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The Mindful IT Company
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PROACTIVE MAINTENANCE OF WIND TURBINES USING DIGITAL TWIN

Digital twins have emerged as indispensable elements in managing wind farm operations. They enable the early detection of potential issues, offer valuable insights into the wind farm's performance, and supply essential data for planning and predictive analysis, leveraging data and artificial intelligence. This, in turn, allows wind farms to optimize efficiency and minimize downtime. Digital twins can continuously monitor and fine-tune turbine performance, ensuring they operate at their highest potential. Wind farm operators can sustain efficient and economical operations by integrating digital twins.

LEVERAGING DIGITAL TWIN FOR OPERATION EFFICIENCY

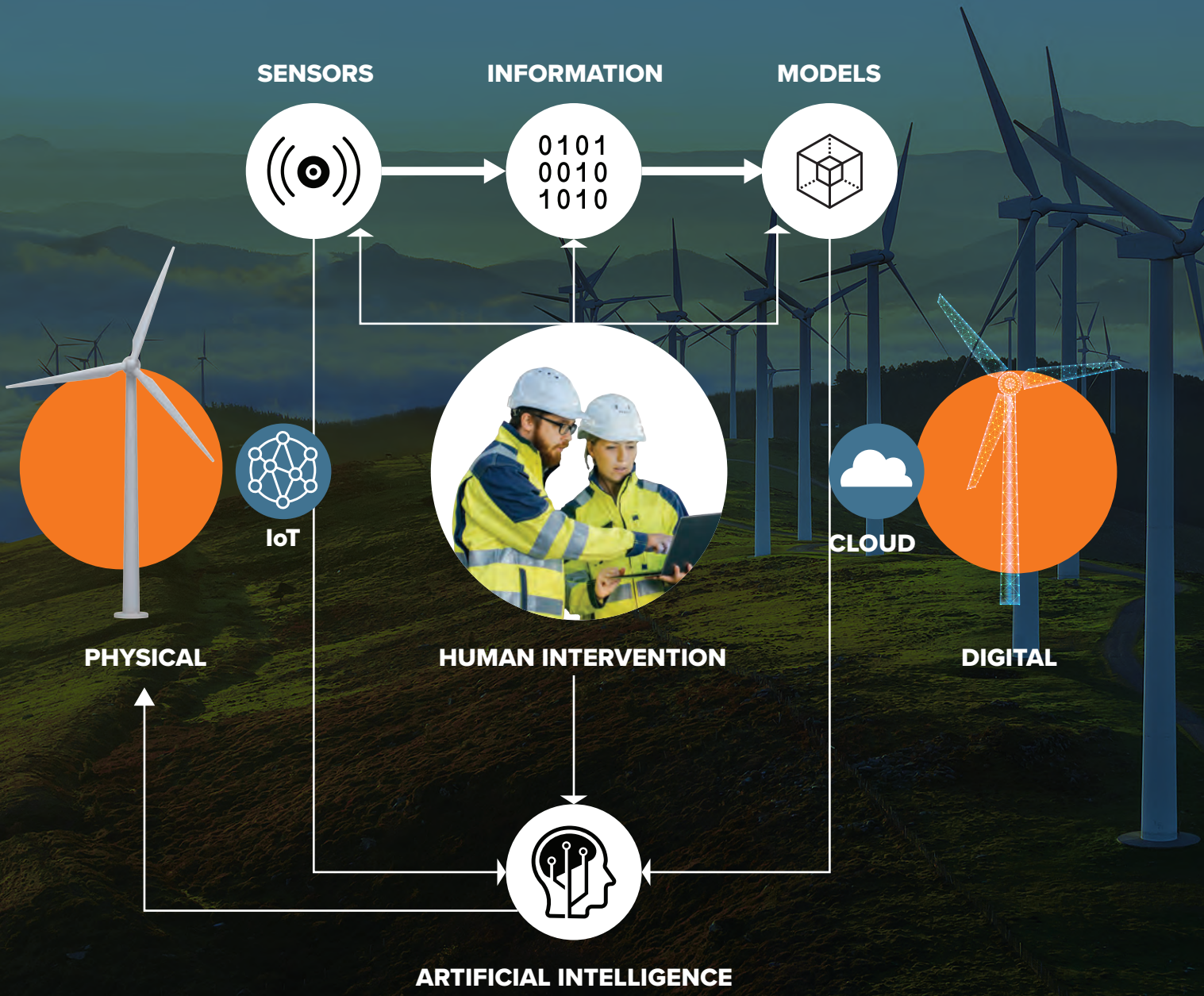
Wind turbine inspections are important and often required at various stages of the wind project life cycle to help ensure reliability, safety, and performance. Wind turbine inspections include inspection of their critical components like

