Digital Twin Technology

(Using AWS Cloud Technologies)

Internship-1 Report Submitted in partial fulfillment of the requirements for the undergraduate degree of

Bachelor of Technology

In

COMPUTER SCIENCE AND ENGINEERING By

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HU21CSEN0101342

Under the Guidance of

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GITAM (Deemed to be University)

Hyderabad-502329

December 2023

DECLARATION

I hereby submit this internship project titled "**Digital Twin Technology**" to GITAM (Deemed To Be University), Hyderabad in partial fulfillment of the requirements for the award of the degree of "**Bachelor of Technology**" in "**Computer Science and Engineering**". I declare that it was carried out independently by me under the guidance of **Dr G. Soma Sekhar,** Associate Professor, GITAM (Deemed To Be University), Hyderabad, India.

The results presented in this report have not been submitted to any other University or Institute for the award of any degree or diploma.

Place: HYDERABAD

Date: 22-12-2023

Name: Jnyandeep Anakapalli

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GITAM (DEEMED TO BE UNIVERSITY)

Hyderabad-502329, India

Dated: 21 - 12 - 2023

CERTIFICATE

This is to certify that the internship project report titled **"Digital Twin Technology"** is being submitted by Jnyandeep Anakapalli (HU21CSEN0101342) in partial fulfillment of the requirement for the award of **Bachelor of Technology in Computer Science**

And Engineering at GITAM (Deemed to Be University), Hyderabad during the academic year 2023-2024.

It is faithful record work carried out by him at the **Computer Science And Engineering**

Department, GITAM University Hyderabad Campus under my guidance and supervision.

Dr. G. Soma Sekhar
Associate Professor
Department of CSE

Dr. Mahaboob Basha Shaik
Professor and HOD
Department of CSE

ACKNOWLEDGEMENT

Apart from my effort, the success of this internship largely depends on the encouragement and guidance of many others. I take this opportunity to express my gratitude to the people who have helped me in the successful completion of this internship

I would like to thank **Dr. Mahaboob Basha Shaik,** Head of Computer Science and Engineering for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present an internship report. It helped me a lot to realize what we study for.

I would like to thank the respected faculties **Dr. G. Soma Sekhar** who helped me to make this internship a successful accomplishment.

I would also like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Jnyandeep Anakapalli

HU21CSEN0101342

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INTRODUCTION TO DIGITAL TWINS

A digital twin is a virtual representation of a physical object, process, system, or environment that mirrors its real-world counterpart as closely as possible. This virtual model is constantly updated with data from sensors attached to the physical object, allowing it to reflect its current state and predict its future behavior.

The market for digital twins is maturing. Targeted for the most part at industry and manufacturing, Fortune Business Insights projected the market to be valued at $11.51 billion in 2023 with a CAGR of 42.6% through 2030. An emerging bio-digital subset is also gaining traction

APPLICATIONS

AEROSPACE

In the aerospace industry, digital twins assist in predictive maintenance for aircraft by monitoring real-time component performance and predicting maintenance needs. Engineers utilize digital twins to simulate various flight conditions, allowing for comprehensive testing of aircraft systems before physical implementation.

AGRICULTURE

Optimize farms, personalized nutrition plans, and revolutionize agriculture. Digital twins monitor crops, predict yields, and ensure sustainable food production for a growing population.

MANUFACTURING

Digital twins streamline product design and development in manufacturing, facilitating the simulation and optimization of designs before physical prototypes are produced. Additionally, they enhance process optimization by creating virtual replicas of production processes, aiding in the identification of bottlenecks and overall operational efficiency improvements.

SMART CITIES

Digital twins contribute significantly to urban planning by providing a virtual representation of cities. This aids in visualizing and simulating the impact of infrastructure changes, such as new buildings and transportation systems. They are also employed in traffic management, creating digital replicas of transportation systems to optimize flow and reduce congestion.

AUTOMOTIVE

In the automotive industry, digital twins play a crucial role in vehicle design and testing. Engineers use digital twins to simulate and test various aspects, including performance, safety, and fuel efficiency. Predictive maintenance for vehicles is another application, where digital twins monitor real-time vehicle conditions, predicting maintenance needs and improving overall fleet management.

HEALTHCARE

In the future of medicine, patients might have digital avatars, mirroring their bodies in real-time. These digital twins could help doctors personalize treatment plans, predict disease progression, and even perform virtual surgeries, paving the way for a healthier tomorrow.

RETAIL

Retailers leverage digital twins to optimize supply chain processes, from inventory management to logistics planning. They also enhance the customer experience by creating virtual replicas of customer interactions, providing insights to better understand and improve the overall customer journey.

EDUCATION

Education transcends classrooms. Digital twins of historical figures come alive, simulating past events and engaging students in interactive learning adventures.

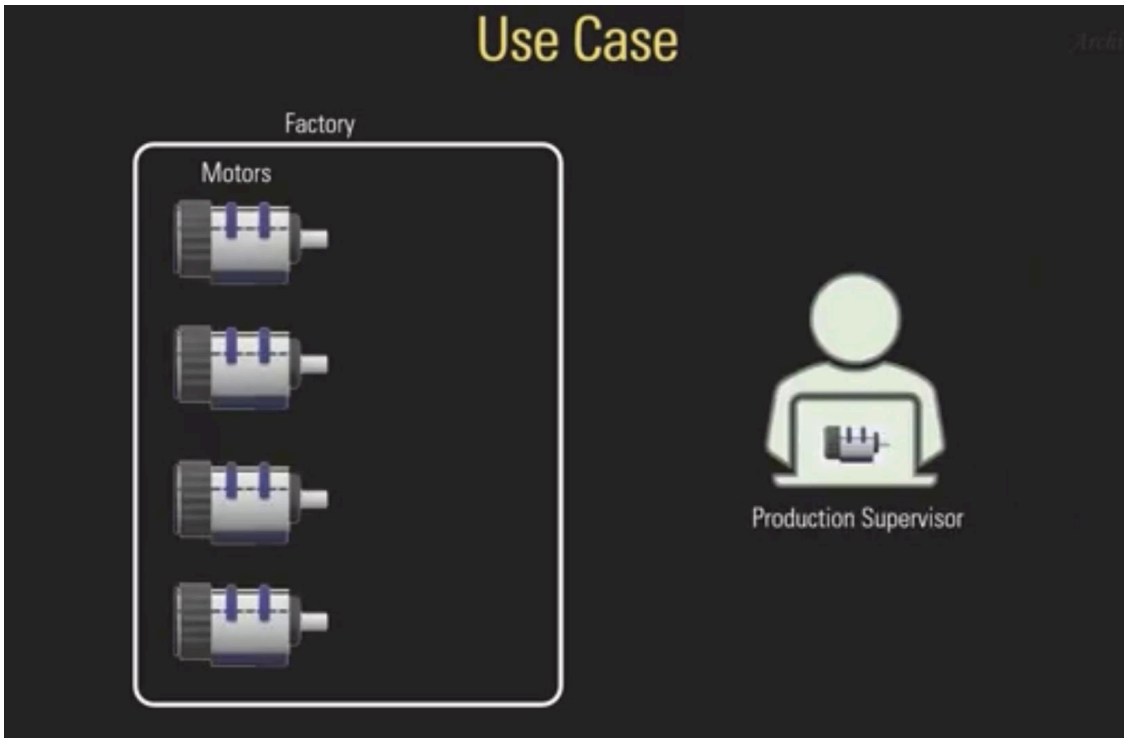
MANUFACTURING

Imagine a factory where machines whisper their secrets to virtual counterparts, predicting glitches before they happen and suggesting tweaks for peak efficiency. Digital twins in manufacturing are revolutionizing production, optimizing processes, and minimizing downtime.

HOW DOES IT WORK?

