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Future Of Manufacturing Efficiency

Surprising benefits of implementing graph technology into manufacturing business

Unlocking the Secrets to Faster and Better Production



"Knowledge has a beginning but no end."

Geeta Iyengar

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In today's competitive market, businesses are always looking for ways to stay ahead of the curve and increase production. One of the most effective tools for achieving this is Graph Tech a powerful technology that can help to unlock the secrets to faster and better production. By leveraging its data driven insights, companies can gain invaluable insight into how their processes are functioning and identify opportunities for improvement.

In this document we'll discuss what exactly Graph Tech is, how it works, and why it's so beneficial in helping organizations optimize their operations. We'll also provide some tips on getting started with Graph Tech so you can start taking advantage of its capabilities right away. Graph technology has emerged as a powerful tool for improving production processes in manufacturing industry. With its ability to combine data in silos process and analyze large amounts of data guickly and efficiently not only in existing system but also from semantic layer it enables organizations to unlock valuable insights and make informed decisions in real time. From supply chain management to predictive maintenance, graph tech is revolutionizing the way companies operate and

drive growth. The possibilities of using Graph Tech to unlock the secrets to faster and better production are immense. With its advanced analytics capabilities, you can quickly uncover patterns that can help you make informed decisions about how best to optimize your operations for maximum efficiency and cost savings.

By leveraging these insights, you can ensure that your organization is able to stay ahead of the curve in terms of productivity and performance. Now it's time for you to take action: start exploring what Graph Tech has to offer, as well as other data driven solutions available today, so that your business remains competitive in an ever evolving market landscape.

Looking at manufacturing, it seems that a data structure based on graph is one realistic solution to create a unified data structure that can manage data of a manufacturing entity in a connected way and creating value out of that never seen before . A graph data structure which connects everything and simulates the real world.



"A new horizon of data driven decisions will be focused on hybrid intelligence which is data fusing with business knowledge"

KNOWLEDGE refers to reasoning, process, rules, business, cognition, objects, events, concepts & so on... Representing knowledge in form of graphical networks consisting of nodes & relationships is GRAPHICAL DATA



Knowledge graphs Empower Datawarehouse / Data lakes

Data warehouses continue to be valuable for providing analytics for a wide range of use case. You may be among the many who are completely rethinking your data warehouse or using different in house technologies to tackle the task with increasing data & existing databases which are not scalable to large extent. In manufacturing entities, there are multiple data silos corresponding to the line of business or the functional areas. Though this data in multiple and distributed systems is a very important asset for the manufacturing entity, its value is sometimes limited to line of business of functional area it corresponds to.

If by any means, such strategic data sources can be combined to create a larger connected structure, its value for the company would grow leaps and bounds. Distributed data in silos is bad and needs to be integrated to create a knowledge hub for the company so that it can move to next level transformation and growth. Looking to at manufacturing, it seems that a data structure based on graph is one realistic solution to create a unified data structure that can manage data of a manufacturing entity in a connected way and creating value out of that never seen before. A graph data structure which connects everything and simulates the real world. Here is a solution, Graph tech are schema free & will work with structured & unstructured data. They enable complex analytics against the data and, can operate in real time. Graph databases, to be used in conjunction with traditional data warehouses. This in turn reinforces

the whole concept of the logical data warehouse which, in turn, means consideration of what you need to support a distributed, heterogeneous warehousing environment required by any time for users.

Graph data helps in simplifying Metadata & Master data, usually data team have less time to manage schema for incoming data from multiple sources. Handling Schemas & potential changes are time consuming challenges; however, NoSQL databases are popular for their ease of use due to flexible schemas. Graph databases can power up data warehouses & data lakes simplifying meta data management, by configuring all your data with unlimited scalability & limit your need to set up complicated ETL & data transformation. A key component of master data management (MDM) is to supply meaningful views of disparate data. The fact/property underpinnings of graph databases are designed to optimize those views. You can easily model both hierarchical and nonhierarchical master data in a graph, making it easier than an RDBMS for visualizing data relationships.



Below is a simple representation of Graph database in Manufacturing





One of the most valuable and fundamental uses of Knowledge Graphs is to express relationships between data. Knowledge Graphs visualize the nature of underlying relationship and how they are interconnected to gain sufficient understanding of the landscape to improve intelligent strategic business decisions.

On a high level, Knowledge Graphs helps banking industry with following benefits:

- 1. Combined Siloed data.
- 2. Combine structured & unstructured data.
- 3. Help businesses & operations make more informed decisions.
- 4. Summarize relationships.
- 5. Insights from Hierarchical data.
- 6. Revealing Communities.
- 7. Visualizing a flow of information.
- 8. Network data.

