Design, Development, and Deployment of ISO 23247 Standardized Digital Twin on Machines

MASTERS THESIS PROJECT

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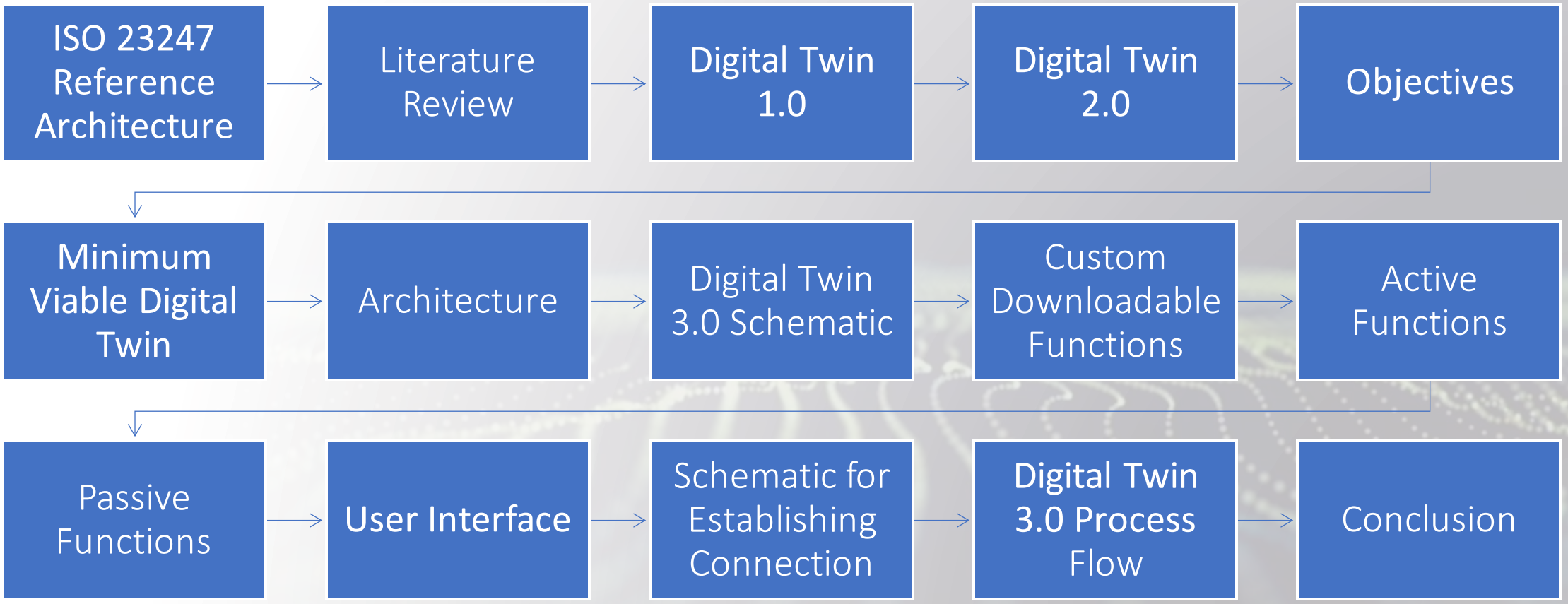
Guided By: Dr. Makarand S Kulkarni

OUTLINE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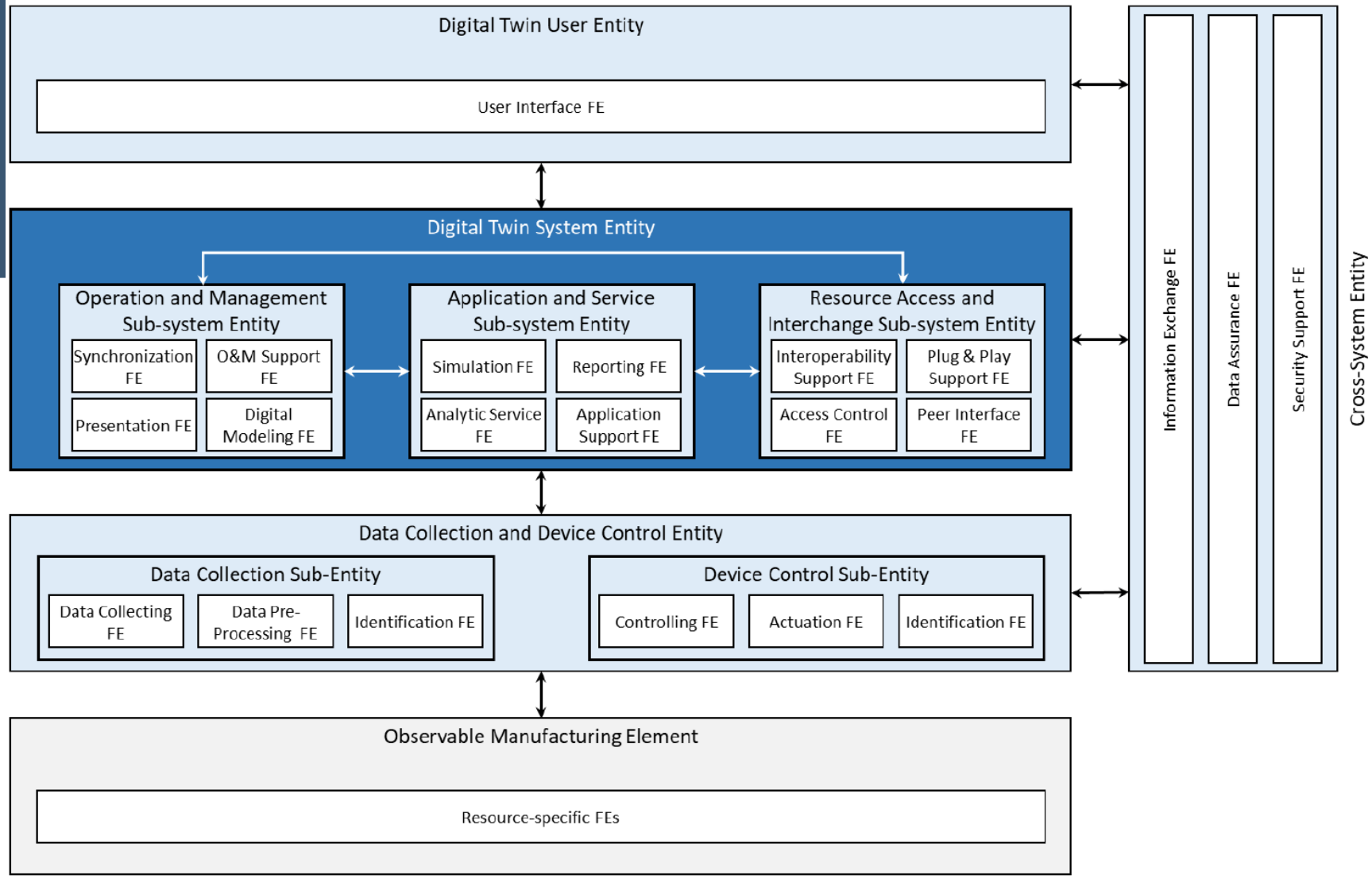
ISO 23247 Reference Architecture



Literature Review

Azure Digital Twin

- It serves as the cloud solution for IoT devices and querying on the platform can be performed using SQL
- It provides a real-time execution environment and twin graph functionality for visualization

