



A Holistic, Innovative Framework for the Design,
Development and Orchestration of 5G-ready
Applications and Network Services over Sliced
Programmable Infrastructure

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Like any other innovative projects that has a start, the MATILDA project is no different. The project which began over 30 months ago, precisely in the middle of 2017, will be coming to an end pretty soon. MATILDA was birthed as a truly innovative project, needed to address identified technological gaps, especially useful for both the vertical application providers and the mobile network operators or communication services providers. Empowered by the emergence of the cloud computing concepts, network Softwarization, network slicing, software defined networking, machine learning algorithms, and many more, the MATILDA project was conceived just about the right time.

MATILDA is a massive project embarked upon by a total of **17 consortium members** with a unique blend of institutions of higher education (university), small and medium-sized enterprises (SMEs) and other established well-known companies such as Ericsson and Orange. The single reason for their coming together is to achieve a **common goal**, which is the **design and implementation** of a **holistic 5G end-to-end services operational framework**. This framework is used to address the **lifecycle of design, development and orchestration of 5G-ready applications and 5G network services** deployed over **programmable infrastructure** following a **unified programmability model** and a set of **control abstractions**.

The union of these consortium members for the special purpose of achieving the above-mentioned project goal is already over **30 months old**. Well into the **3rd year** of existence, the MATILDA project has significantly evolved over the span of this developmental period with notable essential achievements and project outcomes. Most notably and thanks to the efforts of the collective alliance of the consortium members, MATILDA is proud to announce the complete implementation and operation of its key products, namely, the **Operational Support System (OSS)** and the **Vertical Application Orchestrator (VAO)**.

In less than half a year to the end of the MATILDA project, the consortium has expectedly recorded tremendous amount of successes and several important events have taken place from the inception of the project until now. For example, there have been a total of 5 plenary meetings and 2 review meetings, where important resolutions have been made and have brought about numerous landmark achievements. With a demo of one of the final demonstrators (Smart City Intelligent Lighting System) scheduled in March 2020 in Bucharest, Romania before the final review meeting, everything seems set for an ultimate and impactful final exhibition to showcase the many success stories born out of the influential union of the consortium partners within the last two and a half years.

Within over 30 months since the inauguration of the project, MATILDA has brought forth a number of notable achievements in terms of project implementations, scientific and technical conference and journal papers, and project deliverables. The MATILDA consortium has indeed harmonized to collectively develop and produce two components of critical importance for any 5G-ready applications that are powered by purpose-built mobile network slices over dedicated physical and virtual resources. These components are the **Operational Support System (OSS)** and the **Vertical Application Orchestrator (VAO)**.

The OSS and VAO are collectively composed of the following fundamental modules: **Slicing Northbound Module, Resource Selection Optimizer, Slicing Lifecycle Manager, VIM Convergence Layer, NFV Convergence Layer, WIM Convergence Layer, Network Service Manager, VAO Dashboard, Policy Editor, Policy Manager, Application Component and Graphs Repositories and Marketplace, Data Fusion and Analysis Toolkit, Deployment Manager, Monitoring Engine, Postboot Configuration Module and the MATILDA Integrated Platform**. With much of the implementations already fully achieved and the project speedily wounding down to completion, there is no doubt that the project is surely in a good shape and its finalization in some months to come will definitely mark the end of a remarkable Horizon 2020 project.

Each of the above-mentioned modules are of crucial essence to the final outcome and recorded achievements of the project; hence, they play fundamental roles in realizing the set objectives. Notwithstanding the mentioned software modules, the MATILDA project has also recorded a major milestone and remarkable stride towards accomplishments in terms of the reach out to both industrial and academic stakeholders through technical and scientific publications. In total, the MATILDA project consortium members have collectively produced over 40 publications including both conferences and journal papers and still counting. In addition to the number of publications realized, the project has also produced over 30 deliverables.

Finally, MATILDA has been leading the technological innovations in both academy and the industry through the publication of not only the technical results derived from the project but also from the innovations that the project is creating in extending state of the art. One of such white papers is titled “**Separation of Concerns Among Application and Network Services Orchestration in a 5G Ecosystem**”. Another already published white paper titled “**OSS for 5G-ready Applications**” detailed the extended functionalities of the OSS component developed in MATILDA.

