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ON

DIGITAL TWIN TECHNOLOGY

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CERTIFICATE

This is to certify that the work embodies in this dissertation entitled **'*Digital Twin Technology*'** being submitted by '**Gudla Rahul' 16881A05K7** for partial fulfillment of the requirements for the award of the degree of '**Bachelor of Technology** in **Computer Science and Engineering'** discipline to Vardhaman College of Engineering, Shamshabad, Hyderabad (T.S.) during the academic year 2019-20 is a record of bonafide piece of work, undertaken by him the supervision of the undersigned**.**

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I '**Gudla Rahul'**, student of '**Bachelor of Technology in Computer Science and Engineering', 2019-20,** Vardhaman College of Engineering, Shamshabad, Hyderabad (T.S.), hereby declare that the work presented in this Technical Seminar entitled '**Digital Twin Technology'** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. It contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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ABSTRACT

The vision of the Digital Twin itself refers to a comprehensive physical and functional description of a component, product or system together with all available operational data. This includes more or less all information which could be useful in all - the current and subsequent - lifecycle phases. One of the main benefits of the Digital Twin for mechatronic and cyber-physical systems is to provide the information created during design and engineering also at the operation of the system. The comprehensive networking of all information, shared between partners and connecting design, production and usage, forms the presented paradigm of next generation Digital Twin. This will bridge the gap between physics-based design simulation and its use in operation and service phases. Based on the example of a point machine the benefits of using the Digital Twin are shown.

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1. INTRODUCTION

1.1 Introduction

Digital Twins integrate internet of things, artificial intelligence, machine learning and software analytics to create spatial network graph, living digital simulation models that update and change as their physical counterpart change. They are used for enhancing performance and reducing operating cost, offer the business including increased reliability of equipment and production lines.

1.2 What is Digital Twin

- Digital twins are virtual replicas of physical devices that data scientists and IT professionals can use to run simulations before actual devices are built and deployed. These are vendor-specific models of a single asset or machine, which tap into operational data for the purpose of asset optimization.
- They are used for enhancing performance, reduce the operational cost, offer the business including increased reliability of equipment and pipelines.
- It continuously learns from sensor data and conveys various aspects of operating conditions.

2. HISTORY OF DIGITAL TWIN

2.1 Brief History of Digital Twin

After the launch of Apollo 13 on April 1970, no one could have predicted it would become a fight for survival as the oxygen tanks exploded early into the mission. It became a famous rescue mission as the world held its breath, with technical issues needing to be resolved from up to 200,000 miles away. A key to the rescue mission, however, was that NASA had a digital twin model of Apollo 13 on earth which allowed engineers to test possible solutions from ground level. Of course, systems have now become predominantly virtual rather than physical simulations. With the concept already being practiced for a few decades, the phrase 'digital twin' was first mentioned in 1998 and was being referred to a digital copy of actor Alan Alda's voice in Alan Alda meets Alan Alda 2.0. Although the digital twins have been highly familiar since 2002, only as recently as 2017 has it become one of the top strategic technology trends. The Internet of Things enabled digital twins to become cost-effective so they could become as imperative to business as they are today.

T**he digital twin concept gained recognition in 2002 after** Challenge Advisory **has hosted a presentation for Michael Grieves in the University of Michigan on technology.** The presentation involved the development of a product lifecycle management center. It contained all the elements familiar with the digital twin including real space, virtual space and the spreading of data and information flow between real and virtual space. While the terminology may have changed over the years the concept of creating a digital and physical twin as one entity has remained the same since its emergence.

3. DIGITAL TWIN

3.1 Essential components of Digital Twin

According to Chris O'Conner, General Manager, Internet of Things Offerings for IBM, if you want to implement digital twins in your business, these are the 3 essential capabilities we must have if you want to reap their full benefit. The three essential capabilities are

- Analytics at every step
- Open and federated data
- Applied industry context
- Future of digital twins

Analytics at every step

A digital twin deals with a staggering amount of data, and its effectiveness is reliant on whether this data is:

- real-time,
- operational,
- high-quality, and
- predictive orientated in its nature.

Open and federated data:

The data has to be accessible from several sources, and be pulled together into a federated model, rather than being centralized in proprietary systems. It is an aspect of data virtualization where the data stored in a heterogeneous set of autonomous data stores.

