Digital Twin

Digital Twin is a virtual model of a physical asset that mimics the behavior and operation of its physical counterpart. Usually, the model resides in the cloud and hence can be monitored and controlled remotely. Sensors in the physical asset are used to capture the operational and environmental data on a continuous basis, and this dynamic data is streamed to the cloud. Here, it is enhanced with static data, such as the engineering specification data of the physical asset, stored in other systems. The combined data is then used as input to a statistical or engineering model in the cloud, and analyzed in real time to generate insights that are fed back to the physical asset to control its ongoing operation, completing the feedback loop as shown below.

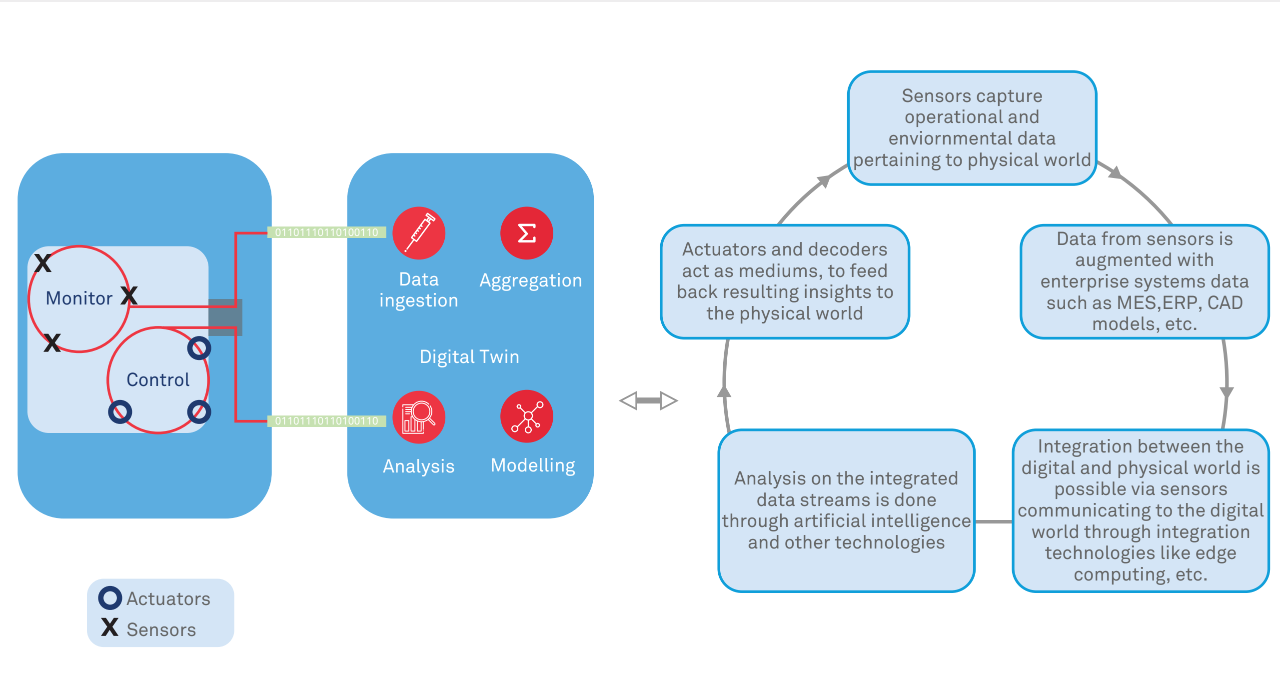

Fig. 1: Integration of physical and virtual asset

The product-specific data traditionally resides in the PDM/PLM systems while operational data is streamed to and analyzed, in the so-called IoT platform, and usually, these two systems are distinct and not connected. Wipro's Digital Twin platform bridges the gap between design and operations as shown below. It uses a sophisticated asset modeling framework that glues together two apparently distinct systems in a seamless manner. The output is fed back to the Plant/Operation system, completing the feedback loop.

