DESIRE6G

Promoting the 6G vision, the DESIRE6G project will design and develop a novel zero-touch control, management, and orchestration platform, with native integration of AI, to support verticals with extreme requirements.

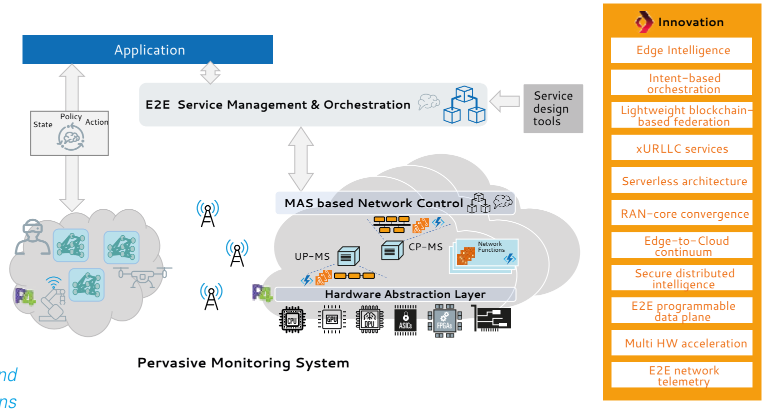
DESIRE6G supports verticals with extreme requirements (e.g., eXtreme URLLC services) over a performant, measurable and programmable data plane. From zero power to extreme low latency or ultra-high reliability: the 6G system should not limit our future use cases, yet it should be simpler and more autonomous than the previous generation. The two key components that will allow us to achieve these goals are the following: 1. A lightweight centralised Service Management and Orchestration (SMO) layer, with distributed and coordinated intelligent control employing Multi-Agent Systems (MAS). This functional split promotes service assurance by enabling faster control loops, ensuring the scalability of the system as its self- operation* relies mainly on the autonomous coordinated operation of the agents. 2. An end-to-end programmable user plane supporting multitenancy, using a hardware abstraction layer to interact with the heterogenous devices e.g., GPUs, Tensor Processing Units (TPUs), Field Programmable Gate Arrays (FPGAs), System-on-a-Chip (SoCs). This will facilitate increased flexibility in function placement and offloading while using simple and abstract control plane APIs. It will also enable simpler customisation of end-to-end network behaviour without sacrificing performance and power efficiency.

SYSTEM ARCHITECTURE

As illustrated in the figure next page, the ***E2E SMO*** Layer oversees all orchestration and lifecycle management aspects, generating the needed guidelines for the agents, allowing the desired degree of freedom for their autonomous operation. The Intent-Based Networking (IBN) approach starts with the ***Service Design Tools*** defining the service and the Intent in terms of policy rules that guide the service behaviour e.g., goals related to quality of service, performance etc. By natively accommodating distributed network intelligence closer to the user plane through ***MAS-based Network Control***, we expect fast and coordinated decision-making across the Far Edge, Edge, Transport, and Core domains.

Because of the envisaged distribution of intelligence, DESIRE6G leverages DLT as a basis for securing agent interactions (*Secure Distributed Intelligence*). Specifically, an infrastructure-agnostic software security DLT-powered framework is introduced that combines automatic security enforcement by binary rewriting and the needed trustworthiness and traceability brought by the DLT structure. To support the seamless execution of services across multiple, heterogeneous administrative domains (e.g., Public Network Integrated Non-Public Network deployment), DESIRE6G will employ *Lightweight blockchain-based federation* at the SMO level.

At the data plane, the DESIRE6G cloud-native mobile network promotes *RAN-core convergence* for 6G. Furthermore, by investigating the *Serverless* approach for network and application-specific function deployment, we aim to take advantage of their programming simplicity and automatic scaling and operation migration capabilities across the *Edge-to-Cloud continuum*.



System architecture and key innovations

Deep Programmability and Secure Distributed Intelligence for Real-Time E2E 6G Networks

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DESIRE6G will further provide the architectural elements and APIs to support the seamless offloading of network functions and application computations to the network. To unify application/network function (e.g., AI/ML processing, RAN network functions, real-time computations) development and deployment on heterogeneous systems a ***Hardware Abstraction Layer*** will be defined. In this context, we introduce "in-network computing as a service", where application developers, Over-The-Top (OTT) service providers etc., will be able to benefit from in-network acceleration and optimisation without the need of domain specific knowledge. Furthermore, by promoting multi-tenancy in the E2E programmable data plane, DESIRE6G promotes deep slicing, allowing slice-specific protocol stacks utilising multi-HW accelerators over the shared infrastructure. On a per-service basis, this can be the market differentiator, enabling novel application-network interactions and enhanced performance.

The system architecture will be complemented by a ***Pervasive Monitoring System*** to support the DESIRE6G architecture. The data plane will be observable and measurable from the user terminals to the cloud, leveraging on E2E in-band *network telemetry* solutions, providing high accuracy and sub-ms granularity. Telemetry data will feed AI/ML algorithms for training, inference and detection or forecasting of anomalies and performance degradations, which will make the data plane highly predictable and reliable. Finally, DESIRE6G will employ distributed, privacy preserving AI/ML approaches, while considering application-level requirements, communication, and compute resource constraints to further support *Edge Intelligence*. For this purpose, a spectrum of AI/ML techniques ranging from federated and collaborative learning will be investigated covering both theoretical and practical aspects. Moreover, data scrambling and normalisation techniques, stemming from privacy preserving image processing, will be exploited to provide third-party intelligent algorithms with required data while preserving confidentiality and privacy.

USE CASES

The developed solutions will be demonstrated and tested through experiments in laboratory environments, and larger field evaluations utilising diverse trialling facilities, namely the 5TONIC laboratory (https://www.5tonic.org) in Spain and the ARNO testbed (http://arnotestbed.santannapisa.it) in Italy. DESIRE6G focuses on two representative 6G use cases: augmented/virtual reality and digital twin industrial applications, targeting extreme key performance indicators. In the context of a factory maintenance application, multiple video streams rendered by UAVs will be merged/processed and delivered to the AR/VR headset, which will allow for tilt and pan of the virtual landscape to be controlled by the maintenance operator's head movements. In the context of industrial robotics applications, the operational factory floor digital twin involving (i) the remote control of a robotic arm and (ii) autonomous navigation and control of a robot dog using Simultaneous Localisation and Mapping (SLAM) algorithms.