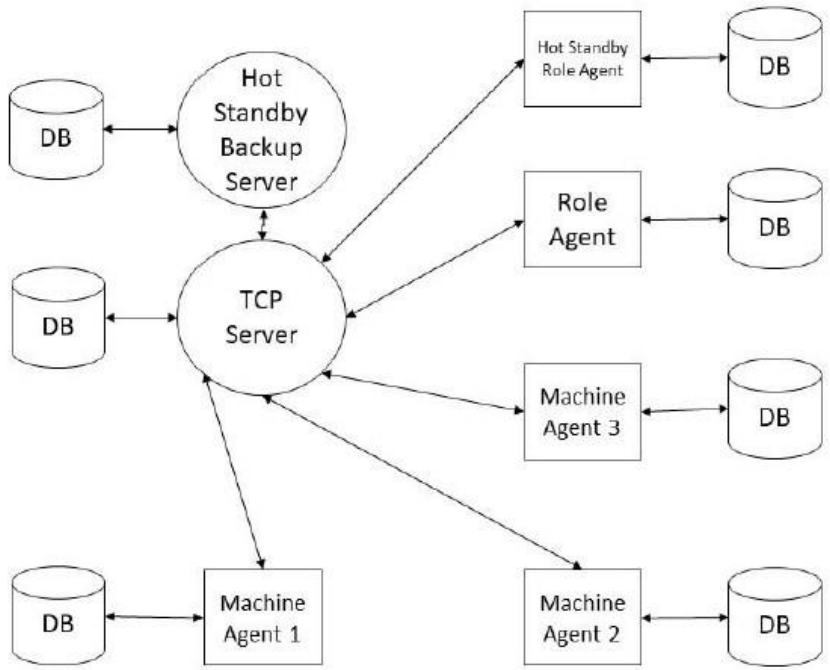
AWS IoT Twin Maker

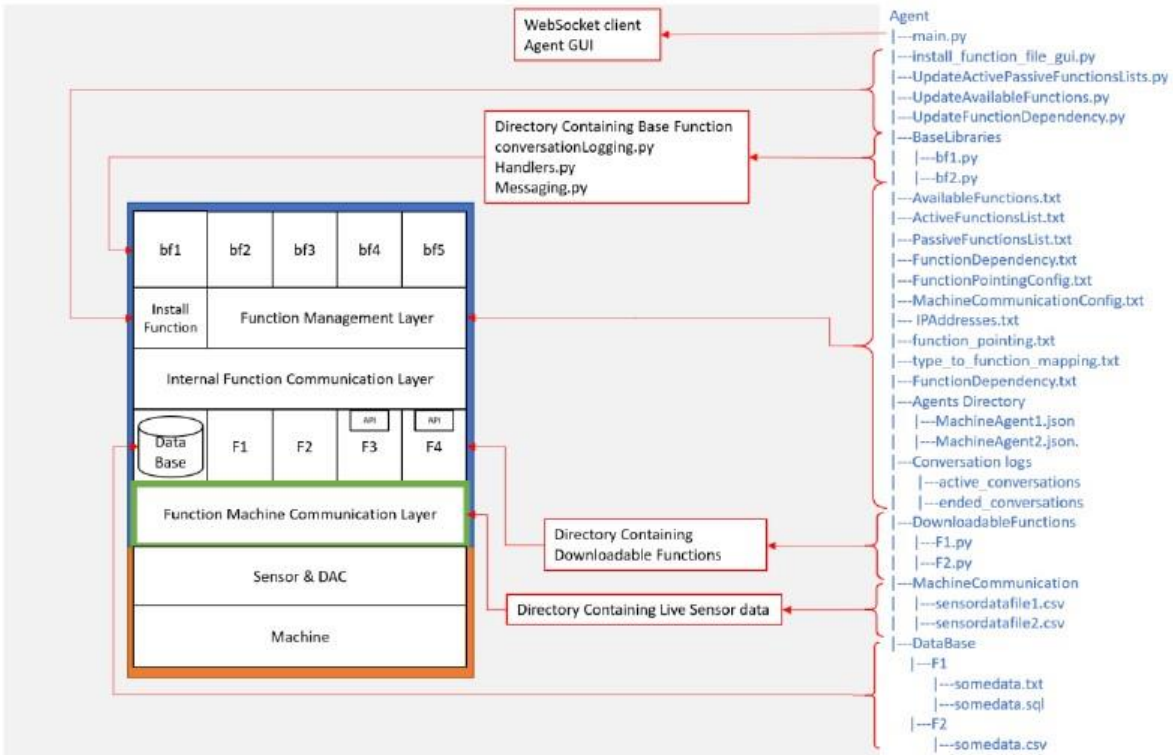
- AWS IoT service enables the creation of operational digital twin models for both physical and digital systems
- These models are then connected to the corresponding devices using IoT technology, enabling the collection of data for analysis, visualization, and the implementation of various functionalities

Siemens Digital Twins

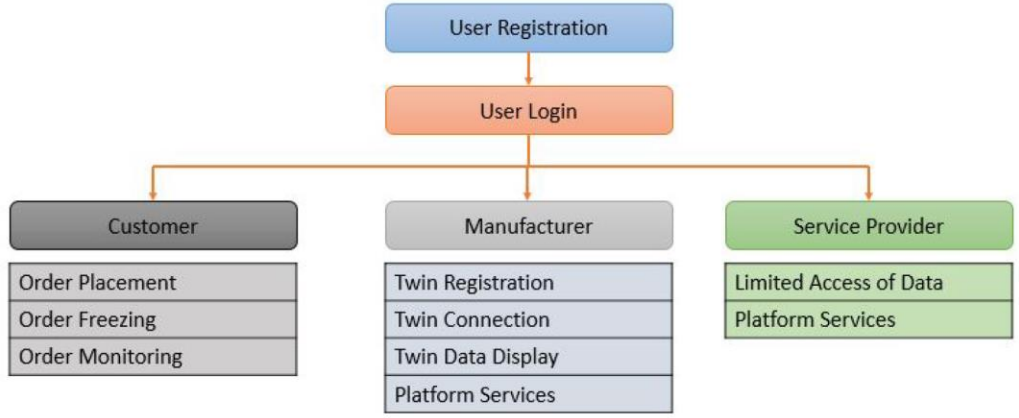
- **Simcenter:** Simcenter provides advanced simulation capabilities, such as finite element analysis (FEA), computational fluid dynamics (CFD), and multi-body dynamics (MBD)
- **Mindsphere:** Mindsphere is Siemens' cloud-based IoT platform that integrates with digital twins. It collects real-time data from physical assets and systems, which is then used to update and enhance the digital twin models
- **Tecnomatix:** It focuses on digital manufacturing, production planning, and optimization

