Digital Twins - a primer

RAIN RFID Alliance
Whitepaper

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Digital Twins – a primer

This white paper attempts to create a baseline understanding of the digital twin concept to allow a discussion of RAIN RFID within the concept. It is assumed the audience is familiar with RAIN RFID.

A Digital twin as enabled by RAIN RFID

We define a **digital twin** as data stored in one or more databases which describe the life, interactions, and status of the object. Data stored on a RAIN RFID tag reference the digital twin allowing digital systems to record the life and interactions of the object and to interact with the object. The reference may be any combination of UII/EPC, TID or user data. This reference, in the classic thinking, is a random number with a pointer to the relevant set of data bases where the digital twin is stored. For more information please see the *RAIN Technical Note: Tag Data and Data Handling*.

Digital twins have existed since we started to keep digital records and journals. Your banking records can be seen as your financial digital twin, and your health records a twin of the physical you, making a health digital twin. These digital twins are not a complete description, but the analytics and augmented information can be an adequate digital twin for the purpose; i.e. allow you to transact without carrying a ton of gold (and get robbed) and be able to receive efficient health care wherever you are. These examples illustrate the concept of digital twins in a non-technical environment and show relevant real-world applications. It is important to note that the modern concept of a digital twin uses multiple independent sources sensing and actuating on the record.

The Internet provides many opinions and explanations of what a digital twin is and how to use it in varying complexity and hype, mostly wrapped in marketing garb. However, the concept of digital twins has been practiced for many years and advanced successfully by insightful and innovative individuals and organisations.

> https://www.digital.nsw.gov.au/digital-transformation/policy-lab/emerging-technology-guide-digital-twin

> https://www2.deloitte.com/us/en/insights/focus/industry-4-0/digital-twin-technology-smart-factory.html

The Wikipedia article (https://en.wikipedia.org/wiki/digital_twin) provides a splendid, but rather "technical" description of digital twins. It is worth a detailed read; key extracts are:

A digital twin is a digital replica of a living or non-living physical entity…

Digital twins integrate internet of things, artificial intelligence, machine learning and software analytics with spatial network graphs to create living digital simulation models that update and change as their physical counterparts change. **A digital twin continuously learns and updates itself from multiple sources to represent its near real-time status, working condition or position.** This learning system, learns from itself, using sensor data that conveys various aspects of its operating condition; from human experts, such as engineers with deep and relevant industry domain knowledge; from other similar machines; from other similar fleets of machines; and from the larger systems and environment in which it may be a part of. A digital twin also integrates historical data from past machine usage to factor into its digital model…

It is widely acknowledged in both industry and academic publications that Dr Michael Grieves, Chief Scientist of Advanced Manufacturing at the Florida Institute of Technology, originated the digital twin concept. The concept and model of the digital twin was publicly introduced in 2002 by Dr Michael Grieves, then of the University of Michigan, at a Society of Manufacturing Engineers conference in Troy, Michigan. **Dr Grieves proposed the digital twin as the conceptual model underlying Product Lifecycle Management (PLM)**…

An example of how digital twins are used to optimize machines is with the maintenance of power generation equipment such as power generation turbines, jet engines and locomotives…

Another example of digital twins is the use of 3D modelling to create digital companions for the physical objects. It can be used to view the status of the actual physical object, which provides a way to project physical objects into the digital world. For example, when sensors collect data from a connected device, the sensor data can be used to update a "digital twin" copy of the device's state in real time. The term "device shadow" is also used for the concept of a digital twin. The digital twin is meant to be an up-to-date and accurate copy of the physical object's properties and states, including shape, position, gesture, status, and motion.

A digital twin can be used for monitoring, diagnostics and prognostics to optimize asset performance and utilization. In this field, sensory data can be combined with historical data, human expertise and fleet and simulation learning to improve the outcome of prognostics. Therefore, complex prognostics and intelligent maintenance system platforms can use digital twins in finding the root cause of issues and improve productivity. Digital twins of autonomous vehicles and their sensor suite embedded in a traffic and environment simulation have also been proposed as a means to overcome the significant development, testing and validation challenges for the automotive application, in particular when the related algorithms are based on artificial intelligence approaches that require extensive training data and validation data sets.

Further examples of industry applications:

- Aircraft engines,
- Large structures e.g. Wind turbines, offshore platforms, offshore vessels etc.
- HVAC control systems
- Locomotives
- Buildings
- Utilities (Electric, Gas, Water, Wastewater Networks)

The various examples show the digital journal contains homogeneous (interoperable with common meaning/semantics and syntax) information about an object whether it is a human, machine, or item, etc. This information, which may include status, history, and environment, allows for decision making about the object and action with or on the object.

This information may come from many sources and the actuation may happen through many channels. The information is not necessarily complete, and it may even be erroneous.