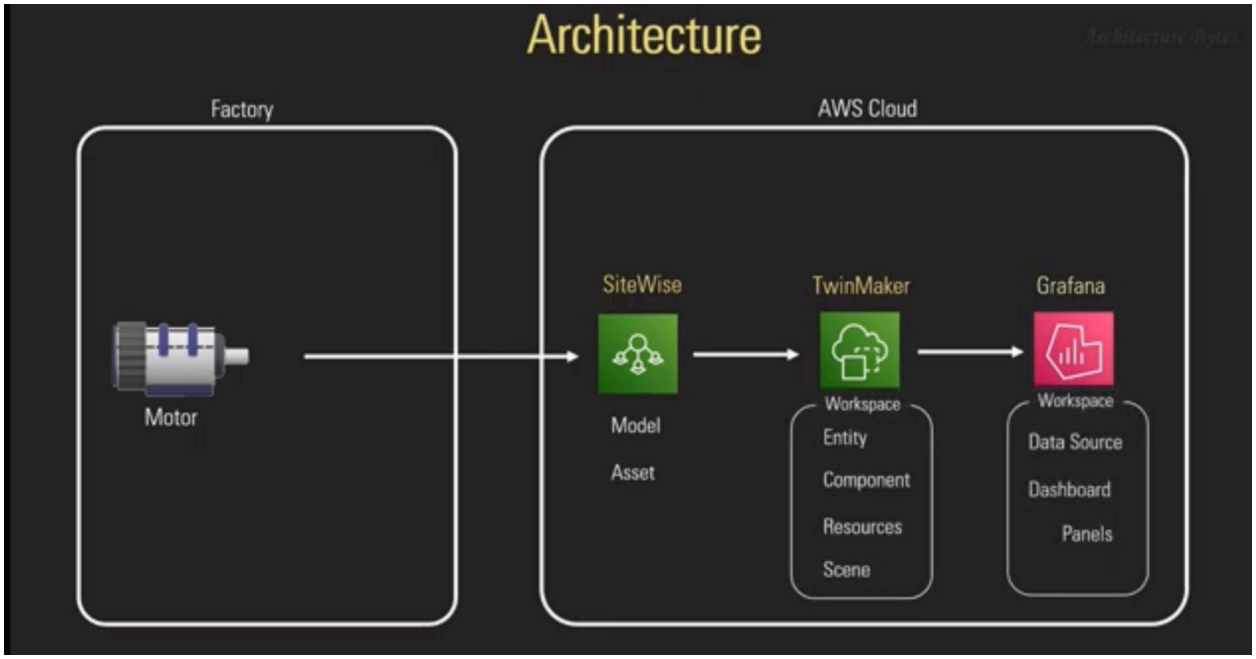
A digital twin works by digitally replicating a physical asset in the virtual environment, including its functionality, features, and behavior. A real-time digital representation of the asset is created using smart sensors that collect data from the product. You can use the representation across the lifecycle of an asset, from initial product testing to real-world operating and decommissioning.

USE CASE



AWS IoT TwinMaker is employed to visualize the status of motors on a factory floor. Production supervisors want to see a visual representation of current and historical data, precisely the speed of the engines.

ARCHITECTURE



For the example, we will be considering a single-motor.The AWS Cloud in this architecture consists of SiteWise,TwinMaker and Grafana

- SiteWise receives the data generated from the motor
- TwinMaker creates the Digital Twin
- Grafana is used for visualizing

CREATING A DIGITAL TWIN

Creating A Motor Model In AWS Sitewise:

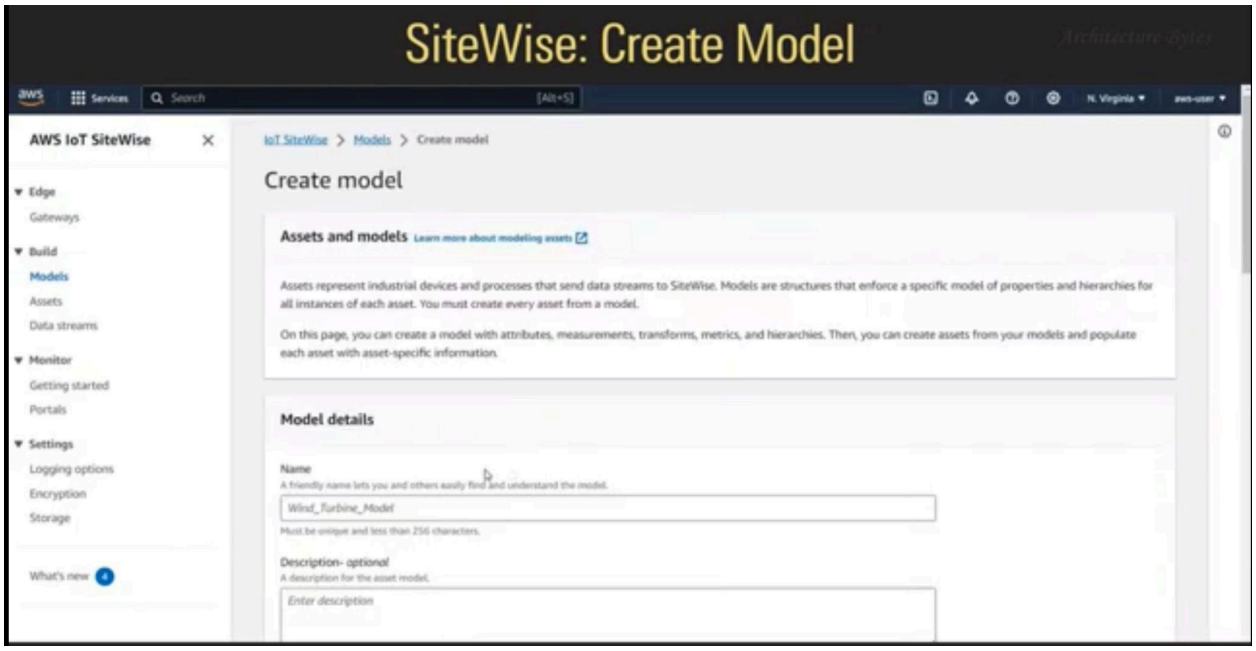
Key actions:

Model creation: A model named "Motor Model" is established within AWS Sitewise.
Attribute definition: The model includes An attribute called "Serial Number" (default value set to "default").

A measurement called "Speed" with units in RPM (Revolutions Per Minute).

Purpose:

- This model is a foundation for representing physical motors within the AWS IoT TwinMaker environment.
- It defines essential properties (serial number) and measures key metrics (speed) for accurate digital representation.



Creating An Asset In AWS SiteWise:

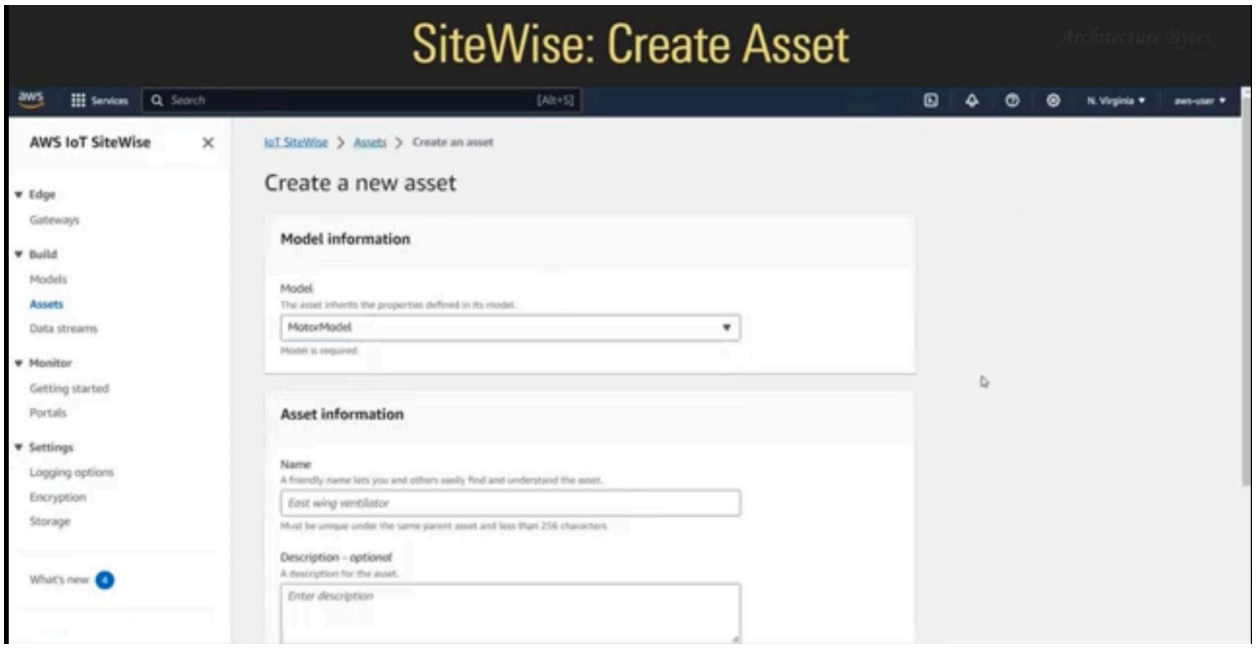
Key actions:

- **Asset creation:** An "Motor One" asset is created using the previously defined "Motor Model."
- **Alias assignment:** An alias called "SL Factory/SL Motor One/Speed" is added to the "Speed" measurement within the asset.
- **MQD notification:** The alias's MQD (Measurement Quality Data) notification status is set to active.

Purpose:

- Based on the general model, this asset establishes a specific motor instance within AWS Sitewise.
- The alias provides a clear, structured way to reference and access the "Speed" measurement data.

- Activating MQD notifications enables alerts for potential data quality issues, ensuring data reliability.