Digital Twin 1.0

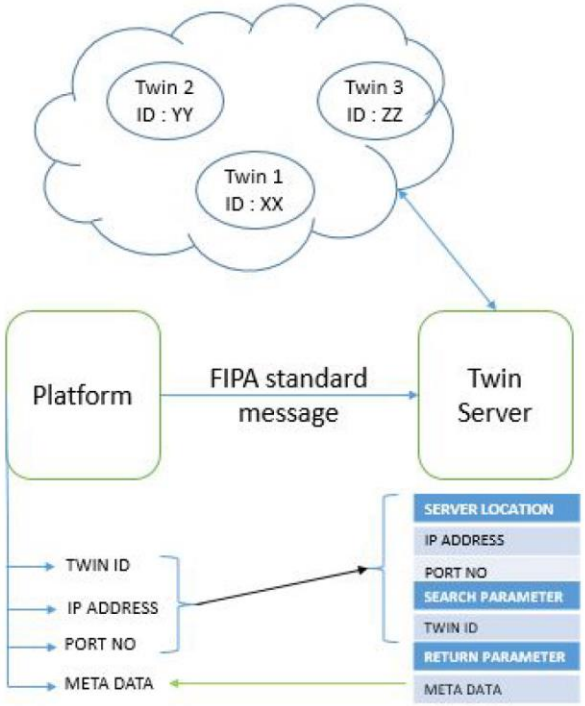




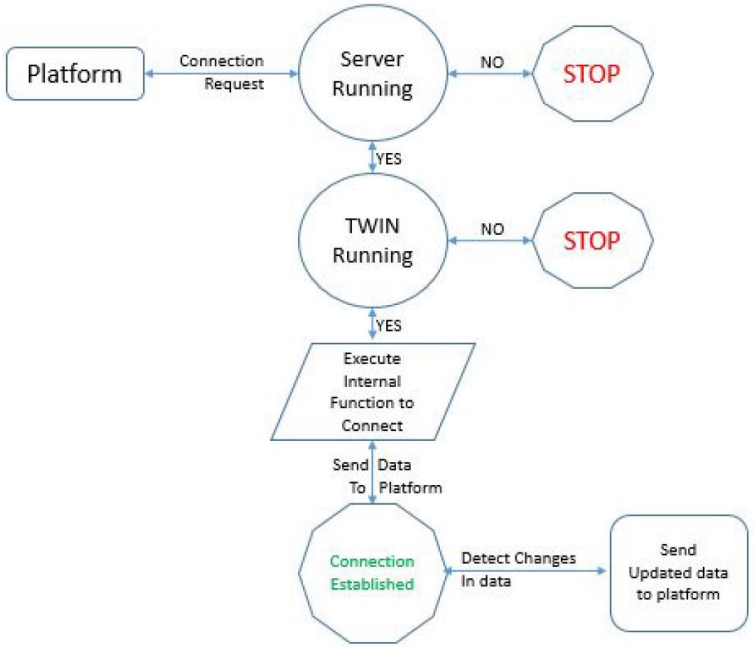
Digital Twin 2.0



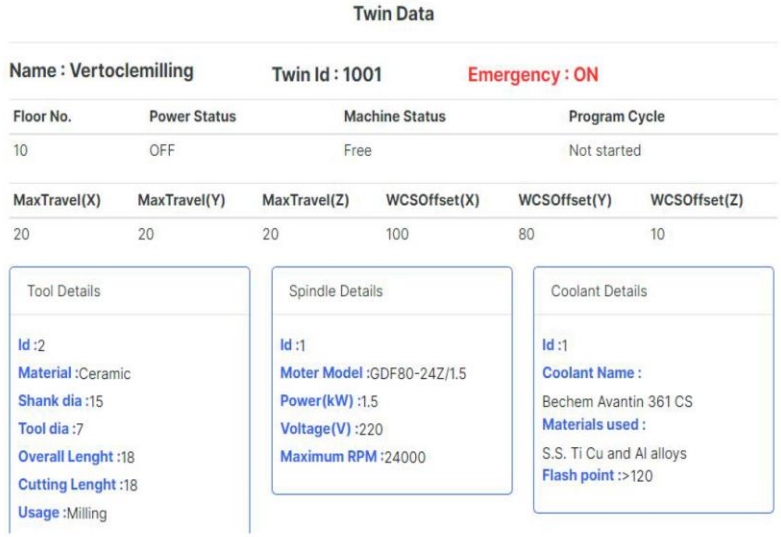
Platform Overview



Twin Registration

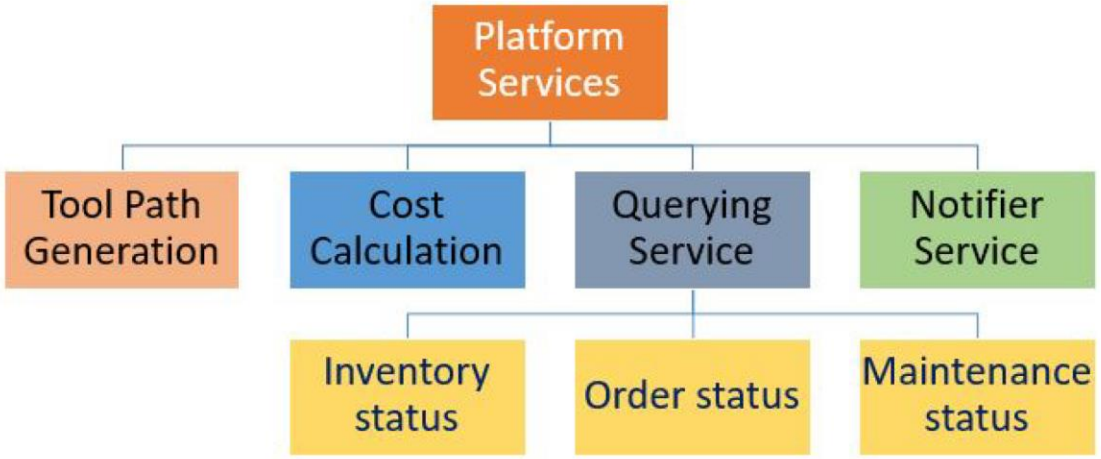


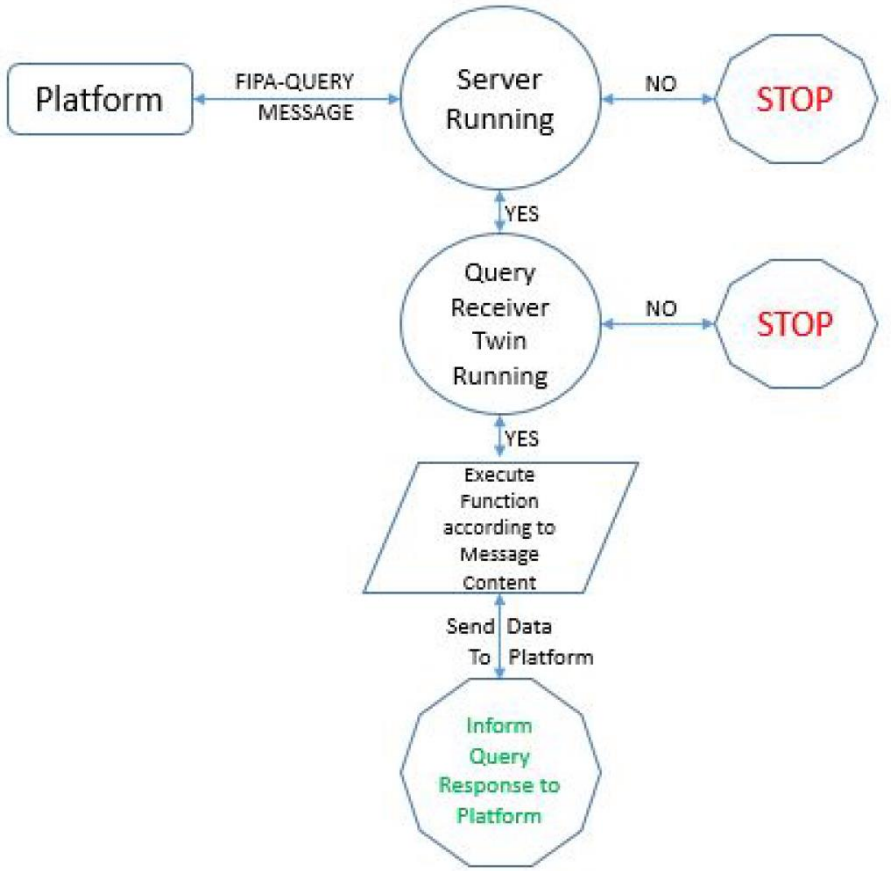
Twin Connection



Twin Data Display

Digital Twin 2.0





Flow of Querying Services

Objectives

- Establishing concept for ISO 23247 standardized Digital Twin based on earlier versions of Twin
- Establishing an Architecture for physical installation of standardized Digital Twin
- Developing a user interface for the initialization of the Server and other Agents to facilitate the deployment of the Twin
- Establishing framework for development, installation, initialization and deletion of downloadable custom function through User Interface
- Developing Application and Service Sub-system Entity with active and passive functions for Machine and Tool Condition monitoring, report generation and alarm generation

