A Multi-Method Grid for Supply Chain Planning and Analysis

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A Multi-Method Grid for Supply Chain Planning and Analysis

Presented at:
“Digital Twinning The Supply Chain” Workshop
17 July 2019 Jakarta, Republic of Indonesia
INTRODUCTION
Introduction

This white paper addresses the complexity inherent in any supply chain that makes it difficult to experiment with probable design challenges piecemeal. A balance is required in orchestrating transformation for responsiveness and efficiency.

A granular virtuous approach, appropriate to the challenges posed in migrating from an as-is to a to-be model is presented where the coarseness of data utilized or gathered is commensurate with the problem statement under study.

A smart multi-method supply chain “cloud” is presented for networked supply chain planning and analysis. The latter aims to create a data-driven supply chain where information is shared across the entire supply chain connecting the various supply chain actors to provide end-to-end supply chain agility. With such a platform, firms can easily develop strategic collaboration with other supply chain partners and conduct business activities more transparently on merged but secure data sets.

The physical supply chain is not easily tweaked. Authors have variously coined the term digital twinning where the essential characteristics of the supply chain are captured in a digital model. However, such a digital twin varies with modelling method, albeit visualization, analytical, optimization or simulation. The twin itself may vary in complexity and data requirements. It is our belief that one can orchestrate to and fro with tools best suited to the task but have a progressively finer matched data set that can be utilized on multi modelling methods - a supply chain meta twin of twins!

Thus, in this information intensive world, the focus has been to progressively turn simple data into worthy out of the box visual intelligence and use that in a smart way to streamline and integrate supply chains that will save time and costs for each participant company as well as its customers.

This whitepaper is adapted from “Urban Grid Logistics – Adaptive Orchestration of Resources Leveraging Smart Technologies” report (Vol 19-Apr-TE)
Logistics is changing rapidly. Today’s logistics industry is truly not comparable to the industry 20 years back in time. Looking 20 years in the future, we can expect even more far-reaching disruptions. In the wake of digitalisation, supply chains become more complex, and claims for agility, responsiveness, and flexibility rise continuously.

As the omni-channel business grows, mix and delivery volumes increase continuously. Simultaneously, countries have to face ever-increasing urban challenges, such as population density, congestion, environmental pollution, and lower logistics asset utilisation rates. Consumer behaviour adapts to digital, mobile technologies and pressure for increasing speed as well as more flexible deliveries at ever lower costs. Demographics, and urbanisation density further fuel these urban challenges.

Therefore, in the realm of increasing connectivity and data availability, today’s logistics ecosystem is now gradually shifting towards omni-channel commerce, characterised by fragmented and highly variable demand, and a higher delivery diversity.
In order to stay on top of these developments and to maintain a competitive edge in international (and urban) logistics, supply chains need to leverage the opportunities of digitalisation. Alarming investigations reveal that more than 70% of all trucks are less than 40% full, delivery routes are substantially longer than necessary, firms frequently struggle with supply chain transparency (e.g., knowing their value chain partners) and traceability of products and disruptions are handled on a less responsive and non-agile react-on-incident basis. In addressing these challenges, digital twinning technologies could help to achieve operational efficiency, eventually leading to supply chain transparency, industry collaboration in order to increase asset utilisation, and flexibility.
SHARING FOR RESPONSIVENESS AND EFFICIENCY

Chapter 1
Digital transformation requires companies to rethink not only their current business models but also their whole business operation and corporate culture, including their supply chains.

Traditional and singular supply chains with linear and long chains before reaching the customers may not be sufficient. A shift to a more connected shared and consolidated load supply chain, via digital interconnected devices and complex webs, is necessary.