Part of the scope of the Matilda project is to design and develop a radically new prototypic framework of the Telecom Layer Platform able to support functional and performance requirements, as well as the effective lifecycle management of 5G-ready Vertical Applications. For that, we built a highly modular architecture aimed to dynamically control, abstract, and suitably expose the 5G network infrastructure resources and services to vertical applications in terms of network and computing slices, taking advantage of OSM for managing the lifecycle and configuration of the network functions.

To this end, the MATILDA consortium is happy to announce that it has been the first Horizon 2020 project to develop from scratch an open source vertical application orchestrator and operational support system, which are fundamentally modular and are powered virtually by open source solutions, too. These components that are an accomplishment of the MATILDA project have been until now a **missing piece** towards the wholesome and comprehensive realization of the goals and operations of the 5G systems. There is no doubt that the functional deployment of this project outcome will begin to make a meaning impact in the both the business and academic realms.

MATILDA participated in a number of notable 5G-PPP projects clustering events tailored towards increasing the outreach of the project and positioning it better in order to elaborate more its position amongst the other EU Horizon 2020 projects. For this reason and in addition to expand the visibility of the MATILDA project, recently, MATILDA organized a clustering event as part of the just concluded plenary meeting that was held at the Orange Romania facility. MATILDA, in collaboration with the SLICENET project, **organized a project clustering workshop** that took place in November 2019 in Bucharest, Romania.

Amongst other things, **MATILDA and SLICENET** consortium members had very fruitful discussions on the positioning of both projects and their respective outcomes. In particular, the focus of the clustering workshop was more focused on the practicalities of the application of the results generated from both projects and their alignment with respect to their set objectives. More specifically, the coordination teams of both projects identified areas of interests in some of the implementation results realized within their respective frameworks. At the end of the clustering event, partners from both consortia came together to take a group picture, which is shown below.



Similarly, partners from the MATILDA project consortium also participated in the 5G-Day workshop that took place in Lucca, Italy in November 2019. The clustering workshop was organized by the Horizon 2020 5G-City project and invited participants from far and wide. During the event, the MATILDA project outcome was also showcased through a presentation that was facilitated by a member of the MATILDA consortium and a demo was also given.



The presentation titled “5G-ready applications in MATILDA – Demo” was given during the 5G Day workshop event, precisely in presentation session 5. During the presentation, the scope of the MATILDA project was elaborated upon, which is to design and develop a radically new prototypic framework of the Telecom Layer Platform that is able to support functional and performance requirements, as well as for the effective management of the lifecycle of 5G-ready vertical applications. In order to achieve this brilliant project goal, the MATILDA project has built a highly modular architecture aimed at dynamically controlling, abstracting and exposing where needed the 5G network infrastructure resources and services to the

vertical applications, in terms of network and computing slices, while also taking advantage of OSM in managing the lifecycle and configuration of the network functions.

At the end of the workshop, the participants from the consortium members of the collaborating projects also came together for a quick picture session as presented below.



A presentation was also given at the second **5G Italy** event organized by CNIT in Rome, Italy, in December 2019 (<https://www.5gitaly.eu/2019/>), titled “Separation of concerns in application, networking and security orchestration platforms in virtualized 5G environments”, along with a contribution to *The 5G Italy Book 2019: a Multiperspective View of 5G* (<https://www.5gitaly.eu/2019/5g-italy-book/>), titled “5G management and orchestration – From cloud-native to 5G-ready applications”.

In September 2019, we had our second successful review meeting in Ljubljana, Slovenia. We were initially all nervous of the outcome but in the end, everything turned out in our favour; yes, we made it happen again! During the review meeting event, there were quite a number of observations from the reviewers, which were also reflected in details in the review meeting feedback document that they sent to us.

Based on the comprehensive feedback received from the review meeting, the overall assessment of the project was one about which the project officer had the following to say: “Project has achieved most of its objectives and milestones for the period with relatively minor deviations”. We are definitely pleased with this feedback, as in our opinion it is a generous comment to be received from the MATILDA project officer who is an expert in the field.

