SIEMENS

MindSphere
The cloud-based, open IoT operating system for digital transformation

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This white paper introduces MindSphere, a cloud-based, open operating system for the Internet of Things (IoT). With data analytics and connectivity capabilities, tools for developers, applications and services, MindSphere helps companies exploit the full potential of their data and transform it into measurable business success.

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Introduction

Internet of Things (IoT)

Siemens foresees great opportunities from the Internet of Things (IoT). The value of the IoT lies in connecting the real world with the virtual world of data. Digitalization technologies offer new business models.

In an Internet of Things, billions of things have addresses and are linked to the Internet. They can transmit data to the cloud for processing, and be managed and controlled via applications. This scenario will become a reality thanks to increasingly miniaturized computers, affordable sensors, ubiquitous networking, and the increasing availability of "smart" devices in many areas. Example applications will range from networked vehicles to fitness-trackers and from smart homes to smart farming.

Siemens has proven success combining hardware with software – including automation solutions in production, rail management, traffic management, and decentralized energy supply systems. These are complex systems that require supervision and control – systems with components from both the real and digital worlds that often involve critical infrastructures. Customers in such areas have very high expectations for safety, reliability, durability, and protection of their data. And they want to enrich their existing equipment with the advantages of digitalization without jeopardizing their existing systems.

That's why Siemens has further detailed and expanded the concept of the Internet of Things for industrial applications. In this approach, devices and machines such as those produced by Siemens, as well as their interactions in systems, are at the center of a digitally-networked industrial landscape.

Siemens is already using this approach in many projects. Examples include:

- Charging systems for electric buses that are in service in Hamburg, Göteborg and Stockholm. Here, all components, including the electronics inside buses, fast charging stations and pantographs, communicate via the Web and coordinate the recharging process.
- The optimization of water supply networks in Saint Petersburg with a smart sensor network that helps detect leaks and minimize energy consumption in pumps. A major emphasis here is on integrating existing control systems.
- New, intelligent transformers as part of a Smart Grid, as already realized in Viennas' aspern Urban Lakeside development project.

The Internet of Things is a cornerstone of Siemens' digitalization strategy. Technologically, it is already feasible and because the approach is transferable, all of this opens up new business opportunities for Siemens and its customers in every industry – whether in energy utilities, traffic control, buildings, manufacturing or other industries.

Digitalization

As the world becomes increasingly connected, digitalization – using digital technologies to transform business operations – is a key lever that will enable companies to remain competitive. Digitalization promises lower costs, improved production quality, flexibility and efficiency, shorter response time to customer requests and market demands, and also opens up new and innovative business opportunities.

The digital enterprise is already a reality, and companies are pursuing its benefits and opportunities through digital transformation, which requires seamless integration of data along the value chain. Initiatives like Industrie 4.0 and the Internet of Things (IoT) are being driven by billions of intelligent devices generating massive volumes of data. Turning this data into value is a critical success factor.

Digitalization is changing everything, in all industries. With dramatic advances in computing, the IoT, and other technologies, companies can now collect and analyze big data in real time to derive actionable information that will drive business decisions. Siemens is addressing these challenges building on experience and expertise in Automation and Electrification.

Digitalization is the key lever that will enable companies to remain competitive into the future. This applies both to smaller operations and to major companies that are active around the world. Increasingly shorter innovation cycles mean that industrial enterprises constantly need to shorten their development and production times. This requires seamless integration of data along the value chain, from the idea of a product to the real product to service. Making use of the opportunities provided by digitalization to respond faster and more flexibly to customer requirements will provide an advantage on the market.

Siemens creating benefit along entire customer value chains

Siemens understands our customers' worlds – and not just from the outside, since Siemens is also a global manufacturing company. Siemens knows from its own experience how customers can get their products to the market faster, more flexibly, with maximum efficiency, and in top quality – in other words, by combining the virtual world of product development with the real world of manufacturing. Siemens is the only company on the market right now that combines the latest software for product lifecycle management with powerful automation technologies and services under one roof.

With Siemens global installed base of millions of devices (30 million automation systems, 70 million contracted smart meters, 800 thousand connected products) Siemens and its partners can develop high-value applications through MindSphere's rich application programming interfaces (APIs) and deliver digital services with deep industry knowledge and experience.

