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Level-Up

Test and Validation

LEVEL-UP'S main aim is to offer a scalable platform covering the overall lifecycle of manufacturing equipment, becoming a predictive and prescriptive factory asset able to predict, diagnose, prevent, estimate, manage, assess, detect, and redesign. To achieve this purpose several cost-effective digital tools were developed and/or improved during LEVEL-UP's project, culminating with the definition of the overall architecture which allowed for their overall integration, testing and validation for each pilot line.

Once LEVEL-UP's overall architecture was defined and, the different Use Cases got clear, the programming, coding and implementation for each pilot line started. As seen in Figure 1 'Overall Architecture', there are a lot of Use Cases, pilot lines and systems. The challenges were, to ensure that all of them communicate, receive and send the required data and work well together. At this point, work package 6 (WP6) with Siemens as work package leader got involved.

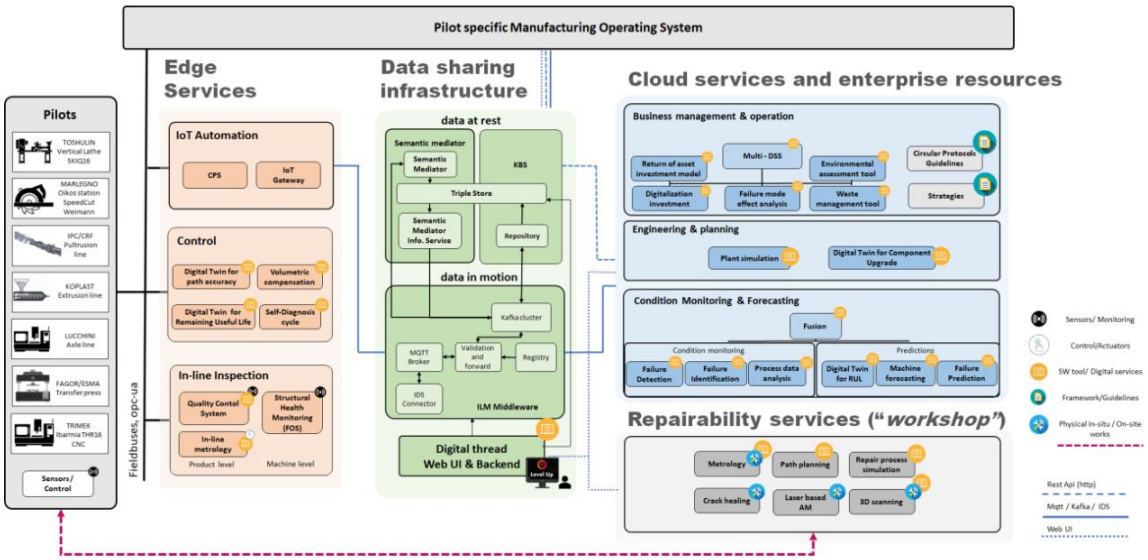

Figure 1: LEVEL-UP Overall Architecture

In order to successfully implement this complex flow of data, from the machine to the data-sharing infrastructure and the cloud services/enterprise resources, Siemens used the PLM experience. As a result, all partners could be efficiently supported through WP6 with an incremental and adaptable test plan. We got a wide variety of projects from mechanical general overhauling to software sub-projects that needed to be harmoniously validated in a comparable structure. The guided incremental test and validation strategy enabled a successful implementation in the partners' production to be carried out smoothly and on schedule and rounded off the research approaches.

As proofed method for agile software projects is the incremental integration and test. The integration of components is done incrementally to the main system. Test and fixing small assemblies are more efficient and less expensive than other strategies. Since issues are isolated from other components, the feedback to the development will be fast and more on target.

The top-down strategy is used in software projects to break down, stepwise, a task to smaller ones and these smaller tasks to functions and routines. Within the project Siemens used this methodology to break down defined KPIs to use cases, approaches and components.

Bottom-up is the opposite of the top-down strategy. After testing the smallest layer, the components, the next higher level the interaction and communication will be tested. In the highest level the use cases can be tested. This methodology is used for the solution test.

The overall integration and test strategy for the LEVEL-UP project is thus a mixture of the three methodologies.

The LEVEL-UP project has seven pilot lines from different industrial fields. These companies want to implement the solutions of the project directly to their production machines which creates additional tasks for development, implementation and testing.

For this industrial environment, the integration and test activities, the incremental strategy was adapted. The integration could not be done incrementally for all the components, since machine stand still times and integration during refurbishment were issues that needed to be taken into consideration.

