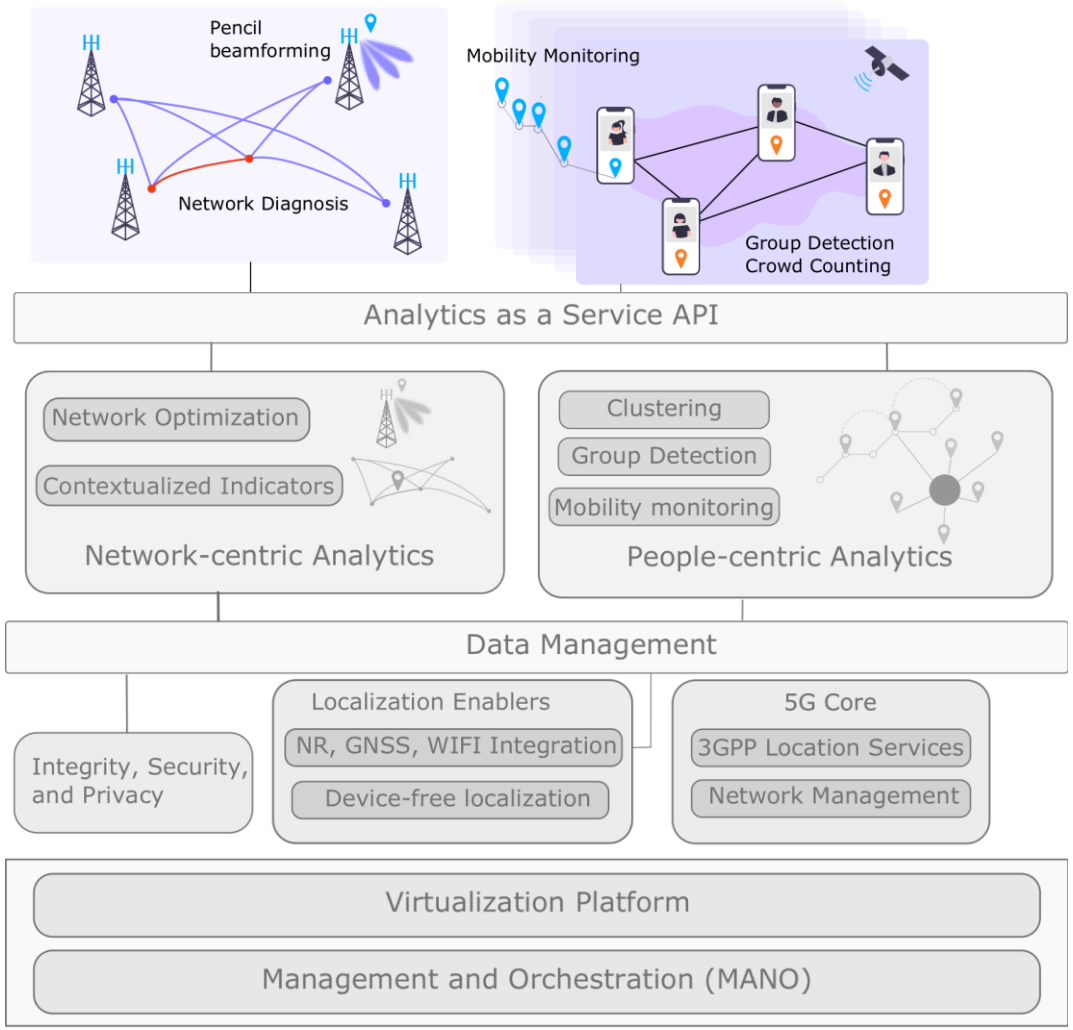
Technical Concept: 7 goals

1. System architecture with built-in security and privacy
2. 5G Terminal Localization, a cellular-based localization thought of as an evolving functionality in terms of performance
3. Integration with non-3GPP localization technologies (GNSS, WIFi, Bluetooth, etc.)
4. Device-free localization technologies
5. Analytics, Learning and Inference: analyse the behaviour of devices and targets
6. Network management: exploit localization information and advanced data analytics to enhance network management
7. Empower exemplary localization-based services