Data is increasing! The problem with existing traditional databases are not scalable upto large scale which in fact organizations need to have huge infrastructures again which will be built on pipelines. Where knowledge graphs can make difference in data use cases listed few below,

- Knowledge graphs helps facilitate end to end analytics enabling max utilization of AI & ML.
- Prevent missing relationships enabling users to answer questions which were not solved from long time.
- Semantic Graphs helps to capture & connect data outside operational use case.
- Graph databases connect in a multi-direction with all users from producers to consumers.
- Less expenditure on data infrastructures.
- Overcome end user discovery challenges within seconds.
- · Clear ownership of core concepts.
- Less involvement of data team to fix the mess
- Come out of Technical debt easily with long term solution.
- One time investment on increasing query complexity.
- Actual real time solutions for all your data needs.
- No investment on multiple products to build solutions.





Some Illustrations of Knowledge graphs for manufacturing







Use Cases for Manufacturing Industry

Use case 1:

Manufacturing Process Optimization (Complete transparency & visibility on process)

If we talk to any process expert in manufacturing industry, we see transparency as a major challenge & one of major prerequisites for process optimization. Transparency not only increases visibility, but it also forms the basis on which all key decisions are taken. In a simple language it translates to, the more information available about manufacturing processes, the more accurate decisions can be made and the easier it becomes to optimize the manufacturing process.

Each machine or a devices generates large amount of data which if integrated to the graph model describing each physical component and device in one knowledge graph, allows a very user friendly and complete process monitoring. It will also help in understanding which processes to optimize, increasing yield and reducing defects in production Graph technology is a data representation method that can be used to optimize the manufacturing process. By using graph technology, manufacturers can model the complex relationships between various aspects of the manufacturing process, such as materials, equipment, and production steps. Manufacturing process optimization is a crucial aspect of the manufacturing industry as it helps to improve efficiency, reduce costs, and increase product quality.

Knowledge graphs can play a significant role in optimizing the manufacturing process by providing a structured and visual representation of the knowledge and relationships between various aspects of the process.

In other hand, RDF, or Resource Description Framework, is a standard for modeling data as a graph, making it well suited for use in manufacturing process optimization. By using RDF, manufacturers can represent their data in a way that is flexible, extensible, and can be easily integrated with other data source even from semantic layer easily.



Business benefits:

- <u>Data Integration</u>: Graph technology can provide a centralized repository for the integration of data from different sources, including manufacturing systems, production databases, and sensor data. This integration of data can provide a holistic view of the manufacturing process, helping to identify areas of inefficiency and improvement.
- Transparent Data Availability: The knowledge graph tells you exactly, where this data is stored and how it might relate (version, redundant set, constraining, etc.) to other data. This saves companies a huge number of complex networked interfaces and data processing time. Knowledge graph platforms are different to typical Master Data Management systems, warehouse infrastructures and ERP systems. They neither create another silo within the already complex IT infrastructure, nor do they require a complex rebuild of the IT architecture.
- <u>Process Modeling:</u> Graph technology can be used to model the manufacturing process, including the relationships between different steps, materials, and equipment. This modeling

can help to identify potential bottlenecks and opportunities for improvement.

- Enabling Decision Making: Graph technology can be used to support decision making in the manufacturing process by providing a visual representation of relevant information, including equipment performance, production data, and supply chain information.
- <u>Collaboration</u>: Graph technology can support collaboration between different departments and teams by providing a shared source of information and enabling real time updates and communication.
- Improved Data Analysis: Graph technology allows more efficient and accurate data analysis. With graph technology, researchers can more easily identify patterns, connections and insights in the data, which can help them make better decisions. The data available for a data subject in a company can be displayed any point, searched, and analyzed on a holistic data map which is independent of and across all applications. This also means that the data can be centrally searched in specific applications.

Knowledge graphs are a possible solution to obtain and communicate domain knowledge among distributed I4.0 partners. Knowledge Graph (KG) is a structured semantic knowledge base that describes the concepts and relationships in the physical world. With the help of a KG, you can integrate "knowledge" with different equipment information and obtain the required information from the manufacturing equipment and its attributes.

Using Knowledge Graphs in manufacturing process optimization & control



Use case 2: Predictive Maintenance

A Predictive maintenance is a proactive approach to maintenance that uses data and analytics to predict when equipment is likely to fail, so that maintenance can be performed before a failure occurs. Knowledge graphs can play an important role in predictive maintenance by providing a structured way to store and represent complex, interrelated data about equipment, maintenance history, and operating conditions. With knowledge graphs, data from various sources such as sensors, equipment logs, and maintenance records can be integrated and linked together to form a comprehensive understanding of the equipment and its behavior.

