mF2C White Paper

mF2C in a nutshell

The normalization in the usage of cloud-based technologies, together with the expansion of IoT into a digital mesh has completely changed the traditional point of view on cloud computing trends.

Connecting people, devices and services into one single digital ecosystem is a real need for the coming years, and new solutions must be sought to meet user needs in a dynamic way.

In such a competitive business arena, organizational change is inevitable and every day more and more companies from traditional sectors are embracing cloud services as a first step towards full digital transformation.

Lower barriers to enter into new markets, emerging business models and updated socio-economic structures are key factors creating new opportunities for businesses, overcoming obstacles between physical and digital worlds.

In this sense, mF2C supports organizations in their digital transformation solving existing challenges and setting the foundations for fog-to-cloud coordinated management, bridging the gap between cloud and fog paradigms.

This is done through the mF2C framework, which provides a coordinated management of traditional cloud architectures and novel fog ones, offering unique capabilities for distributed execution of applications throughout IoT, fog and cloud environments across a wide variety of industry verticals.

mF2C facilitates the efficient usage of resources within the stack built from the edge up to the cloud, taking into consideration services' requirements (e.g. immediate data collection and processing, low latency) and user demands (e.g. high QoS and high security), proposing new peer-to-peer business models based on the concept of sharing economy, while fostering the participation in a cooperative resource sharing framework. Thus, covering all aspects of new digital businesses, boosting cloud, fog and IoT markets.

mF2C Offering

mF2C provides a novel framework that increases the efficiency of resources' usage taking into consideration not only service requirements but also user demands. mF2C is agnostic of the application domain, meaning that the solution proposed can solve the needs of different verticals of different sizes, leveraging the European industries' competitiveness, enabling businesses to scale on the principles of sharing economy in a cooperative framework.

Therefore, different stakeholders can be impacted by mF2C in the following ways:

Cloud/Fog Providers

- Improving the competitive position of the fragmented European cloud sector, mainly occupied by big players coming from the US.
- Allowing the extension of the current portfolio of offered services and products in a combined fog-to-cloud environment.
- Facilitating new models of collaboration between providers and individual users leveraging the resource sharing paradigm.
- Supporting the creation of new digital business services on top of mF2C in an extended scenario.

Technology Providers

- Providing new research opportunities based on next-gen devices.
- Fostering the massive use of IoT devices based on added-value services developed through the adoption of the proposed mF2C model.
- Boosting revenues coming from improved IoT and fog devices and requests for more sophisticated technology.

Service Providers

- Facilitating the integration of IoT and cloud platforms in a combined fog-to-cloud paradigm.
- Fostering the creation of new added-value services and solutions on top of mF2C.
- Easing services' execution in heterogeneous, volatile and mobile resources lowering costs.

Overall European Businesses

- Allowing SMEs to access the offered resources at lower costs, improving their competitiveness in emerging markets.
- Improving living conditions and generating new business opportunities for citizens by

provisioning advanced tools for Governments.

- Generating new digital businesses for new solutions, paving the way for new market opportunities.
- Pioneering fog-to-cloud technologies in Europe.

Business Goals

In order to cover real market expectations and needs, mF2C has set a list of accomplished business goals that allows different organizations to understand how mF2C may benefit them:

Connectivity: Extends the cloud to be closer to the 'things'. mF2C reduces bandwidth usage and improves agility via faster access to data. Security is also improved by reducing the amount of sensitive data to be sent over the network.

Interoperability: Ensure interoperability of the mF2C framework with existing solutions. mF2C facilitates its integration with other solution by using widely adopted de-facto market standards.

Common framework for collaboration: Integration of IT and OT in a single framework. mF2C bridges the gap between cloud and fog in a single framework, bringing cloud capabilities closer to IoT, as well as enabling collaboration and communication between businesses so they can work together.

Shared and spread: Create and add new value to existing businesses while expanding their scalability. The mF2C approach enables efficient and cost-effective solutions, opening the door to new revenue streams by enabling the development of a new generation of more efficient, and therefore more cost-effective, applications and services.

Extension and optimization of current solutions: Shift data processing to the edge. mF2C improves the current portfolio offering by adding fog extensions, aiming to reduce operational costs and unnecessary data analysis from a cloud provider perspective.