- Inspection of gearboxes, bearings, main shafts, and pitch systems
- Vibration measurement and diagnosis for the drive train and shaft alignment
- Inspection of blade
- Inspection of generator

Proactive diagnosing of the critical components to predict any failures is a key success factor in improving the overall operational efficiency of Wind Turbines.

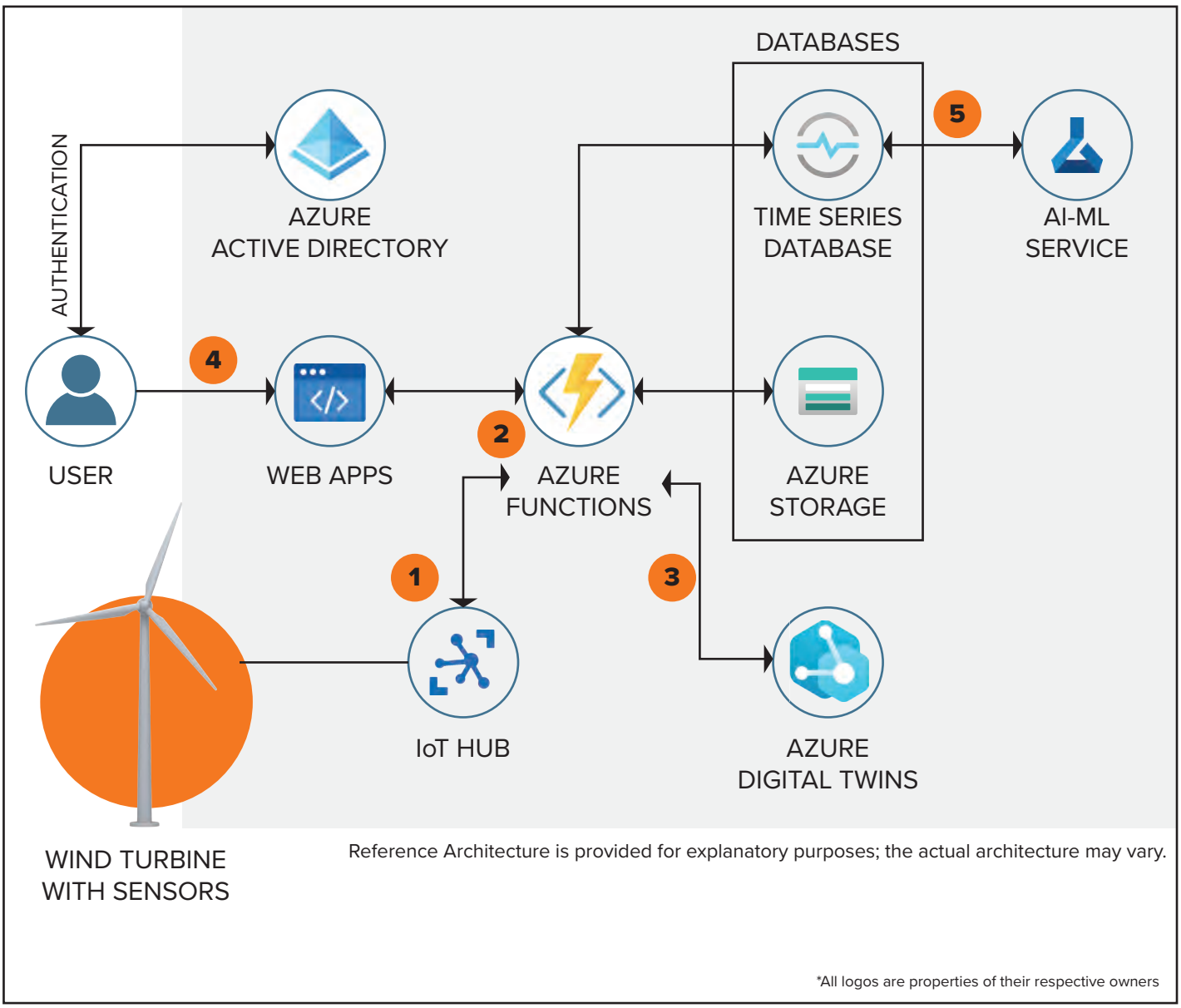
IMPLEMENTING DIGITAL TWIN TO INCREASE OPERATIONAL EFFICIENCY