Minimum Viable Digital Twin

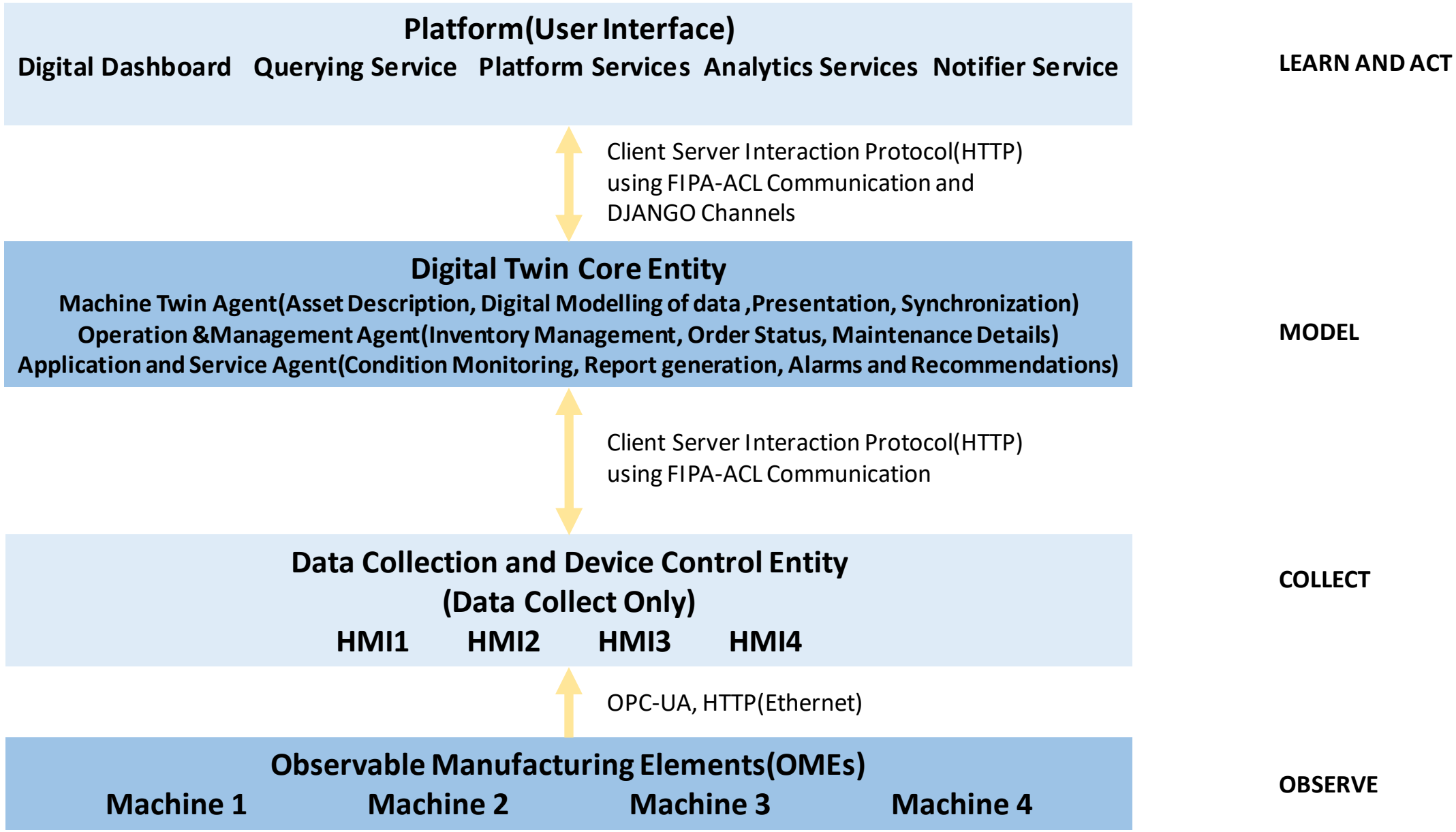
Digital Twin Standard Modules

- Asset Description
- Monitoring
- Communication
- Visualization
- DT Management

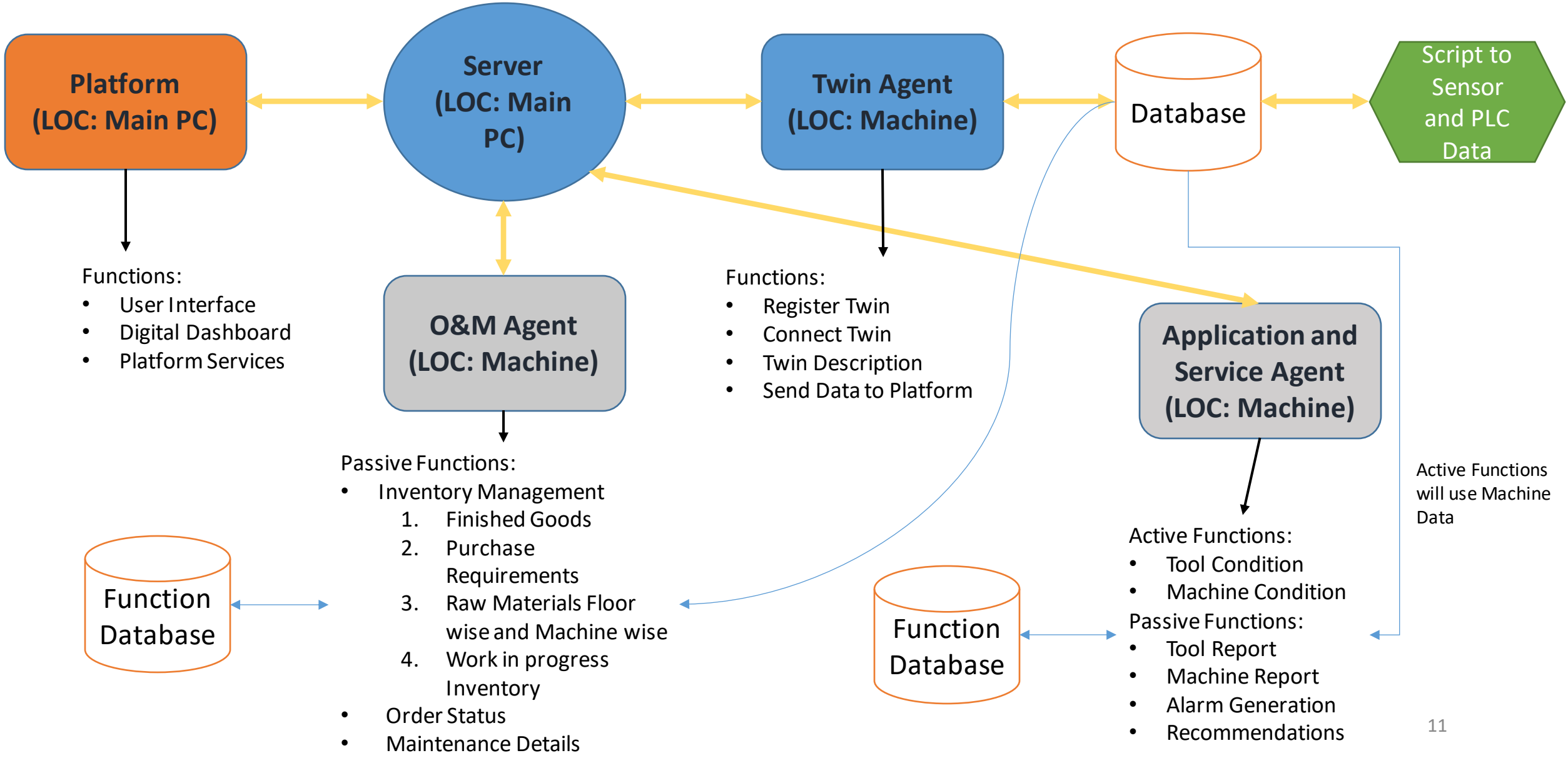
Digital Twin Role

- Respond
- Display
- Alarms
- Recommendations

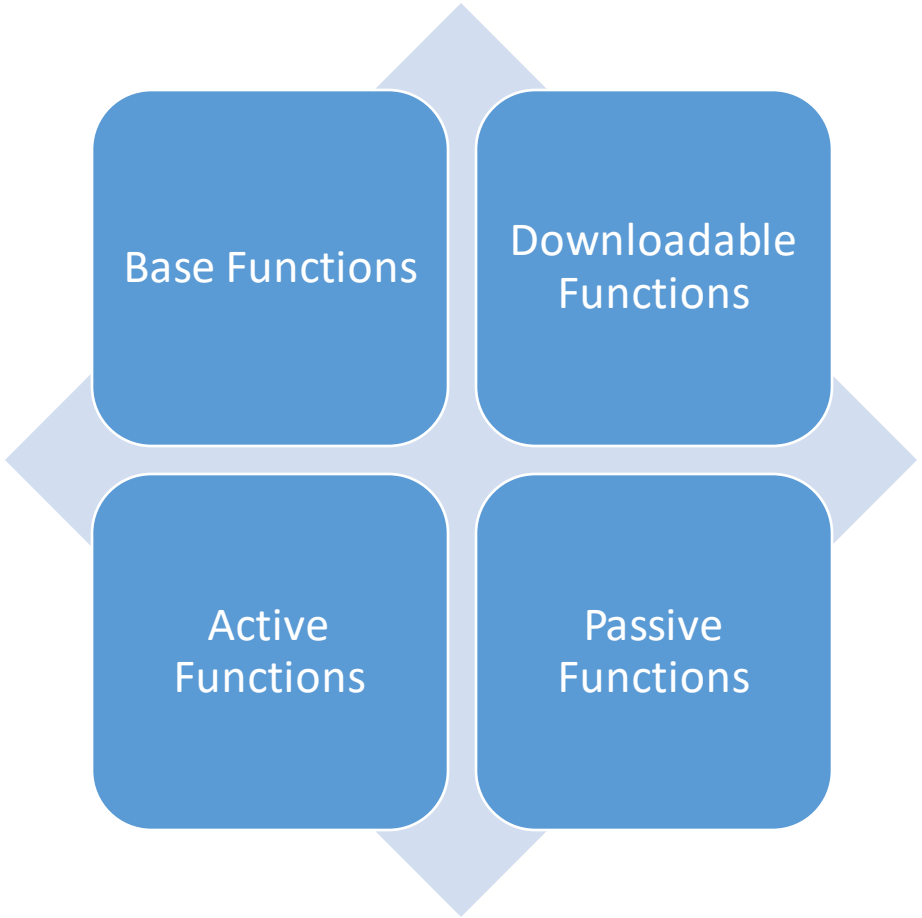
Architecture



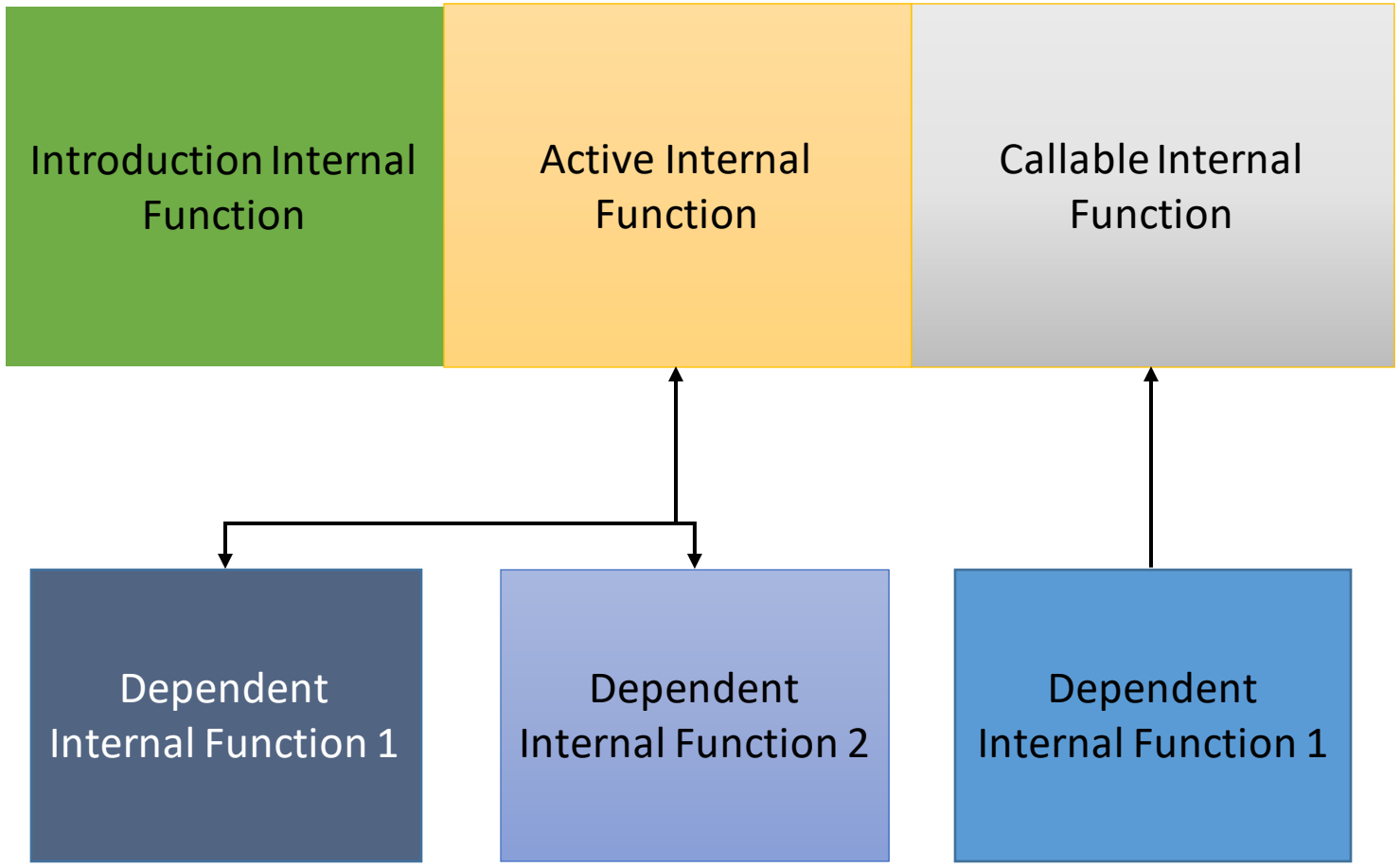
Digital Twin 3.0 Schematic

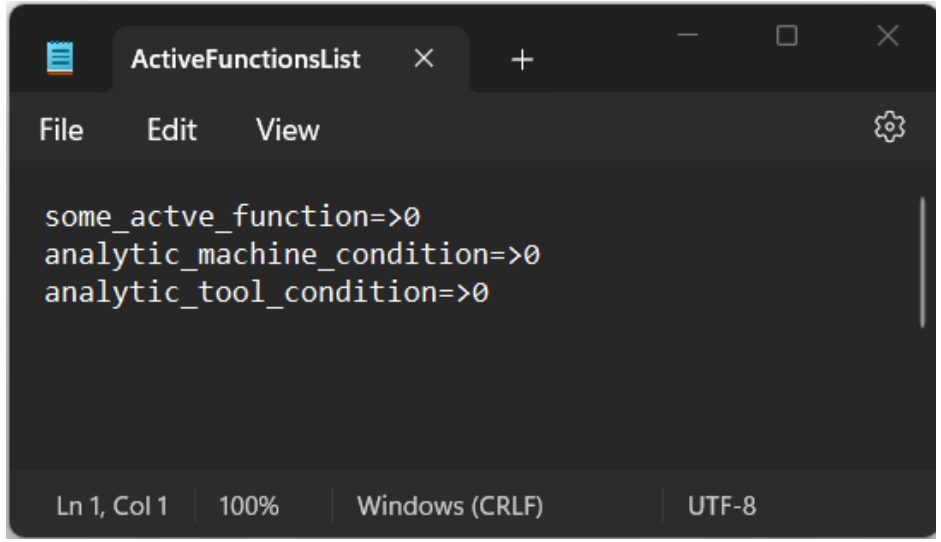


Custom Downloadable Functions

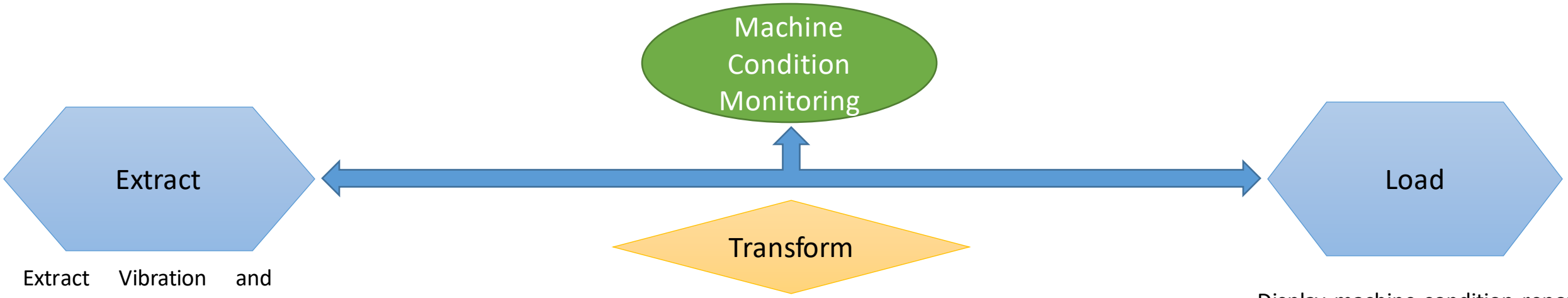