Improve customer experience: Improve reliability and make the process as quick and smooth as possible. mF2C reduces response time by executing applications in the most suitable deployment scheme.

Features

The increased usage of IoT devices, has highlighted the existing breach between traditional cloud computing service offerings and current IoT needs. mF2C aims to close this gap, providing a framework capable of managing resources and services in an optimal way, making the most out of the distributed computing capacities deployed close to the edge.

The mF2C framework can be adopted 'as a whole', benefiting from all offered functionalities from the edge up to the cloud. However, in order to ease its adoption and further integration with existing solutions, mF2C offers a smaller range of products with the minimum required functionalities to cover specific needs:

dataClay: Object oriented model to manage the data in fog-to-cloud platforms and applications. It allows data management, of both management and application data, as regular objects in applications.

Service Orchestrator: Service execution environment that ensures the best conditions for each service execution. This service management framework allows the best service allocation and execution based on the available resources.

Telemetry Monitoring: An extensible, adaptable, telemetry-gathering and analytics framework for the fog infrastructure. It provides rich, dynamically configurable telemetry from across the fog, and can host the analytics needed to extract insights from the data.

Resource Manager: Novel framework for location and source agnostic management of resources in a fog-to-cloud scenario. It implements a strategy for discovering, identifying, characterizing, monitoring and managing related data sources.

COMPSs: Programming environment for the definition and parallel execution of applications in fog-to-cloud platforms. It allows mobile application execution and computation in parallel, distributing tasks among all available devices.

CIMI: Standalone micro service which eases the addition of new infrastructure resources in a secure manner. It provides a unique interface for customers and other agents to interact with each other.

Demonstrated benefits of mF2C

There are still many unsolved challenges in the fog-to-cloud arena, as it can be seen in the latest version of the fog reference architecture released by the OpenFog Consortium. Digital businesses have arisen, and this is influencing the traditional business culture making citizens not only technology customers but a centrepiece of the businesses core. mF2C connects people, devices and services into one single digital ecosystem where businesses are able to adapt their solutions to specific user needs, improving customer experience and boosting cloud, fog and IoT markets.

Success Stories

75 billion connected devices are expected to be installed worldwide by 2025[1]. We are living a phenomenon where smart devices are integrated in daily life. Internet of Things is not just a matter of industry. In a relatively short time connectedness has extended to an endless list of 'things' as citizens are becoming more and more dependent on their own devices. It is the dawn of a new era. In the Digital Era, mentality is changing: it is not only about consuming technology but changing lifestyle. In this context, organizations are experiencing a full transformation looking for new ways to interact with customers, being innovative and remaining ahead of their competition.
In order to demonstrate the benefits that mF2C adoption can bring to different organizations, three use cases have been realized, providing quantitative measurements that show the improvements brought by this adoption at different levels. The three use cases are an example of how devices will improve citizens lives.

Emergency Situation Management in Smart Cities (ESM)

As the world's population grows in the next few years, urban areas will have to deal with the strain of hugely growing needs and demands. This first use case caters to this field of innovation by demonstrating an alarm manager for emergency situation management in smart cities. In critical situations, the response time of the emergency vehicles that assist people is of outmost importance as a short amount of time can make a big difference. The main service provided in this project will be a decision-making system that, according to an inclination sensor that monitors smart infrastructures, will declare whether a specific situation is normal or represents an emergency.
The tracking of assets is an important part of the Emergency Management on Infrastructure Construction solution, as it allows logistics improvements regarding workers and machinery. Furthermore, it improves safety in the case of a critical situation as it helps to geolocate people at risk. In the case of the smartphone alert integration, this will also enhance the security of the solution and of infrastructure construction workers that should be warned about alerts and risky situations. Finally, the integration of the mF2C agent to the Jammer Detector device will add a powerful fog device to the ecosystem. This smart sensor is idle most of the time (only activated when sensors time-out), which offers a set of useful resources to be exploited by the rest of the solution.
The deployment of the mF2C architecture in the ESM system in a Smart City scenario provides better reliability and QoS, as well as improving the latency of a response to an alert situation when the software runs on the Fog. Moreover, thanks to the intrinsic redundancy provided by the mF2C architecture, the number of devices installed can be reduced without lowering the quality of the service proposed, so the cost can be reduced (mainly for the hardware), but also for the service as the necessity of hosting on the cloud is also reduced. In addition, the time response to emergency situations will improve if the services are run locally, rather than on the cloud, and the emergency services will be able to intervene faster.
Regarding KPIs, latency is improved by approximately 30% and QoS is improved by approximately 7%.