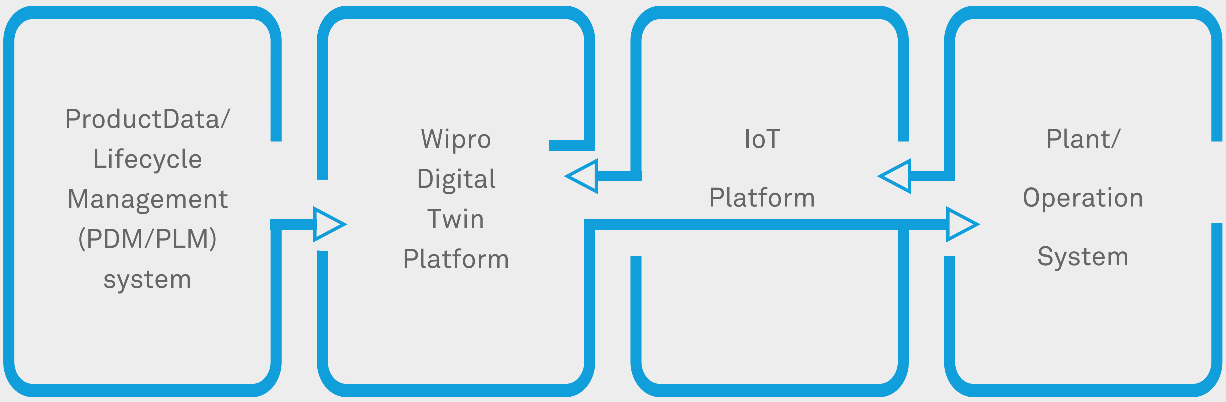

Fig 2: Wipro's Digital Twin platform - bridging the gap

Digital Twin mimics the behavior of a physical asset

Let's dissect the diagram on Fig.4. It shows an excavator digging in a field, somewhere in the world. While it's digging, its engine is running and the engine parameters have certain values, the battery has a certain voltage and the fuel level also keeps changing. The excavator has a certain state, characterized by specific values of various operational parameters at different points in time. A sampling of the operational parameter values at a given instant is shown in Fig.3. As these values are stored against the respective variables of the Digital Twin model as time series data, the state of the Logical excavator (the Digital Twin), at any point in time is exactly the same as that of the physical excavator. Literally a twin!

Operational parameters

Data item	Value
Altitude	4.2
Engine Running Band1	2
Engine Running Band2	18
Engine Running Band3	4
Engine Running Band4	551
Engine Running Band5	0
Engine Running Band6	0
Engine Running Band7	0
Engine Running Hours_Curent	1.200000
Engine Temperature	35
External Battery Voltage	13.3
Fuel Level	110
FW_Version_Number	09.01.02
GPS Fix	true
Hour	1344.8
Internal Battery Charge	100

Fig 3: Data from a field excavator being recorded by Digital Twin

As a result, one can diagnose a problem with the physical asset in the field (say in India) by analyzing the Digital Twin in the cloud from anywhere in the world. This is a powerful feature because the expert who can diagnose problems with the excavator could be based in the UK or Japan, while the physical asset experiencing issues could be in India. This is a huge cost-saving measure for the company that deploys the excavators.