Scenarios, Use Cases, and Requirements



Definition of a large set of LOCUS use cases

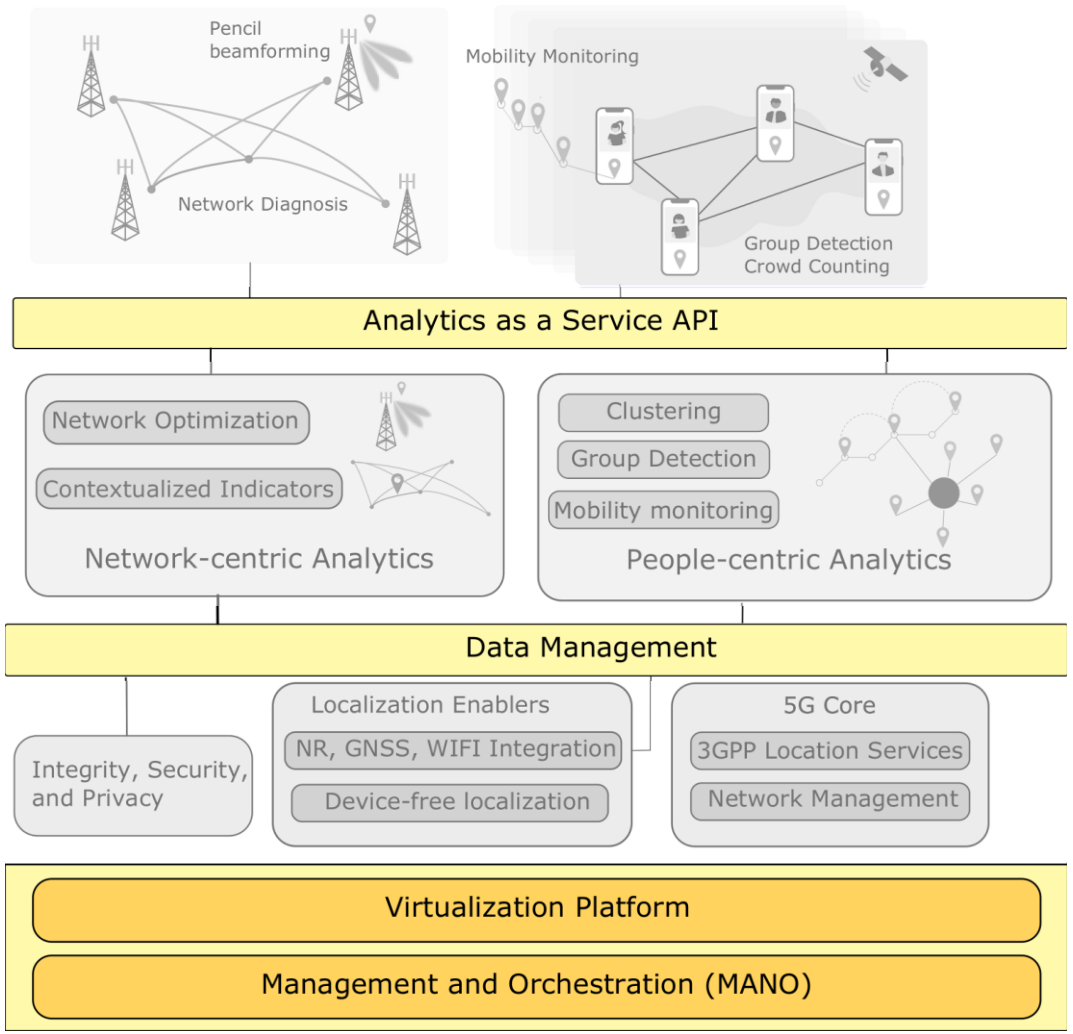
Analysis of the end-users demands and requirements in terms of positioning accuracy, availability and privacy matters

A subset of use cases has been selected for implementation and proof-of-concept

Scenarios, Use Cases, and Requirements

Location Security and Privacy	Localization Enablers	Localization and Analytics for Smart Network Management	Localization and Analytics for New Services
LSP-UC1 Location Security UC	**LEN-UC1** 3D Indoor Localisation for Emergency Services	**SNM-UC1** Knowledge building for smart network management	**NSE-UC1** Flow Monitoring and Management in Large Venues and Dense Urban Environments
LSP-UC2 Location Privacy UC	**LEN-UC2** Positioning and Flow Monitoring in Large Venues and Dense Urban Environments	**SNM-UC2** Location aware network planning in 5G	**NSE-UC2** Crowd mobility analytics using mobile sensing and auxiliary sensors
	LEN-UC3 High accuracy indoor positioning for industrial IoT	**SNM-UC3** Location aware network optimization in 5G	**NSE-UC3** Vulnerable Road User
	LEN-UC4 Localization and Network Management for Education	**SNM-UC4** Location aware network resilience in 5G.	**NSE-UC4** Logistics in a seaport terminal using AGVs
	LEN-UC5 Device-free Localization		**NSE-UC5** Transportation optimization based on identification of traffic profiles
			NSE-UC6 Positioning and Flow Monitoring for Controlling COVID-19

Architecture and LOCUS Platform



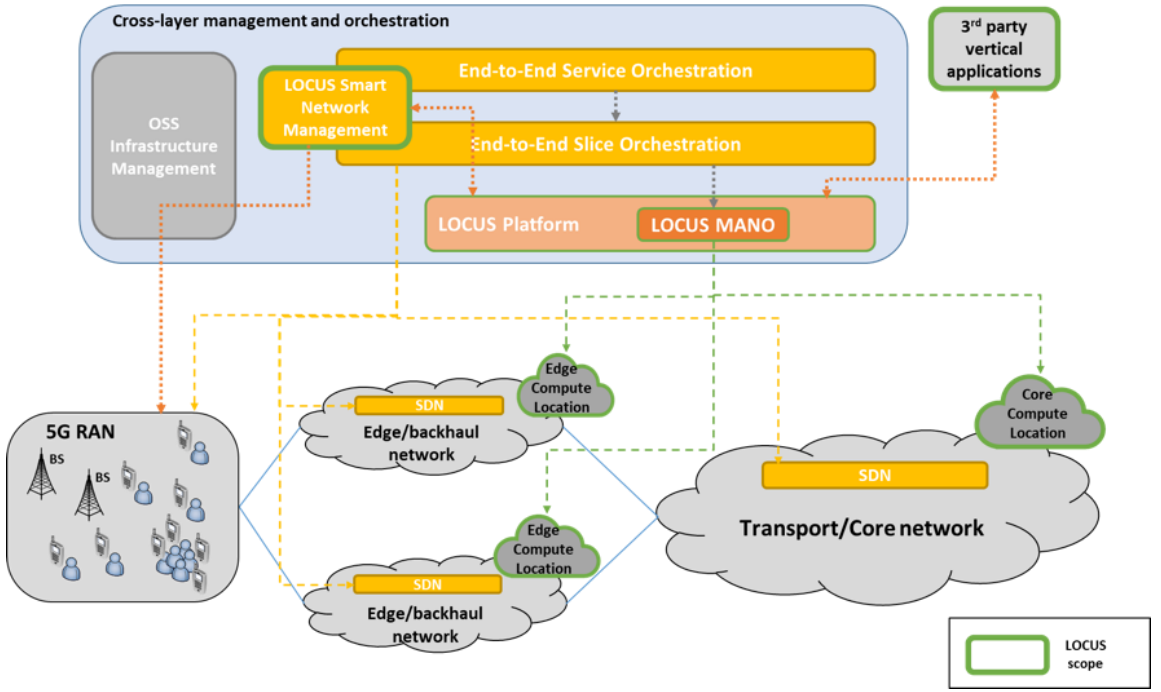
- Development of a unified and generalized localization analytics platform relying on built-in data analysis, correlation, ML/AI capabilities.
- The architecture of LOCUS is based on the use cases and their **high-level, system-level, and security and privacy** requirements
- Finalization of the functional architecture, together with the description of all functions and components of the LOCUS Platform

