DIGITAL TWIN IN IOT CONTEXT INSIGHTS

Abstract

Digital twin (DT) is a sophisticated technology that combines several engineering specialties. Industry is being revolutionised by digital twin. The technology of digital twins will eventually allow for the digital replication of everything in the real world. Digital twin is a cutting-edge technology that has drawn a lot of interest. Many engineering researchers and participants are unsure about the best technologies and tools to utilize. In order to give technologies and different tools standard for the applications of digital twin in the future, this literature review attempts to examine and describe the frequently used enabling technologies and tools by top Indian companies.

Keywords: Digital Twin, DT technologies, Five DT model, tools, Applications

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I. INTRODUCTION

As the top trend, digital twins [1, 4-6, 14] are described as having "an estimated 21 billion associated sensors and will continue to exist for billions of objects in the near future." Before real devices are manufactured and deployed, simulations can be done on digital twins, which are virtual analogues of physical equipment. Additionally, digital twins can use AI and data analytics to enhance performance using real-time IoT data [8, 9]. IoT connects and gives intelligent access to physical things and sensor data. In short, a digital twin is a software program that accepts actual data about a physical thing or system as inputs and delivers projections or simulations of how those inputs will impact that physical object or system as outputs [14].

The main advantage of digital twins in IoT is that you don't have to connect to the asset to gather and transfer data. Instead, you may simply put programs in a safe sandbox in the cloud, which interacts with digital twins as if they were physically deployed IoT devices [4-6].

Due to the fact that the programs are only deployed in the cloud rather than on the asset, the sandbox method lowers security threats. Finally, development expenses are lowered, allowing IoT applications to be produced more quickly [5].

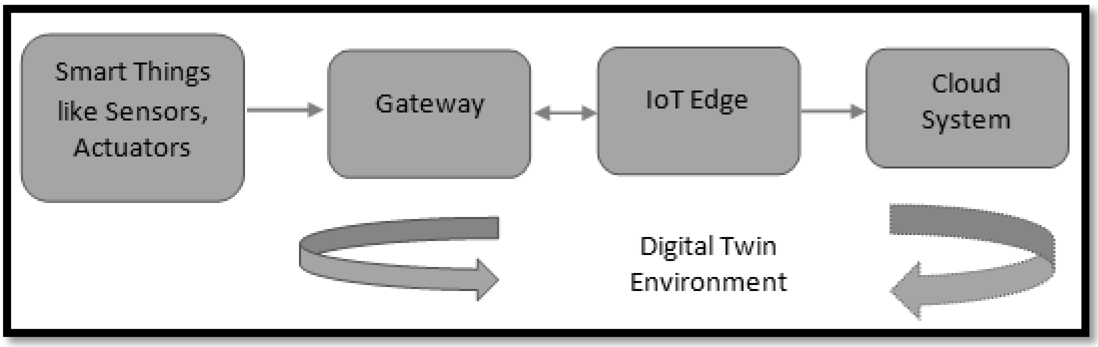

Figure 1: Digital Twin Environment Components

As a result, cloud-based digital twins have the potential to enable numerous new tasks and solutions. Figure 1 shows the Digital Twin (DT) Environment Components.

Gathered data from sensors, devices and actuators are transferred through gateway to IoT Edge. A gateway connects physical objects and the Digital Twin, allowing data pre-processing and filtering and transmitting commands from the Digital Twin to the Physical Object. Data Analytics employs Machine Learning Algorithms to provide Forecast, Behavioral, and Inferential analysis from data in a Data Warehouse [8,9].

1. **Twin technologies:** A Digital Twin application incorporates four technologies that enable the creation of a digital representation, the collection and storage of real-time data, and the provision of valuable insights based on the information gathered.

   - Internet of Things (IoT)
   - Extended Reality (XR)

- Cloud, and
- Artificial Intelligence

Are examples of Digital Twin technologies [3,12]. A certain technology can be applied and shown in figure 2 to varying degrees based on application type.