Asset Utilization Through Sharing and Consolidation

1) Singapore URA Urban Logistics Exhibition, 4th December 2018
URBAN GRID ORCHESTRATION PLATFORM

Chapter 2
Leveraging 3D geospatial data as well as company-specific shared data, this project aims to implement a superior shared logistics platform (cloud), the first of its kind to provide a full suite of capabilities to support supply chain distribution network design, day-to-day delivery fulfilment operations, and the efficient allocation of resources to help our partners in tackling complexities of the digital supply chain and addressing their problem statements.

The platform will use intelligent engines to analyse, visualise, and optimise the supply chain recommending solutions from an as-is state to a to-be supply chain.
Iterative Orchestration

The platform architecture is aligned with the typical iterative optimisation process including the solution’s implementation. Initially, the current status quo (As-Is) has to be recorded, analysed and visualised. Secondly, optimisation tools and algorithms can find an optimal (To-Be Ideal) solution for the identified problem.

However, in the real world, defined by huge amounts of constraints, and exceptions, an ideal model solution will most likely not be ready for implementation. Thus, thirdly, a realistic and implementable solution (To-Be Real) has to be derived from the ideal model solution. Finally, as conditions change dynamically on a rolling basis, the to-be real solution becomes the new as-is status, closing and restarting the iterative optimisation loop. This process loop, which is accessible through the platform visualisation UI, mathematically builds on a broad set of intelligent platform engines (i.e., algorithms and concepts).
Every supply chain is unique and comes with its own idiosyncrasies. The data visualisation layer which comprises of As-Is and To-Be allows users to capture the features and make adjustments to represent the changing traits of the supply chain network. System constraints, rules, and risks can be pre-set and used to generate accurate visualisation of the actual and simulated environments. Supply chain specific engines (e.g., Greenfield analysis, fleet optimisation, vehicle routing) support relevant logistics decision making.

The platform itself is fed by two main data sources, namely 3D geospatial data and company sharing data. Further data sources (e.g., commercial reports or news and web data) could optionally be included.
Orchestrated Collaborative Supply Chain Planning
@ Macro (Regional), Meso (Country / Industry) or Micro (Company) Levels
TURNING VISIBILITY INTO VALUE IN MODERN SUPPLY CHAINS

Chapter 3
Supply Chain Visibility is a Real Challenge, and a Need!

**RISING COMPLEXITY OF SCM**
Many stakeholders involved on a global scale, unknown second and multi-tier suppliers, multiple interconnected supply networks, numerous transportation modes.

**MEETING CUSTOMER DEMAND**
Customers have greater choice of products, higher demand, risen expectations on deliveries.

**KEEP UP WITH DEMOGRAPHIC CHANGES**
Generational change, Increasing last mile complexity, booming of e-commerce is challenging urban distribution: 70% of trucks are 40% full.

**FROM HOLISTIC TO A GRANULAR VIEW**
Visualize and understand supply chains with a high level of detail including visibility over bottlenecks, Vulnerable nodes, and demand clusters.
Achieve Resilience, Cost-effectiveness, Time-Responsiveness, and Agility through Visualization!

Schematic representation of supply chain network

Supply networks are traditionally represented as a series of nodes (warehouses) and arcs (logistics facilities such as roads etc.). These schemes are useful to convey information related with material flows.

Visualizing supply chain network using Geospatial Analytics

Supply networks can be visualized on geographic maps using GIS coordinated. This alternative view provides deep insights on the network such as vulnerable nodes, distances, road distances, demand density, material flows, presence of clusters, network structure, opportunities for improvements (e.g. consolidation of storage assets) and more.

Objectives

- **Visualize**
  Multi-tiered view of suppliers and critical supply nodes, products, assess of disruptions.

- **Identify**
  Bottlenecks, critical locations, vulnerable nodes and arc, and demand clusters.

- **Connect**
  Understand flows, and gain deep insights into demand and supply.

- **Understand**
  Visualize supply chains on a high level as well as on a granular level.
How distant are your distribution centers from strategic infrastructures such as ports and airports?

What is the Geographic Distribution of your Demand?

Are your distribution centers located in disaster prone areas?

