Coupling the benefits of cloud and edge computing

Abstract

Edge computing allows data produced by Internet of Things (IoT) devices to be processed closer to where they are created instead of sending them across long routes to data centres or clouds. Doing this computing closer to the edge of the networks enables organisations to run near-real time analysis of important data, a need across organisations on many domains. The disruptive potential of edge computing is fuelled by the unprecedent growth of data, the imminent impact of 5th Generation (5G) networks and the growing importance of latency in modern applications. When specialised and expensive solutions are preferred over generic edge computing or cloud infrastructures, it creates additional costs or excludes a wide set of SMEs from being competitive or even operational.

Furthermore, it is clear that current approaches on edge computing are not sufficient to address this forthcoming massive usage of edge computing, especially in the frame of large IoT deployments in smart cities and industrial applications. The massive data generated by new modalities are soon expected to account for an increasing portion of edge computing processing. The main goal in such scenarios is to ensure that the overall offered Quality of Service (QoS) fits the application needs over the edge or edge/cloud deployment. Speed and latency issues have been identified as the top barrier in this domain, while cost and reliability (meeting the provider Service Level Agreements (SLAs)) are the top and second most important factors for evaluating edge and cloud services. Furthermore, achieving trust in such large scale IoT deployments is another crucial area of interest. With the recent introduction of blockchains as an enabling technology for distributed and peer-to-peer (P2P) systems, it comes as a challenge to check whether modern edge computing approaches are suitable for being coupled with emerging decentralised applications built on blockchains. A distributed trust technology, ensuring scalability, privacy, and reliability, is a cornerstone for the growth of IoT and edge computing environments.

PLEDGER introduces necessary improvements across the Adopter-Provider value chain by following a black box approach in order to adapt to the specifics of the ecosystem and the corresponding lack of knowledge. Thus, the proposed approach does not assume any kind of interaction between the two main roles, but all the necessary information is extracted via non-intrusive methods, abiding to this role separation imposed by the cloud business model.

In this sense, PLEDGER supports the European organisations in their (digital) transformation process providing a set of tools that combines the low latencies of the edge computing paradigm with the robustness and resilience of traditional cloud computing one, ensuring the highest levels of Quality of Service (QoS) and Quality of Experience (QoE) and securing the approach introducing blockchain technologies. To strengthen trust, PLEDGER also provides a set of benchmarks to allow potential end users to compare the benefits of the proposed solution with other existing applications. Leveraging, in this way, industry technological path.

Keywords

Edge computing, Cloud computing, innovation, security, trust, 5G, offloading, scaling, QoS, QoE

Motivation

In the cloud computing era, anything that can be centralized has been already centralized. This does not mean that cloud market will not continue growing, as there are still many companies in the process of migrating their services to the cloud. It just means that cloud computing is coming near to the users, and this is the rise of edge computing. Compute and analytics have been moved to the edge of the network, near data origin and consumption. And this is the rise of the edge computing era.

PLEDGER delivers a new architectural paradigm that paves the way for next generation edge computing infrastructures, combining edge and cloud benefits. It also allows edge computing users to understand the nature of their applications, research understandable Quality of Service (QoS) metrics and optimize the competitiveness of their infrastructures.

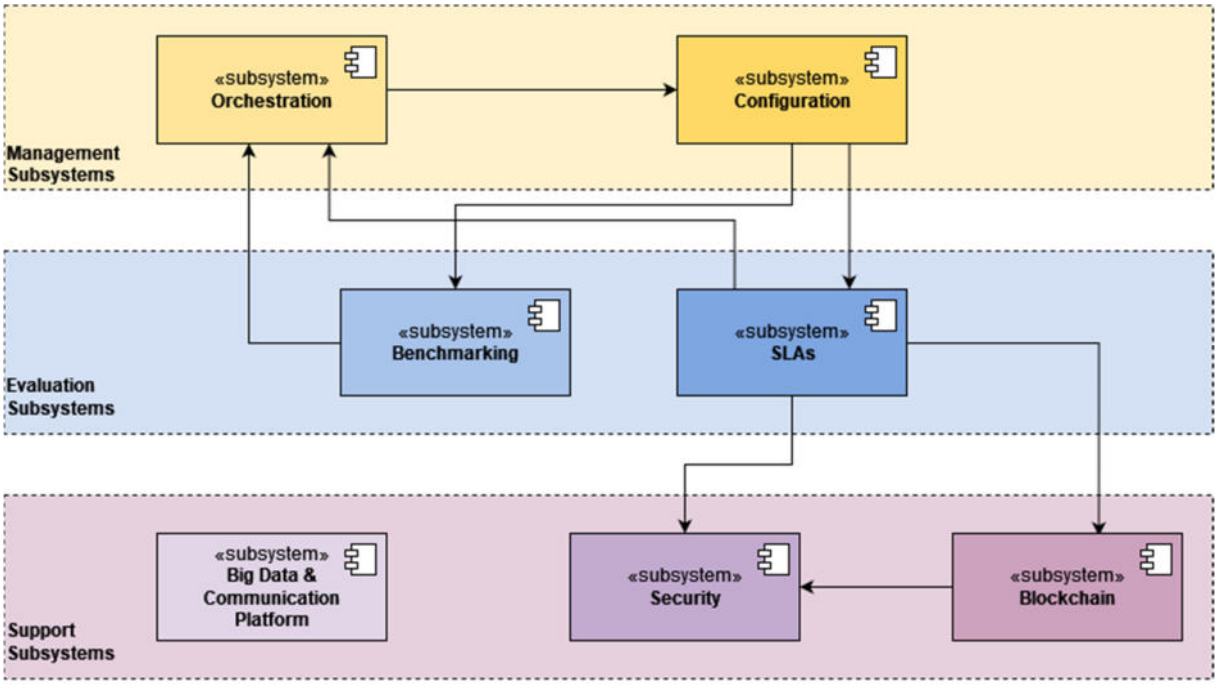
For doing so, PLEDGER provides a set of tools and processes that enables:

- Edge Computing Providers to enhance the stability and performance effectiveness of their edge infrastructures, through modelling the overheads and optimal groupings of concurrently running services, runtime analysis and adaptation.
- Edge Computing Adopters to understand the computational nature of their applications, investigate abstracted and understandable QoS metrics, facilitate trust and smart contracting and identify how they can balance their costs and performance to optimize their competitiveness and monitor their SLAs.
- Other industry verticals to act as independent validators of QoS features in IoT applications, enabling new decentralised applications and business models, thus filling a large gap in the emerging Edge/IoT computing market landscape.

PLEDGER Core Platform

Connectedness has grown up in the last year with the increased usage of smart devices now integrated in citizens daily life. This IoT digital mesh has split traditional edge approaches into three different concepts: near, far and data center edges. The situation is highlighting, even more, the need of improved control and data planes to manage several different resource offloading in multiple ways, and not only on an edge-to-cloud bidirectional approach.

To solve this, PLEDGER proposed an integrated modular reference architecture which covers all needs that may arise.



Far beyond other cloud/edge platforms, PLEDGER provides an additional set of innovations:

- Network slicing in 5G and other networks in order to run them isolately as virtually independent business operations into one physical infrastructure.
- Multi-layer security protection, including blockchain and machine learning algorithms to detect anomalies and priorities risks. Thus, offering privacy, trust and security on edge computing.
- Application performance benchmarking metrics taking into account the variety of edge nodes with different capabilities and available software.
- A smart decision support mechanism for offloading services taking into account different criteria, such as energy, cost, bandwidth, computing requirements and SLA terms among others.
- An auditing mechanism for providers in order to enable compensation claiming in case of agreement violation.
- Secured microtransactions using blockchain mechanisms.
- A smart contract development framework based on previously specified SLA terms.

Conclusions & Recommendations

PLEDGER has finally released its core platform, a full modular stack of cutting-edge tools, technologies and solutions able to solve operational needs along the continuum for a plethora of stakeholders, from application to infrastructure providers.

In order to demonstrate its viability, it has been validated into three real-world use cases representing three different verticals of application:

- Mixed reality applications, where latency and security are the biggest issues. PLEDGER solved them using smart deployment mechanisms as well as handshake blockchain ones without affecting the QoE.
- Vulnerable road user protection in Barcelona city streets, where scooters are continuously moving and there can be connectivity issues. In this case, PLEDGER offered network and computing slicing mechanisms, on top of the core functionalities, to ensure the user is always connected and can receive risk alerts.
- Data mining on manufacturing environments, where it is of paramount importance to secure transactions from the edge up to the cloud and take the best location decision for doing the analysis at the right time. PLEDGER focused here on more horizontal and/or vertical scaling for data placement as well as on securing transactions using blockchain technologies.

PLEDGER toolkits, **service provider**, **infrastructure provider**, **blockchain** and **security**, are fully combinable and can be downloaded and tested from the project public repository.

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Authors

Glossary

Acronym	Description
5G	5th Generation network
IoT	Internet of Things
P2P	Peer-to-Peer
QoE	Quality of Experience
QoS	Quality of Service
SLA	Service Level Agreement
SME	Small Medium Enterprise

About PLEDGER

PLEDGER provides a set of tools, integrated into a modular reference architecture, that can cover specific needs for those companies embedded in a digital transformation process.

Ranging from technical innovation to business growth, PLEDGER provides:

- Means for communicating cloud, edge and IoT layers, covering all potential needs of application providers.
- Reduction of bandwidth and amount of data sent over the network, extending computation closer to things.
- Security and privacy mechanisms all over the value chain.
- Integration with well-known technologies to ensure the maximum uptake.
- More affordable domain agnostic tools for both cloud/edge providers and application providers.

PLEDGER's modular solution allows its integration with other already existing solutions and its deployment in a wide variety of use cases, independently of the vertical domain they applied.