Active Function Architecture





Machine and Tool Condition Monitoring

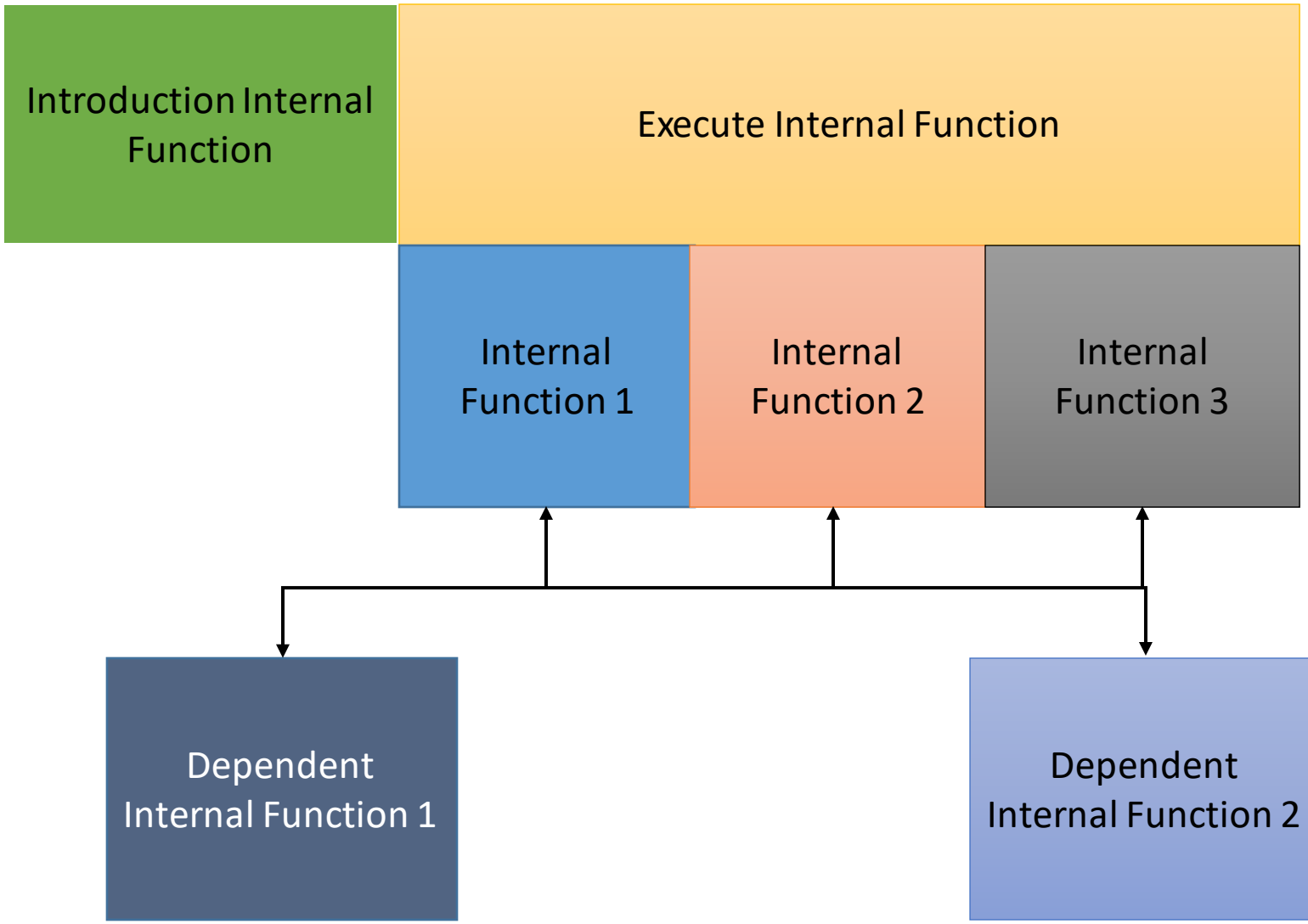


Extract Vibration and Temperature Data from Machine Communication Folder of Twin Agent

- Develop a statistical hypothesis for amplitude of vibrations for recent data and historical data with two sample t-test
- Split Data between most recent 20 percent and 80 percent
- Update the p-value of t-statistic and temperature in function database