What are the ideal locations for your distribution centers?

How many customers are you able to serve within specific timeframes?

Can you cluster up your demand points based on geo-information and volumes?
Visualizing the Supply Chain for Fast Problem Solving

The modelling approach starts from the current status quo (As-Is), which has to be analysed and visualised. Secondly, algorithms are used to identify the ideal solution (To-Be Ideal) for the problem at hand. Finally real-life constrains are embedded in the model to identify the actual implementable solution (To-Be Real).

Modelling is a time-consuming exercise, which requires extensive datasets along with an in-depth understanding of the various supply chain processes.

Visualization provides quick insights on As-is and To-be Ideal. It helps to identify bottlenecks, criticalities, vulnerabilities, and opportunities for improvement, and visualizes the problem statements in a user-friendly interface.
Supply Chain Visualization

Intelligent Engine

Planning Layer

Supply Chain Mapping
- Current Supply Chain Mapping
- Geographic Data Analysis
- Interactive Location Mapping
- Demand/Supply Geographical Mapping

Supply Chain Simulation and Analytics
- Demand/Supply Planning
- Unified Asset Management
- Greenfield Analytics
- Collaborative Logistics Planning

Network Optimization
- Brownfield Analysis
- Supply Chain Risk Assessment
- Predictive Analysis - Machine Learning
  
  Sequential planning activities

Current Supply Chain Mapping

Geographic Data Analysis

Interactive Location Mapping

Demand/Supply Geographical Mapping
Supply Chain Visibility: Current Supply Chain Mapping

The modelling approach starts from the mapping of the current status quo (As-Is). A good understanding of the status quo is a key requirement considering that any bottlenecks, criticalities, vulnerabilities, and opportunities for improvement has to be identified at this initial stage.

The advantage of geospatial mapping is that it gives data a different view, it moves away from spreadsheets, and shows data patterns through a user-friendly user interface. Supply chain managers can identify critical patters, visualize issues in their supply chains, and make prompt decisions accordingly.

High-level KPIs

In a context of increasing customer expectations, logistics providers need to equip themselves with supply network that are able to deliver high service levels. Locations of nodes and distances between demand point and distribution centres are crucial elements for network responsiveness.

Demand Distribution

Demand points carry different weights. A visualization of demand patterns, on the time dimension, enables to identify shortages & criticalities along the supply chain.
Supply Chain Visibility: Geographic Data Analysis

Data can be analysed from a geographic perspective. Geospatial analysis leverage on wide-array of techniques, which can be extensively applied to address various supply chain problems. Geospatial solutions add a new dimension to the problem-solving, speeds up the process, and provides new insights.

**Demand Density**

Various demand points absorb different volumes. A geo-visualization of data patterns helps the identification of most critical zones.

**Clustering**

Demand points. A visualization of demand patterns, on time, enables to identify shortages & criticalities along the supply chain.
Supply Chain Visibility: Interactive Location Mapping

Users can interact with the geospatial mapping tool. Besides inputting the data, the various network nodes can be dragged into new locations, new data can be inputted, ad-hoc spatial analysis of selected data subsets can be performed such as determination of localised centre-of-gravities, drive time isochrones and more.

Centre of Gravity
Based on demand distribution, techniques such as Centre-of-gravity can be applied to determine a central locations in a geographic area.

Selection of a sub-set of data
Geographic Data Analysis can be performed on the entire data-set, or on a selected sub-set of data.

Drive time isochrones
It is possible to determine drive time isochrones from every distribution centres based on road distances. If actual trip duration (e.g. in consideration of traffic) are available, those information can be embedded in the algorithm.
Supply Chain Visibility: Demand/Supply Geographical Mapping

Nowadays, supply chains are becoming extremely complex with many stakeholders, located across multiple geographies involved. As a result, supply chain managers are usually not aware of second and multi-tier suppliers, which puts company’s operations at stake.

