Abstract: Dynamic Composition and Automated Deployment of Digital Twins for Manufacturing

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ABSTRACT

Digital twins represent an emerging trend and are already widely applied in the manufacturing sector to simulate the behaviour of manufacturing lines or industrial products, and to enhance or optimize their performance. The DIGITbrain project [1], funded by the European Commission's H2020 Programme aims to extend the traditional digital twin concept towards the Digital Product Brain that steers the behaviour and performance of an industrial product by coalescing its physical and digital dimensions, and by memorising the occurred (physical and digital) events throughout its entire lifecycle. With such capabilities, the Digital Product Brain can steer the quick and convenient customization and repurposing of manufacturing lines/industrial products and support the realization of a smart business model based on Manufacturing as a Service (MaaS). MaaS can lead to more customised manufacturing processes and products, and can also support the refactoring of manufacturing lines in the case of crisis situations, such as a pandemic.

The technical developments in DIGITbrain are based on the results of the CloudiFacturing project [2] that implemented a cloud-based platform, combined with a digital marketplace as a business gateway, for the execution of simulation or optimisation applications and workflows. However, workflows and applications in CloudiFacturing are typically monolithic, tightly coupling algorithms with models and data sources, making them applicable to only one particular scenario. In order to improve the reusability of various assets (i.e. data, models and algorithms), DIGITbrain clearly separates these assests from each other and enables the creation of DMA (data-model-algorithm) tuples that represent a certain instance of a digital twin. Such digital twin or DMA tuple instances can then be executed as a set of interconnected microservices on the targeted cloud, or even on edge and fog computing resources.

For the automated deployment and run-time management of microservices-based applications, DIGITbrain utilises the MiCADO cloud to edge orchestration framework [3] that is responsible for deploying the instantiated DMA tuples on central cloud computing resources, or on edge and fog nodes closer to the data sources. However, as the various data, model and algorithm assets are created separately, a specific challenge has emerged to automatically and dynamically generate the deployment descriptors required by MiCADO during the publishing and authoring process.

MiCADO uses an Application Description Template (ADT) based on the OASIS TOSCA (Topology and Orchestration Specification for Cloud Applications) standard specification [4] to describe the application topology to be deployed and the various policies that govern the application's run-time behaviour. In all previous application scenarios, the ADT was created in a single manual step by the application developer/owner. However, in DIGITbrain the ADT needs to be programmatically assembled from previously published fragments that represent the individual data, model and algorithm assets, as well as representations of the cloud, fog and edge resources that comprise the infrastructure.

This presentation will give an overview of how MiCADO is applied within the DIGITbrain platform, what extensions were required to support the targeted application scenarios, and how a MICADO ADT can be dynamically assembled from metadata of individual assets.

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Keywords — Digital marketplace, digital twin, cloud to edge orchestrator, TOSCA.

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