Simulating Motor Data with Python Script:

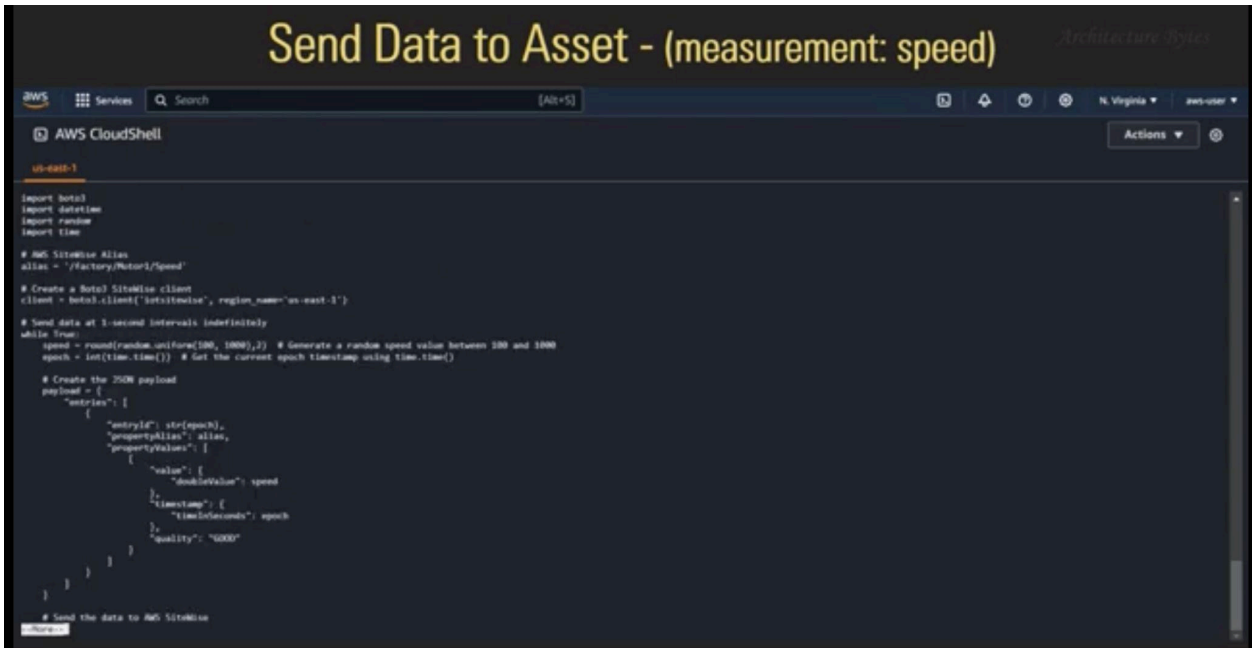
Key actions:

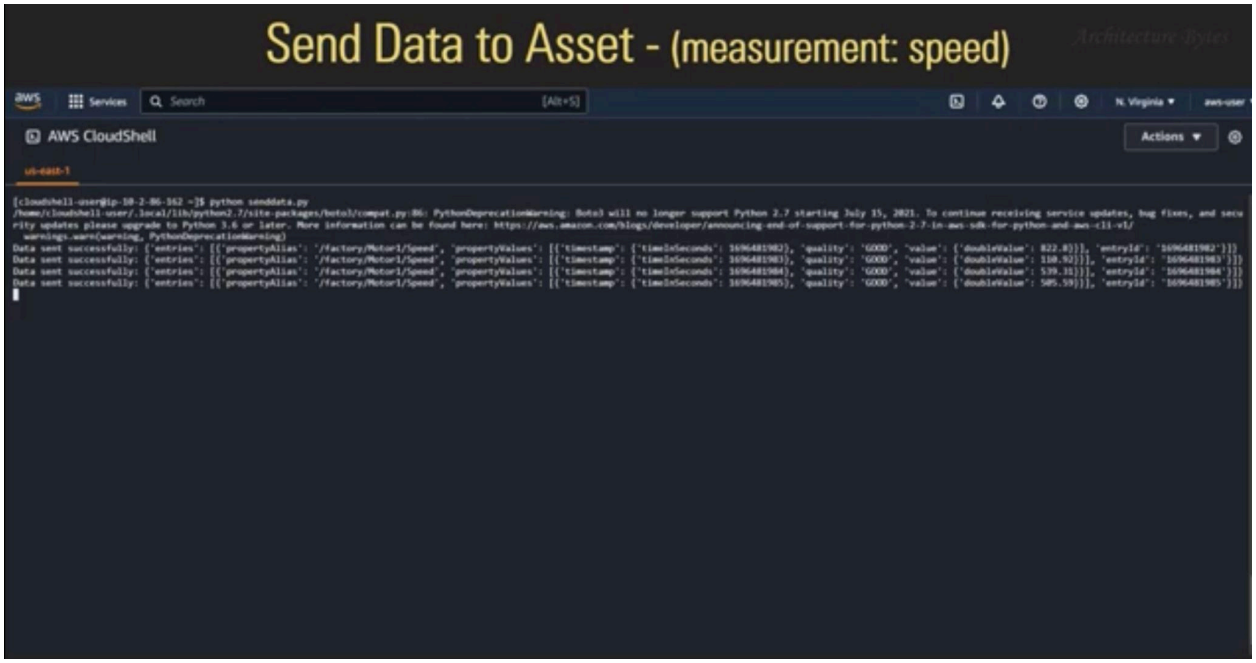
- **Data generation:** A Python script produces simulated motor speed data.
- **Data transmission:** The generated data, which includes timestamps, is sent to AWS Sitewise.
- **Destination:** The data is directed to the "SL Factory/SL Motor One/Speed" alias.
- **Frequency:** The data transmission occurs at one-second intervals, providing a continuous stream.

Purpose:

- This step simulates real-world motor operations by generating a continuous speed data flow.
- It enables testing and visualization within the AWS IoT TwinMaker environment without requiring actual physical motor hardware.

- The one-second interval simulates a near-real-time data flow, mimicking real-world conditions.



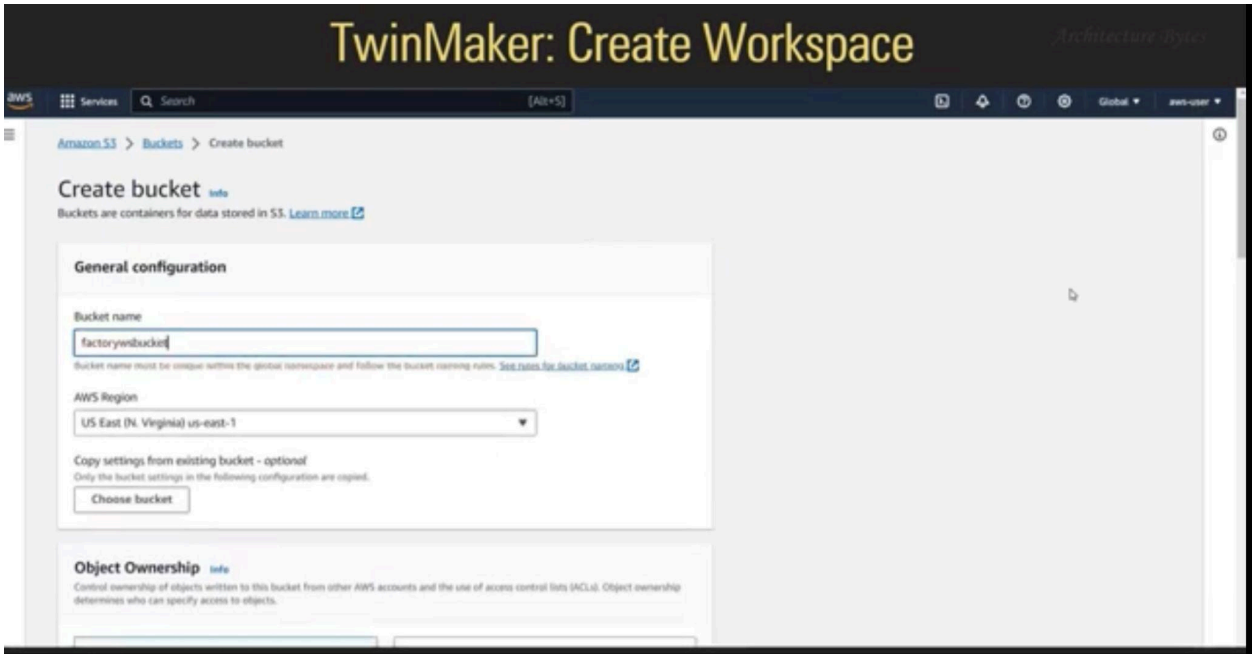


Creating A Workspace In AWS IoT TwinMaker:

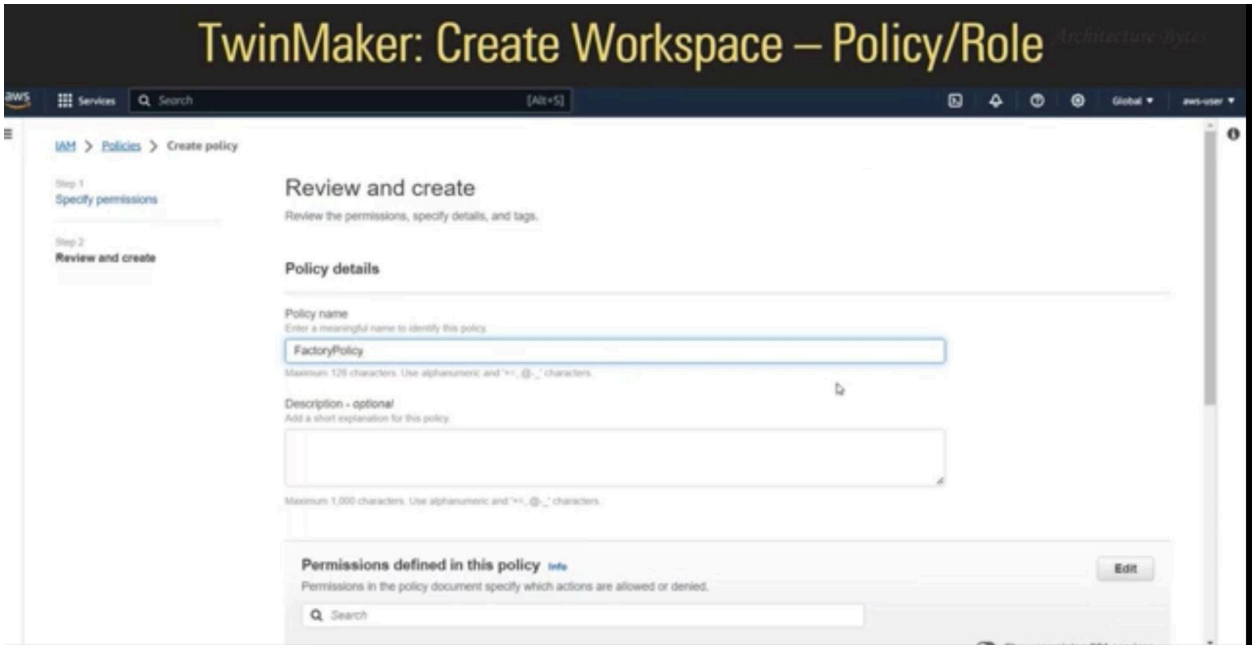
Key Actions:

Workspace creation: A workspace named "Factory Workspace" is established within AWS IoT TwinMaker.

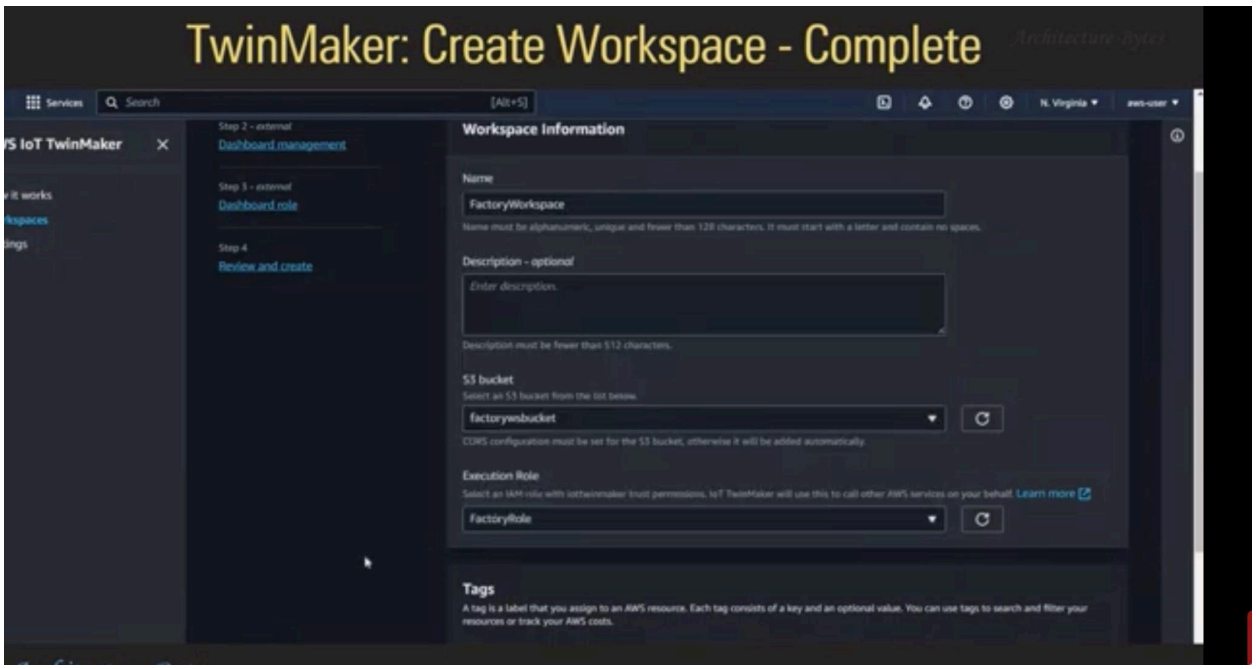
S3 bucket association: An S3 bucket named "Factory WS Bucket" is linked to the workspace for data storage or retrieval.



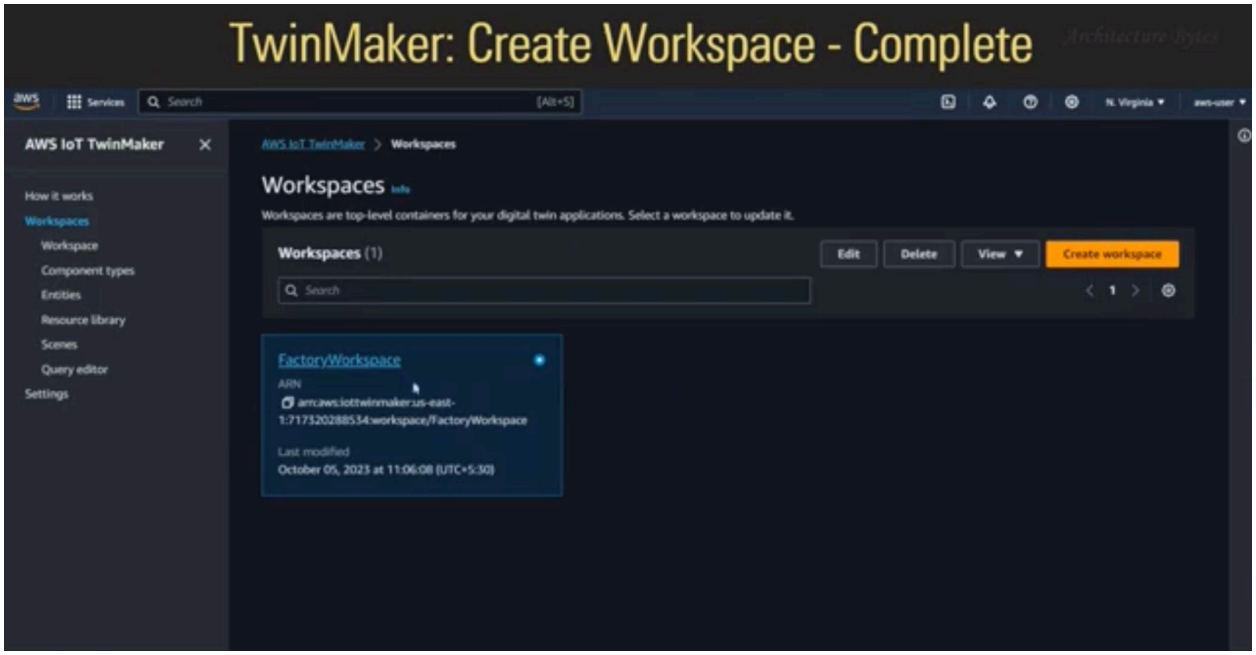
Policy creation: A policy named "Factory Policy" is defined, containing permissions for various AWS services:



TwinMaker: Enables interacting with digital twins within the environment.
Sitewise: Allows access to the motor data stored in AWS Sitewise.
S3: Provides access to the associated S3 bucket for potential data interaction.
Role creation: A role named "Factory Role" is established, incorporating the "Factory Policy".



Workspace role assignment: The "Factory Role" is assigned to the "Factory Workspace," granting it the necessary permissions.