LOCUS Virtualization Platform and MANO

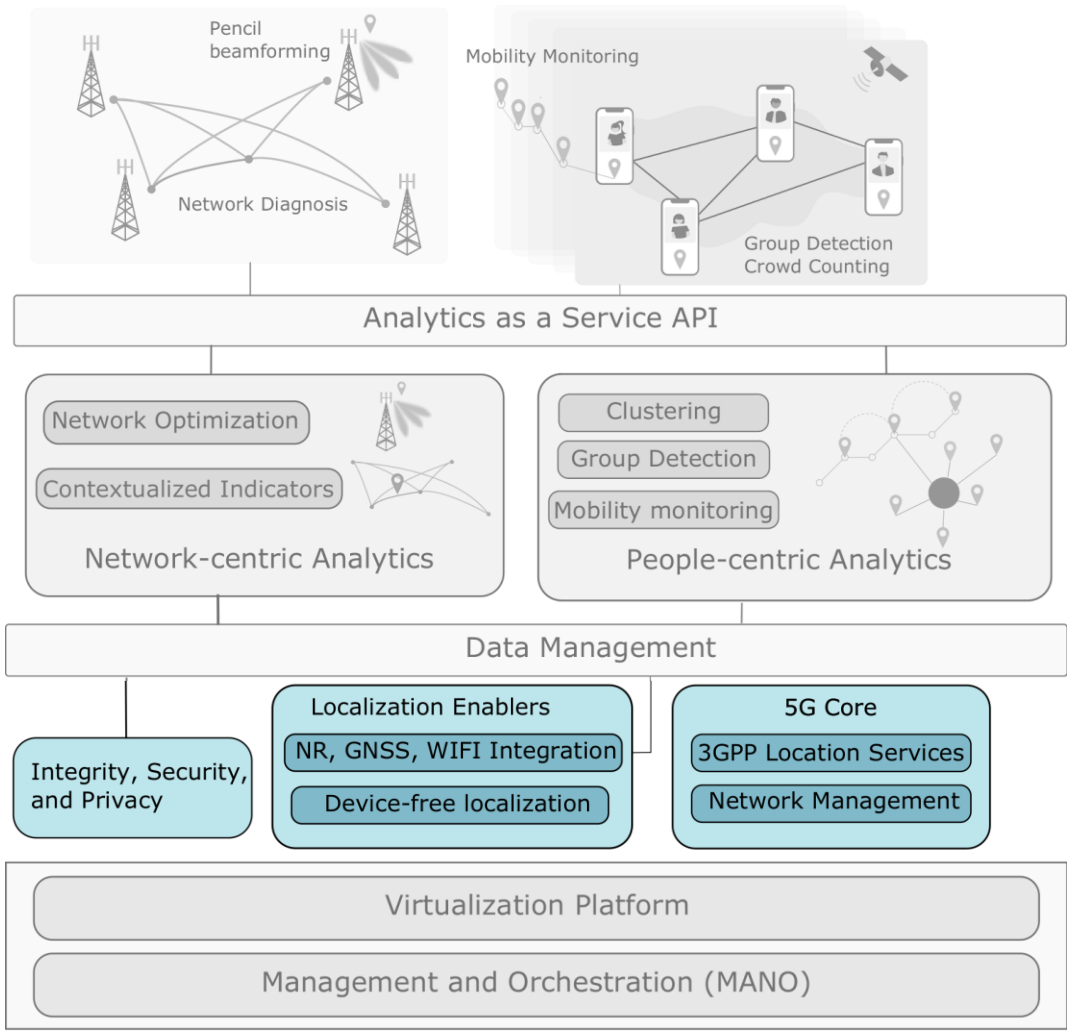
A hybrid virtualization platform that integrates different technologies and solutions to distribute the LOCUS virtual functions across edge and core computing locations within the 5G end-to-end infrastructures

Full automation capabilities through LOCUS Management and Orchestration (MANO)

Developed a preliminary software prototype, which combines an initial version of the LOCUS MANO with a small-scale virtualization platform