In addition to connected Siemens devices, customers are using Siemens software to design, simulate, and produce millions and millions of IoT enabled products from in high tech electronics, consumer products, automotive, aerospace, and many other industries. As a leading global provider of product lifecycle management (PLM) and manufacturing operations management (MOM) software, systems and services with over 15 million licensed seats and more than 140,000 customers worldwide, no other IoT provider can drive closed-loop innovation through complete digital twins for products, production, and performance like Siemens.

MindSphere

MindSphere is the cloud-based, open IoT operating system from Siemens that connects real things to the digital world, and enables powerful industry applications and digital services to drive business success. MindSphere's open Platform as a Service (PaaS) enables a rich partner ecosystem to develop and deliver new applications.

Digitization, and the transformation of IoT data to productive business results, are core drivers of MindSphere. High value Industry based applications built on MindSphere deliver measurable results through digital services that are based on best practice solutions. In addition, companies can leverage MindSphere to close the loop through product ideation, realization and utilization to seamlessly integrate operational data throughout the value chain – not only driving operational efficiency, but also comparing simulation and test results with real-world observations.

This white paper describes the capabilities and benefits of MindSphere in four key areas:

- Quickly and easily connecting real things to the digital world
- Creating a strong partner ecosystem with open platform as a service (PaaS)
- Driving business success with powerful domain specific industry applications and digital services
- Enabling unmatched closed-loop innovation with complete digital twins

As part of a complete digitalization strategy, MindSphere enables new ways to solve problems and enables companies to consider innovative new business models.

Connecting real things to the digital world

Eight billion devices are now connected to the internet. One trillion by 2030.

Source: World Economic Forum, 2016

Connectivity, it is one of the main topics in IoT. Siemens global installed base of millions of devices, assets and automation systems from Power Generation, Energy Management, Transportation, Industrial Production to Building Technology. In most cases data is already available in contextualized form, but not leveraged to the potential benefits. Siemens will provide add-ons and extensions to existing systems so MindSphere can easily connect these to make use of this data.

Millions of new devices, assets and automation systems are shipped by Siemens on a constant base. These will come with MindSphere ready connectivity build in, so benefit from generated data can be accessed from the start of installation.

With open communication standards also devices, assets and automation systems from other suppliers will be able to transfer data to MindSphere. This ensures a homogeneous approach and enables combinations of data analytics which has not been possible so far.

In addition to Siemens systems, companies that are designing, developing, and manufacturing products based on Siemens Digital Enterprise Software suite of PLM and manufacturing software will be putting billions of IoT-enabled products into the hands of consumers. Some of the endless list of examples includes laptops, computers, televisions, cars, trucks, planes, heavy equipment, fitness devices, white goods, etc. IoT data from these products will come from many different sources. Siemens envisions MindSphere connecting to a variety of IoT sources so that data from these products can be collected and used in MindSphere applications.

The variety of different asset types which are connectable to MindSphere seems almost unlimited, and MindSphere will support the major open standards needed to connect:

Energy	e.g. Turbines, Windmills, Batteries, Smart Meters, Substations, Compressors
Transportation	e.g. Trains, Subway stations, Ships, Trucks, Luggage, Container
Industrial Production	e.g. Machines, Conveyers, Controls, Drive Trains, Pumps, Valves
Building Technology	e.g. Heating, Ventilation, Air Condition, Lightning, Access & Security, Fire & Safety
Healthcare	e.g. Medical Equipment, Implants, Hospitals
and many more	e.g. Agriculture, Smart Home, Retail

High value Apps will be utilizing data from various sources and provide unique benefits to MindSphere users.

MindSphere has a simple and clear structure that is designed to enable customers to quickly connect their assets to the cloud and realize value from their IoT data.

To achieve end-to-end integration of their data, business must first take the fundamental step of connecting their assets to the digital world. The raw data produced by plants, machines and systems cannot be comprehensively analyzed without first being linked, captured and managed.

MindConnect for easy and secure connectivity

To simply and securely link assets to MindSphere, Siemens provides a wide range of MindConnect Elements. MindConnect Elements are software and/or hardware solutions that enable plug-and-play connectivity to collect relevant data. Examples include status data from energy meters, moving assets like trains, air conditioners, individual drives and conveyor systems - transmitted to MindSphere at set intervals. Establishing a connection using MindConnect can be accomplished in less than 15 minutes, while not requiring any asset downtime (i.e. connecting in operations). This

enables companies to quickly and inexpensively gather and feed performance data to MindSphere for analytics.

MindSphere enables customers to get started quickly

MindSphere has been created to help customers instantly start realizing their digital business models. No programming skills or asset downtimes are necessary.