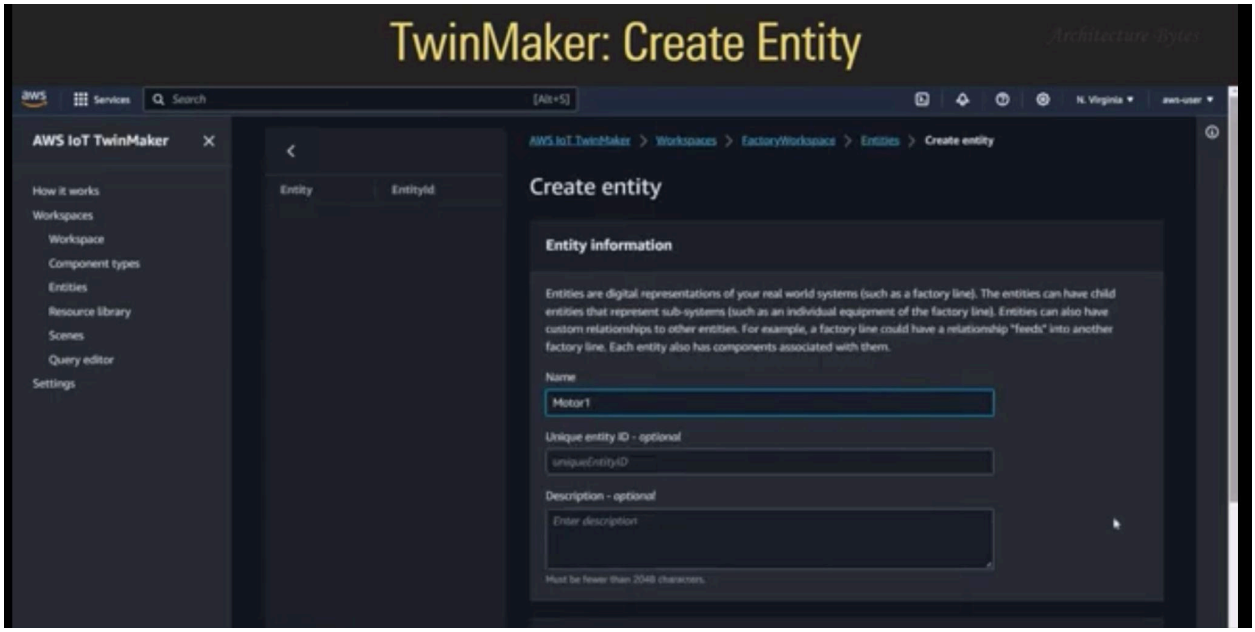
Purpose:

- This step establishes a dedicated workspace within AWS IoT TwinMaker for managing and visualizing the virtual representation of the factory floor.
- The associated S3 bucket potentially serves as a storage or access point for relevant data related to the factory floor (e.g., motor data).
- The "Factory Policy" ensures secure access to various AWS services for proper functioning within the workspace.
- The "Factory Role" incorporates these permissions and is assigned to the workspace, enabling secure operations.

Adding An Entity And Component To Workspace:

Key Actions:

- **Entity creation:** An entity named "Motor One" is established within the "Factory Workspace".

- 

- **Component addition:** A component called "Motor" is added to the "Motor One" entity.
- 

    - **Component configuration:** The "Motor" component is configured in two ways:
    - **Model association:** It's linked to the previously defined "Motor Model"

from AWS Sitewise.

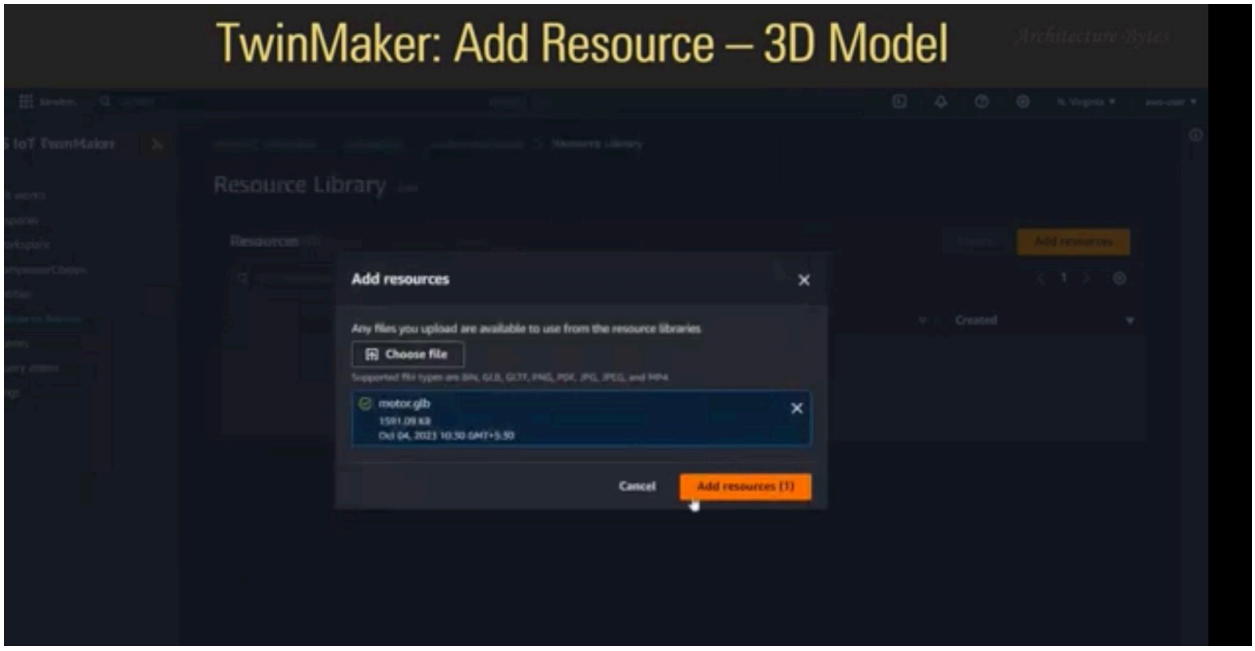
- **Asset linking:** It's connected to the specific "Motor One" asset representing the simulated motor data.

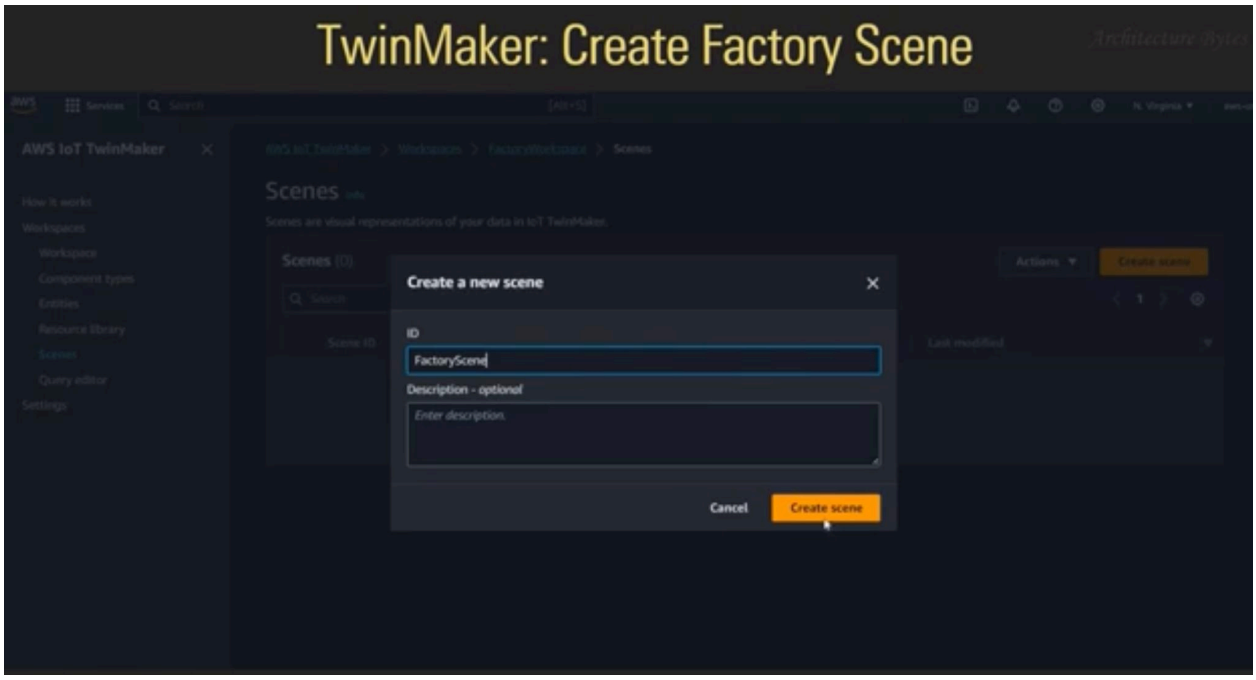
Purpose:

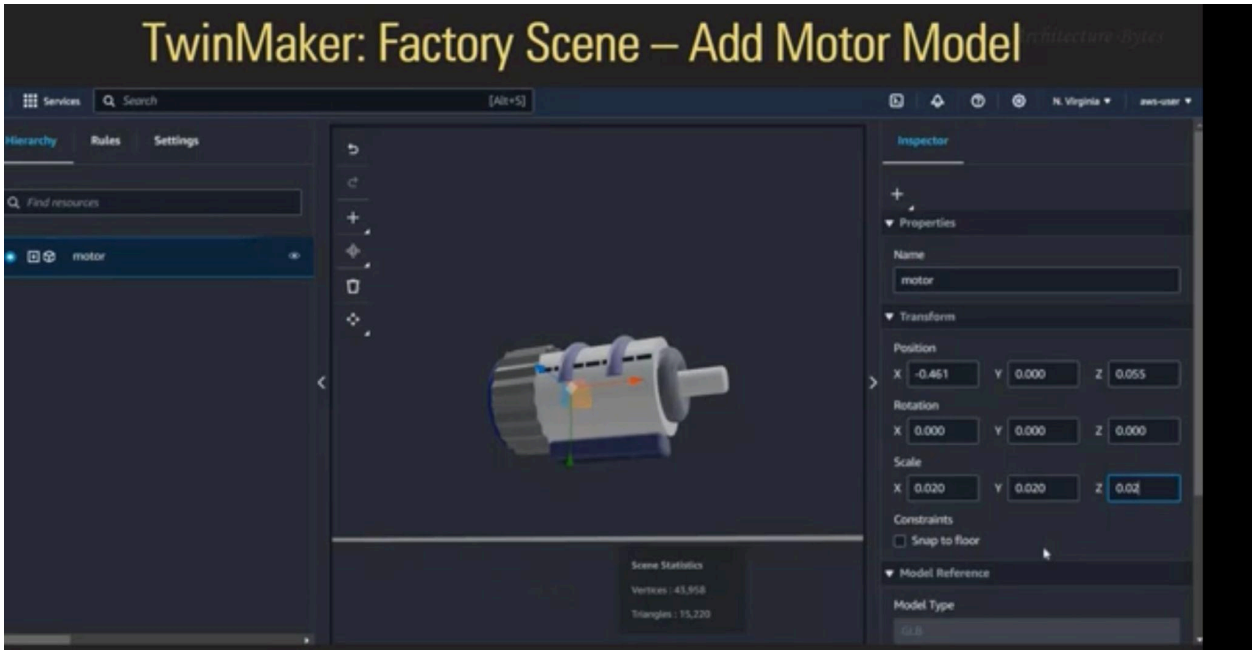
- This step bridges the gap between the simulated motor data and its visual representation within the AWS IoT TwinMaker environment.
- The "Motor One" entity acts as a digital twin of the actual motor on the factory floor.
- The "Motor" component defines the specific characteristics and behaviors of this digital twin, drawing information from the "Motor Model" and real-time data from the "Motor One" asset.

Adding A 3D Model And Scene:

Key Actions:

- **3D Model import:** A 3D model of a motor is uploaded to the resource library within the AWS IoT TwinMaker workspace.
- 

- **Scene creation:** A new scene named "Factory Scene" is created within the workspace.
- 

- **Model placement:** The imported motor model is added to the "Factory Scene."
- 

- **Model manipulation:** The speaker demonstrates moving and scaling the motor model within the scene to customize its position and size.

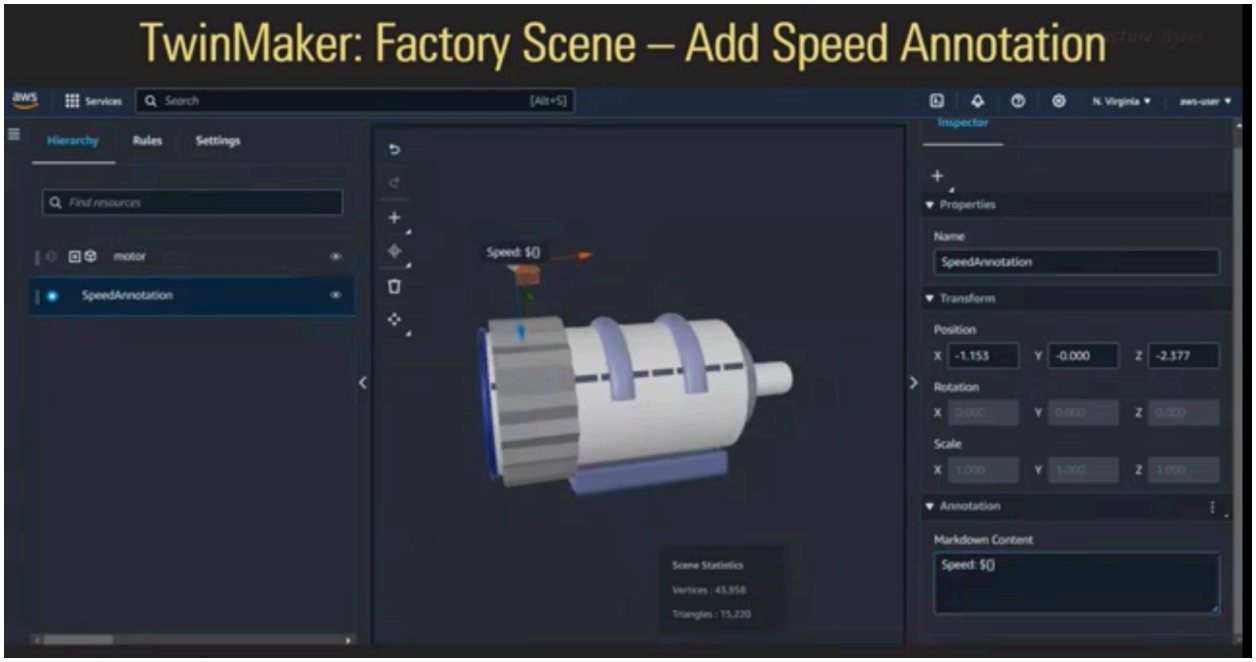
Purpose:

- This step introduces a visual representation of the motor alongside other elements of the factory floor within the AWS IoT TwinMaker environment.
- The imported 3D model provides a realistic depiction of the physical motor.
- The "Factory Scene" is a virtual canvas for arranging and visualizing various factory components.
- Customizing the position and size of the motor model allows for an accurate representation of its actual placement on the factory floor.

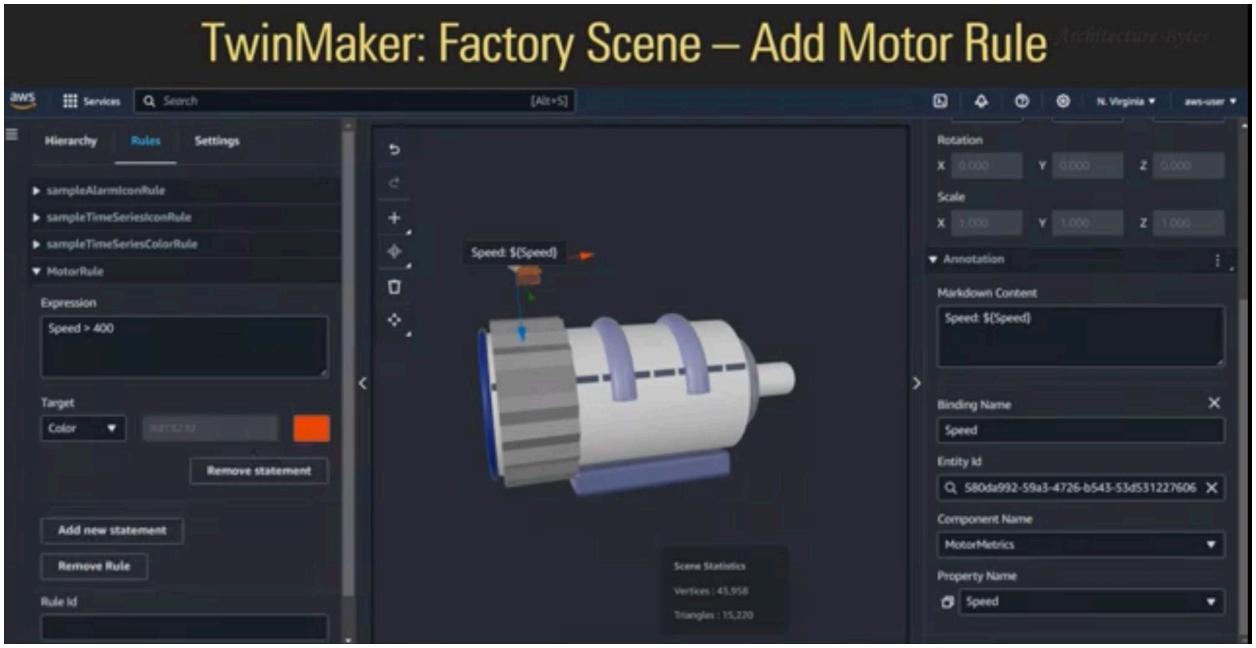
Adding Annotations And Rules To The Scene:

Key Actions:

Annotation addition: This step involves adding an annotation to the "Factory Scene" that displays the current speed of the "Motor One" entity in real time.



