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DIGITAL TRANSFORMATION: TOWARDS A CLOUD NATIVE ARCHITECTURE FOR HIGHLY AUTOMATED AND EVENT DRIVEN PROCESSES

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Abstract – Introducing new information systems in organizations, often result in information sinks that disrupt people's productivity and prevent a successful change management process. In this paper the Operation Layer is presented. A Cloud Native concept to break up data silos, to streamline workflows and to centralize IT services while maintaining the department's workflows. This concept will simplify the IT maintenance while flattening the change management curve at the same time.

Keywords: Digital Transformation, Universal Service Hub, Metrological Processes, Robotic Process Automation

1. INTRODUCTION

Digital transformation in public administration is taking place at a heterogeneous pace and often falls short of the expectations and requirements associated, for example, with the Online Access Act (OZG) in Germany. While the current pandemic situation has accelerated digital transformation measures for mobile work in general and in public administration, it has also highlighted the existing weaknesses. There is an obvious need to support the design and use of digitally supported work methods and appropriately designed process flows. To this end, existing obstacles must be systematically identified and, ideally, eliminated or dissolved by digital technologies and methods. Among other things, these relate to the legal security of digitally transformed processes, billing procedures and models, as well as associated financial and organizational structures, personnel capacities, competencies, and qualifications. In addition, there is now an opportunity to rethink and redesign process workflows in order to fully exploit the potential of digital transformation - simply transferring existing workflows into the digital domain is not enough.

At the same time, digital quality infrastructures must be established internally and externally, in order to link previous data silos and leading to new synergy and efficiency gains (BMWi - Qualitätsinfrastruktur Digital [1]). In addition, suitable concepts are required for designing the transition from analog to digital processes. Currently, E-service and E-file are being introduced at PTB, but there is a major obstacle in connecting and digitally transforming the working groups, laboratories and their workflows. Often, the hurdles for the individual work groups are very high and the upcoming change management processes are overwhelming.

This gap is to be closed by the Operation Layer (OP-Layer), which uses uniform interfaces to connect to the already existing infrastructures at PTB and enables simple data transfer from E-service and E-file. Through uniform interfaces (REST interface), the connected internal systems can maintain their previous workflow, while at the same time harmonizing the data. The automatic data transfer drastically increases the confidentiality, integrity and availability of the data and greatly reduces the susceptibility to errors.

The OP-Layer thus makes an enormous contribution to the automation of workflows and can reduce the workload of employees. Automation frees up staff time for research, laborious calibrations and related tasks.

The rest of the paper is structured as follows, section 2 describes the concept and infrastructure of the OP-Layer. Section 3 outlines the use cases and their implications. A summary and outlook is given in section 4.

2. CONCEPT & INFRASTRUCTURE

In the last years a distributed microservice archtitecture has been built and designed explicitly in the domain of legal metrology with a focus on interconnecting external stakeholders [2, 3, 4]. While the generic IT architectural design approach has proven to be successful, a similar approach will be pursued to digitally transform the internal process flow.

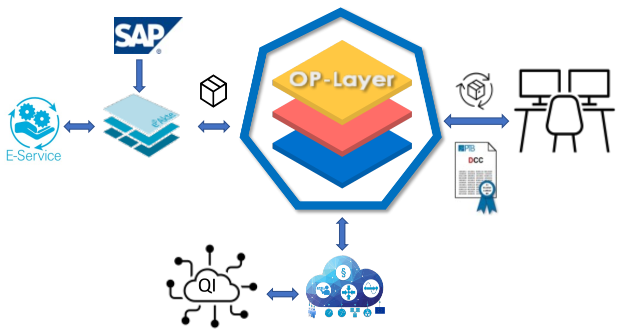

Fig. 1: Overview of the workflow with integration of the OP-Layer. The OP-Layer hosts special tailored applications within a scalable cloud native infrastructure.

This time the focus of the IT architecture will be extended to be cross-domain and linking internal stakeholders. Further targets are the stakeholders' isolated workflows as well as internal and external IT infrastructure. The foundation of the IT infrastructure will be more sophisticated in terms of scalability, availability, portability and security (see section 2.1). Furthermore, the Infrastructure as Code (IaC) paradigm will be put at the heart of the OP-Layer.

Figure 1 gives an overview of the digitally transformed workflow [5] with the E-Service web portal as a contact point for a range of services. Once the order has been placed, an electronic file will be created in the E-file service. The E-File service stores all information centrally. The necessary administrative data is maintained independently by the customer while the required metrological data is stored as machine-readable document [6].

This is where the OP-Layer comes into place and links seamlessly the laboratories' workflows and internal departments' use-cases (see section 3) with the E-File service via an API. Moreover, the OP-Layer will feature a microservice architecture and host specific tailored applications and services that will harmonize the service infrastructure within PTB. While centralizing the service infrastructure, the individual and adapted workflows of each department will be protected. This will reduce the maintenance costs for IT-services and increases efficiency of digitally supported services.