The digital twin concept requires the following key components:

1. A trusted and homogenous object identity where the object is identified and linked with its digital twin for use by both automated and manual operations.
2. Reliable, deterministic, and timely connectivity.
3. Sensors, both automated and manual.
4. Actuators, both automated and manual.
5. A defined and interoperable method for creating homogenous information about an object and its interactions.

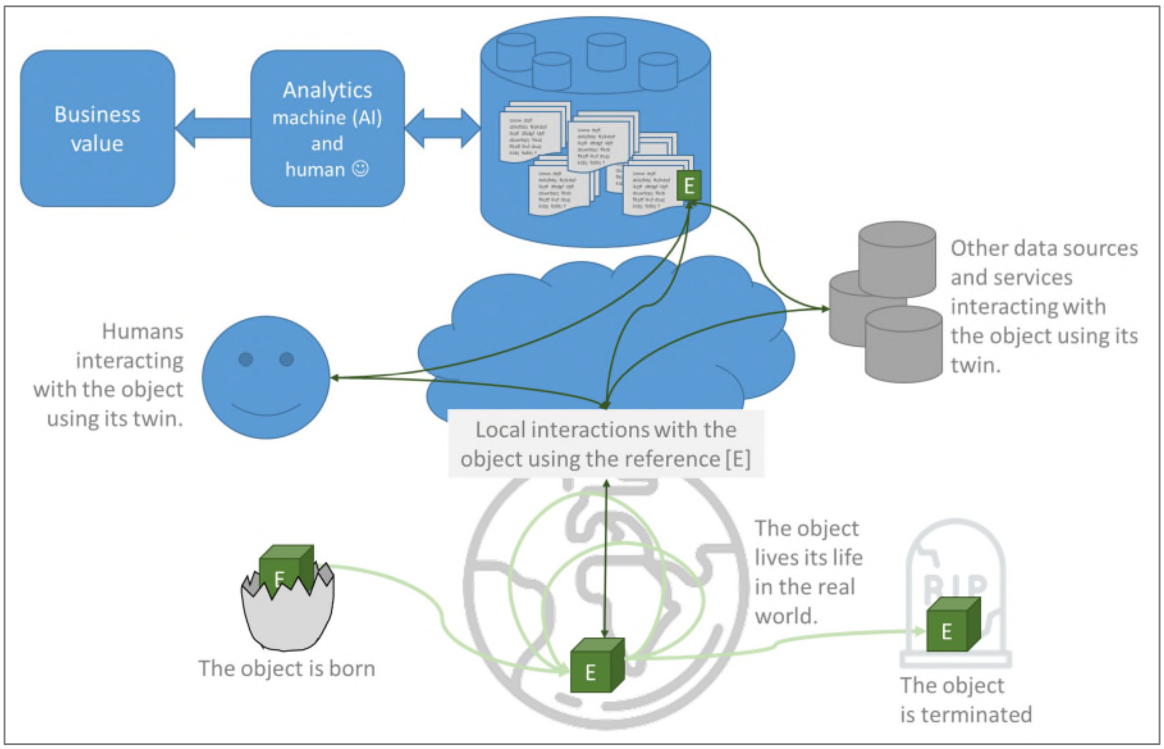

Figure 1 - An illustration of the lifecycle and digital twin of an object

The lifecycle of an object follows the same path as a human:

1. Birth: The object identity is embedded in the object and the digital twin is born.
2. The object is sensed, handled, and even transformed through sensors, actuators and external information and analytics.
3. Death: The object is no more, and the identity link is terminated, but the digital twin will remain for eternity.

RAIN RFID is a perfect technology to create the required trusted and homogenous object identity to have a digital twin. It provides an optimum balance between cost, longevity, durability, automation, and integrity. It may carry sensors and other additional information assisting the digital twin concept to operate even where connectivity is problematic. Most important, it is economical.

The *RAIN Technical Note: Tag Data and Data Handling* and *RAIN Reader Communications Interface* (RCI), see rainrfid.org, provide insights in how to enable digital twins with RAIN.

ABOUT RAIN RFID ALLIANCE

The RAIN RFID Alliance is an organization supporting the universal adoption of RAIN UHF RFID technology. A wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate, and engage each item. The technology is based on the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard. For more information, visit www.RAINRFID.org. The RAIN Alliance is part of AIM, Inc. AIM is the trusted worldwide industry association for the automatic identification industry, providing unbiased information, educational resources, and standards for nearly half a century.

RAIN RFID Alliance

One Landmark North
20399 Route 19
Cranberry Township, PA 16066

Visit the RAIN RFID website – RAINRFID.org.

If you are interested in learning more about the RAIN RFID Alliance, contact us at info@rainrfid.org.