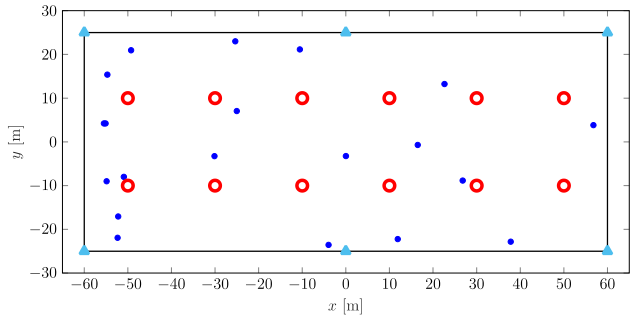


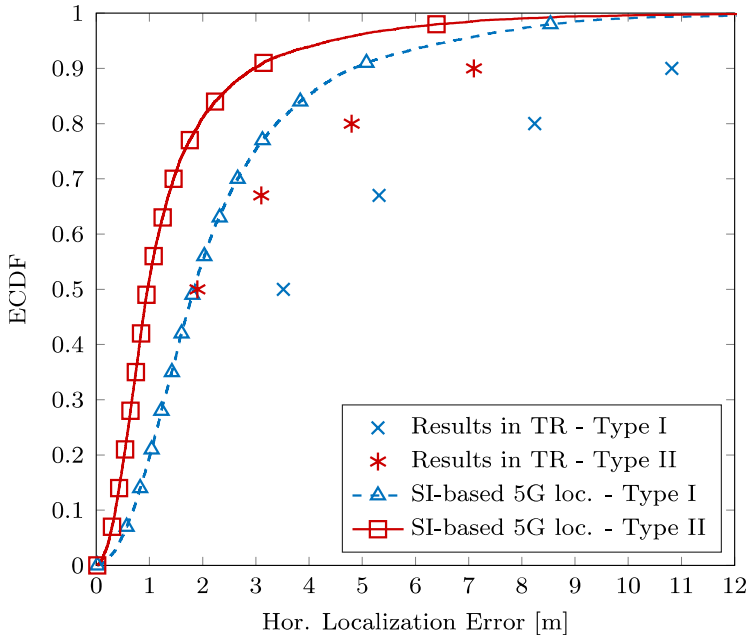
Localization Enablers



- Development of innovative signal processing techniques for enhanced 5G localization
- Exploiting heterogeneous technologies such as multi-RAT, multi-carrier, multi-connectivity and mmWave to be integrated within the LOCUS platform
- Analysis and design of device-free localization systems
- Location security and privacy

Localization Enablers

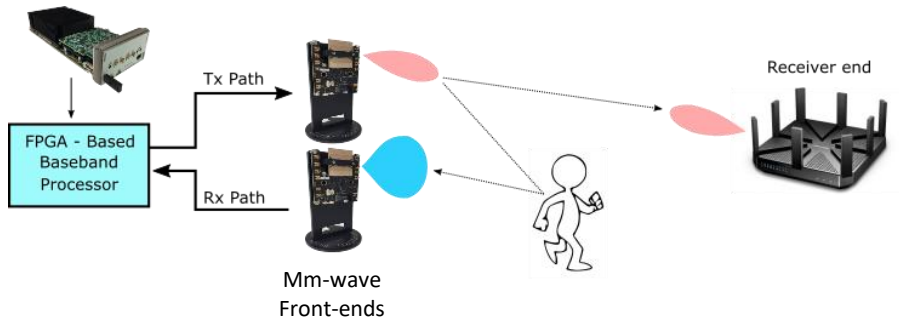


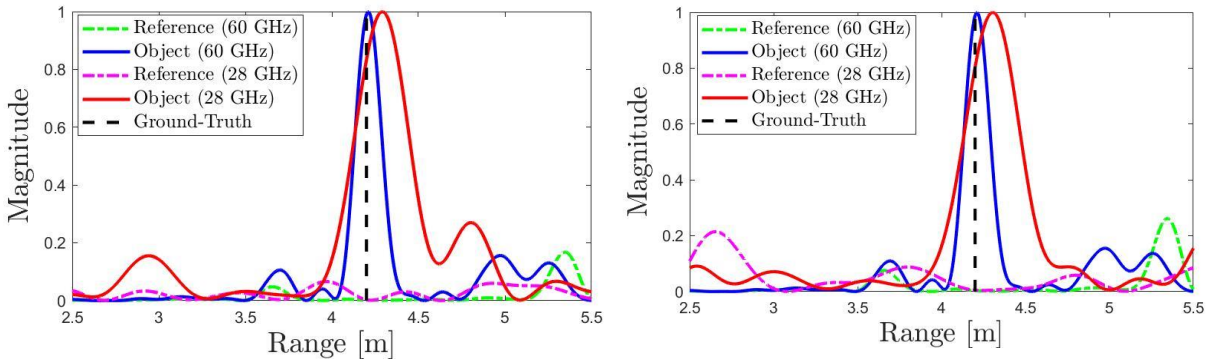


- Signal processing for enhanced 5G localization
- Integration of heterogeneous technologies: multi-RAT, multi-carrier, multi-connectivity and mmWave

Device-free Localization

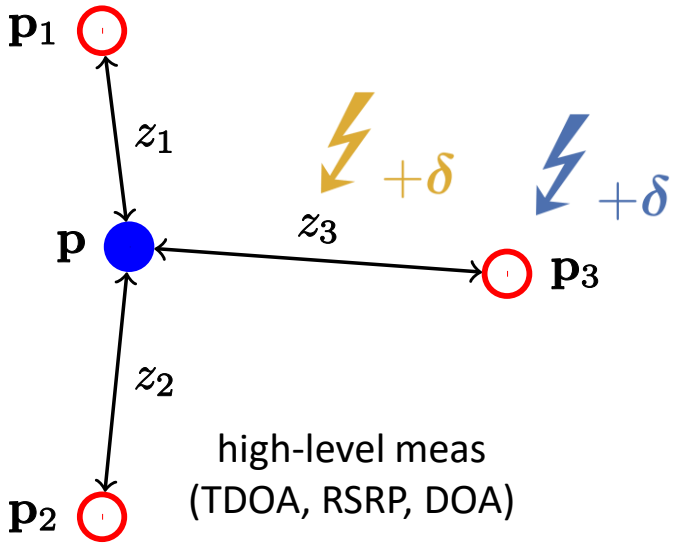
- Research spanning from fundamental limits to signal processing techniques and on-going experimentations with both millimetre-wave (mm-Wave) and ultra-wideband (UWB) sensor radar networks (SRNs)
- **Joint Radar and Communication:** Reuse reflections of data communication signals for radar operation
- **mmWave measurements campaign (Samsung)** investigate the concept of device-free localizatic through the backscattering from an illuminated passive object - vehicle