Rule creation: A rule is established within the scene that dynamically changes the color of a section of the motor model based on the real-time speed data.



Speed range conditions: Different color shades are assigned to specific motor speed ranges (e.g., green for normal, red for critical).

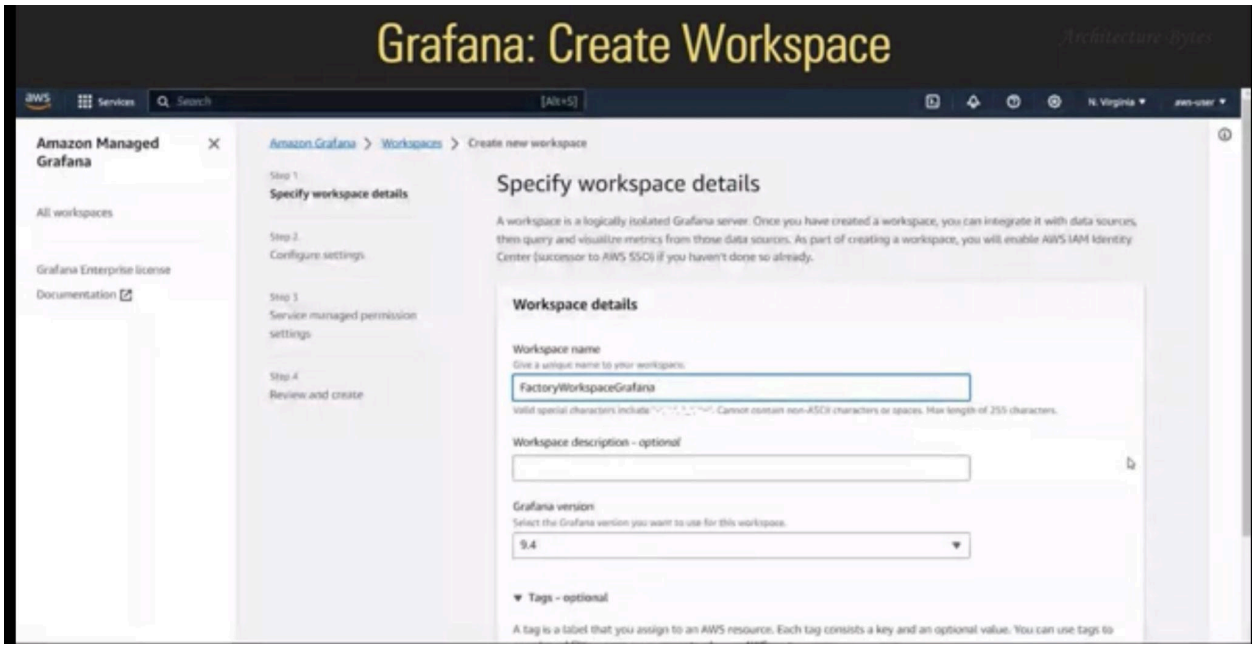
Dynamic adaptation: The color of the motor section automatically updates as the real-time speed data changes, providing a visual indication of its current state.

Purpose:

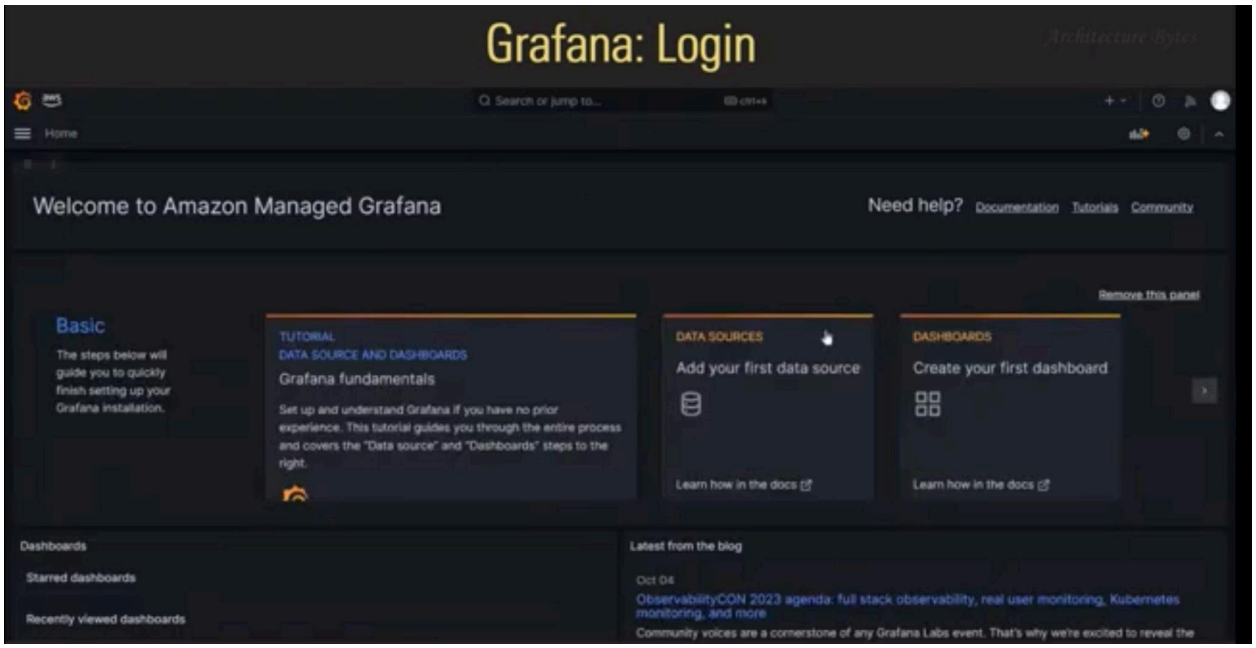
- This step enhances the visualization of the motor data within the "Factory Scene."
- The real-time speed displayed as an annotation helps production supervisors readily grasp the current state of the motor.
- The color-changing rule provides a quick and intuitive way to identify potential issues based on speed variations, aiding in proactive monitoring and intervention.

Setting Up Grafana For Visualization:

A workspace named "Factory Workspace Grafana" is established within Amazon Managed Grafana.