The three main strategy increments (steps) are: component integration, information flow testing and use case validation.

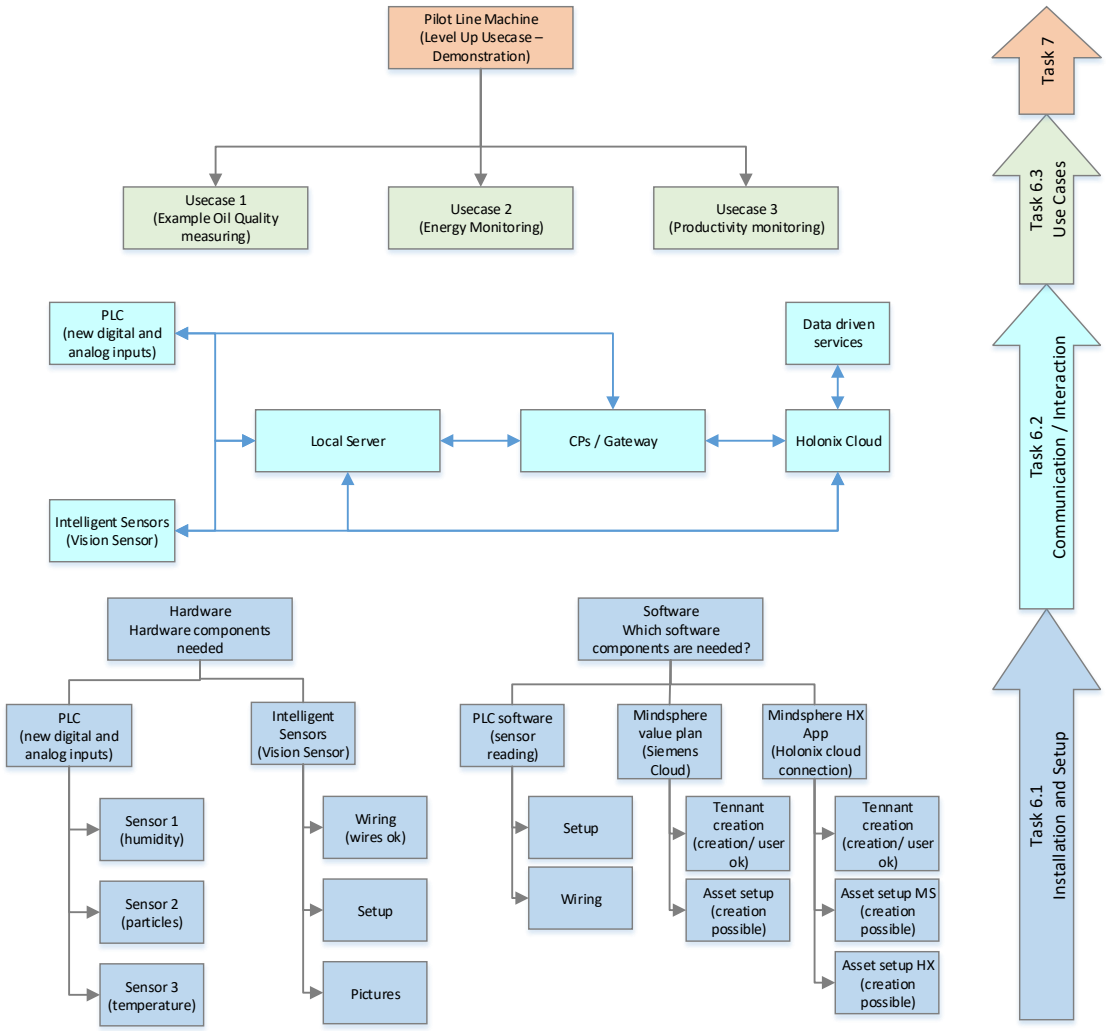

Figure 2: Bottom-Up / Incremental Testing – 3 Steps to solution

In the first main increment all the components that have been named and implemented in the earlier work packages were integrated and tested. In this level, several components were integrated in parallel, e.g. sensors added to a PLC. To ensure a high quality in testing, Siemens created a standardized test template for each pilot line, were all the components were listed. Each component has standard tests for wiring and correct connection as well as specific tests for validity and accuracy.

With these important tests, full functionality was ensured. The detailed reports and documentations are useful for quality management.

In the second step, Siemens focused on the interconnection and communication between the different LEVEL-UP components. In the digital industry data has become a major aspect. With the collected data, existing models could be verified or optimised, and new models could be invented. As an example, predictive maintenance models could be created for different machines by condition monitoring and data evaluation.