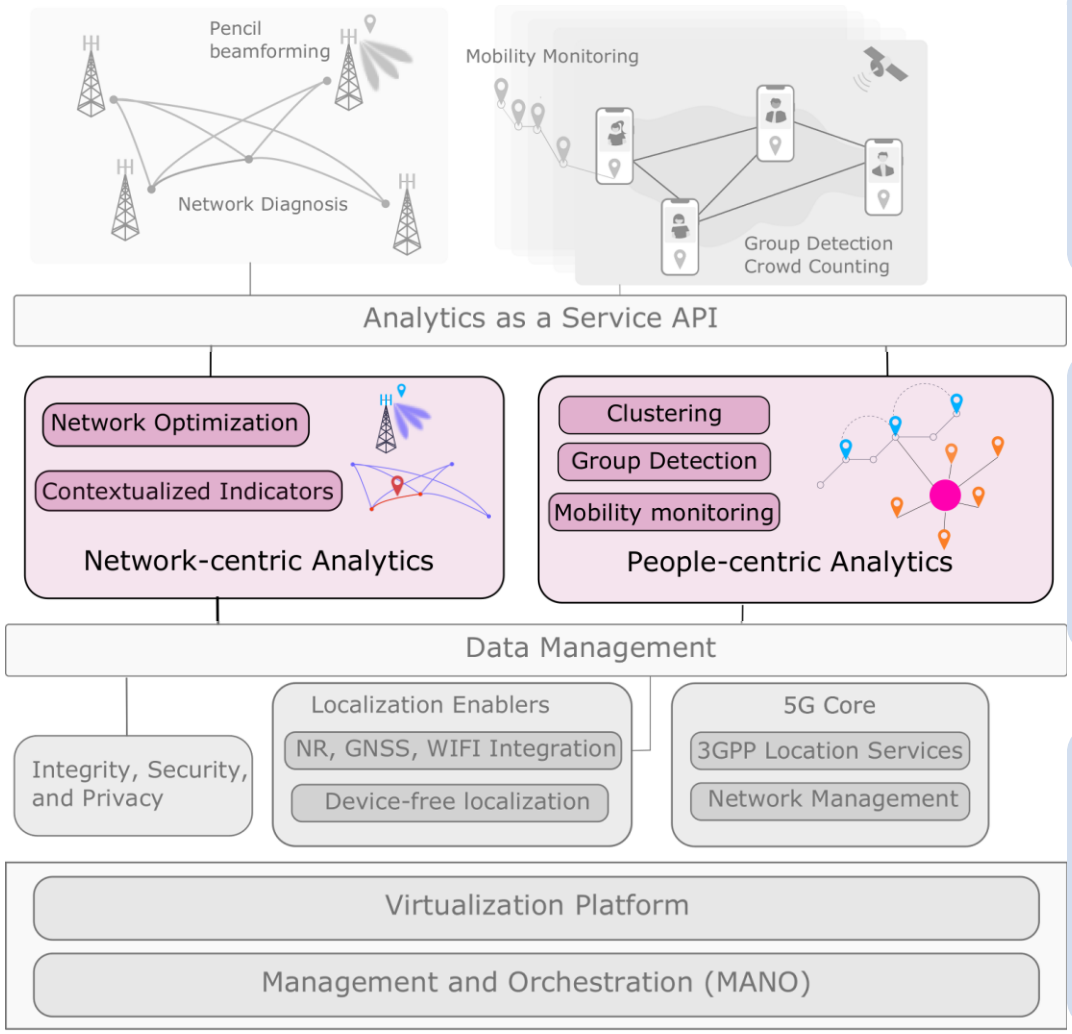


Location Privacy and Security

- Location Privacy
  - attacker should not be able to
  - **Determine who I am**
    by gathering my persistent identity (IMSI/SUPI)
  - **Track my movements**
    by tracking users despite temporary/anonymized IDs
- Location Security
  - attacker should not be able to
    make me believe to be in a different position
  - E.g. «move» me, change direction of arrival, etc
- Privacy in Location-based Services
  - **Control personal data disclosure**
    in applications and services



Network-centric and People-centric Analytics



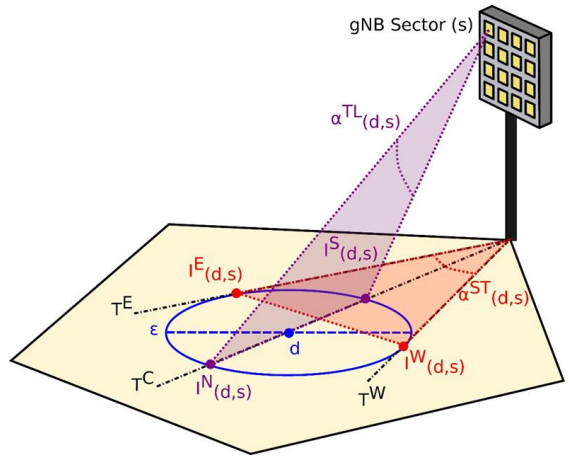
The multi-layer and flexible architecture extends the 5G network functions to interface with location data and provide location-based analytics