Every customer gets a customizable login. The main home page is clear and simple, showing only what is necessary to set-up connectivity ("Asset Configuration"), administer clients and user logins ("Customer Management" and "User Management") and the MindApps.

With plug and play connectivity of MindConnect elements, customers can quickly get started with MindSphere by:

- Setting up and connecting MindConnect elements
- Configuring data that needs to be send into MindSphere
- Using Fleet Manager with the integrated rule engine to get first insights and define actions

MindSphere enables customers to get started quickly

Open standards for connectivity

Open standards and interfaces make it possible to obtain data from assets, devices and systems from a wide variety of manufacturers. MindConnect ensures sound, manufacturer-independent communication by relying on established industry standards. These include the OPC Unified Architecture (OPC UA) standard, a machine-to-machine communication protocol for industrial automation interoperability developed by the OPC Foundation industry consortium. Support of additional standards and protocols for various asset types described earlier in this paper will be provided by Siemens or via partners.

MindConnect Software will allow easy extension to all types of different assets, protocols and communication standards. Through these extensions, MindSphere customers can access a global base of MindSphere-ready assets from Siemens and third parties, efficiently extracting data from them via embedded or added connectivity. This will enable endless possibilities for all kinds of assets from any supplier being connected to MindSphere.

In addition the MindConnect Library will assist developers to connect custom software agents to the MindConnect API:

- Small footprint Code Library for integration in 3rd party assets
- Custom data acquisition

- Send data directly to the MindSphere, without any knowledge of internet protocols
- Simplifies communication and commissioning to MindSphere

Secure Communication

The MindConnect Elements employ security mechanisms that connect and send data only to the MindSphere Platform. It identifies the MindSphere back-end by validating its security certificate. Certificate and key management measures are applied to handle the certificates and keys used by MindConnect Elements.

During the on-boarding process, the MindConnect Elements must go through an authentication process with MindSphere. Once this is done, the two entities agree on cryptographic keys for use in further communications.

Thus, the MindSphere Platform is designed to receive data only from valid MindConnect Elements which have successfully completed the authentication procedures during the on-boarding process.

Encrypted communications with MindSphere

As the level of digitalization increases, so too does the importance of comprehensive security concepts for applications. With defense in depth, Siemens provides a multi-layer concept on security, network security and system integrity as recommended by ISA 99/IEC 62443 and IT Security oriented to industry standard ISO 27001/BSI. The data in motion is always at least 256 bit SSL/TLS encrypted.

All communications between the MindConnect Elements and the MindSphere Platform are encrypted via the Transport Layer Security (TLS) 1.2 standard. The TLS configuration is regularly checked to comply with the applicable Siemens Information Security guidelines. This helps in protecting against man-in-the-middle attacks or any manipulation of communication to the MindSphere Platform.

The MindConnect Nano for example, communicates via firewall friendly outbound internet traffic over HTTPS (HTTPS port 443) with only outbound HTTPS connections are established to the MindSphere Platform (the connection is always initiated by MindConnect Nano and not by the MindSphere Platform). The “outbound only” rule is followed even for firmware updates on the MindConnect Nano.

Maximum confidentiality

The MindSphere customer is the owner of the data and controls the authorization levels. MindSphere provides a highly secure data environment, which allows the data owner to execute full control over authentication levels for data access. Data is stored in highly secured infrastructures provided by leading cloud datacenter partners (IaaS). These professional IaaS providers can offer much higher security standards, than typical on-premise and local data storage.
In addition data access rights are strictly managed via separated tenants, which technically allows only data access by the assigned owner of the tenant (data owner).

MindSphere was developed with data security as a top priority, with access protection, segmentation and encrypted communication, providing protection from manipulation and protection of confidentiality. Customers can be confident that they fully control access to their data.

Open platform as a service (PaaS)

Siemens offers the MindSphere IoT operating system in the form of a platform as a service (PaaS), a cloud-based service that enables customers to develop, run and manage their applications without the complexity of building own infrastructures or managing complex software stacks.

As a PaaS, MindSphere offers further significant advantages. With the cloud managed infrastructure, companies take affordable advantage of the infinitely scalable computing capacity, which can readily accommodate the demands of global and fully digitalized enterprises. The platform can automatically scale to required data volumes and the numbers of connected assets and users. It is also cost-efficient, with on-demand flexibility and pay-per-use pricing.

