The Cognitive Digital Twin
AI Powered Virtual Models

Introduction

Cyber physical systems are becoming more complex. It is becoming exceedingly difficult if not impossible to identify and collect the right data sets and put them in the right context to enable the optimization of designing, manufacturing, and operating such systems. However, with help from a digital twin that can sense, reason and act, such intelligent systems will be able to help humans to take the right decisions or autonomously trigger the right actions in digital or physical world.

Applying the concept of "Cognitive Digital Twin" to solve such problems has become possible over the last few years due to the major advances in various technologies including AI/ML.

Understanding The "COGNITIVE" In The Digital Twin

The Digital Twin adds much intelligence to the physical twin across its lifecycle as required. This requires a lot of data over time and the application of different AI capabilities to create insights. Therefore, creating a digital twin for an existing equipment or for a complex cyber physical system in its early design phase is an evolving process to continuously enhance its technical and functional capabilities. While the Digital Twin concept adds more values to new products, it is being used to unleash trapped business values within normally connected and locally optimized massive installed base of business-critical equipment.

BigR.io is helping companies in implementing the digital twin as:
- A digital representation of the physical asset driven mainly by the expected functional capabilities.
- A digital augmentation to the physical asset's capabilities enabling a completely new set of digital solutions and services.
- An intelligent companion to physical asset including its subsystems and across all its life cycles and evolution phases.

The concept of Digital twin is not limited to just physical assets. Considering the same concept in business areas such as R&D in products innovation, optimization of complex supply chain processes or even understating markets and consumer's needs does add tremendous value.

To make the best out of the trending Digital Twin technologies and platforms, BigR.io is helping companies evaluate the underlying architectural principals of a Digital Twin such as:
- DTs should be able to act, interact and collaborate across functional domains as well as physical and digital worlds.
- DTs should continuously evolve to be able to autonomously take contextual decisions and execute more complex tasks in the digital as well as physical worlds.
- As a cognitive system, the technical and functional capabilities of DT should be built and learnt step by step over time.
- As DT spans digital and physical world, cyber physical security is very critical especially in connected systems.

DTs and their physical twins will provide semi or fully automated digital smart services, which either of them cannot offer alone.

Also, a paradigm and culture shift is required to accelerate the business transformation by having the right adoption of Digital Twin:

- From Data-driven to knowledge-driven business models.
- From Business analytics to intelligent Enterprise (processes and systems).
- From traditional computing systems to cognitive systems.
- From Systems to be decommissioned to systems which will continue creating the collective knowledge of an enterprise.

The Digital Thread, Data Engineering Flow

The Digital Twin in its core is a digital brain added to its physical twin that relies completely on having the right data in the right time and be able to put it in the right context. The Digital Thread is a purpose-driven framework that defines, guides and controls how data is created, collected, shared, and used across the lifecycle of the physical twin. It connects different siloed elements of data, processes, and actions together and provides an integrated data flow and knowledge creation process required for the digital twin and humans to make a decision or take an action.

Therefore, the BigR.io Digital twin approach has a mechanism with which it can collect, aggregate, and pre-process the required sets of data from the right sources (sensors, Databases …) at the right time. This mechanism is called "Digital Thread."
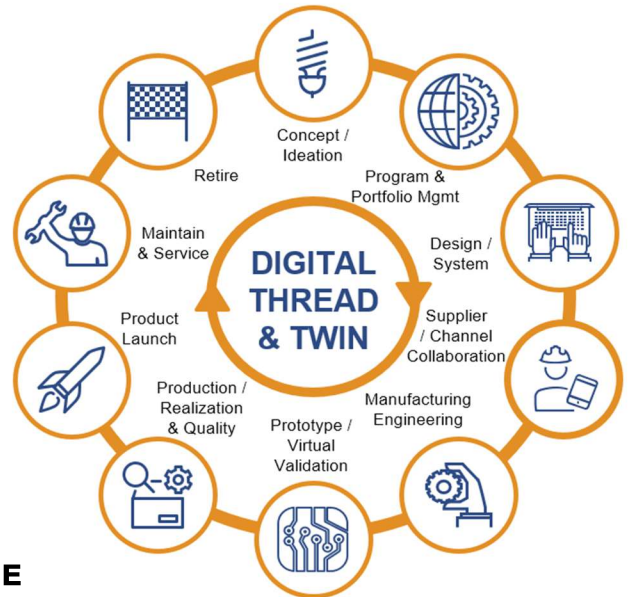

The Digital Swarm, Collective Intelligence

Typically, physical assets and the processes around them are not in silos. They might be a part of factory, fleet of cars or aircrafts in the same place or distributed across the globe. The biologically inspired concept of "swarm intelligence" is a major value multiplier if considered in the right time and implemented in a way that uses the collective intelligence of moderately intelligent physical and digital twins to make the members of a digital swarm more intelligent and extremely efficient.