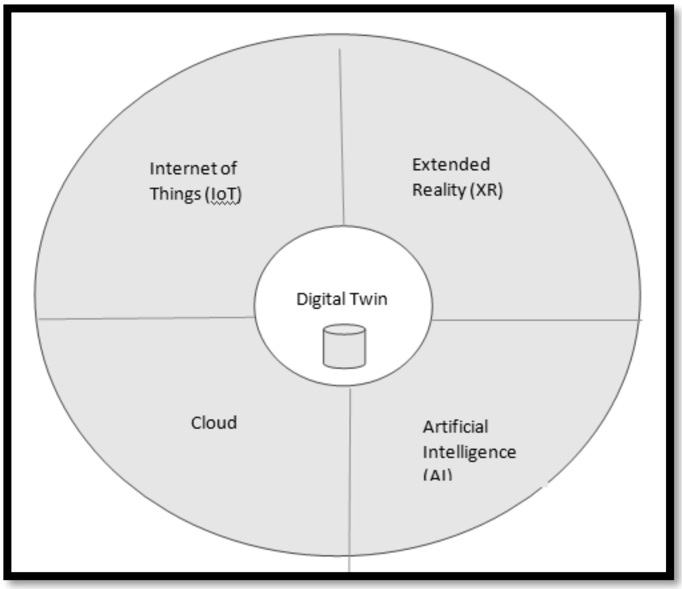

Figure 2: Enabling Technologies in Digital Twin

IoT is the prime technology utilised in all Digital Twin applications. The exchange of information across a system governs the flow of data generated by IoT. IoT enables Digital Twin applications to interconnect a virtual representation in real time with a physical object, keeping it continually updated. This IoT technology which comprises of data collection technology and transmission technology (Data Collection and Data Transmission).

The visualization technique that produces digital representations of items is known as Extended Reality (XR). Digital Twins with XR capabilities can digitally model actual things, allowing people to engage with digital material. XR integrates Visualization technology and fusion technology which are purely based on data fusion and data visualization.

Cloud computing allows you to store all of your data in a virtual cloud and simply access it from anywhere on the network. The essential process to be done by cloud computing is depends on data storage and data processing i.e Storage technology and Processing technology.

Artificial intelligence (AI) is a sophisticated analytical technology capable of automatically analysing data and providing significant insights. It may also predict future outcomes and provide recommendations on how to avoid such difficulties. AI comprises of processing technology like data Analytics and Data Prediction.

Digital twin applications are numerous and are not limited to a particular industry or sector. They may be utilised in a variety of situations.

2. **Digital twin applications:** Digital twins can be used to assess the entity's present state but, more crucially, to forecast future behaviour, improve control, or enhance operation. So it is preferable in major domain applications. Few applications are discussed below and depicted in figure 3:

- **Digital twin in manufacture engineering:** Future manufacturing and all types of industrial enterprises are primarily concerned with improving manufacturing process and developing client interactions. These manufacturing organisations and consumers are interested in the process of product customisation. Twin Create Customisation, which allows to digitally design and re-design things before generating a tangible product that fully meets the needs of the user [5, 7].

- **Digital twin in vehicle engineering:** The most visible applications of Digital Twin technology are weight monitoring, aeroplane tracking, precise weather forecasting, and automotive flaw identification. It may measure certain patterns and functional information about the vehicle in order to help improve its performance [2].

- **Twin in health sector:** Digital Twin were originally employed in the healthcare environment for Biomedical device predictive maintenance and performance improvement The ultimate goal is to assist hospitals and government agencies in the administration and synchronization of patient care activities with a social and demographic focus [6].

- **Digital twin in smart cities:** Planning and implementing a smart city using Digital Twins and IoT data helps to improve economic growth, effective resource management, ecological footprint reduction, and overall quality of life for citizens. City planners and politicians may use the digital twin concept to plan smart cities by learning from diverse sensor networks and intelligent systems. They can make future judgments that are well-informed thanks to the information provided by the digital twin [6, 14].

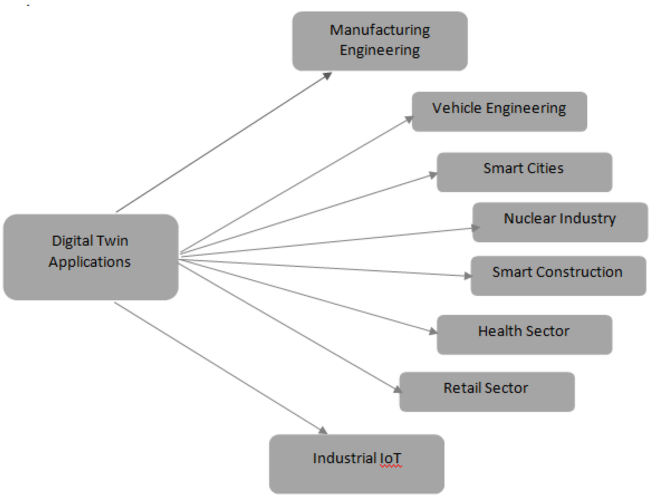

Figure 3: Digital Twin Applications

- **Digital twin in retail sector:** In the retail industry, providing a favorable consumer experience is crucial. Better in-store planning, security implementation, and energy management are all made possible by digital twins in the retail industry [10].