Display machine condition report on Web based Platform on request through passive function

Passive Function Architecture



PassiveFunctionsList

File Edit View

```
floor_div=>0
report_machine_generation=>request_machine_report
alarm_machine_generation=>request_machine_alarm
alarm_tool_generation=>request_tool_alarm
recommendation=>request_recommendation
report_tool_generation=>request_tool_report
```

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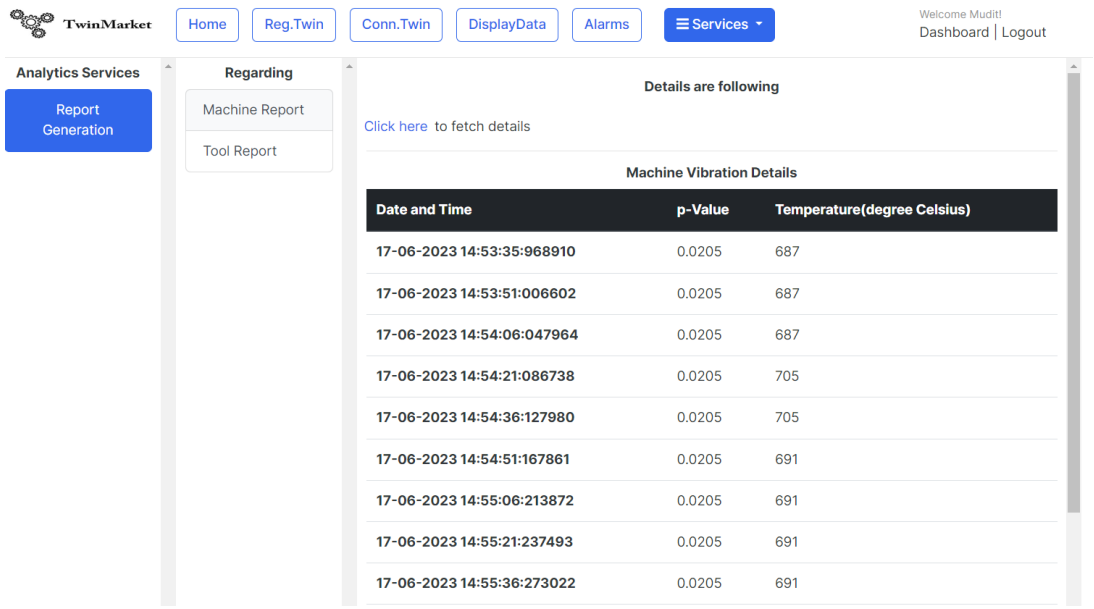
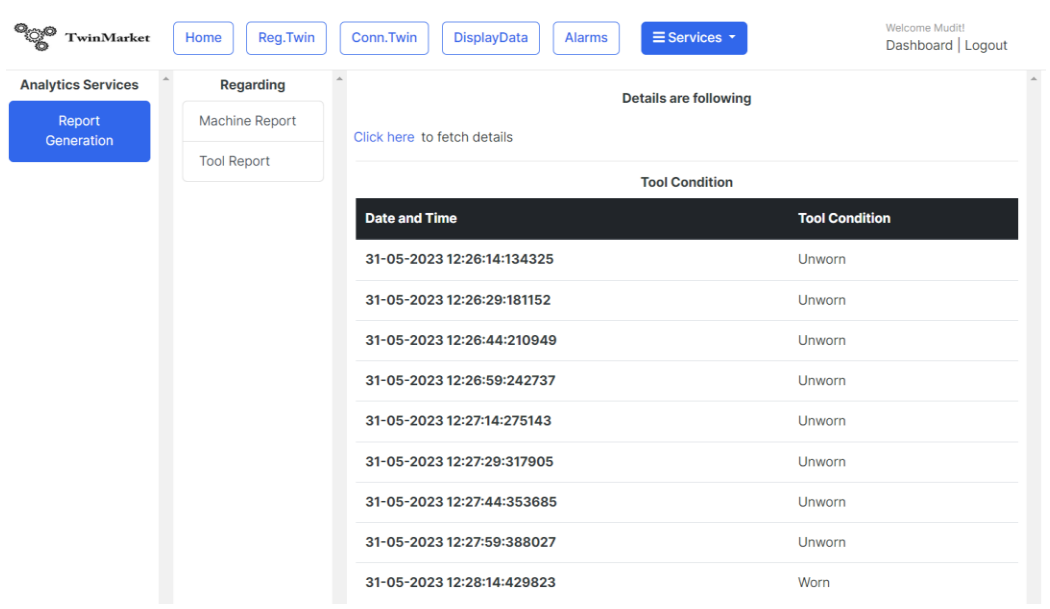
Passive Functions