A swarm of DTs enabling smart manufacturing
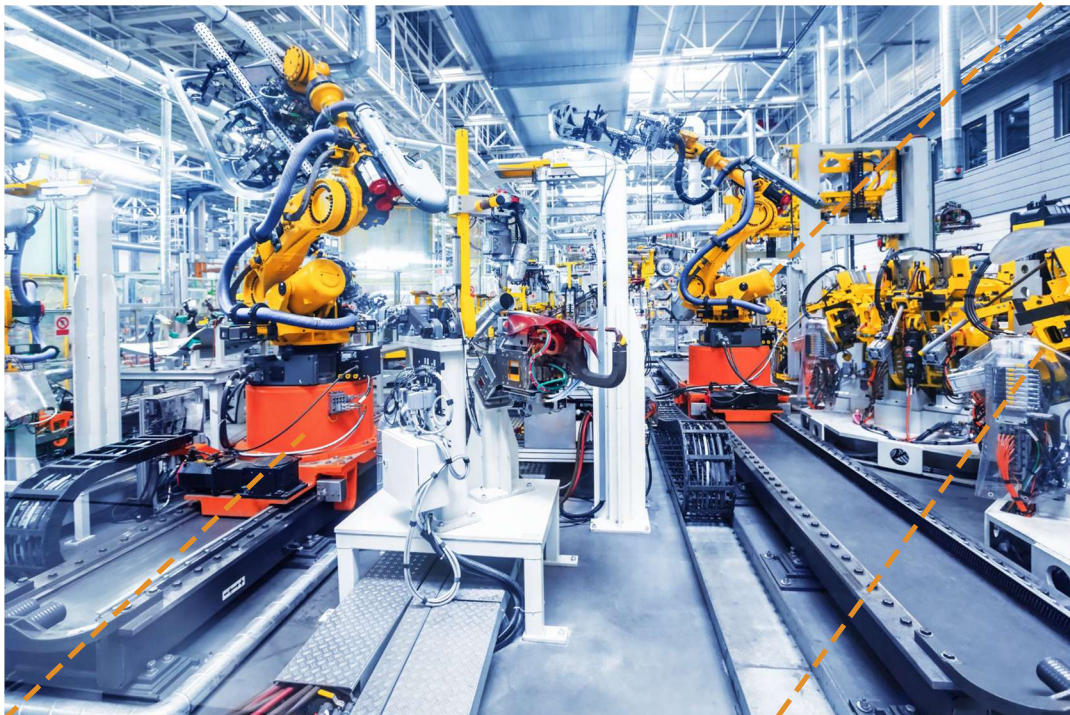
There are different system integration and the communication technologies which makes it possible and secure to implement different types of Digital swarms from standalone Digital twins based in specific criteria and set of goals. Therefore, BigR.io helps with the design and implementation of Digital twins considering different models of collaboration with other digital twins that can add values to the overall business.

Key Application Areas

The major early adopters of the concept and technologies of Digital Twin are industries building and/or operating complex physical equipment and systems such as Aviation, Defense, Oil & Gas, Renewable energy, Mining, Automotive, and industrial manufacturing. However, over the last few years other new applications emerged strangely such as Drug discovery and testing in Pharmaceutical and Patient Medical records in Healthcare industries.

Some of the key functional capabilities of Digital twin are:

- **Enabling Model based system design (MBSD) and operation across the product lifecycle**

  Model-Based Systems Design (MBSD) is mathematical and visual methods addressing the design of complex cyber physical systems including digital and physical control, embedded software, and interactions. AI and the architecture principals of Digital twin are increasingly playing a major role in all aspects of designing and testing complex systems. The information generated during this phase would be the core of a Digital twin to accompany the equipment being design.

- **QA/QC: A swarm of Digital Twins is controlling and assuring production quality**

  Swarm intelligence is a capability multiplier if designed and implemented in the right way. A swarm of Digital Twins of manufacturing systems and processes could collaborate over specific period to control and assure that the quality stays always above a preset level.

- **Equipment continues health monitoring**

  A digital Twin enables the continues collection of valuable operational data and convert it to actionable knowledge about specific equipment. Leveraging pretrained ML algorithms, operators with help of the digital twin can proactively detect anomalies and possibly prevent equipment failure. Additionally, other valuable knowledge can be extracted and be used to optimize other areas of the business.

- **Digital Twin guided inspection, maintenance and repair of the physical twin**

  Once a digital twin is monitoring the health of an equipment, it can be used to plan, support, and guide the technicians to inspect and repair the equipment. This is usually supported by augmented / extended reality technologies.

- **Equipment Performance optimization**

  The knowledge extracted by Digital Twin combined with other data coming from different business systems can be used to optimize the performance of an equipment whether it is functioning standalone or a part of a larger swarm of equipment.

- **Workforce management optimization**

  Once the Digital twin can accurately predict equipment failure or changes in operation, these events can be used to effectively schedule operational as well as maintenance workers on time. Also, Digital twin can be used to drive simulated training especially for complex systems to increase quality of training and enhance safety of workers for example.