- **Twin in industrial iot:** Businesses that have used digital twins in their operations may now track, monitor, and manage industrial systems digitally. In addition to operational data, the environmental data that the digital twins collect, such as location, configuration, financial models, etc., aids in forecasting future operations and abnormalities [7, 9, 13].

- **Digital twin in nuclear industry:** Digital twin (DT) technology have been used recently in the nuclear sector to build improved reactors as well as the present fleet of light-water reactors [6].

- **Digital twin in smart construction:** Design and construction of structures and civil infrastructure can be aided by DT. In order to create a DT of a smart building, sensor networks with Internet of Things (IoT) support were used [6].

3. **Digital twin models:** The connections between data, physical entities, simulation models, and different services help the researchers to expand the number of dimensions to simulate the entity behaviours from different levels of users.

Grieves, Tao et al. proposed the five dimension reference digital twin model [11] and shown in figure 4 which describes how the above mentioned components are communicated and predicting the future. The dependent connections (Conn) functionality are given in equation 1:

- Connection between physical entities (PE) and data(D)
- Connection between physical entities (PE) and services (S)
- Connection between physical entities (PE) and simulation models (SM)
- Connection between simulation models (SM) and data (D)
- Connection between simulation models (SM) and services (S)
- Connection between services (S) and data (D)

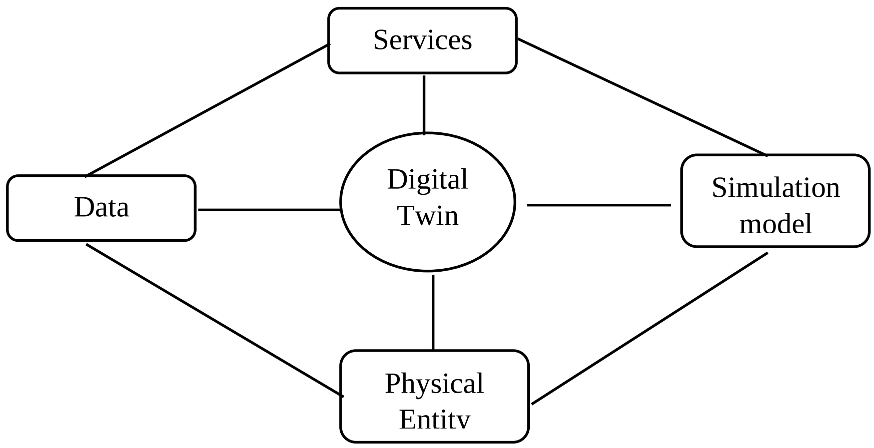

Figure 4: Five Dimensions in Digital Twin models

Five dimension reference model can be estimated by using the following dimensions:

Digital Twin Dimensions = (PE, SM, D, S, Conn) – (1)

- **PE in digital twin:** Systems, activities, processes, and organisations may be found in the physical world. They carry out tasks in accordance with physical rules and work in unstable conditions. To imitate the behaviour of physical entities, DT will generate virtual representations of such entities. The basis of DT is the physical universe.

- **SM in digital twin:** A simulation model is a software program that may simulate the size, characteristics, behaviours, and laws of an actual object. The shape, size, tolerance, structural relationship, and connection to the physical environment of an item are all described by dimension geometric models. They are meant to be exact copies of tangible things.

- **Data (D) in digital twin:** DT works with data that is multi-dimensional, multi-source, and multi-temporal. Virtual models produce some data that represents the outcome of simulations. Services provide data that details the invocation and execution of the service. All of the aforementioned data are combined to create some data known as fusion data.

- **Services (S) in digital twin:** Service is a crucial part of DT in the Everything-as-a-Service scenario (XaaS). The functioning of DT necessitates the ongoing maintenance of several platform services that may handle the creation of software solutions, the construction of models, and the provision of services.