Sensors will detect the type, location, and size of damage in different subcomponents, such as load-carrying spar caps, webs, and life-generating surface panels. Information processing involves the translation of physical data into a digital representation. Models are damage-prediction models that AI enables. Human Intervention is sometimes needed to break AI-based decision-making.



Key Enabling Technologies
IoT, AI, and Machine Learning

Below is the high-level architecture for reference for implementing Digital Twin using the Azure Platform.



1

Gather real-time data from the wind turbine through sensor inputs and transmit it to the IoT Hub.

2

Azure functions will assess and store this data in a Time Series Database for future use.

3

The Digital Twin will present the data collected from the sensors on the 3D Model via Web Applications.

4

Web Applications will oversee and manage the wind turbine utilizing Azure Functions and Azure Digital Twin.

5

The Time Series Data will be employed for in-depth analysis, supporting predictive maintenance tasks through Azure's AI-ML Services.

Below is the dashboard implemented at Happiest Minds, which indicates which turbines are online and which are offline, and the amount of energy they are producing daily.

The below dashboard indicates an alert raised due to an increase in the temperature of a particular wind turbine. The user can drill down to see the 3-D model of the wind turbine where the temperature is WTN 005, showing red due to an increase in temperature of the shaft. The user is given a recommendation levering predictive analytics that the shaft of WTN 005 must be replaced.

SUMMARY

Digital twins have become essential in efficiently managing industry operations. These digital replicas enable early issue detection, offer valuable insights into performance, and provide crucial data for planning and predictive analysis by integrating data and artificial intelligence. This optimization enhances efficiency while reducing downtime, with digital twins continuously monitoring and optimizing turbine performance. By incorporating digital twins, wind farm operators can maintain efficiency and cost-effectiveness. This implementation involves sensors to detect damage in various components, such as load-bearing spar caps and webs, with AI-driven models predicting potential failures. Key enabling technologies include IoT, AI, and machine learning, and the architecture typically involves platforms like Azure. Dashboards like the one at Happiest Minds provide real-time information on status and alerts, allowing users to visualize the device's health and receive recommendations based on predictive analytics.

ABOUT THE AUTHOR

Rakesh Kumar has 15+ years of experience with Microsoft .NET, Cloud and Cognitive service technologies and is an Azure cloud and IoT specialist. He is an expert in translating functional and non-functional requirements to high- and low-level design documents and has worked closely with stakeholders to make sure the design is efficient, scalable, and maintainable. Rakesh has previously worked as .NET / Azure solutions architect and has handled critical projects involving dynamic requirements and critical timelines and is currently working as an architect at Happiest Minds.

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A Great Place to Work-Certified™ company, Happiest Minds is headquartered in Bangalore, India with operations in the U.S., UK, Canada, Australia and Middle East.

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