Geospatial mapping allows to map in a single user interface all factories, suppliers, distribution centres, and demand points involved in the supply chain, thus providing full-visibility end-to-end.

Demand and Supply Mapping

Various stakeholders and interconnected supply networks can be visualized – and opportunities for synergies can be identified.
Delving into Supply Chain Visualization using a Case Study

Chapter 3.1
Problem:
How to select locations of distribution centres?

Benefits:
Reduce Cost     Improve Service Level

Traditional Research Approaches:
MCDM, Network Optimization, Dynamic Simulation, Green/Brown field Analysis
Good methods, typically leveraging upon large datasets.

What are the ideal locations for Distribution Centres?

Data Requirements

Centre of Gravity
The Centre-of-Gravity determines a central location in a geographic area based on:
• Distances (road distances)
• Weights (demand)

Outcomes

Outcomes

As-is
To-be (Ideal)
To-be (real)
How many customers are you able to serve within specific timeframes?

**Problem:**
Supply Chain Performance, high-level KPIs

**Benefits:**
*Improve Service Level*

**Traditional Research Approaches:**
Dynamic Simulation

Good methods, typically leveraging upon large datasets. Time consuming.

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### Data Requirements

<table>
<thead>
<tr>
<th>Public Data</th>
<th>Company Sharing Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>Infrastructure &amp; Network</td>
</tr>
<tr>
<td>Locations</td>
<td>Customers</td>
</tr>
<tr>
<td>Roads</td>
<td>Demand</td>
</tr>
<tr>
<td>Road courses</td>
<td>Volume</td>
</tr>
<tr>
<td>Ports</td>
<td>Locations</td>
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<tr>
<td>Locations</td>
<td>Locations</td>
</tr>
<tr>
<td>Air</td>
<td>Locations</td>
</tr>
<tr>
<td>Dock locations</td>
<td>Locations</td>
</tr>
<tr>
<td>Suppliers</td>
<td>Locations</td>
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<tr>
<td>Locations</td>
<td>Locations</td>
</tr>
<tr>
<td>Wholesalers</td>
<td>Locations</td>
</tr>
<tr>
<td>Retailers</td>
<td>Locations</td>
</tr>
</tbody>
</table>

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### KPIs based on Isochrone maps

Through drive time isochrone maps, it is possible to determine demand density within the various zones and thus high-level KPIs.

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**Outcomes**

<table>
<thead>
<tr>
<th>As-is</th>
<th>To-be (ideal)</th>
<th>To-be (real)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding of existing infrastructure, operations, and regulations</td>
<td></td>
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</tr>
</tbody>
</table>
Can you cluster up your demand points based on geo-information and volumes?

Problem: Demand Clustering

Benefits:
- Improve Service Level

Traditional Research Approaches:
- Dynamic Simulation
  Good methods, typically leveraging upon large datasets. Time consuming.

Data Requirements

Outcomes

Demand points are not all the same. Some of them are more crucial and thus require higher attention. Clustering enables the definition of effective customer-centric strategies.
What is the Geographic Distribution of your Demand?

**Problem:**
How’s the demand geographically distributed?

**Benefits**
- Improve Service Level

**Traditional Research Approaches:**
- Dynamic Simulation
  Good methods, typically leveraging upon large datasets. Time consuming.

**Data Requirements**
- Public Data: Infrastructure, Locations, Customers
- Company Sharing Data: Infrastructure & Network, Demand, Locations, Suppliers, Wholesalers, Retailers

**Outcomes**
Demand points carry different weights in terms of volumes. An understanding of demand patterns, on the time dimension, enables an accurate planning of logistics capacities.
Are your distribution centres located in disaster prone areas?

Problem:
How likely will your supply chain be disrupted by a natural disaster? What are the viable mitigation strategies?

Benefits:
- Reduce Cost
- Improve Service Level

Traditional Research Approaches:
- MCDM, Network Optimization
  Good methods, typically leveraging upon large datasets. Time consuming.