This data can then be used to build predictive models that can identify patterns and trends that indicate an increased risk of failure. For example, a knowledge graph could link together information about operating temperature, vibration levels, and maintenance history to predict when a particular component is likely to fail In addition to helping predict failures, knowledge graphs can also support decision making by providing a clear and concise representation of the information needed to make informed decisions about maintenance.

For example, a knowledge graph could be used to show the impact of different maintenance strategies on equipment reliability, cost, and safety In summary, knowledge graphs can provide a powerful tool for predictive maintenance by enabling the integration, analysis, and visualization of complex and interrelated data. By using knowledge graphs, organizations can improve the efficiency and effectiveness of their maintenance processes and reduce the risk of equipment failure. A knowledge graph can be used as a digital twin of a machine or even of an entire production facility. Using a graph, organizations can model each component of a machine, its parameters, relationships to other components, even alternative parts that could replace it. Each piece becomes a node in the graph with a semantically defined relationship to the others. Running an analysis of this digital model allows companies to identify what could go wrong and proactively intervene.

Business benefits:

- <u>Improved Equipment Reliability</u>: By using graph technology to analyze large amounts of data and predict when equipment is likely to fail, organizations can reduce the risk of equipment failure and improve the reliability of their equipment. This can result in lower costs and higher productivity, as well as improved customer satisfaction.
- Lower Maintenance Cost: Predictive maintenance enables organizations to perform maintenance only when it is necessary, rather than on a set schedule. This can reduce the overall cost of maintenance and improve the efficiency of the maintenance process.

- <u>Increase Equipment Utilization</u>: By reducing the risk of equipment failure, organizations can increase the utilization of their equipment, leading to higher productivity and increased revenue.
- Enabling Mccurate Decision Making: Graph technology provides a clear and concise representation of complex and interrelated data, making it easier for decision makers to understand and use the information they need to make informed decisions about maintenance.
- <u>Increased Operational Efficiency</u>: Predictive maintenance enables organizations to perform maintenance in a more proactive and efficient manner, reducing the need for reactive maintenance and improving overall operational efficiency.
- <u>Better Data Management:</u> Graph technology provides a structured way to store and represent large amounts of data, making it easier for organizations to manage and analyze data from various sources. This can lead to improved data quality and reduced data management costs.



Representation of Predictive maintenance using Knowledge Graphs



A data digital twin with knowledge graphs is a virtual representation of a real world system or process, in which the data and relationships between data entities are modeled using a knowledge graph. This allows for a comprehensive and interconnected view of the system or process and can provide valuable insights into its behavior and performance In manufacturing, a data digital twin with knowledge graphs can be used to represent the design, production, and quality control processes of a product. The knowledge graph can be used to model the relationships between various components of the product, such as design specifications, production processes, and quality control measures.

By using a knowledge graph to represent the digital twin, manufacturers can leverage AI and machine learning algorithms to analyze the data and identify patterns and relationships that may not be immediately obvious. This can provide valuable insights into the product and help improve efficiency, reduce waste, and enhance quality. A data digital twin with knowledge graphs can also be easily updated as new data and information becomes available, allowing manufacturers to stay up to date on the latest developments and improve their processes over time. In industry a data digital twin with knowledge graphs can provide manufacturers with a powerful tool for optimizing their operations, improving product quality, and increasing efficiency by providing an abstraction layer for data. Since data are heterogeneous, up to 80% of the data scientist's time is spent on retrieving data, rather than on their core tasks. Our approach provides a single interface to access all data in a uniform way;• formal modeling of data, information and knowledge in a knowledge graph. Data, information & knowledge is modeled according to the problem domain, rather than the technical solution or representation of data.

Exploration and querying tools allow data scientists to acquire data, information & knowledge about domain concepts such as part, machine, operation, etc., and allow common understanding of the domain between data engineers, production engineers and date scientists;• reasoning about knowledge. As knowledge is made explicit and is formalized in a knowledge graph, this opens up possibilities of (automated) reasoning to generate new knowledge. While there are several possibilities (e.g., ontological reasoning, translation to Bayesian networks, etc.).