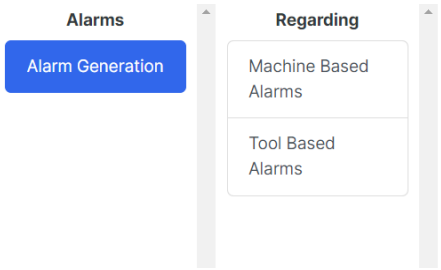


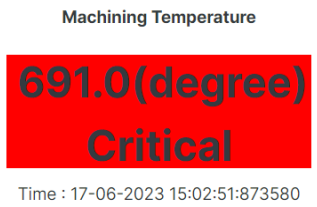
Machine Report



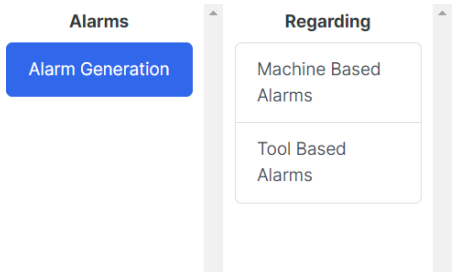
Tool Report

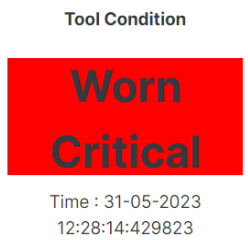
Passive Functions



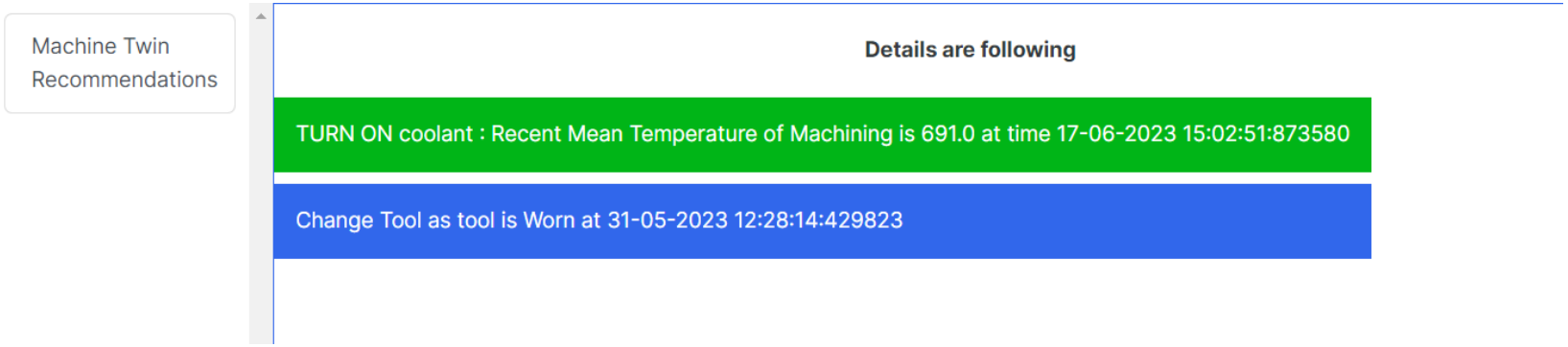


Machine Based Alarms



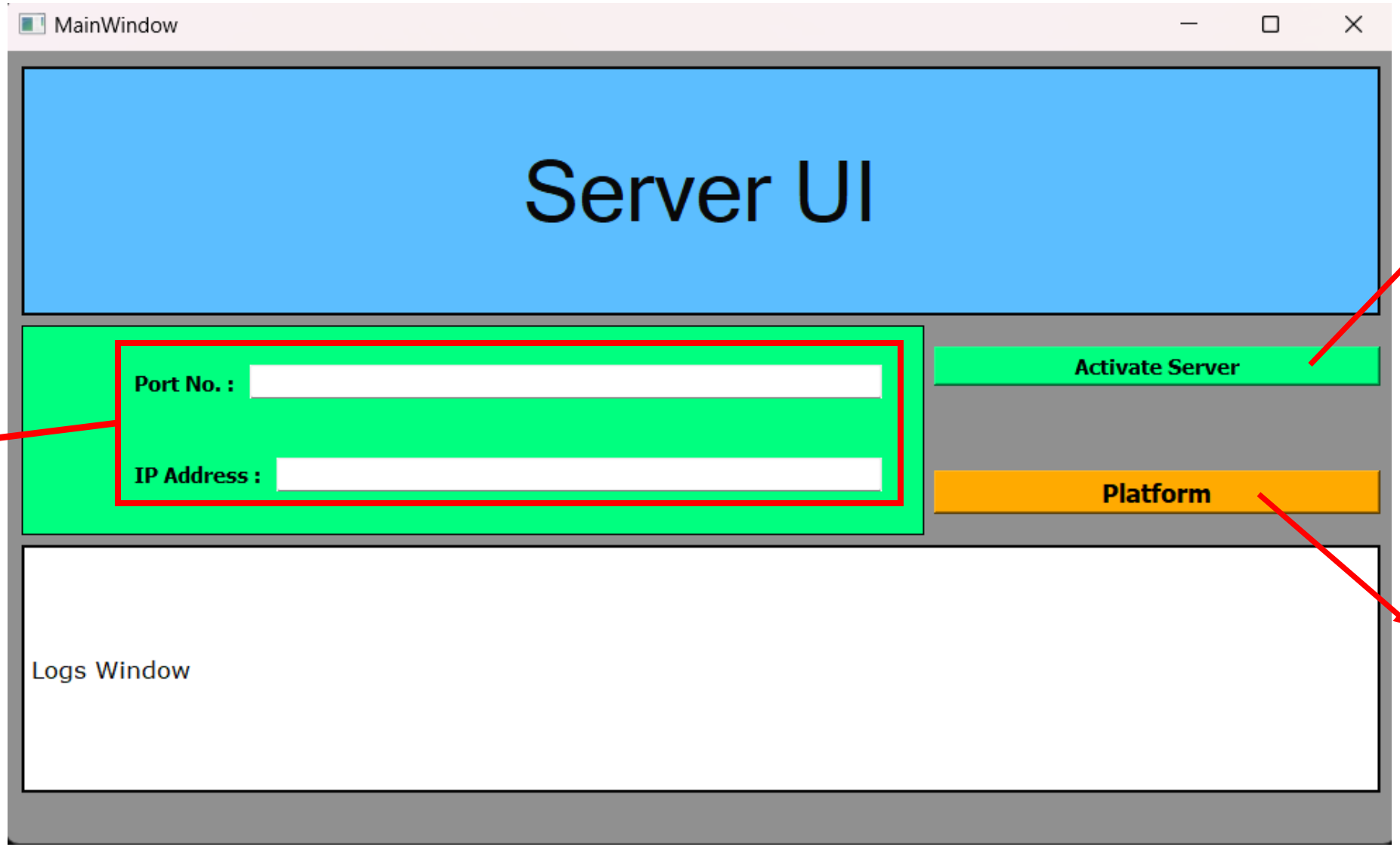


Tool Based Alarms



Recommendations

User Interface



Writing Port, No and IP Address in server_ip.txt

Activating script server.py in Server Directory of Main Directory

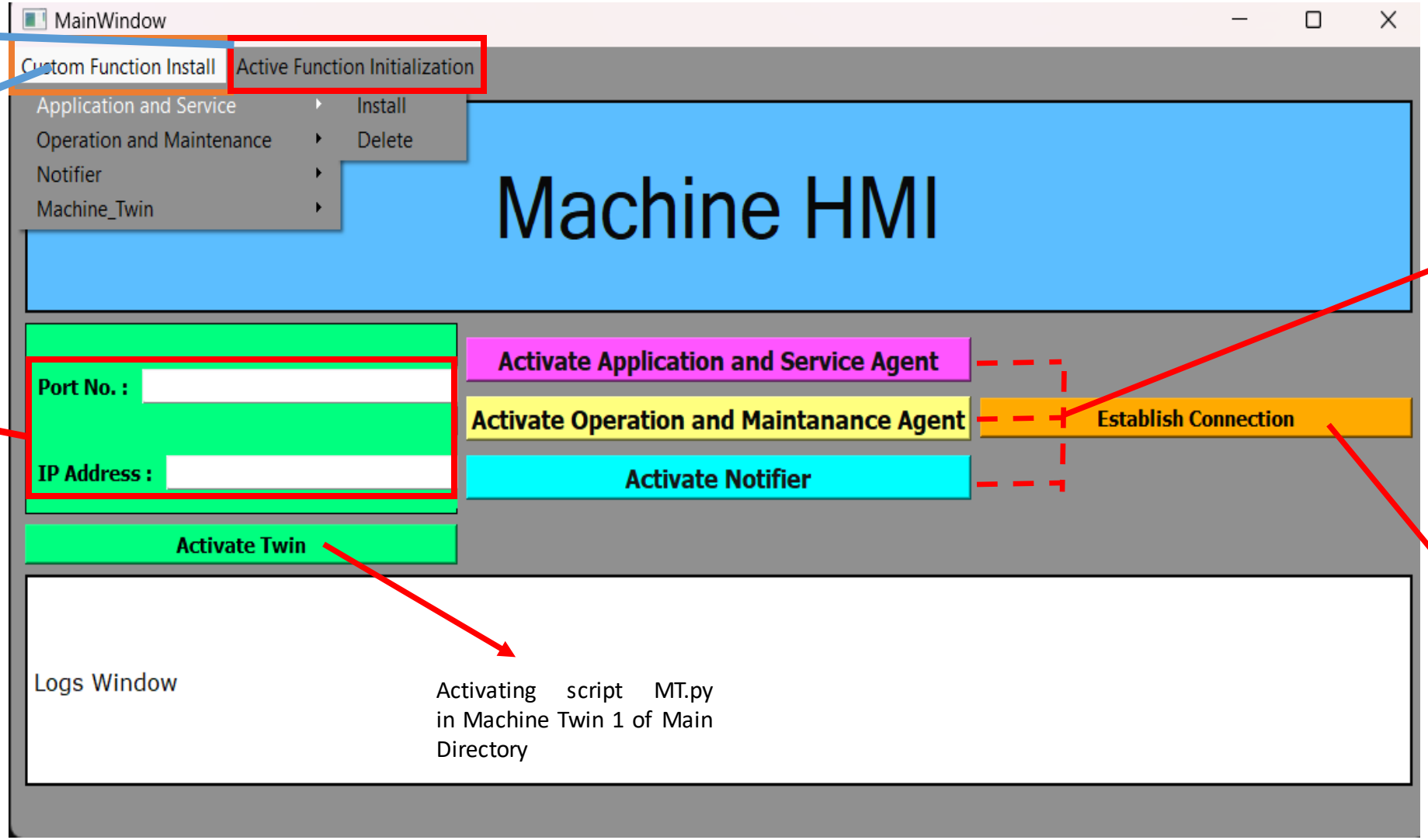
Launching Platform for real-time data display and accessing Platform Services by running manage.py and opening local host URL