Leading cloud infrastructure support

MindSphere is built on Cloud Foundry™, an industry-standard cloud application platform that abstracts the infrastructure so that developers can focus on application innovation. Cloud Foundry is collectively developed by global enterprises and vendors using open source governance. With this infrastructure-agnostic foundation, MindSphere applications can run on the customer's preferred cloud infrastructure, including Amazon Web Services, Microsoft Azure, SAP Cloud Platform and Atos Canopy.

MindSphere can be deployed on public clouds hosted by third-party service providers, and in the future also on private clouds built exclusively for an individual enterprise. Customers can choose the cloud deployment that best suits their requirements for cost, control, configurability, scalability, location and security.

Open interfaces for application development

To help customers build and integrate their own software applications and services, MindSphere delivers open application programming interfaces (APIs) and development tools. With these tools customers can deploy software applications in hours or days instead of weeks and months. Modularizing monolithic software solutions with these interchangeable applications offers customers much more flexibility and tailored functionality, faster and more cost efficient updates and agile development.

MindSphere provides a wide variety of APIs for developers which facilitates the development of applications and reduces development costs considerably.

MindApp APIs include for example the following services:

Notification Service	Send information to your users and customers via email, sms or social media channels like twitter
Timeseries Service	Read, write and edit timeseries values from storage
File Service	Read, write and delete Files values from storage
Event Requests	Add custom information like alarms or warnings in generic ways (e.g. system information, timeseries value)
Workflows	Create custom rules based on events like „New Request ", „New Timeseries" and many others and define your action based on this information
Customer Management	Manage customers (e.g. add new ones or change existing)
User Management	Create, edit or remove users, assign predefined roles
Asset Management	Represent physical assets from your site in MindSphere. Create, edit and delete elements
Aspect Management	Define your data model, add standardized meanings for a better understanding and reusage of you
Usage Transparency	Understand your customer by analyzing usage information of you application and create reports

In order to generate information from the data, MindSphere provides analytic functions which developers can use to be integrated in their applications:

Gradient Check	Detects the gradient of time series and delivers the results
Linear Regression	Calculates a linear regression of time series data and delivers the resulting curve data
Outlier Detection	Detects outlying time series data and delivers the results

In the future, MindSphere will have additional analytical capabilities, such as:

Trend Prediction	Provides calculus on individual or multiple 1d time series, including basic algebra and statistics (mean, sum, variance)
Sequential Pattern Mining	Detect alarm patterns and predict failures from (inverter) event logs. The service learns automatically patterns from sequences that lead to major events
Multidimensional KPI Supervision	Based on trained models, this services derives quantitative measures from multiple aspects
Demand Prediction	Executor for prediction models based on deep neural networks (pre-trained) for time-series data

Support development with integration of IDEs

Plugins for common development environments (e.g. IntelliJ and Eclipse) make it easy and quick to develop and integrate applications for MindSphere. Local debugging analysis and performance optimization also contribute to this. MindSphere also supports developers with a local development sandbox. They will be able for download providing a complete simulation of the MindSphere environment in order to get a first MindSphere experience.

Application developers will also be able to draw on the resources of the MindSphere development community, such as a developer portal, a developer conference, free demo applications, templates and more.

For developers that offer their customers customized applications and services, the developer cockpit allows them to keep track of the utilization of their services and to manage their resources.

Data and Data Configuration are at the core of success

MindSphere enables customers to connect their assets and devices as easy as possible. Domain specific Data configuration is at the core of the success of such an approach.

The MindSphere IoT model supports standardized data configuration, data model catalogs and mapping between data source (e.g. a MindConnect device) and data consumer (e.g. a 3rd party application) along with all required cleansing and normalization

MindSphere provides a hierarchical asset model to accomplish these goals:

To adapt to individual customer needs data separation is key for a flexible IoT Model. MindSphere embraces that challenge by providing a dynamic IoT Model, which will allow for a deeper meta-modeling capability:

Metadata: Defines classification and Relationships between Types, Attributes and Actions

Concrete Object: Concrete Instances of Classification (types) and defined Structure an relation to other concrete instances

Time Series: Time Series Data, reference to Instance and Attribute, Value

Connectivity developers will be able to describe their devices on a meta-level and provide these definitions to their customers to integrate their assets in their MindSphere environment seamlessly.

Cloud to Edge Computing with MindSphere

Customers who want to benefit from both Cloud and on-premise technology innovation can extend MindSphere by deploying software on Edge devices through the use of the MindConnect Library and API.