Modeling an excavator

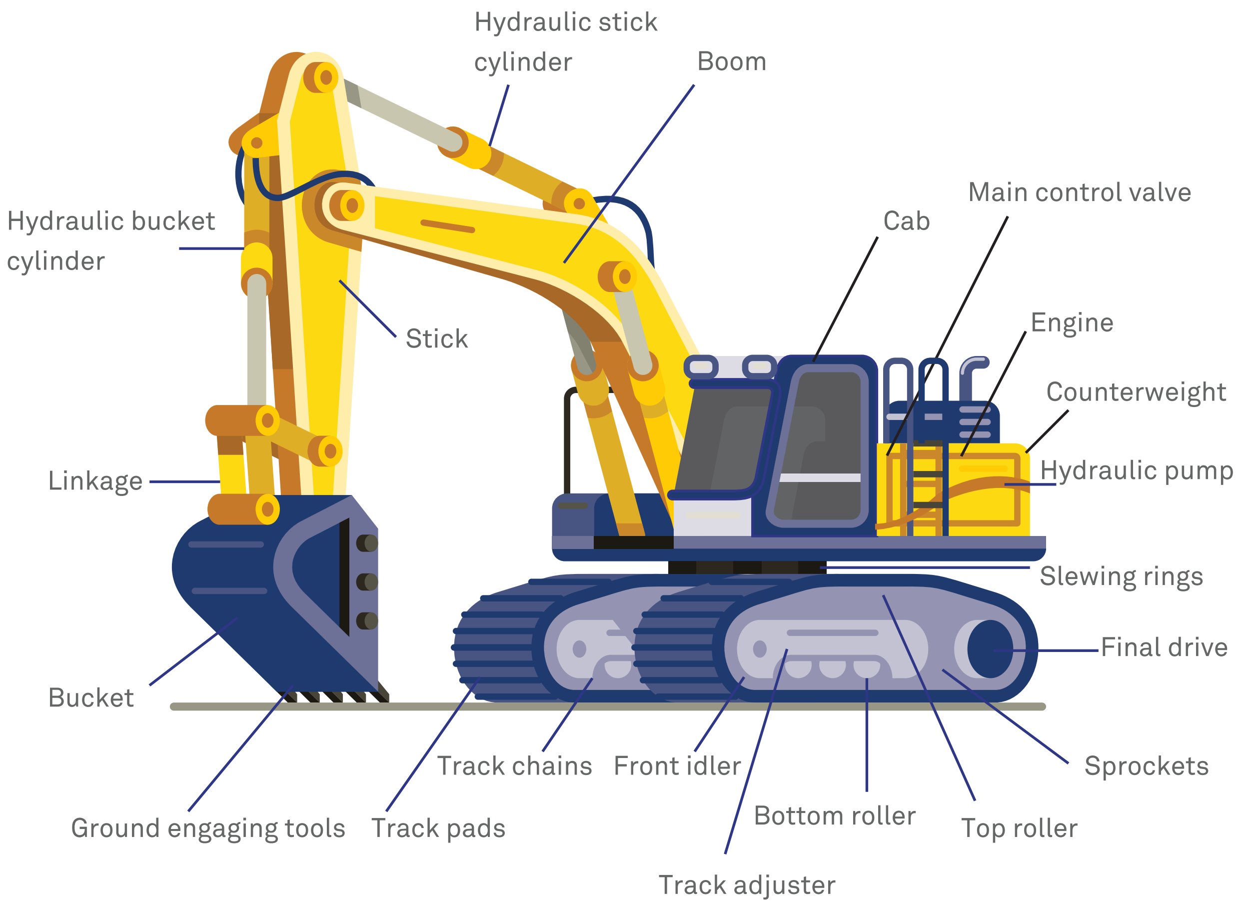

Fig. 4: Various parts of a physical excavator

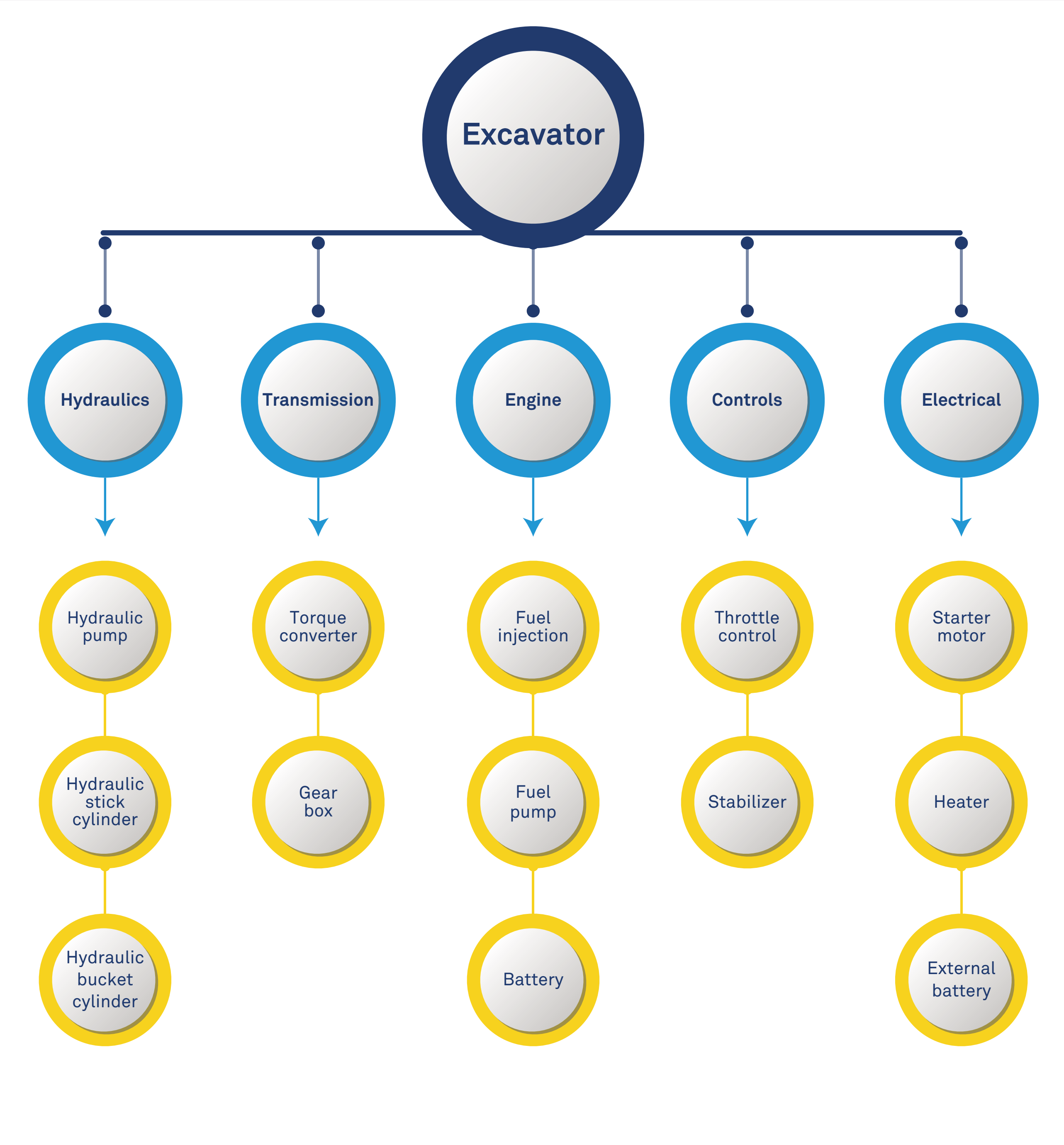

Fig. 5: Corresponding virtual model of the excavator

Against each one of the parameters (such as, Fuel Pump or Battery), one can maintain the corresponding time series data from the field, thereby reflecting the exact state of the physical asset at any point in time. Thus, the abstract model captures static as well as dynamic data (time series data) plus the actual location (GPS coordinates).

Time series data (both current as well as historical) can be used for:

- **Predictive maintenance:** Developing statistical models can help predict failure of the asset and enable proactive maintenance preventive, predictive and prescriptive can be carried out, thereby saving time, money and productivity.

- **Remote control:** Location data can be used to enforce geo-fencing, leading to tracking and tracing of stolen vehicles. An excavator in the field may be allowed to operate only in a specified region and during specified business hours, on a business contract. If the contract is breached, alerts will be generated for the relevant stakeholders.
- **Product design:** When R&D engineers design a specific model of excavator, they use several reference performance curves to perform sizing of the various parameters like max engine-capacity, max RPM, max bucket-depth, etc. Digital Twin can help understand the performance of a new variant in an excavator before committing to expensive changes in the manufacturing process.
- **Remote monitoring:** With the help of Digital Twin, an operator can visually experience the operation of the excavator and immediately figure out if there's a problem and if yes, where it is. An expert, sitting in, say New York, can instruct the operator of the excavator from any corner of the world.
- **Remote operation:** It is a continuous process of tracking various parameters of the asset and comparing their values against the optimal operating values. The goal is not only to avoid outage but also to automate service assurance by automatically identifying performance issues and giving the insight needed to manage problems proactively.
