Technology Trends

Digital Twins

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Version 0.1
Date 2019-7-12

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Business Brief

A Digital Twin can be defined as a digital representation of a physical asset. This asset can include processes, people, places, systems and devices that can be used for a variety of reasons. When defining a Digital Twin, the first important point to note is the connection established between a physical model and its virtual counterpart. Secondly, with the progression of Internet of Things (IoT) devices, real time data can be collected about the state of the physical model and then fed to a digital model allowing it to adapt its own state and become an accurate representation of the other, given the proper functionality.

A Digital Twin will often make use of technology such as artificial intelligence, machine learning, and software analytics. The data is acquired from multiple sources including humans, similar machines, large systems, as well as the environment it resides in. Digital Twins have the potential to completely change certain industries. For example, when designing an integrated solution architecture a Digital Twin can integrate data from cloud platforms as well as asset related applications. This creates a single source of data and analysis for every asset.

Since real-time data provided through IoT sensors is integrated by a Digital Twin, a variety of use cases exist for their application. An organization can apply the technology to their sell-able products turning them into connected products where they are able to perform Product-Life-Cycle-Management from the design phase to the service provided to the customer [1]. Manufacturers can also benefit by connecting their end to end processes within a production Digital Twins can provide the capability to offer new product-as-a-service business models. Doing so also allows a Digital Twin to transition from being a data-driven simulation model to a tool for financial accounting and planning. In the context of Enterprise Architecture an architect can create an EA blueprint as a Digital Twin for the organization.

Technical Brief

A Digital Twin can utilize a combination of Artificial Intelligence (AI) and Machine Learning (ML) to correctly represent current and future states of a physical asset Digital Twin. Developing a Digital Twin requires an information communication technology framework integrated with physical properties as well as software for data visualization. This means the twin requires the proper processing power for the data where trends and analysis can be represented or visualized on a dashboard. This can represent real world events as well as the characteristics of objects and processes [9]. A Digital Twin can be thought of as a software module or a series of data sets that is logically distinct from an application using the twin. The application can then interact with the twin rather than the actual object. Gartner proclaims that the top practice for applications interacting with a twin is through a well-defined interface [4]. This can be an event-based API or a request reply API. When public API methods or functions are invoked the twin's logic can then perform a variety of actions including receiving data or generating alerts, or whatever functionality has been implemented based on system requirements. By using an API the twin's data and logic is encapsulated and decoupled from the application's logic, making the system loosely coupled. The API is exposed on the twin's side, allowing the application to make calls to the lower level software modules that process the twin's data. This now means as long as the semantics of interface are maintained, either the twin or the application can be altered without harmful changes propagating through the entire system [4]. This also means that a twin can be shared and accessed by multiple applications. There are several advantages to this including the avoidance of data duplication, a common operating picture of the state of an object, a reduction in the number of communication protocol stacks and network ports needed, and lastly security can be improved because all network traffic through the object can be redirected through the twin providing a single point of entry.

Industry Use

Several organizations have remarked the benefits of Digital Twins, and are now using them to monitor their physical assets, operation dynamics, and business processes. General electric is one of the largest firms currently making use of Digital Twins. The company had begun using the twins to analyse data collected from the wind turbines, oil rigs and air craft engines they produce. For example when using the twin on an aircraft engine the system will monitor the engine and all its sub-components during a flight. A real-time Digital Twin is then generated from the data transferred from the on-board sensors to the company's datacenter [3]. If a potential defect is detected they are able to determine precisely which part is causing the fault and have a replacement ready once the aircraft has landed. The technology also has huge medical potential. A research collaboration between Stanford University and HPE called "The Living Heart" creates a 3D multiscale model of a heart [11]. From there circulation can monitored and medications are able to be virtually tested. Much like its use in aircraft engine maintenance automotive vendors are also noting the potential of Digital Twins. Volkswagen has begun using the technology to monitor their production process. They have also begun using the Digital Twin in combination with Augmented Reality via Microsoft HoloLens [10]. Engineers and designers are now able to modify the Digital Twin using gesture control and vocal commands.

Canadian Government Use

There is a significant lack of documented Government of Canada (GC) initiatives and programs promoting the current and future use of Digital Twin technology. As a GC strategic IT item, Digital Twin technology is absent from both the GC's Digital Operations Strategic Plan: 2018-2022 and the GC Strategic Plan for Information Management and Information Technology 2017 to 2021.[i] This may be due to the fact that the GC is currently grappling with the implementation of Cloud Services, and the majority of resources and efforts are occupied with implementation challenges, as well as security concerns related to the protection of the information of Canadians.

Future in-depth interviews and research will need to be conducted within Shared Services Canada (SSC) and with client departments in order to ascertain the level of Digital Twin capabilities that are ongoing and planned for future implementation.

Implications for Shared Services Canada (SSC)

Value Proposition

The business value impact of Digital Twin is to help inform situational awareness of the IT ecosystem, improve GC asset management, drive business process improvements, and lead to overall better IT strategic decision making. Digital Twin technology is about modelling assets in a one-to-one relationship and evolving the blend between digital and physical across environments. Digital Twin technology drives consolidation access. Since Digital Twin is a proxy which provides an object with an Internet Protocol (IP) address it can clarify and identify specific objects/assets. This is extremely helpful when dealing with issues of asset scale and complexity.