The use of MindConnect Library on Edge devices will provide advanced analytics and performance intelligence in proximity to the equipment, in a secure way. It will enable multiple use cases for descriptive, diagnostic, predictive and prescriptive analytics, by leveraging cloud connectivity in combination with Edge Apps from Siemens or 3rd party, in an integrated hardware/software environment.

MindSphere's industrial edge approach consists of cloud-based Edge Services and the modular Edge Runtime.

Edge Services and the modular Edge Runtime need to play perfectly in concert from an engineering and runtime perspective. This edge approach is the transparent integration of cloud services with field automation platforms enabling seamless extensibility of an installed asset / device base (e.g. Siemens Simatic, Climatix, Siprotec etc.) and an Edge App eco-system at the field level managed through MindSphere

Agile development driving innovation faster to our clients

MindSphere software development is based on the usage of modern agile and development operations (DevOps) approaches: building, testing and deploying software in a highly automated fashion using continuous integration and deployment technologies. These sprints shorten development – and innovation – cycles and enable rapid delivery of new capabilities. Frequent customer feedback can be incorporated to improve functionality and content for the next sprint.

Digital Exchange with MindSphere

Applications that run on MindSphere are delivered via the MindSphere Digital Exchange. Customers can choose from the applications developed by Siemens, e.g. Energy Analytics and Fleet Manager for Machine Tools, as well as the applications developed across the broad MindSphere ecosystem.

Companies developing applications for MindSphere can market their applications through the Digital Exchange, which offers a monetization and promotion channel to potential customers. Through the Exchange, Siemens ensures that the software is deployed in MindSphere and handles billing and invoicing.

MindSphere Partner ecosystem

MindSphere, the cloud-based open IoT operating system from Siemens provides partners with an unparalleled opportunity to participate in the digital transformation of companies regardless of industry or size. With Siemens global installed base of millions of devices, partners can develop high-value applications through MindSphere's rich application programming interfaces (APIs) and deliver digital services in partnership with Siemens. With Siemens unmatched ability to enable closed-loop innovation though product development, production, and field performance, no other IoT provider can connect customers to the complete digital twin like Siemens.

To address the broad scope and high complexity of the digital transformation, MindSphere has a network of partners built around it. These partnerships enable MindSphere to provide a holistic set of IoT solution and services, precisely matching the specific requirements of our customers, whereas it provides partners numerous opportunities to build and operate own digital offerings around MindSphere.

Our partner's success is our success, leading to the highest customer satisfaction.

Therefore we highly value the technical and operational excellence of our partners. In consequence, we significantly focus on their enablement and support of the MindSphere partner ecosystem. The constant evolution and thrive of the MindSphere ecosystem is therefore actively promoted by our MindSphere partner program, offering the following benefits:

- Leverage global Siemens installed base of millions of devices (30 million automation systems, 70 million contracted smart meters, 800 thousand connected products, e.g. trains, turbines, automation system, etc.)
- Get the support and enablement needed for your business ambitions, including training, consulting, promotion of partner offerings, etc.
- Leverage from the MindSphere brand and marketing activities
- Receive a first class enablement package, for special discounted partner prices
- Receive support for pre-sales and after sales activities, including a special customer support
- Benefit from a program, that rewards you based on your own performance and commitment

To cover the wide range of requirements of our customers, MindSphere partners with:

- Consulting and strategy partners
  Improving digital business or implementing Industrie 4.0 strategies
- Application developers
  Developing customized application, or offering the application as managed service
- System integrators
  Integrating data sources of different systems with data from MindSphere
- Technology provider
  Providing e.g. tools or special analytic modules for MindSphere
- Infrastructure as a service (IaaS) providers
  Providing infrastructure for deployment of MindSphere upon customer choice
- Connectivity developers
  Developing customized connectivity solutions or creating replicable devices

The MindSphere partner program focusses on generating win/win for our customers and our partners: Partners generate business around MindSphere by creating Apps and Services for their customers, while the MindSphere customer base benefits from numerous available applications and services that address their toughest challenges. Please see the contact information at the end of this whitepaper for more information.

Domain specific industry applications and digital services

MindSphere provides a solid foundation for applications and data-based services from Siemens and third-party providers, for example in the areas of predictive maintenance, energy data management, and resource optimization.

MindSphere builds on Siemens' data analytics, which are already used to monitor and check some 800,000 systems all over the world – systems such as gas turbines, traffic control centers in more than 200 cities and entire skyscrapers. Built for converting big data to smart data, MindSphere is ideally engineered for industrial datasets and use cases.