User Interface

Activation of active functions

Installation and Deletion of Custom Downloadable Functions in Agents

Writing Port, No and IP Address in hmi_ip.txt

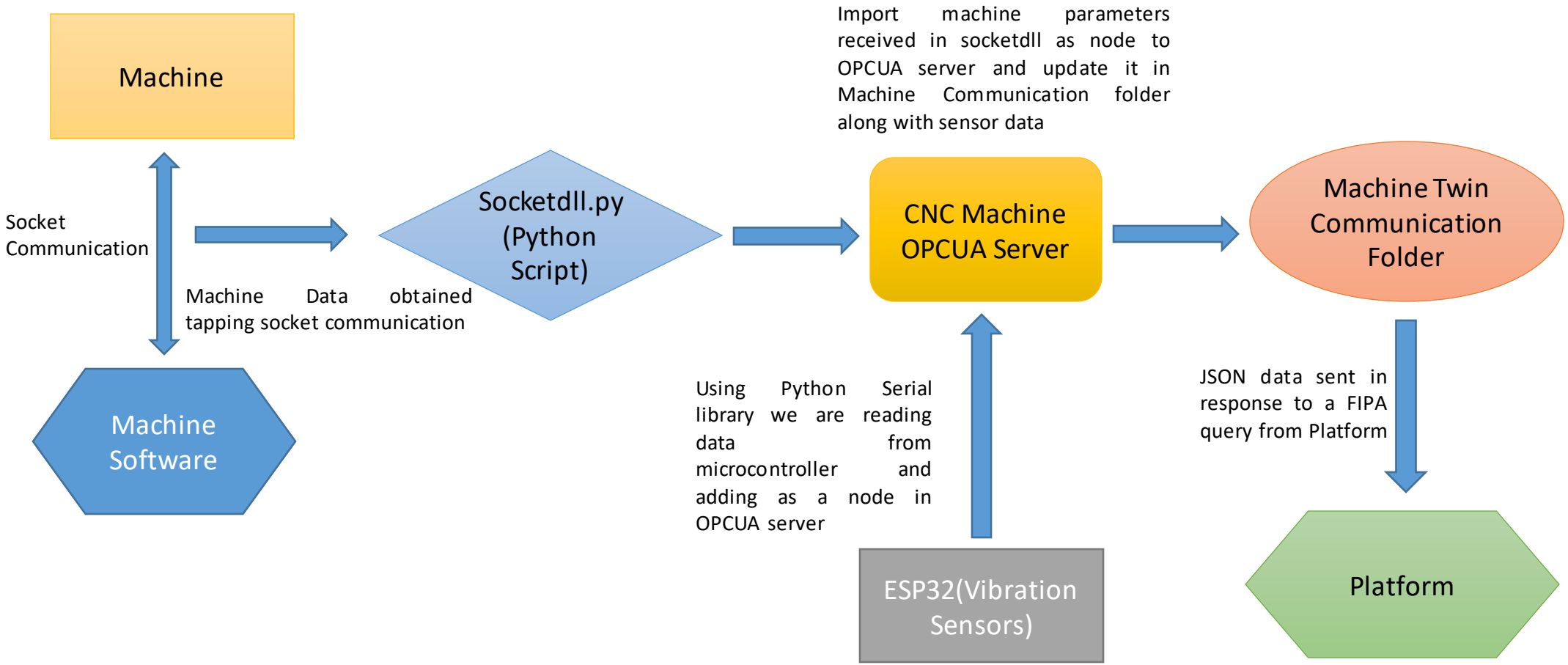


Activating script MT.py in Machine Twin 1 of Main Directory

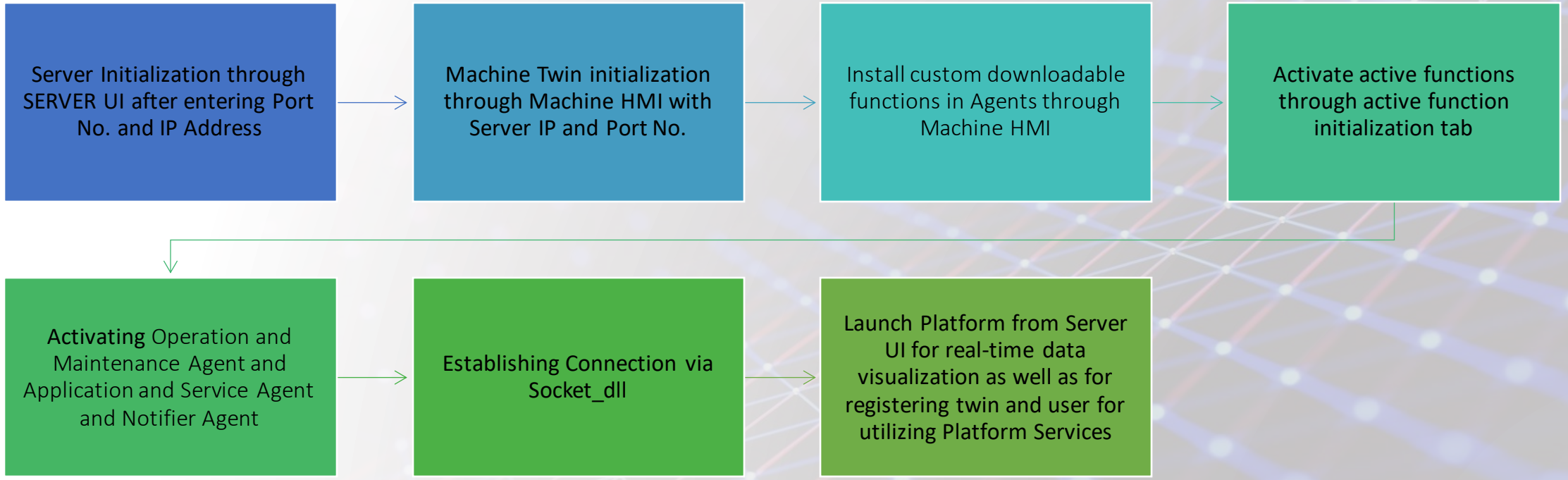
Activating Role Agents to respond to Platform Queries after analyzing Machine Twin Database

Activating socketdll.py to tap data from Machine Application and PLC communication and store it in Machine Communication folder of Machine Twin

Schematic for Establishing Connection



Process Flow



Conclusion

- **Digital Twin Roles:**
  - Digital twin developed **respond** to the query generated from user interface
  - Digital twin **displays** the data collected on a digital dashboard on platform graphically
  - We have integrated **alarms** also in our twin
  - Twin also shows **recommendations**

Conclusion

- **Digital Twin Modules:**
  - **Asset Description** in our digital twin has been incorporated as we display twin data which **describes twin id, name, machine limits**, etc.
  - Digital Twin 3.0 also **supports real time monitoring** as data collected is displayed on platform simultaneously
  - **FIPA-ACL based communication protocols** has been utilized which enables interaction and transfer of data
  - Data collected in digital twin is **presented in a graphical and dynamic boxes**
  - **Digital Twin management** is also incorporated by providing **install and delete functionalities in UI**

References:

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