It is made accessible to data consumers as one integrated data store by using on-demand data integration. *Open data* is the idea that some data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents

Applied industry context:

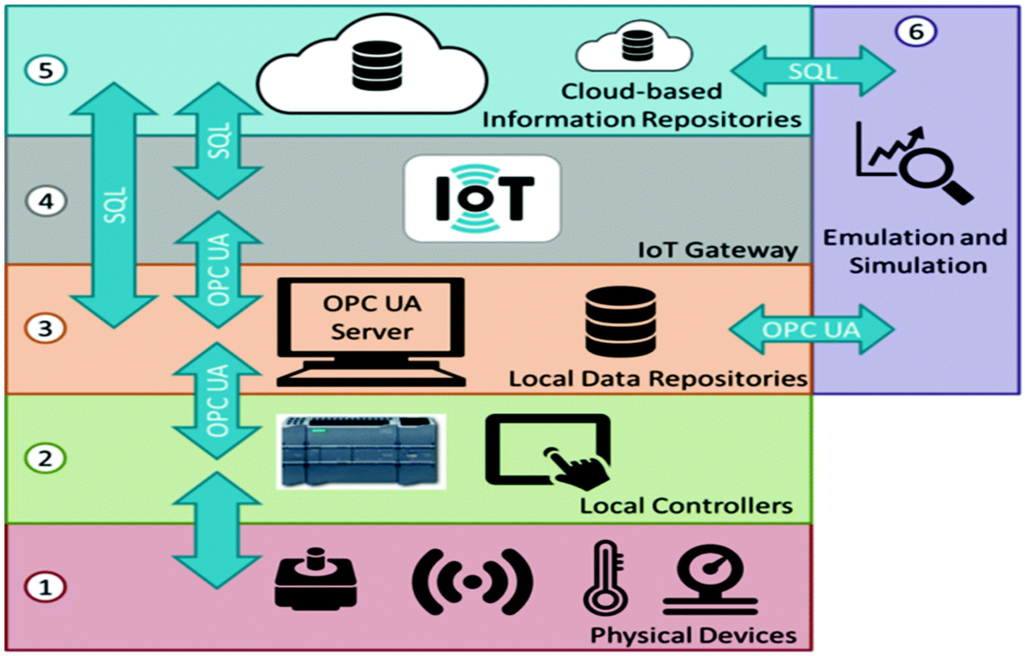
Applying industry context is essential to getting maximum value out of a digital twin. In fact, it is possible to have two different digital twins for the same product that is being used in two different industries, because of how the industry context is applied to the twin.

Future of digital twins

As digital twins become more advanced and more widespread, what we'll see is digital twins interacting with each other, creating models of highly complex systems. We'll have digital twins for entire cities, and even human beings.

"Over time, digital representations of virtually every aspect of our world will be connected dynamically with their real-world counterparts and with one another and infused with AI-base capabilities to enable advanced simulation, operation and analysis," says vice president and Gartner Fellow David. "City planners, digital marketers, healthcare professionals and industrial planners will all benefit from this long-term shift to the integrated digital twin world."

3.2 Architecture



As in the above architecture generally six stages are involved in the digital twin architecture namely physical devices, local controllers, local data repositories, IOT gateway, cloud-based information repositories, emulation and simulation. The stages are explained in detail as below

1.Physical devices

Devices such as sensors, routers which is source of our data.

2.Local controllers

Local controllers control the data locally either manually or through some specified devices according to our need as show in above figure

3.Local data repositories

Depending on amounts of data we choose our local storage accordingly such as databases, data warehouses etc. OPCUA Sever is use for machine to machine communication

4.IOT gateway

IOT gateway plays an important role in digital twin architecture as it is where the actual communication is established between local repositories and cloud-based repositories.

5.Cloud-based repositories

The data obtained from sensors stored in the local system will be loaded into clod repositories using IOT gateway, OPCUA server which will be used for further processing by cloud-base system.

6.Emulation and Simulation

This stage involves developing virtual twin which is main task involved in the architecture. Emulation generally shows the output. Simulation shows the output virtually.

4. WORKING OF DIGITAL TWIN

4.1 Creating Digital Twin

Digital twin creation can be broken into three stages as follows.

- Design
- Operation
- Augmentation

Design:

- First element is selecting the enabling technology to integrate the physical asset with its digital twin to enable real-time flow.
- Second element is understanding the type of information across the lifecycle of the asset.

Operation:

- We should decide the function.
- Whether we want the twin to control and alter the asset?
- Whether we want to use data and models within the twin to perform simulations?

The answers to these questions help us to determine the operation involved

Augmentation:

- First bring a number of smaller digital twins together to give a complete picture of entire machine
- Secondly adding more sophisticate capabilities into an existing digital twin.