In addition, when asked regarding the significance of the results generated from the work efforts spent in the project with respect to dissemination, exploitation and impact potential of the project, the reviewers also passed a benevolent observation saying: “The project will likely provide results with significant immediate or potential impact in the next reporting period...”. The project officer also mentioned that the MATILDA ecosystem has recorded innovations from the project while focusing on important modern concepts such as: **Network slicing, Intelligent Orchestration, Network-aware Applications and Multi-site Virtual Infrastructure Management**, all of which are underpinned by the novel SDN/NFV network and Artificial Intelligent paradigms that are being applied to the 5G PPP network technologies and services.

Finally and in overall, the project officer highlighted the main achievements of the project as presented below:

- Finalization of the reference architecture
- Implementation and testing of graphical editor’s toolkit for components, composing of application graphs and policy rules
- Development of a set of VAO mechanisms
- Development of an extended OSS layer with APIs for the creation of slices according to the slice intent
- Integration and testing of components
- Plans for 5 demo use cases with related KPIs and first release of some of the 5 demonstrators.

In all, MATILDA has produced good quality results and adequately followed the work plan as defined in the proposal, and main objectives set for the second year of the project have been achieved.

The sixth plenary meeting of the MATILDA consortium members took place in Bucharest, Romania, from the 12th to 14th of November, 2019. The 3 days plenary meeting was hosted in the facility of the CAMPUS Research Center on the premises of the Polytechnic University of Bucharest, Romania. We had three days of comprehensive and extensive discussion regarding the progress of MATILDA with respect to the different phases and stages of development in which the different work packages and their respective tasks are in. In addition, we also had the already mentioned 5G PPP project clustering workshop between the MATILDA project consortium partners and the SLICENET consortium members. The meeting kicked off with discussions regarding the reviewers' feedback and general remarks from the previous review meeting that took place in Slovenia. Both the positive remarks and feedback revealing points of concerns were all deliberated upon by the consortium members there present. During the meeting, the work package leaders and the project partners whose representatives were available all contributed in one way or another.



After this plenary meeting, a number of events was lined up for the coming months and towards the end of the project. A notable event was the planning of the MATILDA project workshop meeting titled **MATILDA – AUTONOMIC DEPLOYMENT AND LIFECYCLE MANAGEMENT OF 5G & BEYOND SERVICES**, which was included in the 6G Summit 2020, to be held in Levi, Lapland, Finland, in March 2020. The workshop, scheduled to take place on Friday, 20th March, 2020, for the whole day, was eventually cancelled (along with the whole 6G Summit), owing to the emergency situation created by the spreading of Covid-19. Plans are underway to collect recorded short presentations by the intended invited speakers, who were the following:

- Panagiotis Gouvas, Ubitech, Greece:
Deploying and orchestrating modern cloud-native applications in the programmable 5G infrastructure
- Ingrid Moerman, IMEC - Ghent University:
How ORCA solutions meet beyond-5G evolution
- Antonio Manzalini, TIM, Italy (Chief Innovation & Partnership Office / Technology Innovation):
Pervasive Artificial Intelligence in 5G and beyond scenarios
- Luka Koršič, Internet Institute Ltd., Ljubljana, Slovenia:
Next generation Public Protection and Disaster Relief systems
- Sławomir Kukliński, R&D Expert, Orange Labs Polska:
Carrier-grade scalable architecture for network slicing
- Kay Burow, BIBA, Germany:
Towards flexible production systems – Chances and limits by using cellular networks
- Rui Aguiar, University of Aveiro, Portugal:
On the network of control
- Artur Hecker, Director of Future Network Technologies at Huawei MRC, Munich – Associate Professor, Telecom ParisTech, France:
From 5G Slicing to fine-granular, autonomic resource management
- Miloud Bagaa, Aalto University, Finland:
High resolution media on demand vertical

Another important event that would hopefully take place soon (possibly remotely, owing to the Covid-19 emergency) is the next demo that will most likely be again hosted on the facilities of Orange Romania.