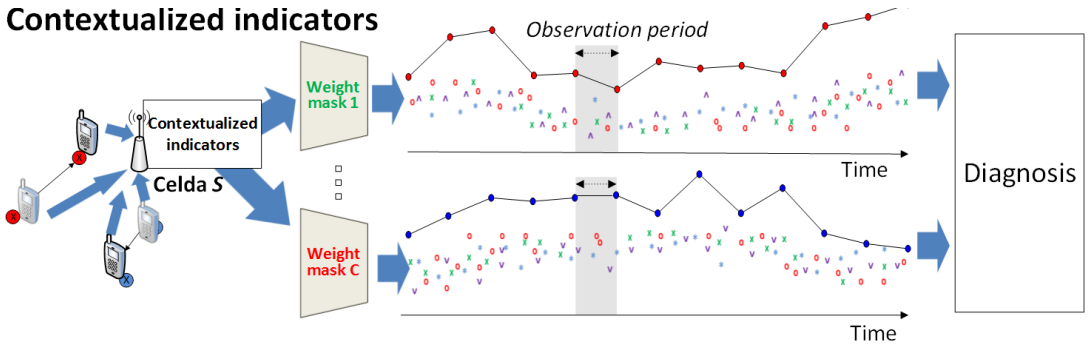
Location-based analytics rely on complex features and mobility patterns extracted from raw location-related data inherent in physical and network events.

People-centric (smart cities and transportation) and Network-centric (network planning, fault detection) analytics

Location-based Network Management

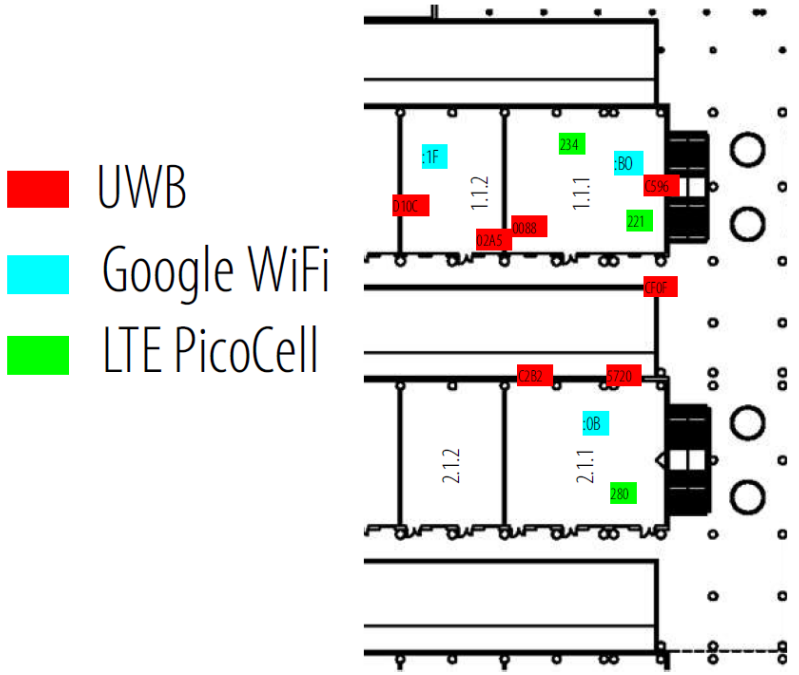
- Localization-enhanced Pencil Beamforming for lower EMF and better QoS.
- Location-Awareness for Failure Management
- D2D-based QoS prediction analysis in beyond 5G V2X
- Location-aware Wireless Resource Allocation in Industrial-like Environment





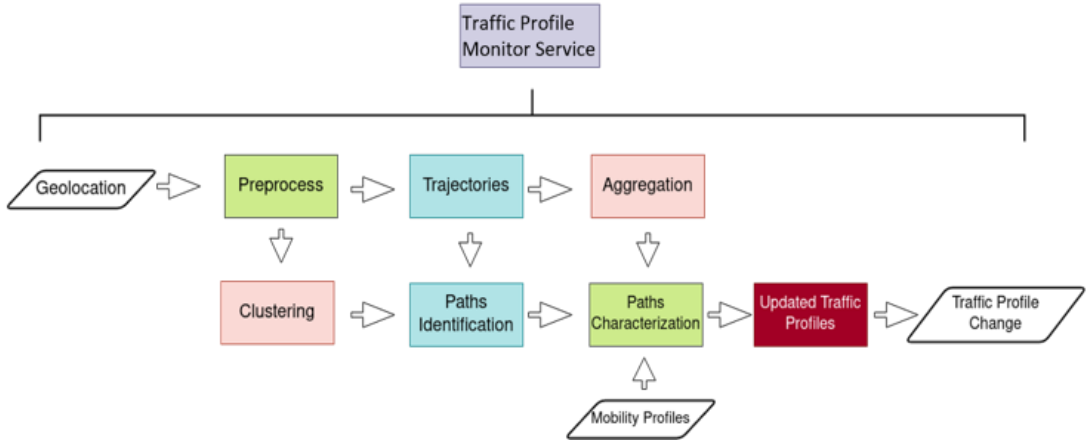
Proof-of-Concept: Network Management based on Location Information