Any GC department with physical assets can benefit from the use of Digital Twins. GC assets and materiel must be managed by departments in a manner that supports the cost-effective and efficient delivery of government programs. Digital Twin technology can make the management of IoT assets across the country easier. The Digital Twin is continuously updated, via sensors attached to the physical object, to mirror the current state of the physical object.

Since Digital Twin is a model of the actual physical object, it can be easily interacted with by analysts to track asset status, simulate unique conditions, and perform what-if analysis to predict failures. The main purpose of a Digital Twin is to act as a proxy for its thing, so any application that needs data from the physical object deals directly with the proxy. Since Digital Twin is a piece of software, it can be programmed to encapsulate data so that changes can be made within the twin without affecting any connected applications, and vice versa.[ii] Additionally, as a model, Digital Twin helps analysts understand, document, and explain the behavior of a specific machine or a collection of machines over a specified amount of time, improving asset management techniques.[iii]

Digital Twins can further increase an organization's situational awareness by analysis of sensor IoT data and information. The rise of Digital Twin technology coincides with the rise of the IoT and AI/ML.[iv] Future advances and investments in both IoT and AI/ML are expected and this continues to support the development of Digital Twin technology. Digital Twin technology is becoming increasingly beneficial because it possesses capabilities that decrease the complexity of IoT ecosystems by creating easy to work with digital models of a physical object. Although, Digital Twins vary greatly in their purposes and the amount of data they hold, they all follow the same principle, there is one twin per physical thing. This decreases complexity for network analysts and improves their situational awareness of the network by identifying crucial physical assets which require organizational monitoring and management.

Digital Twin can also be leveraged to drive business process management. A contextualized model can be created by a Digital Twin for individual business processes or work processes. This allows an organization to identify parts of an organization that are directly providing enterprise value. For example, enterprise risk management is a complex process often involving multiple stakeholders, within an organization, a Digital Twin can be leveraged to create visibility on the dependencies within various aspects of this process. A Digital Twin can provide accountability and governance as well as performance indicators and objectives. Making the entire process more visible and easily trackable [6]. When combining Digital Twin data with business rules, optimization algorithms or other prescriptive analytics technologies, Digital Twins can support human decisions or even automate decision making.

Lastly, improved situational awareness and asset management provided by Digital Twins can be used to help make better strategic business decisions. There are three types of Digital Twin with varying values to enterprise decision making, they are: Discrete, Composite and Digital Twin Organization, also known as Product, Production, and Performance.[v] Discrete/Product emphasizes monitoring physical objects (individual assets), Composite/Production emphasizes operations involving a combination of discrete/product Digital Twins and resources (things, people, and processes), and Digital Twins Organization/Performance emphasizes on monitoring processes across entire business operations (maximizing business processes).

Challenges

There are many challenges that SSC could face in the development and deployment of Digital Twins in coordination with IoT devices. Most notable is the large amount of time, guidance, effort, resources, and funding required for establishing and maintaining Digital Twins and a robust GC IoT program that also has a high level of interoperability. Additional planning will be needed for SSC's infrastructure to accommodate increased Digital Twin requirements.

One of the biggest challenges with regards to Digital Twins is the overwhelming convergence of IoT data from sources such as Digital Twins, design, and process and quality control data, with existing data from legacy systems. Often it is the system supporting the Digital Twin which becomes overloaded. This is because the goal of Digital Twin adoption is often to provide a full lifecycle view of a product in service. The processing of this data is a concern since many Digital Twin solutions involve the use of AI or ML to provide real-time representations of the physical assets. IoT sensors will need to make use of edge computing and processing since handling all of the raw data entirely in-house can become overwhelming when the IT infrastructure cannot support it [8]. However, even when edge computing shares the processing burden, a data center may still be overloaded with Digital Twin data processing demands.

Accompanying data processing issues is the challenge of interoperability. If crucial physical assets are being monitored using Digital Twin technology this requires a high level of availability and interoperability between the Digital Twin technology, the IoT, and the hosting infrastructure. This is very challenging given that the GC network is large, highly disparate, and has numerous legacy systems that were never designed to interoperate with each other. Integrating IoT-connected products can be a complicated task, and since Digital Twin is an intrinsic part of IoT the implementation of interoperable IoT is an intractable issue when discussing Digital Twin. In order to successfully implement a Digital Twin project it would require a significant number of sensors. In a lot of cases this can be cost prohibitive. Additionally, managing the deployment of so many sensors is complex and time consuming. Hardware can also become a bottleneck within the IoT space since many vendors of sensors will require early prototypes of physical assets they are designing sensors for, to verify their design. A corporation making use of the IoT sensors to create their Digital Twin will be forced to purchase a significant number of sensors which can be expensive when the complexity of these sensors is high.

Governance is also a major challenge as over 85% of Digital Twins are managed by multiple-stakeholders. This brings this issue of ownership and visualization access needs to the forefront of managing Digital Twins. There is the issue of who actually owns the Digital Twin and the data populating it.