- **Proactive cyber and physical security for equipment and workers**

  As the equipment's digital twin monitors and analyze different operational and environmental parameters, its cognitive core analyzes these data sets to detect specific anomalies. A subset of those anomalies could be for proactively detect cyber security threats for such cyber physical systems. Also, some anomalies could be used to enhance the physical safety related to humans operating or in the proximity of this specific equipment.
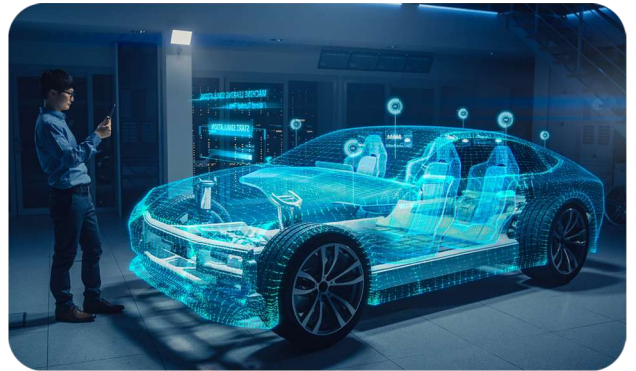
The business benefits of implementing Digital Twins for equipment, complex processes and humans are clear. Missing these capabilities driven by a wave of key transformative technologies would not be only wasted business opportunities but also could be an existential threat to the whole company.

"Companies' buying decisions for critical equipment and systems are increasingly driven by the digital capabilities delivered with the physical systems especially a Digital Twin."
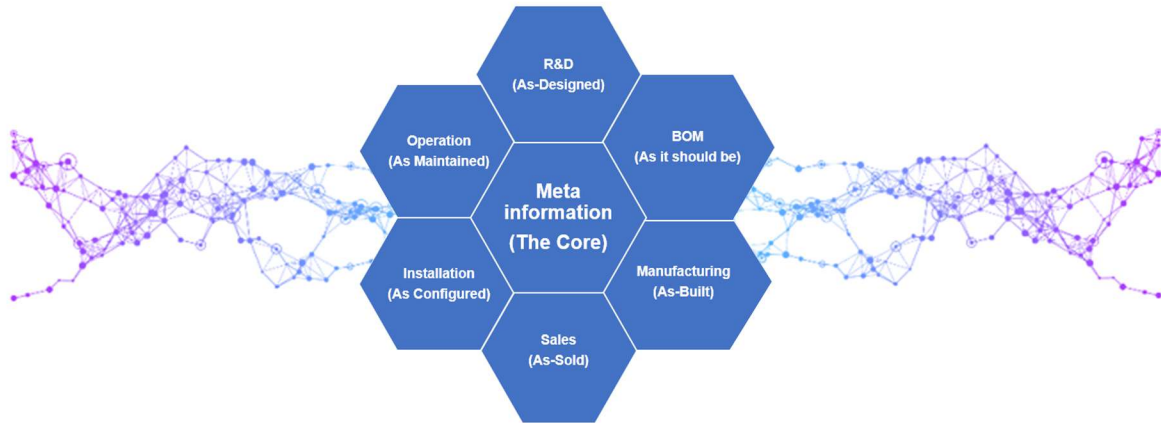
Typical data sources for a Digital Twin of an Equipment

BigR.io is a US based consulting company with its headquarters in Boston. BigR.io empowers its clients to drive innovation and achieve the "intelligent enterprise" through the use of contextualized data and sophisticated ML capabilities. When it comes to Digital Twin, BigR.io has deep experience in delivering product engineering services, with our excellent expertise in this domain across all phases of the product and the supporting enterprise functions.

Our team of experts and headed by specialists in Digital Twin supported by industry SMEs with extensive experience in the Automobile, Oil & Gas, Utilities, Manufacturing, Chemicals and Pharmaceutical. They have been able to turn around the strategic goals of business into reliable solutions driven by the architectural principals of the cognitive digital twin as well as key capabilities of AI/ML, and industrial IoT technologies.

BigR.io Services

- Educating business and technology leaders via interactive workshops, roundtable discussions and seminars on how Digital Twin could help transform your organization, decrease operational costs, and create new revenue streams.

- Create business and technology overall strategy and roadmaps to help setup the organization for a successful adoption of Digital Twins. From POCs, Pilots to Production systems.

- Carrying out business and technical gap analysis to different business areas where Digital twin could solve major problems or add values to the company and its clients.

- Leverage the right mix of technologies from our technology partners to implement your Digital Twin plans in a phased approach.

- Data Engineering with the Digital Thread approach.

- Accompany the swarm of digital twins to guarantee their continuous learning and enhance their capabilities over time.

Our experience shows that collaboration is the key to success. We collaborate closely with the companies and key decision makers to understand the details of the engagement. We evolve the working model together to arrive at the desired POC. We stay ahead of the curve working towards your success. Thus, if you are looking at testing out the model with a workable POC and are interested to partner with us you can write to us innovation@bigr.io