The MindSphere Core Applications provide cross-domain, ready-to-use applications and extensions addressing major use cases around the connected assets like:

- Data Representation & Visualization
- Asset Information & Management
- Condition Monitoring
- Asset Analytics

With this core functionality users can instantly use MindSphere to start their digital journey right away.

Fleet Manager for all industries

The Fleet Manager is the core application to quickly get an overview of the data of all connected assets. Flexible search options help to stay in control when having a big number of assets from different customers – either spread worldwide or located in one site. By quick access to all the connected assets and their current and historic data it is possible to turn data quickly into insight.

The integrated rule system uses wizards to support transferring the generated insights into actions. For every exceeding of a rule, priorities and actions can be defined. This enables preventive maintenance, service or supervision use cases to increase productivity.

Dashboards and automated reports are essential for daily live to get an overview about fleet status, productivity, KPI and much more. A Dashboarding & Report MindApp will make it possible to create different dashboards to fit the needs of different use cases.

There are also various domain-specific MindApps and offerings available on MindSphere addressing use cases, leveraging the domain expertise and know-how of Siemens. Some examples of these dedicated offerings are described in the following sections.

Rail Asset Management

Developed for the rail transport industry, the mobility-specific Railigent helps to increase availability, improve efficiency, reduce operational risks and costs and improve maintenance. It includes remote monitoring, fast diagnostics and preventive failure prediction for Rolling Stock and Infrastructure. Examples include visualization of vehicle health status and location, prediction of component failures for gearboxes, bearings, traction motors, doors, power transformers etc., operation support, analysis of error conditions of ETCS, prediction of point machine failures and throughput analysis for rail networks

Proven outcomes for our customers are:

- Prescriptive maintenance – with proven availability of > 99%
- Optimized operation planning – with up to 20% fewer delays
- Transparency in real-time – with GPS position and hundreds of sensor readings per second for a high speed vehicle
- Root cause analysis – with reduction of complex fault resolution times by >20%

With Railigent running on MindSphere the customer is furthermore able to improve the entire asset fleet and along their lifecycle. For example, a rail operator will be able not only to improve its rail vehicle availability, but also the operation of stations and optimization of energy consumption. All MindSphere applications and the development community will also be available to the Railigent users.

Energy Management for grids

EnergyIP is a leading and broad range of grid applications for utility grids. The solution covers use cases like meter data management, decentralized energy management, market transaction management and customer engagement over portals and mobile devices. It can integrate and process data from millions of distributed assets e.g., smart meters, remote terminal units, and inverters, process meter data automatically, monitor and control distributed energy resources and manage market participation for virtual power plants and demand response solutions. Furthermore, EnergyIP offers an analytics environment based on state of the art technology, and advanced analytics applications to leverage more value from the existing data.

Value proposition of EnergyIP:

- Management of data from millions of distributed assets in near-real-time
- Efficient IT-OT integration between IT-applications and field devices
- Utility data model to interpret data from energy assets
- Bi-directional, closed-loop communication

EnergyIP will further extend its current leading functionalities and gain significant value, as its applications will be available as MindSphere applications. This will enable cross vertical use cases, new business models, and new service offerings to consumers and prosumers. EnergyIP customers will also benefit from new partnerships with leading technology providers like IBM Watson or best in class infrastructure providers like Microsoft Azure, Amazon Web Services, etc. The open ecosystem of MindSphere will foster more innovative applications to be available in shorter time from Siemens as well as from 3rd party developers.

Building Performance and Sustainability

Navigator helps turning data in to results throughout the entire lifecycle of your building portfolio. It is designed to enhance system performance, achieve sustainability goals, reduce energy spend and maximize energy and operational efficiency.

With Navigator, customers gain visibility into the long-term performance of their facilities. Monitoring building system performance, energy consumption, and energy supply are becoming more effective and efficient than ever. Navigator is a fully-customizable, cloud-based platform, which can be used to analyze a single building, a campus, or an entire real estate portfolio.

Built with powerful reporting and analytic capabilities, Navigator collects and analyzes large volumes of building performance data, so customers can not only optimize efficiency and cost-savings investments, but also generate actionable information to make informed decisions and improve business efficiency.

Navigator and its applications will be made available on MindSphere.