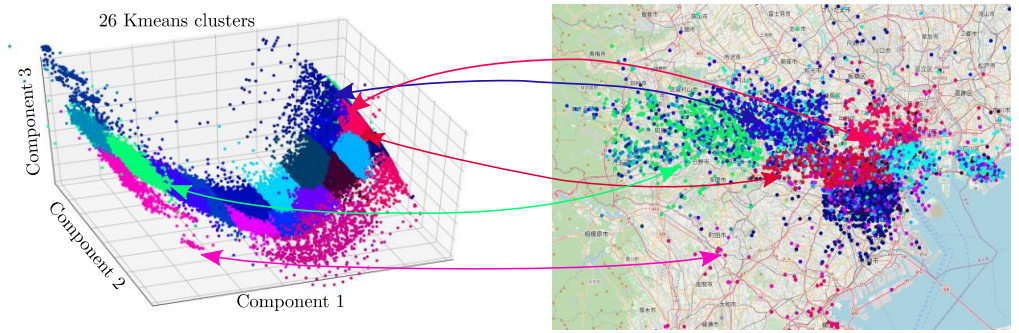
- Localization and network management for education: Virtual Reality (VR) and Augmented Reality (AR), which have stringent location accuracy and latency requirements
- Integration of the OTE cloud infrastructure with the physical deployment site of an LTE network and WiFi/UWB technologies provided by the University of Málaga
- Network optimization and failure management



User-centric Analytics

- Development of techniques for location-based analytics, using ML and neural networks
- User-centric analytics: group detection, mobility monitoring
- Validation using open data sets; validation using real data is planned for the PoC





User-centric Analytics

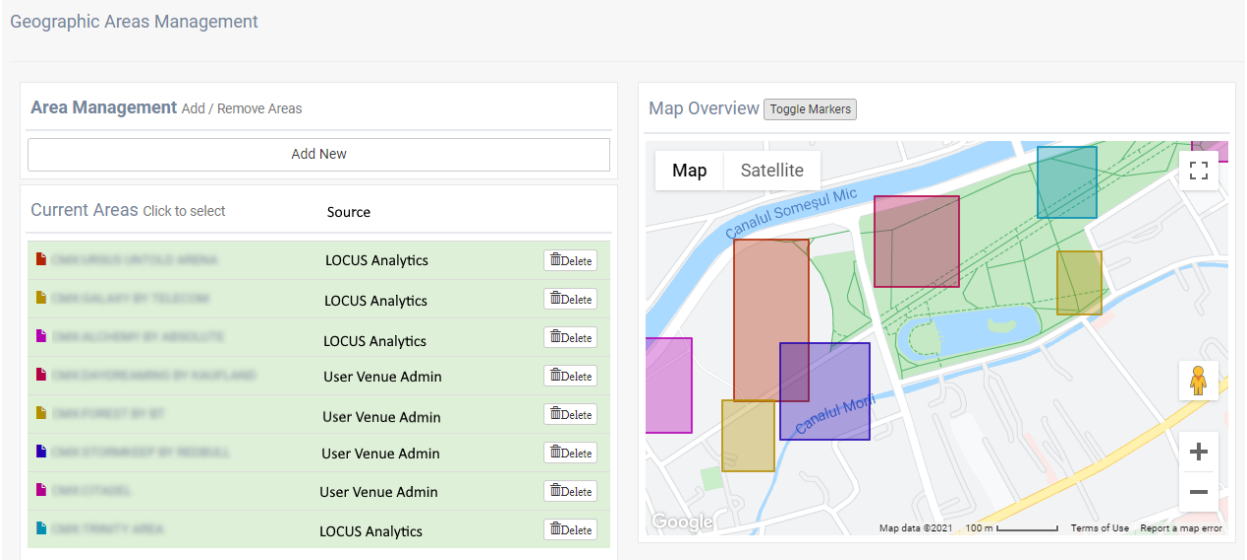
Design and implementation of a high performance navigation system for automated guided vehicles (AGVs) in a seaport terminal

The real time position data of the AGVs collected at regular intervals, map of the shuttling area

The AGV can be simulated into the area, and it is possible to see in real time the trajectory of the AGV guided using the 5G positioning system and the optimal planned trajectory. The VR environment can be explored with a VR helmet.

Proof-of-Concept: Flow tracking for smart retail and venue management

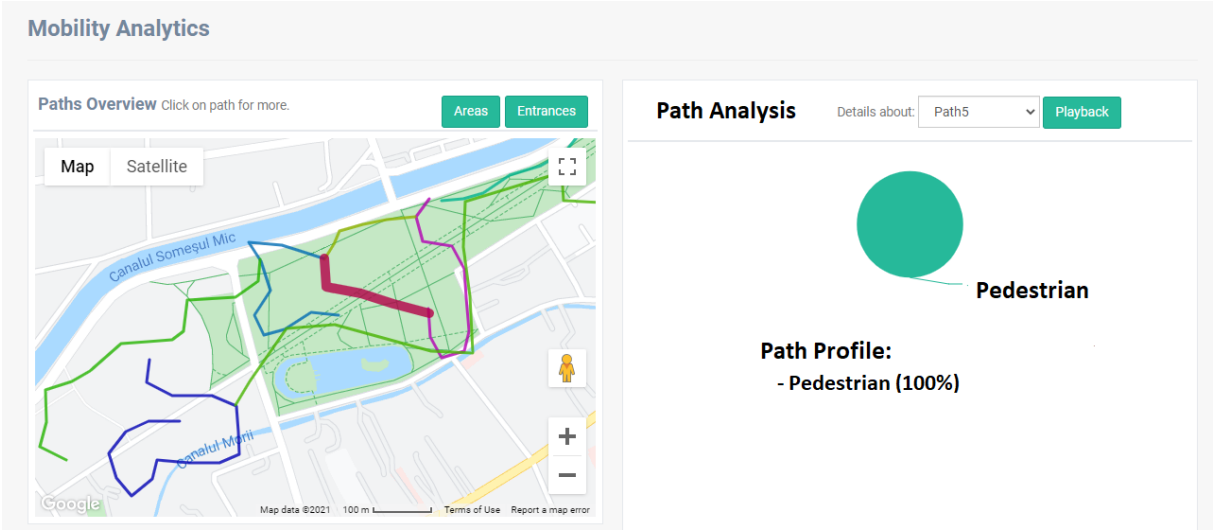
- Interactive user interface consuming the outputs of the LOCUS platform services: selected map area, including the “POIs” that have been identified by the LOCUS analytics function.