The first step for this analysis was to create a model of the data flows (Figure 3) using the digital thread tool from BIBA to identify the different data streams. The visualization of data flows is perfect for further analytics.

Project name	LevelUP	System	Excel 365
Testcase number	11	Version	0.0.1
created by		Comments	05.09.2022

Date	TEST NR.	Description	expected result	result	passed
	1	Test Siemens NC TraceRecorder for Sinumerik One of SKIQ	ServoData is received by DT at IPC without exceptions		
	2	Check that Digital Twin (DT) for RUL is working properly	RUL and loads on critical components are determined and plausible		
	3	Check that DT for accuracy is working properly	Accuracy values are calculated and plausible		
4.5.2022	4	Test connection from Tosh to Mindsphere	Data from IPC (sensor data, loads, RUL values) is received by Mindsphere without errors		Partly
9.5.2022	5.1	Test HX connector for the connection between Mindsphere and Holonix middleware	Data from Mindsphere is received by Holonix middleware without errors		OK
30.6.2022	5.2	Ensure normal KBS operation - Check data retreval with APIs and retrieved data matching with published data	No related error resulting in the KBS logs - non-empty data returned - same values in ITK Daedalus Gateway and KBS	kbs	OK
4.5.2022	6	Test direct connection from Sinumerik One to Mindsphere	Data from Sinumerik One is received by Mindsphere without errors		OK
1.9.2022	7	Test connection between Middleware and predictive maintenance component	Data from middleware is received by predictive maintenance component		OK
1.9.2022	8	Check if prediction result is properly sent back to Middleware	Prediction result from predictive maintenance component is received by Middleware without errors		
	9	Fusion receives data analysis results	Fusion of the prediction results with no problems		
1.9.2022	10	Multi-Level DSS retrieves data from the environmental assesment tool	Multi-Level DSS can poll data from the environmental assessement tool		OK
1.9.2022	11	Multi-Level DSS retrieves data from the FMECA	Multi-LEVEL DSS retrieves FMECA results		OK
1.9.2022	12	Multi-Level DSS receives predictive data	Receives data as Json file		OK

Figure 3: Data flow analysis

By analysing the data streams in the digital thread tool, it was possible to create a test template for all the information flows and to adapt them to the specific components and needs of the pilot lines.

Telegram structure, data assets and metadata could be tested as well as the sampling rate and data volume.

Checking the data flows from start to the end helped to find problems in the communication, to locate possible issues and to solve them. Within this step, Siemens could verify and guarantee that the data flows are valid from sender to receiver and all data needed are available.

The third main step of the integration and test activities is the analysis of the use cases. A use case represents a technological idea to improve a KPI and is supported by at least one approach. Where an approach is defined as technical solution that needs components and information flows.

Based on this, Siemens designed top-down a test template for use cases that includes the test results of the previous steps of the integration and testing. By gathering the available test results, it was proved that all required components and data flows are working. Siemens focused on the tests for the use cases, that have been defined by the pilot lines and INEGI. The Technology Readiness Level 6 (TRL Model by NASA) was reached after all pilot lines were able to prove that all use cases are working as expected.

Within the next steps of the project, the pilot lines will analyse data to optimise the models and technologies from the LEVEL-UP project. Furthermore, they will collect datafrom the LEVEL-UP technologies and evaluate the KPIs.

About the project

LEVEL-UP will offer a scalable platform covering the overall lifecycle, ranging from the digital twins' setup, modernisation actions to diagnose and predict the operation of physical assets, to the refurbishment and remanufacturing activities towards end of life. In-situ repair technologies and the redesign for new upgraded components will be facilitated through virtual simulations for increased performance and lifetime. LEVEL-UP will therefore comprise new hardware and software components interfaced with the current facilities through IoT and data-management platforms, while being orchestrated through eight (8) scalable strategies at component, workstation and shopfloor level. The actions for modernising, upgrading, refurbishing, remanufacturing, and recycling will be structured and formalised into ten (10) special Protocols, linked with an Industrial Digital Thread weaving a seamless digital integration with all actors in the value chain for improved future iterations. LEVEL-UP will be demonstrated in 7 demo sites from different sectors.

Details

Project title: Protocols and Strategies for extending the useful Life of major capital investments and Large Industrial Equipment

Project ID: 869991

Start Date: 01/10/2019

Project Duration: 48 months

Project Consortium:

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