Control Loop Performance Analytics for Process Industries

Control Loop Performance Analytics running on MindSphere adds a new layer of transparency to process data available in a Distributed Control System (DCS) supporting an efficient optimization process. Transparency is generated through automatic state detection and KPI calculation for different control states. With Control Loop Performance Analytics the user gets a hierarchical plant overview from management view to single control details allowing automated data analytics on a regular basis to support long time process optimization and fine-tuning. Additional expert reports for critical control loops can be generated. Control Loop Performance Analytics work fully automated to provide reliable results on a regular basis. Analytics results are provided via a MindApp. This ensures effective collaboration of all levels – from the plant manager to the process operator. Long term availability of data ensures measurable optimization results.

Energy Analytics for production facilities

With Energy Analytics as a Service, Siemens provides energy data management as a managed service and compliments existing know-how and systems. Intelligent reports and data analytics prepared by Siemens energy management experts show hidden savings potential in plants or production facilities.

Energy Analytics takes energy data management to the next level in an easy and cost-effective way. Depending on the selected scope of service, the customer has access to load profiles, analytics and reports based on operations data. The data is acquired either by connecting the Energy Box to existing meter infrastructure or by installing the Energy app. The transmitted data is processed and analyzed and made available on Mindsphere in the form of graphics and analysis charts as well as in reports.

Siemens also provides powerful analytical and reporting capabilities to maximize energy and operational efficiency giving the customer visibility into the long-term performance of facilities and infrastructure. Focus is on monitoring system performance, energy demand and energy supply for single building, a campus, or an entire real estate portfolio more effectively and efficiently.

Fleet Manager for Machine Tools

The Fleet Manager for Machine Tools running on MindSphere monitors machine tools worldwide at small or large production sites and their availability and productivity enhanced. With little effort, users gain transparency over machine utilization and performance, and can thus reduce costs and improve service and maintenance. Furthermore, machine tool builders can start developing new digital services. The app is particularly well-suited for the end customers of small to medium-sized original equipment manufacturers (OEMs). Fleet Manager for Machine Tools interfaces Sinumerik 840D sl controls to MindSphere in a simple and intuitive way - with additional Siemens as well as third-party control systems on the roadmap.

Analytics for rotating equipment

To ensure productivity and availability of production anytime, smooth operation of rotating machines in production environments is the key. An important lever to optimize availability is to establish cloud based condition-based maintenance for e.g. drives, motors, and gear units, leveraging the manufacturer's know-how. A condition-based maintenance plan enables the user to find the best match of maintenance measures and production plans. Early detection of upcoming faults is essential for an optimized condition-based maintenance plan.

Drive Train Analytics running on MindSphere is providing the connectivity, the analytics as well as the visualization to take advantage of latest technology and innovation to maximize the uptime of rotating equipment.

Product Performance Intelligence in a global value chain

Insights from product performance data are used to create actionable intelligence in order to close the loop between product design and actual product performance. Disparate and often inaccessible data is searched, cleaned, unified and drilled down into contextualized big data. This significantly reduces the cost and time spent searching for the source of value chain problems, enabling teams to focus on solutions. Omneo as a MindApp is a cloud based, software-as-a-service (SaaS) solution that delivers the product performance intelligence needed to make impactful decisions across a global value chain. By providing greater visibility into both products and supply chain performance, customers can easily identify and monitor supplier issues, prevent costly recalls, spot emerging trends, solve quality problems faster, and improve your customer's experience.

Product Performance Intelligence will leverage the potential of MindSphere to integrate data from a wide variety of systems to execute analytics and provide an intuitive user interface.

Industrial cyber security Apps

With MindApps for industrial cyber security, companies in can identify threats, security loopholes and anomalies in their production environment.

Industrial control systems become more and more interconnected increasing the risk of cyber or operational incidents in the field. MindSphere will be a central source for security applications, e.g. reports, security alerts, further services in the future.

Closed- loop innovation with complete digital twin

Siemens Software and Digital Services enable digitalization of the entire lifecycle, seamlessly integrating product, production and service processes. MindSphere connects to real-world devices and processes, and feeds performance data back into a performance digital twin to drive improved decision making and intelligence.

The foundation of the software portfolio is Siemens' Digital Enterprise Suite from Siemens PLM Software. The Digital Enterprise Suite is a comprehensive, integrated family of software-based systems that covers all of the requirements of the value chain, from product design, through production planning, engineering and execution to services. The Digital Enterprise Suite is built on Teamcenter, a common collaboration platform and data backbone that integrates product lifecycle management (PLM), manufacturing execution system/manufacturing operations management (MES/MOM), Totally Integrated Automation (TIA), and lifecycle and performance analytics (MindSphere).