- The user (smart venue admin) will be also able to define his own POIs and see the analytics of user data (i.e., footfall, average duration, density, etc.) for all the system areas.

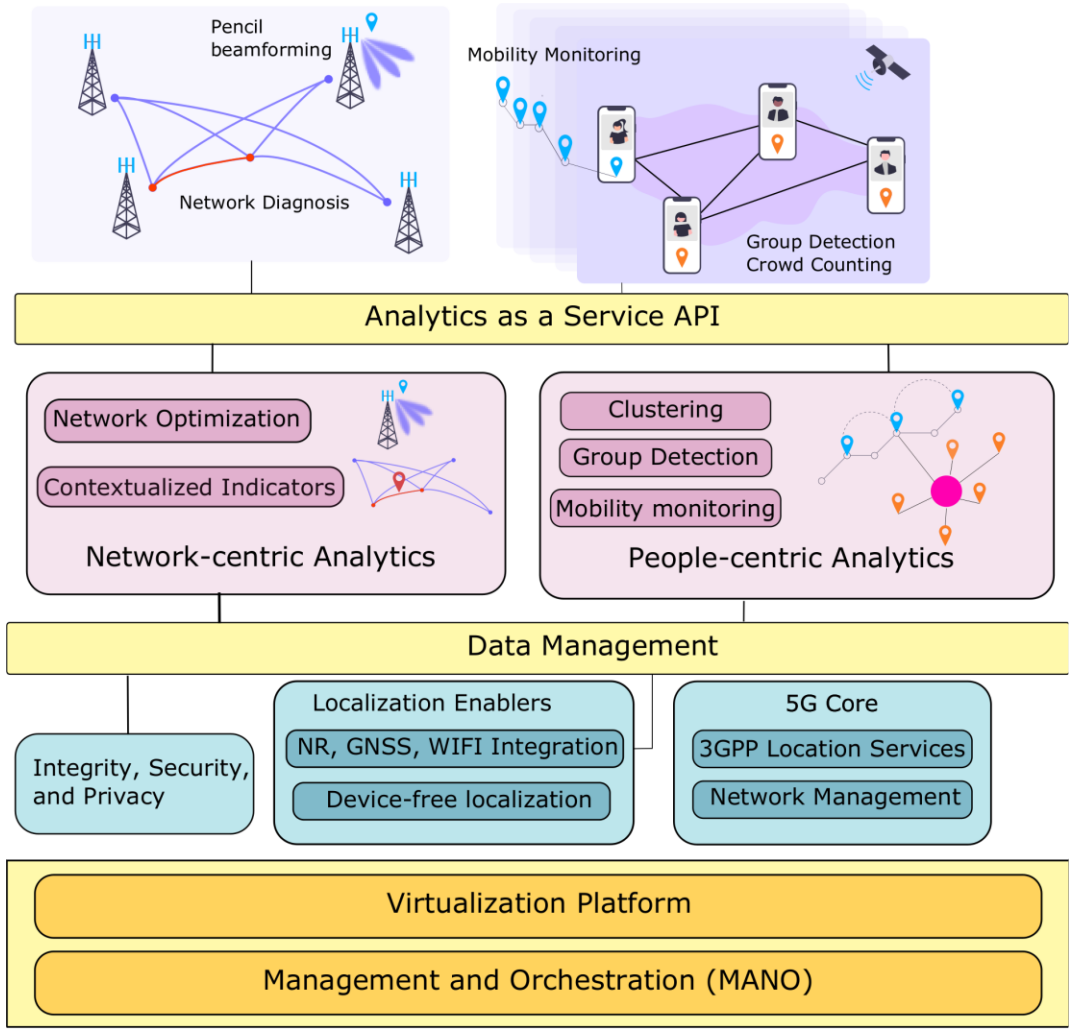
Proof-of-Concept: Crowd mobility analytics using wireless and auxiliary sensors

- Interactive user interface consuming the outputs of the LOCUS platform services: selected map area, including the various “paths” that have been identified by the LOCUS analytics functions.



- In addition, continuous polling of the REST API will provide the transportation profiles of each path. This can be used to detect changes in the status of these paths that can possible be caused by an incident, such as an accident or traffic jam which in turn will require an action by the system operator

Conclusion



LOCUS defines a new system architecture for the provision of location-based analytics as a service

Such architecture will enable a plethora of new people-centric and network-centric applications for 5G verticals

The proposed system architecture is an augmentation of the 5G architecture, where network and user data from heterogeneous technologies are combined to extract on-demand analytics

The ready-to-use localization analytics can serve third party applications and can be used to optimize the network performance.

Example PoC for use cases involving people grouping, mobility clustering, network optimization, as well as network diagnosis are under test, showing the effectiveness of the proposed architecture.

Social Media

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Thank you


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