4.2 Working of Digital Twin

Step-1:

First smart components that use sensors to gather data about real-time status, the working condition of the digital twin are integrated with a physical item. Sensors compatible with devices must be used to prevent any data loss.

Step-2:

The components are connected to a cloud-base system that receives and processes all the data that sensors monitor. Major task involved is done in the cloud-base system which must be efficient so that it can handle huge amounts of data coming from sensors and process them accordingly.

Step-3:

This input is analysed against business and other contextual data. Analysis is done here from the output obtained from the previous step where data is processed against the needs which is analysed based on the requirements.

Step-4:

Lessons are learned and are uncovered within the virtual environment that can be applied to the physical world and used accordingly. Feedback is obtained in the previous step plays a most important role in improving the performance.

By implementing the four steps accordingly we will be able to build a digital twin successfully according to our requirements.

5. TYPES OF DIGITAL TWIN

Digital Twin

There are a few variations on the types of digital twin that successfully employ digital twin technology. Although some are relatively dated, others are very pertinent.

5.1 Digital Twin Prototype

It describes the prototypical physical artifact. It contains the informational sets necessary to describe and produce a physical version that duplicates or twins the virtual version.

Throw some sensors on a product and wire that to some kind of embedded system, then wire that to your antenna and start sending data to an IoT platform. We run into limitations on the experiments you can conduct with physical prototypes. Swapping out a sensor isn't easy when it's soldered in place. We may run into electromagnetic interference for the antenna.

5.2 Digital Twin Instance

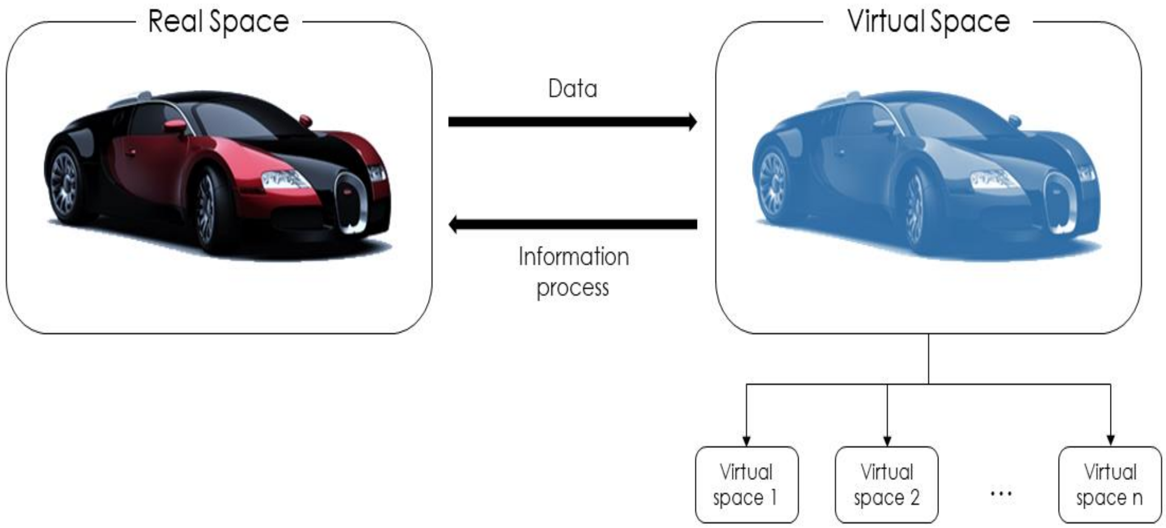
This type of Digital Twin describes a specific corresponding physical product. An individual Digital Twin remains linked to the product throughout the life of that physical product. Depending on the use cases required for it, this type of Digital Twin may contain the following components.

A fully annotated 3D model that describes the geometry of the physical instance and it's components. A Bill of Materials that lists current and past components. A Bill of Process that lists the operations and results of any measurements and tests. A Service Record that describes past services, components replaced and operational States.

5.3 Digital Twin Aggregate

This type of digital twin is aggregation of digital twin instances. Unlike the DTI, the DTA may not be an independent data structure. It may be a computing construct that has access to all DTIs. It queries DTIs either ad-hoc or proactively.

Proactively, the DTA might continually examine sensor readings. It correlates those sensor readings with failures to enable prognostics.



Example of a digital twin

6. APPLICATIONS OF DIGITAL TWIN

6.1 Applications of Digital Twin

Digital twin technology is used in many applications such as Customer experience, Performance tuning, Digital machine building, Smart cities, Healthcare, Maintenance to improve the productivity, customer experience of the product by giving the virtual experience of the product in the initial stages before the actual launch of product and improving the performance of the product according to the needs and requirements of the customer.