The Siemens Digital Enterprise Software suite spans domains with a comprehensive portfolio of solutions for digitalization. Using the Digital Enterprise Suite, companies can create intelligent virtual models (digital twins) that accurately duplicate and simulate the real-world properties and performance of physical products, production lines and processes. Throughout the product lifecycle, the digital twins enable tremendous productivity and efficiency gains, providing companies with the means to design, simulate, validate, and optimize products, processes and plants in the digital world.

Digital Product Twin

In product design. A digital twin includes all design elements of a product, namely:

- 3D models (using CAD systems)
- System models (using system engineering product development solutions, such as systems driven product development)
- Bill of Materials
- 1D, 2D and 3D analysis models (using CAE systems)

- Digital software design and testing (using ALM systems)
- Electronic design

Using these elements results in a comprehensive computerized model of the product – enabling almost 100 percent of virtual validation and testing of the product under design. All of this eliminates the need for prototypes, reduces the amount of time needed for development, improves quality of the final manufactured product and enables faster reiteration in response to customer feedback.

Digital Production Twin

In manufacturing a digital twin enables flexibility to reduce time needed for manufacturing process and system planning and for production facility design, including:

- Manufacturing Process model – the "how" – resulting in an accurate description as to how this product will be produced.
- Production facility model – providing a full digital representation of the production and assembly lines needed to make the product.
- Production facility automation model – describing how the automation system (SCADA, PLC, HMI, etc.) will support the production system.

The value of the digital twin in manufacturing offers a unique opportunity to virtually simulate, validate and optimize the entire production system. It also lets you test how the product with all its primary parts and sub-assemblies will be built using the manufacturing processes, production lines and automation. Within this digital twin, we can also incorporate the logistics aspects. The digital twin of the in-process logistics systems can help planning teams design an effective sideline logistics solution to feed the production lines. Process logistics could be part of the manufacturing process's digital twin and also the physical part of the logistics system.

Digital Performance Twin

Using MindSphere, companies can connect with real-world product, plants, machines and systems to extract and analyze actual performance and utilization data. Data analytics can derive information and insights from the raw data. These insights can then be applied to close the loop with the digital product twin and digital production twin to optimize products, production systems and processes in the next cycle of innovation.

No other IoT provider can drive closed-loop innovation through complete digital twins for products, production, and performance like Siemens.

And as more and more information is collected about performance in the field, Siemens vision for analytics expands as well, as shown in this diagram.

What's next? – Full leverage of the closed-life-cycle data-loop and artificial intelligence

Summary

The Internet of Things (IoT) and Digitalization are already a reality, offering opportunities for product and business model innovation, which could not have been imagined only years ago. Seamless integration of data from billions of intelligent devices to feed software solutions like design and simulation as well as digital services tailored to specific use case, will allow unmatched transparency and opportunities along the entire value chain. Closing the loop to realize the digital twin and leveraging domain specific solutions and services that turn data into value are critical success factors for the future of any business.

In addition, IoT with scalable connectivity and easy to use tools for application building and commercialization, offer vast opportunities to leverage domain specific know-how for building own digital revenue streams.

MindSphere is the cloud-based, open IoT operating system from Siemens that connects real things to the digital world, and provides powerful industry applications and digital services to drive business success. MindSphere's open Platform as a Service (PaaS) enables a rich partner ecosystem to develop and deliver new applications.

This white paper described the capabilities and benefits of MindSphere in four key areas:

- Quickly and easily connecting real things within to the digital world
- Creating a strong partner ecosystem with open platform as a service (PaaS)
- Driving business success with powerful vertical industry applications and digital services
- Enabling unmatched closed-loop innovation with complete digital twins

Benefit from IoT and Digitalization, and try MindSphere for your business environment. Leverage the scalable connectivity to connect your assets and start to collect data within minutes. Realize immediate benefits from transparency and predictive applications seamlessly provided by the rich MindSphere partner ecosystem.

Make Siemens your partner to provide you an unmatched completeness of portfolio from a leading position in electrification, automation and digitalization!

For more information, please register under www.siemens.com/mindsphere

About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of product lifecycle management (PLM) and manufacturing operations management (MOM) software, systems and services with over 15 million licensed seats and more than 140,000 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with its customers to provide industry software solutions that help companies everywhere achieve a sustainable competitive advantage by making real the innovations that matter. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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