In the preparation phase of the OP-Layer project it became obvious that companies and research institutes face the same challenges while digitally transforming their processes and infrastructures. The following list describes common challenges of organizational transformation that have to be comprised, addressed and reflected in the architectural concept of the OP-Layer:

- isolated (research / IT) infrastructures within organization
- no centralized or harmonized workflow
- no streamlined process chain across departments
- interfaces are programmed several times within one organization
- no IT management on executive level
- IT management without qualified technical experience
- no IT security awareness and organizational structure
- area of conflict between centralization and decentralization within organization
- isolated responsibilities and knowledge in each organizational units
- lack of transparency of process flows and chains

2.1. Distributed Cloud Native Infrastructure

A distributed IT architecture (see Figure 2) that is able to support a microservice approach has to map the requirements such as high availability, (auto-) scaling, portability and security. The Kubernetes design principles fulfill most of the mentioned requirements for a modern distributed infrastructure approach. The following paragraphs give a short overview of the requirements:

Scalability - Avoiding technical bottlenecks in a distributed infrastructure is vital, because those can lead quickly to points of failure. Being able to scale applications horizontally, that means starting the same application several times, will redistribute the request load on several "shoulders" to cope with peak in demand. Kubernetes provides load balancing and horizontal scaling capabilities out of the box.

High Availability - Backups and replicas address the high availability requirement. While backups focus on data restoration on a specific time point, replicas support business continuity. Often replicas ensure access to critical data and application infrastructure from a secondary location. Kubernetes addresses high availability both at application and infrastructure level.

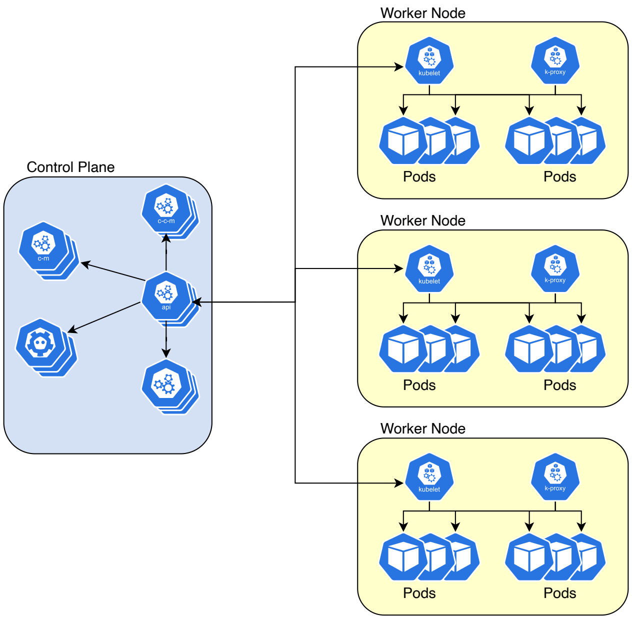

Fig. 2: Overview of a generic Kubernetes architecture with a control plane on the left side, which consists of API-Module, Cloud-Controller-Module, Contoller-Manager and the Scheduler. The control plane provides the global operations for the Kubernetes architecture, like scheduling, scaling and steering pods. On the right side are three worker nodes that consists of a Kublet and a Proxy module. These provide functionality and network capabilities to the pods that hold the containerized application. A worker node can handle several pods a time. A pod can host several containers.

Portability - Software development and deployment changed drastically. With container and pods, applications can run on any platform and cluster. Kubernetes provides many container runtimes that enable application portability and easy deployment for an agile development approach. This concept facilitates workloads across private and public cloud environments and supports availability fault tolerance zones within the infrastructure design.

Security - Security has to be addressed on multiple layer such as cluster, application and network. API endpoints are secured via TLS (Transport Layer Security). Furthermore, strict role and rights management (see section 2.2.2) has to be enforced for each user, so that only authorized operations can be executed on the cluster. Finally, network communication flows for pods have to defined, so that only wanted communication behaviour is feasible.

2.2. *Distributed Software Architecture*

The envisioned distributed microservice software architecture borrows heavily from the concepts designed and developed in [2, 3, 4] and adds the following requirements:

- **No-configuration debugging**: The same image runs in test and production.
- **Containerization**: All the code runs in a container plus shared resources.
- **Blue/green deployment**: Sending traffic only after the server exists. That means no downtime and simplified rollbacks.
- **Application composition**: Individual pieces of functionality can be composed in separate images, while being technology agnostic.
- **Load balancing**: Scaling stateless containers is a stark requirement for architecture performance.
- **Service registry and discovery**: Microservices have to automatically register in a registry service to enable auto-discovery of dependent microservices.
- **Once-Only principle**: Harmonizing processes and software development by parameterizable services that fit all internal stakeholders.