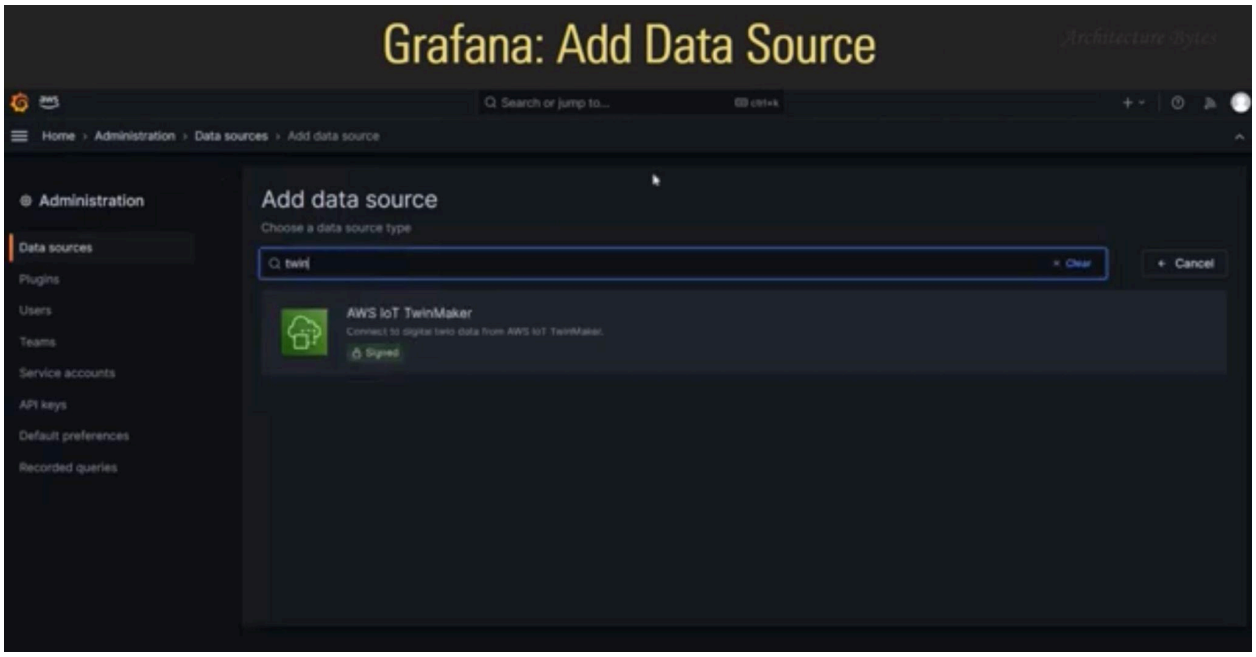


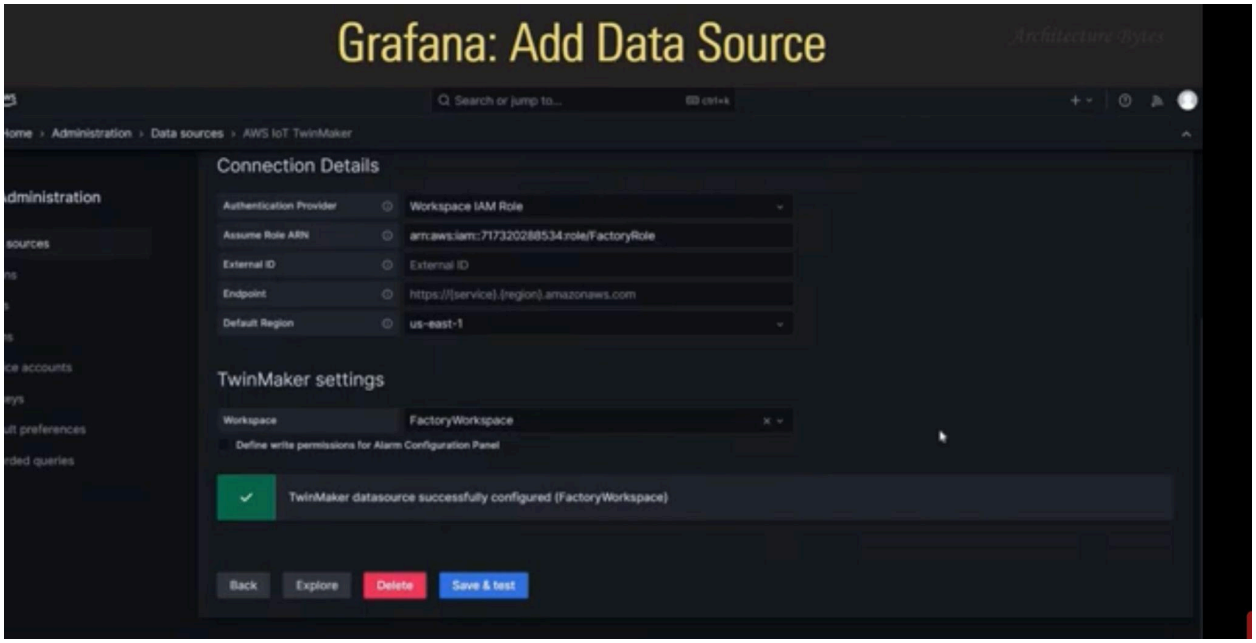
The "Factory Role" IAM role is assigned to the workspace for access to AWS resources.



Configuring A Data Source And Creating A Dashboard:

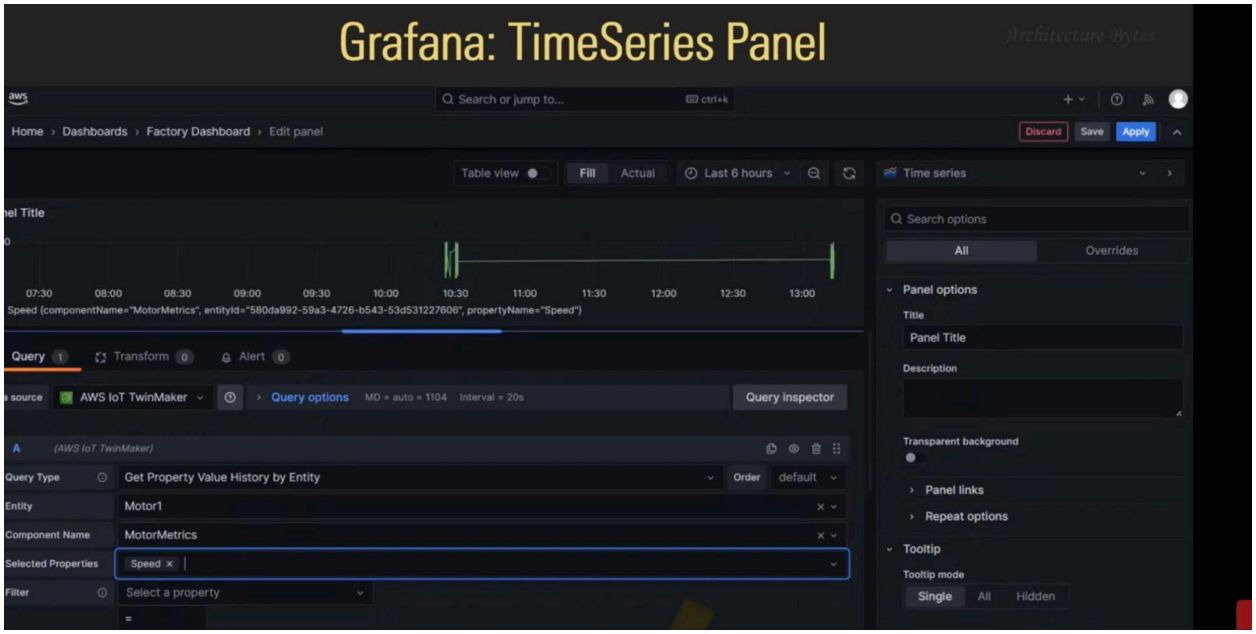
Data source for AWS IoT TwinMaker is configured within Grafana.





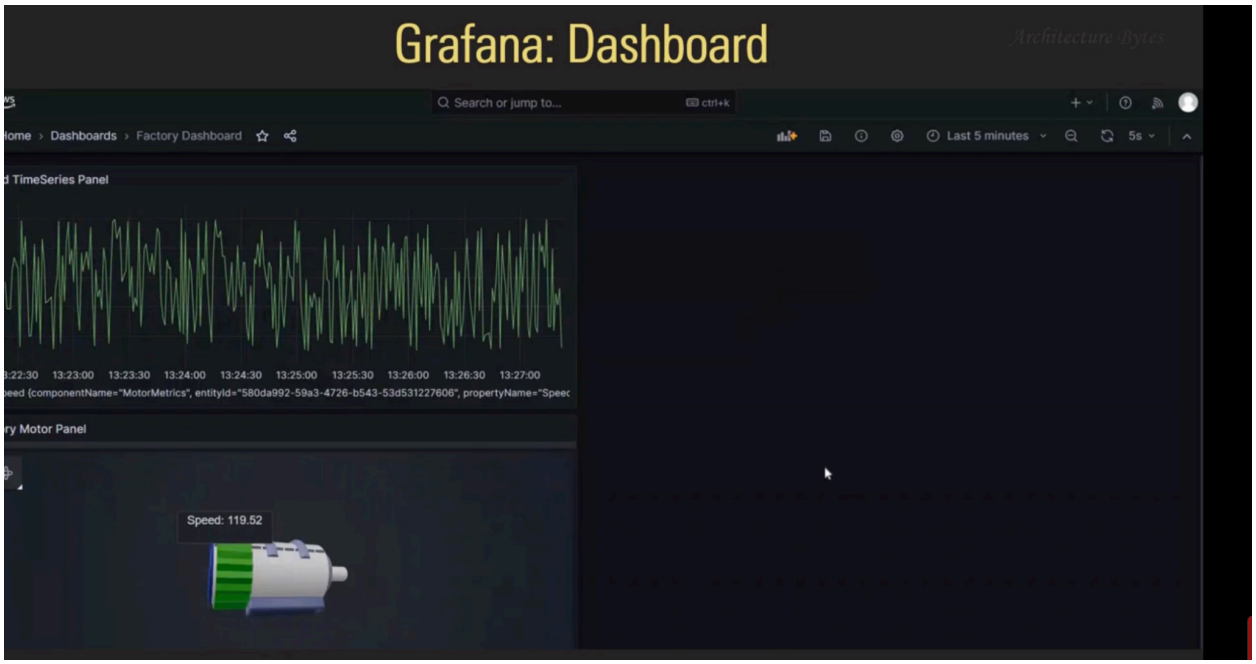
A dashboard named "Factory Dashboard" is created, incorporating two distinct panels:
Panel 1: Displays the motor model with the color-changing section, visually indicating its speed status in real time.

Panel 2: Presents a time series graph that tracks the motor speed over time, enabling historical analysis and trend identification.



RESULTS

- It has improved operational efficiency and productivity.
- Proactive maintenance and reduced downtime.
- It has enhanced visibility and understanding of factory floor operations.
- Better Research and Development



CONCLUSION

Digital twins have emerged as a top technological initiative in the 21st century. The ability to move work from the physical world into the virtual world will enable products to be faster, better, and cheaper. The proliferation of products that are more complex with emergent capabilities will require the information capabilities of digital twins throughout the entire product lifecycle.

Digital twins will need to evolve in order to meet the challenge of increasingly complex products. The advances in AI and Machine Learning will make possible the Intelligent digital twin. Digital twins will move from being an information repository to providing constant guidance to their human users.It will enable Intelligent Digital Twins and will greatly assist humans in the work with developing emergent products.