Connectivity is another major challenge for many Digital Twin concepts. Most physical objects that are both vital and interesting to study from a Digital Twin perspective, do not remain stationary. Making sure a connection or network reception can be established all the time to a network is a challenge moving forward when the number of physical assets being tracked on an organizations network is large and in semi-continual motion. Most IoT architectural patterns currently rely on data caching on the edge and processing in the cloud models. However, the bandwidth required to gain value from a Digital Twin scenario that could potentially be processing billions of data points is a tremendous connectivity issue.[vi]

Another challenge in pursuing Digital Twins is the shifting of an enterprise's business model. The enterprise must now place Digital Twins as a core component of their business model and this can be difficult with large organizations who are more susceptible to changes in their business model [7]. The Digital Twin can then be used to support strategy execution. However, leveraging a Digital Twin in this manner can only be done when it is provided with full visibility into business processes and performance and any interdependencies between them [6].

Considerations

SSC should consider reviewing the IoT strategy to establish a vision for Digital Twins and their incorporation with IoT initiatives and services. Build Digital Twin Architecture starting with asset engagement with enterprise systems and expanding throughout the ecosystem. A strategic approach to IoT investments will need to be developed to ensure accompanying Digital Twin opportunities are properly leveraged. The GC invests a significant portion of its annual budget on IT and supporting infrastructure. Without strategic IoT direction, the fragmented approaches to IT investments, coupled with rapid developing technology and disjointed business practices, can undermine effective and efficient delivery of GC programs and services. [vii] A clear vision and mandate for how Digital Twin and IoT will transform services, and what the end-state Digital Twin initiative is supposed to look like, is a prominent consideration. Additionally, since the IoT is fast becoming a pervasive attribute in IT, many companies will likely need to combine IoT and Digital Twin processes. Organizations will need to ensure that any acquisition of IoT has Digital Twins as an embedded feature. Additionally, when updating IoT strategy, the physical assets themselves, and digital applications for improved IoT, Digital Twin should be an inherent consideration and component wherever IoT is concerned.

Enterprises like SSC should be cognisant of not flooding their ability to conduct business with massive amounts of data without properly planning for its analysis, simply due to a fear-of-missing-out. An IoT device on its own doesn't understand what is happening around it, for this reason IoT devices and near/real-time analytics constitute a package. Organizations will often deploy IoT for a specific purpose in silos but fail to handle the new influx of data or fail to connect these devices with other systems for aggregate analysis. In order to achieve value from Digital Twin technology, projects need to adapt an intelligent edge architecture, a process where data is analyzed and aggregated in a spot close to where it is captured in a network.[viii] Data needs to be analyzed and processed on the edge. The volumes of data needed to effectively analyze these scenarios can be too high to depend only on the cloud and data centers. Using the processing power of an outside provider like Microsoft Azure or Amazon AWS reduces the impact of these risks so long as the assets are of low enough security clearance where their data and processing can be accomplished through a cloud service provider.

To add value, organizations should consider the Analytics of Things (AoT)[ix] before creating sensors that stream enormous amounts of data to databases from the devices. This also means that decisions will need to be made on how much local processing the IoT device does, including what data to keep, what data to abbreviate or discard. Also when buying machines and other assets, support for Digital Twins and continuous development of twin capabilities should be a selection factor.[x]

SSC should consider acquiring portfolios of IoT Digital Twins in order to standardize and streamline situational awareness of enterprise assets and components. Choosing a Digital Twin integration pattern and portfolio that best fits the business process or situation will help implement and integrate discrete and composite Digital Twins. Tracking and supporting industry standards may be required by SSC in the future. SSC may need to assess ongoing efforts by industry groups, such as the Digital Twin Interoperability Task Group of the Industrial Internet Consortium, that are in the early stages of considering standards and frameworks to support Digital Twin interoperability. While these industry groups are beginning to work on Digital Twin formats, protocols and other integration simplifying standards, the rapid pace of Digital Twin evolution is high-paced and should be closely monitored.

Application leaders, who are active participants in developing application strategies and challenging the status quo, in SSC must have a good understanding of the different types of Digital Twins and their relationship to each other. These leaders should have a good understanding of the three types of Digital Twin technology, when to use them, and their relationship to existing business applications. Digital Twins are used to increase situational awareness, to better understand and respond to a business resource’s changing state, and to apply these capabilities more broadly so as to drive improvements in commercial processes and other forms of business value. These leaders should experiment with Digital Twin pilots and low-scale initiatives in order to discover how SSC can use digital-twin-enhanced situational awareness to improve service and business applications. This approach will help to identify which approach for acquiring and integrating Digital Twins with existing applications will work best for SSC.

Lastly, SSC may wish to consider evaluating the current Service Catalogue in order to determine where IoT can be leveraged to improve efficiencies, reduce costs, and reduce administrative burdens of existing services as well as how a new IoT service could be delivered on a consistent basis. Any new procurements of devices or platforms should have high market value and can be on-boarded easily onto the GC network.

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