Business benefits:

- Improved Product Design: A digital twin created using a knowledge graph can provide a comprehensive and interconnected view of the product, allowing manufacturers to simulate its behavior and performance under different conditions. This can help improve product design and reduce the need for physical prototypes.
- <u>Enhanced Process Optimization</u>: By using a digital twin, manufacturers can identify bottlenecks and inefficiencies in the production process and make data driven decisions to optimize their operations.
- <u>Increased Efficiency:</u> A digital twin can help manufacturers automate and streamline processes, reducing waste and increasing efficiency.
- <u>Better Customer Experience</u>: By using a digital twin, manufacturers can provide customers with real time information about their products, including its current state and performance. This can enhance the customer experience and build customer loyalty.
- <u>Competitive Advantage</u>: The use of digital twins and knowledge graphs can provide manufacturers with a competitive advantage by allowing them to quickly and effectively respond to changes in the market, reduce costs, and improve product quality.

- Interoperability: RDF helps to standardized format for representing data, which allows for seamless integration of data from different sources and enables the creation of linked data across systems. This makes it easier to create a comprehensive digital twin that integrates data from different parts of the organization.
- <u>Scalability</u>: RDF allows for easy scalability of the digital twin, as new data and relationships can be easily added without disrupting existing data.
- <u>Reusability</u>: The use of RDF enables the creation of reusable and interchangeable data components that can be used in different digital twins and applications. This can help reduce the time and resources required to create digital twins for different products and processes.
- <u>Improved Data Management</u>: RDF enables the creation of a clear and organized structure for data, which makes it easier to manage and maintain the digital twin over time.
- <u>Enhanced Analytics</u>: The use of RDF enables the creation of complex relationships between data entities, which can provide valuable insights into the product and production processes. This can help manufacturers make data driven decisions to improve efficiency and reduce waste.







Supply chain visibility refers to the ability to track the movement of goods and materials through the supply chain, from the manufacturer to the end consumer. Knowledge graphs can be used to support this process by storing and analyzing large sets of data on the movement of goods, suppliers, and the relationships between them.

In supply chain visibility, knowledge graphs can be used to represent the complex relationships between products, suppliers, transportation, and other related Graph databases can also be used to store and analyze large sets of data from the supply chain, such as inventory levels, shipping information, and production data. This can help companies understand the flow of goods through the supply chain, identify bottlenecks, and make decisions about where to invest in improvements. Graph databases can be used to integrate data from various sources such as sensor data, electronic records, and external databases. Knowledge graphs can be used to support the implementation of SCOR by storing huge multi dimensional data Using knowledge graphs in SCOR can help companies more effectively analyze and understand complex data sets, identify potential issues in the supply chain, and make more informed decisions about supply chain operations. This can help to improve supply chain efficiency and support compliance with regulatory requirements.



Supply Chain Structure

Business benefits:

- <u>Improved supply chain visibility</u>: Knowledge graphs can help companies gain a better understanding of the flow of goods through the supply chain and identify bottlenecks or other issues that may be impacting performance.
- <u>Increased efficiency</u>: Knowledge graphs can help companies optimize the supply chain by identifying areas where performance can be improved. This can lead to reduced lead times, lower inventory levels, and improved delivery performance.
- <u>Better decision making</u>: Knowledge graphs can help companies make more informed decisions about supply chain operations by providing a more complete view of the supply chain and allowing them to identify patterns and connections that may not be immediately apparent.
- <u>Reduced costs:</u> Knowledge graphs can help companies identify opportunities for cost savings, such as by reducing inventory levels or streamlining logistics operations.

- <u>Better compliance</u>: Knowledge graphs can help companies stay on top of regulatory requirements and ensure that supply chain operations are conducted in compliance with relevant guidelines.
- <u>Better risk management</u>: Knowledge graphs can help companies identify potential risks in the supply chain, such as by identifying suppliers who may be at risk of disruption.
- <u>Improved collaboration</u>: Knowledge graphs can help to improve collaboration between different entities in the supply chain, such as suppliers and logistics providers, by providing a common platform to share and access information.
- <u>Unambiguously</u>: identify the parties, transactions, markets and instruments involved in the activity along with visual information consumption and investigative interfaces, replicating and enhancing the workflow.



Smart Supply Chain with a Centrailzed View

Supply Chain graph data overview



Supply Chain data captures from multi sources





As more and more devices are connected to the internet of things (IoT), the volume of data generated by these devices is increasing rapidly. This presents a significant challenge for businesses looking to collect, process, and analyze this data in a timely and efficient manner. One solution to this challenge is to use knowledge graphs to reduce the time and network load of device data transmission to the cloud. Knowledge graphs can be used to preprocess data, compress data, and provide contextual analysis, among other things, allowing businesses to reduce the amount of data that needs to be transmitted to the cloud, while improving system performance, data quality, and decision making.