- **Conn in digital twin:** Information and data interchange are made possible through connections between physical elements, virtual models, services, and data. Advanced modelling and analysis is made possible by the dynamic connection between digital representations and their real-world counterparts. There are six connections in DT, which include those between physical entities and virtual models.

4. **Tools for DT modelling:** Various DT modelling tools [3, 12] are available in market and which are categorized as follows

   - Geometric Modelling tools
   - Physical Modelling tools
   - Rule Modelling tools
   - Behavioural Modelling tools

   Basic Requirement for above models is data. This huge volume of data to be collected and to be managed.

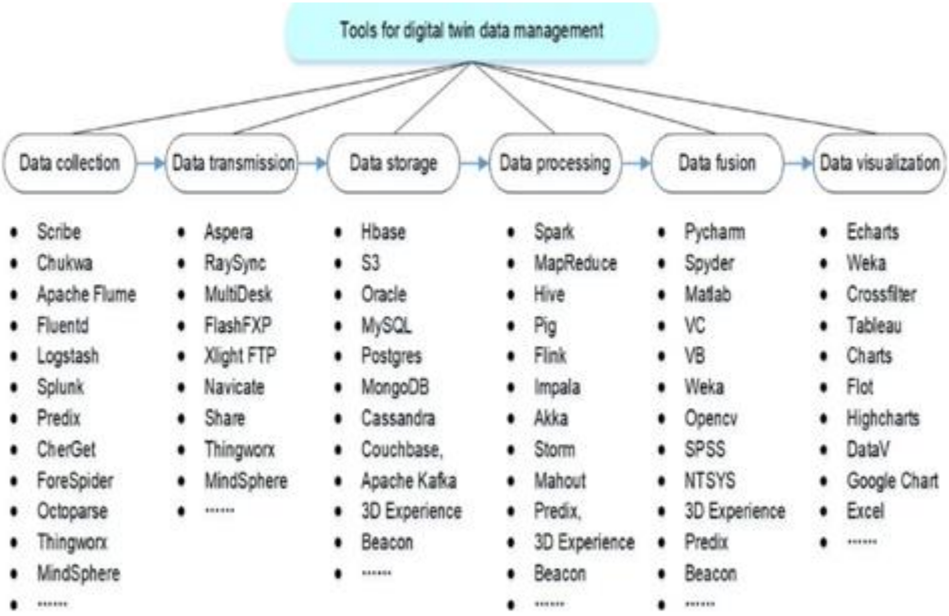

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Figure 5: Tools for DT data management

Implementing digital twin is a complex system and long-drawn process. Digital twin involves a wide range of technologies and tools that are invented or developed by different top companies [15] like Bosch, Microsoft Corporation, General Electric Company, IBM Corporation, Siemens, Oracle Corporation, Cisco Systems. Data and models should be standardized and delivered in common formats, protocols and standards to enable them to work together [11].

5. **Open Challenges in DT:** As will be mentioned below, there are several difficulties that must be overcome in order to answer open research issues about digital twins.

- First, interdisciplinary
- Second, standardisation
- Third, International Progress

6. **Integration of AI with various domain:** Intelligent Decision Support systems are very attractive prospects in various domain of application. AI based DTis an extensive potential to optimize the performance and also fine tune the existing services. Medium sized companies using Cloud based AI applications. Current research activities on AI are listed below [8, 9].

- Neural network-based system that incorporates relearning and predictive analytics.
- Big Data analytics may helpful to monitor the traffic status and accident with several drone fleets.
- Deep neural network learning for image recognition, segmentation and modification in different areas like manufacturing, computer vision and space monitoring.

- Fuzzy logic-based logistics expert systems will improve the transportation and managing the demands in productivity.
- Employing deep learning neural networks to recognise text and patterns.
- Application of AI to the creation and deployment of IoT in commercial sectors.
- AI application for cyber security and ensuring the safety of important applications online.

II. CONCLUSION

In the Summary, digitization unifies all of your ideas, procedures, tools, stakeholders, and activities into a single digital enterprise. Digital twins will emerge as the standard in many businesses as a result of this development. The traditional method of assessing and monitoring the equipment will alter as a result of the digital twin, better analytic techniques, and machine learning. A new age of predictive maintenance will be made possible.

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