Customer experience

Customers play a key role in influencing the strategies and decisions in any business. The ultimate aim of any organization is to gain and retain a large customer base; and this is means enhancing your customer's experience A digital twin can help boost the services directly offered to customers. For example, a digital twin could be used for modeling fashions on a visual twin of the customer.

Performance tuning

A digital twin helps determine the optimal set of actions that can help maximize some of the key performance metrics, and alsso provide forecasts for long-term planning. For example, the performance of a scientific device, which is deployed on a spacecraft, can be tuned from Earth using digital twin as a 3D real-time visualization.

Digital machine building

A digital twin can be used as a digital copy of the real machine, created and developed simultaneously. Let's take the example of a German machine manufacturer that decided to digitally map the packaging and special machinery that it produced for many industries. The data of the real machine was loaded into the digital model before the actual manufacturing began. So, a digital twin enables simulation and testing of ideas, even before the actual manufacturing begins.

Healthcare

A digital twin can help virtualize a hospital system in order to create a safe environment and test the impact of potential changes on system performance. Not just operations, digital twins can also help improve the quality of health services delivered to patients. For example, a surgeon can use a digital twin for a digital visualization of the heart, before operating it.

Smart cities

A digital twin can be used for capturing the spatial and temporal implications to optimize urban sustainability. For instance, 'Virtual Singapore', a part of the Singapore government's Smart Nation Singapore initiative, is the world's first digital twin of an existing city-state, providing Singaporeans and effective way to engage in the digital economy.

6.2 Digital Twin examples in practice

Digital Twin technology on city infrastructure:

To improve the transportation and travel systems in New York City, the government decided to build a digital replica of the city itself. Having data on the average deterioration rate of a road in one of the busiest streets of the city, they are able to make safe predictions.

Digital Twin is used for aerospace engine monitoring:

By creating a digital twin of an aircraft's engine, pilots will have the ability to monitor engine health and progress the simulation 10 hours at a time (during a flight) in order to see if the potential risk of the engine experiencing a fatal failure in the near future.

7. ADVANTAGES & DISADVANTAGES

7.1 ADVANTAGES

- **Comparison of digital vs physical product**

  Comparing the digital and physical product becomes easier as the twin model tracks the progress of the physical product development directly.

- **Performance monitoring**

  Tracking the state of the physical product under the development helps to monitor the performance.

- **Improved productivity**

  By giving the virtual experience of the product in the initial stages before the actual launch of product and improving the performance of the product according to the needs and requirements of the customer.

- **Increased reliability**

  Products become long lasting because of improving performance of the product by handling virtual twin to the customer and making them experience the product and getting the feedback and implementing them accordingly.

- **Performance tuning**

  Improved product quality, enhanced insight into the performance of your products, multiple real-time applications and environments.

- **Customer support**

  Improved customer service as customers can remotely configuring customized products.

7.2 DISADVANTAGES

- **Compatibility challenges**

It mainly addresses challenges on technologies of sensors, communication, database and data processing. It becomes a big challenge in establishing compatibility between processes involved.

- **Inconsistencies**

Inconsistences between models and entities appear. We need to choose models and entities which are consistent and support each other in their working conditions in creating digital twin.

- **Handling data**

Integrate and converge the increasing data is a challenge. Handling large amounts of data coming from sensors and others physical devices seems to be a difficult task. We need to maintain large data storage to maintain and process the data accordingly.

- **Security**

Security is another focus that ensures the normal operation of physical and virtual spaces. As we use many models and entities in designing digital twins, we face many security related issues.

8. CONCLUSION

8.1 Conclusion

In recent years, there has been an unexpected progress in the technologies and capabilities of both the physical product and virtual product, the Digital Twin. Digital twins will evolve from concept to reality for nearly everything—everyone, every service, and every network. Digital twin usage is being driven through the rise of IoT designed sensors with the future of both going hands in hand. Sensors are able to deliver the data on how an object is operated and its reaction to the environment while implementing digital twins can improve analysis, condition simulation, operations, and value.

8.2 Future Scope

It's estimated that in the next few years billions of things will be represented by either digital twins, software models, and physical systems. It's predicted that digital twins will be utilized by half of the large industrial companies and approximately 21 billion digitally connected sensors by 2020, which could potentially save billions in maintenance repair and operation. It's also predicted by 2020 that up to 60% of manufacturers will monitor product performance and quality through using digital twins. Up to 60% of global companies will also use digital twins to deliver better customer service experiences. With the significance of digital twins evident, potential growth and use could be in effect for billions of years in the future.

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