In this way, knowledge graphs are becoming an essential tool for businesses looking to make the most of the vast amounts of data generated by IoT devices. In manufacturing, Knowledge graphs are currently used to preprocess the data before it is sent to the cloud. This can involve filtering, cleaning, and transforming the data so that only the most relevant and important information is sent to the cloud. This reduces the amount of data that needs to be transmitted, which in turn reduces the time and network load. Another use is to compress the data that is sent to the cloud. This can involve grouping similar data together and representing it in a more compact form. This reduces the amount of data that needs to be transmitted to cloud. Intelligently route data to the cloud based on its content and importance.

For example, data that is time sensitive or critical can be given priority and sent directly to the cloud, while less important data can be stored locally or sent at a later time. This reduces the time and network load by minimizing the amount of data that needs to be transmitted and ensuring that only the most important data is sent to the cloud. In current scenarios Knowledge graphs are most used solution to provide contextual analysis of the device data. This involves understanding the relationships between different pieces of data and using this understanding to extract insights and identify patterns. By doing this, the amount of data that needs to be transmitted can be reduced, as only the most important insights and patterns need to be sent to the cloud.

Business benefits:

- <u>Cost Savings</u>: By reducing the amount of data that needs to be transmitted to the cloud, businesses can save on data transmission costs. This is especially important in IoT systems where large amounts of data are generated and transmitted from multiple devices.
- <u>Improved System Performance</u>: By reducing the time and network load of device data transmission to the cloud, businesses can improve the performance of their IoT systems. This can lead to faster data processing and analysis, more efficient resource utilization, and quicker response times.
- <u>Better Data Quality</u>: Knowledge graphs can be used to preprocess data and filter out noise and irrelevant information. This can lead to better data quality and more accurate insights and decision making.
- <u>Enhanced Security</u>: By reducing the amount of data that needs to be transmitted to the cloud, businesses can improve the security of their IoT systems. This is because less data is

transmitted over potentially insecure networks, reducing the risk of data breaches and cyber attacks.

- <u>Improved Decision Making:</u> Knowledge graphs can provide contextual analysis of device data, allowing businesses to extract insights and identify patterns. This can help businesses make better decisions, optimize their operations, and improve their bottom line.
- <u>Single Unified Platform</u>: Connection to presentation to decision, yes connected data from internal & external data & integrate within the system, without storing data in platform. Real time updates & visualization on your data. These platforms are enablers for AI & ML which include missing data. Values & parameters for decision.



Knowledge graphs in real world scenario in IT infrastructure



Smart manufacturing is a manufacturing approach that involves leveraging advanced technologies to optimize and streamline the manufacturing process. Main key technologies which are increasingly being used in smart manufacturing are Knowledge Graphs the Resource Description Framework (RDF). Knowledge graphs are being used to represent and manage the vast amounts of data generated in the manufacturing process, from product designs and production plans to quality control data and maintenance records.

By using knowledge graphs to represent this data in a structured and connected way, businesses can gain insights into the manufacturing process that were previously impossible to obtain. In other hand, RDF is a standard for modeling and exchanging data on the web. It is being used in smart manufacturing to represent and manage manufacturing data in a structured and interconnected way. By using RDF, manufacturers can create a semantic web of linked data that provides a rich and flexible representation of the manufacturing process. It is most likely that the maturing of technologies will pave the way for new disruptive scenarios to form, gain acceptance and rule out current scenarios. In order to realize the shift from traditional to smart industry, most experts agree that collaboration is key: the era of proprietary solutions is over and replaced by the new era of human knowledge plus data driven. It is important to agree on these underlying principles which are ENABLERS & ENHANCERS.

Enablers have come about from recent rapid developments; which are cheap, fast, and ubiquitous. They are now mature enough for industry to leverage. Enhancers are vital in order to enhance the development from traditional manufacturing to smart manufacturing. Which draw more ROI in short & long term as per use case which are solved. As per many standards & expertise if enhancers are leveraged in a clever way, the effects will be realized. Currently, a lot of work is ongoing, at a national and international level, as well as on a company and organizational level. The aim is to find out the additional principles that are urgently needed in order to make the shift from traditional to smart industry;

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ENHANCERS for Smart Manufacuring



Positive effects of Graph technology in Smart manufacturing



ROI with Knowledge Graphs





Increased productivity of 70% with data team & 60% with business team.



20x faster & Better Decision making.



Accelerate innovation 10x faster.



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