Smart Boat Services

This use case demonstrates a Smart Boat monitoring and control system for boat owners and users. The main service is to provide the owners and the users with insight into the boats' status over the fog or the cloud – depending on the network possibilities.
The Smart Boat application caters to two types of users: the owners of the vessels, but also the guests, which are the sailor or skippers currently operating or visiting the boat.
Boat users require constant insights on the boats' current state, regardless of whether they are on the boat or not, through reliable hardware mounted on the boat or vessel. This is due to the fact that boats are relatively seldomly occupied as they may only serve free-time activities, while an owner would generally like to have an overview of their expensive asset. Also, boat rentals and hobby usage are becoming increasingly popular and serve a high-value market. All marine equipment, and especially their upkeep and maintenance, has a relatively high cost, which is significantly larger that the cost of IoT equipment and services available for the boats. This opens up a very dynamic and expressive market for high-end high-added-value solutions that cloud, fog and IoT providers strive for in terms of business. The potential impact and target market are thus very large, especially with a solution that can ease and enhance

[1] *"Internet of Things (IoT) connected devices installed based worldwide from 2015 to 2025 (in billions)",* Statista

the deployment and execution of services for the developers and the services' users alike.
The results from the Smart Boat application setup demonstrate the reliability of the fog part of the application allowed by the addition of the mF2C agent. The main improvement brought by the inclusion of the mF2C architecture in this scenario is the expansion of the coverage.
The Smart Boat use case foresees two business strategies to be formed and applied through the combination of Smart Boat and mF2C. The first one is based on the fog and cloud management of the mF2C platform. This approach focuses on services directly linked to the internal Smart Boat management, facilitating the way the overall boat systems perform. The second one is the market demand for a variety of IoT solutions across all fields. The potential impact and target market are thus very large, and services do not need to make compromises that traditional mass-market consumer-oriented products face. Requirements for low cost products in this sector are much more flexible in terms of up-front or periodic cost and depend more on perceived premium added value that the product or services can provide the end users.

Smart Fog-Hub Service

According to recent marketing research by McKinsey and Gartner, business applications of IoT have greater economic impact than consumer applications. While consumer uses of IoT receive significant attention and show a tremendous potential for creating value, there is even greater potential value from IoT use in business-to-business applications. This happens more frequently in environments with high concentration of IoT devices. These places can be considered the building blocks of the Smart City and can be interconnected leveraging the main pillars of the so-called OpenFog Reference Architecture. The airport is such an example: some billion passengers, with a significant number of novice travelers, will concentrate in airports, with an average of two connected devices per passenger. For both novice and experienced travelers, the experience of moving through large airports to reach the right gate at the right time can be a stressful part of their journey.
For this reason, the use case extends the concept of "cloud hub" to a new concept of "fog hub", driven by real market needs: it tracks the presence of people and other objects in the field, pursuing an indoor navigator and recommender solution, providing suggestions on shops or services nearby based on users' behavior and choices, thus providing travelers a more enjoyable experience, particularly for users with special needs, such as those with disabilities or travelling with kids.
The deployment of the mF2C framework in the Smart Fog Hub system leverages the mF2C capabilities to optimally orchestrate resources in a fog-to-cloud approach, balancing processing loads and communications to reduce latency and guarantee real-time response. It gets advantage from the security- and privacy-by-design features of the mF2C platform to guarantee the confidentiality of personal data.
The use case will be soon deployed and tested in Cagliari Elmas Airport, leading to a commercial product that can be offered to other airports.
At the same time, this application can be adapted to be deployed in other smart city scenarios, like metro or railway stations and shopping centres, behaving as several interconnected fogs, to constitute building blocks for a smart city implementation.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730929. Any dissemination of results here presented reflects only the consortium view. The Research Executive Agency is not responsible for any use that may be made of the information it contains.