- **Virtual Reality (VR) based training on the Digital Twin:** The field agent can be trained using virtual reality to fix various issues in step-by-step manner, dramatically reducing the cost of maintenance.

From a Digital Twin of an asset to a Digital Twin of a collection of assets

Imagine a factory with several machines, each performing a separate task. A Digital Twin can be created for every machine in the factory. Once created, one needs to capture the interaction between the Digital Twins – what information is exchanged between a pair of Digital Twins and how the states of twins change on receiving specific messages. This actually creates a sophisticated model with rich visualization of a system of state machines with complex interactions between various Digital Twins.

Wipro, by virtue of its Digital Twin Platform, is able to bring two distinct worlds of PLM and IoT together and create a unique value proposition in a seamless manner.

About the author

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Sanjoy is an innovator and has been granted 88 US patents. He is the author of 2 high-tech books and 200+ publications. He has a key role in driving profitable growth for clients via business process transformation, leveraging innovative digital technologies such as industrial IoT (IIoT), voice conversations, Cloud, blockchain and Artificial Intelligence/Machine Learning. Sanjoy has over 25 years of industry experience. Before joining Wipro, Sanjoy worked with Accenture where he led the Digital Go to Market for Chemicals, Natural Resources and Energy industries in North America. Sanjoy holds a Bachelor of Technology degree from IIT Kharagpur, an M.S and a Ph.D. degree from the University of Maryland, College Park, and an MBA from the Wharton Business School, University of Pennsylvania. He is a Fellow of IEEE and IET.

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