2.2.1. *Functional and security requirements*

The OP-Layer is able to provide a variety of exchange formats such as JSON, XML and CSV. For the internal communication JSON is used to exchange data from one service to another. The interfaces will be implemented as harmonized REST interfaces. The data will be signed, validated and archived. While the data is at rest or at transport, it will be encrypted and secured against unauthorized access. The OP-Layer supports an Open ID Connect access management solution with single sign on capabilities. A sessionless and tokenized access management solution is intended, in order to increase security and avoid session handling in a highly distributed environment. Further the CIA triad attributes (confidentiality, integrity and availability) are deeply incorporated in the basic infrastructure design.

2.2.2. *Identity and Access Management*

The following requirements for an Identity Access Management (IAM) solution are described in [7] and are adapted to meet the criteria for the proposed distributed microservice software architecture:

- **Separation of concerns**: Users and roles must be isolated within the platform, but differentiated and centrally managed across the entire process.
- **Single Sign-On**: A user should log on only once and should have access to the functions assigned to him by means of roles in the frontend and in the backend services.
- **Identity Federation**: It should be possible to authorize additional identity servers of third-party organizations (federated ID), so that their users can log on directly to the proposed platform with their organizational ID and use its services.
- **Audibility and Traceability**: Due to the highly decoupled and decentralized approach of the architecture, user-based sessions are not used. A token-based approach is implemented to login. The token will contain further information about the user, such as roles and the validity period of the token, in encrypted form. This means that every request to a backend service and every processing step in the respective processes can be traced back to the initiating user.
- **Harmonized Login Procedure**: In addition to users, measuring devices and external services should also be authenticated and authorized by the IAM system on the platform in the future.
- **Harmonized Authentication Protocols**: By using a standard-compliant OpenID Connect IAM solution which also supports SAML2, developers can focus on the business requirements and their implementation, as there is no longer any need to develop IAM mechanisms. This also simplifies the maintainability of the platform and makes it comparatively easy to exchange the IAM solution used.

3. USE-CASES

Each use case is implemented as a separate containerized back-end service. They all provide REST API endpoints for communication, such as triggering actions, or providing information. The following subsections describe the three use-cases of the proposed OP-Layer platform.

3.1. E-File Connector

The E-File Connector service will have no graphical user interface. Instead, this service bridges the gap between the automated data access from the laboratory workflow, in order to import data. As a first step, only administrative data will be converted and exported. Later this restriction will be lifted and all necessary data will be available to support the automation of workflows.

The use-case consists of five steps. Finding the electronic file and filtering the administrative data. Then the export in a preselected exchange format, such as JSON, XML or CSV, is triggered. The laboratory can start their workflow and create for example a digital calibration certificate with the exported data. This XML certificate can now be uploaded and will be validated. If the validation is successful it will be put into the electronic file in the E-File-Service.

3.2. DCC-Service

The digital calibration certificate service (DCC-Service) will be a centralized service that harmonizes the creation of a DCC-XML-certificate. Depending on the laboratory the object of the calibration and their measurement might differ. However, the frame and shaft of the document are the same, so that parameterized service will map the requirements of each laboratory. This will harmonize and unify the DCC creation and simplify the workflow for laboratories.

A first simplified use-case will consist of three steps. First selecting the object of calibration. Then importing the administrative data will take place. Depending on the selected object of calibration, the specific measurement and device management part will be imported from the laboratory workflow. Lastly, the creation of the digital calibration certificate will be executed and a XML file will be made available.

3.3. DoC-Service

The digital declaration of conformity (DoC) service works similar to the DCC service. However, the resulting XML is not a calibration certificate but a declaration of conformity that consists of different norms and directives that the measurement instrument has to fulfill. The use-case consists of three steps, such as the selection if the measuring instrument, the import of administrative data for the declaration and the instrument specific norm and directive part that has to be included in the declaration document. Finally, the creation of the declaration of conformity takes place and the resulting XML file can be downloaded.

4. CONCLUSIONS

In this paper the concept of the Operation Layer has been presented, which links already existing infrastructures at PTB via uniform interfaces to enable data transfers from previous isolated data silos. Through uniform interfaces (REST interface), the connected internal systems can maintain their previous workflow, while at the same time harmonizing the data. The automatic data transfer drastically increases the productivity, integrity and availability of data and greatly reduces the susceptibility to errors.

The OP-Layer makes an enormous contribution to the automation of workflows and can reduce the workload of employees. In times of decreasing skilled workers, an increasing automation can lead to more efficiency, more time for research, laboratory activities and related tasks.

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