Data Requirements
- Public Data
  - Infrastructure
  - Locations
  - Facilities
  - Parking
  - Airports
  - Ports
- Company Sharing Data
  - Infrastructure & Network
  - Customers

Outcomes:
Location of facilities matters. Knowing where natural disasters might occur, enables companies to identify the most appropriate locations for their storage facilities and minimise risks of disruptions.
How distant are your distribution centres from strategic infrastructures such as ports and airports?

**Problem:**
How your network positioned against your demand points?

**Benefits:**
- **Reduce Cost**
- **Improve Service Level**

**Traditional Research Approaches:**
Dynamic Simulation

Good methods, typically leveraging upon large datasets. Time consuming.

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**Strategic Infrastructures**

**Data Requirements**

<table>
<thead>
<tr>
<th>Public Data</th>
<th>Company Sharing Data</th>
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</thead>
<tbody>
<tr>
<td>Infrastructure</td>
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<tr>
<td>Roads</td>
<td>Facility</td>
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<tr>
<td>Sea</td>
<td>Parking</td>
</tr>
<tr>
<td>Port locations</td>
<td>Parking/location</td>
</tr>
<tr>
<td>Air</td>
<td>Transshipment Areas</td>
</tr>
<tr>
<td>Airport locations</td>
<td>Locations</td>
</tr>
<tr>
<td>Dock locations</td>
<td>Wholesalers</td>
</tr>
<tr>
<td>Docks, Gates</td>
<td>Locators</td>
</tr>
<tr>
<td>Customers</td>
<td>Retailers</td>
</tr>
</tbody>
</table>

**Outcomes**

Strategic infrastructure such as ports and airports enable supply chains to function. A high-level assessment of distances between such infrastructures and supply chain nodes...
ORCHESTRATED NETWORK SIMULATION AND OPTIMIZATION

Chapter 4
Analytical Optimization and Dynamic Simulation
Supply Chain Modelling to Solve Complex Supply Chain Problems

Analytical optimisation is probably the most common technique for improving supply chains. Most of the analytical optimisation tools work the following way: a manager visually describes their supply chain as a graph and parameterize it with a set of tables; after that, the manager describes the constraints, populates the model with data, and then pushes “solve” to find the optimal, or suboptimal, solution to the problem. Problems that can be solved using analytical optimisation: Supply chain design - where to locate facilities, what their throughput should be, how to arrange product flows and transportation - what size fleet is required.

A dynamic simulation model is a description of a system and the rules by which it operates – business process logic, and the interdependencies between system components. A simulation model is dynamic because it is executable – you can run the model and see how the system behaves over time, just like in a computer game. Dynamic simulation is especially useful when the operational logic and processes inside the supply chain significantly influence financial efficiency and, as a consequence, need to be accounted for during the supply chain design stage.

Simulation helps describe the system with all the details and complexity. Time-dependent, random, and interacting effects within the system can cause such complexity, with examples being demand fluctuations, lead-time variability, or multi-echelon inventory policies. These traits cannot be taken into account with an analytical model.

This is a summary adaptation of Chapter 3 in “Orchestrated Planning” from the “Urban Grid Logistics – Adaptive Orchestration of Resources Leveraging Smart Technologies” whitepaper (Vol 19-Apr-TE).
Typical Challenges Addressable using Analytical Optimization and Dynamic Simulation

How to improve internal processes at DC or factory level, and how does it influence operations across the whole supply chain?

Where to locate facilities, how many, what their throughput should be, how to arrange product flows?

Where to produce or stock goods, how much to produce and order, how to provide for seasonal peaks in demand?

What are the risks of disruptions, and what are the viable mitigation strategies?

What size fleet is required?

Estimate safety stock at each facility for each product.

How to implement a solution suggested by network optimization?

Which solution has higher potentials? Which parameters should you tweak, and how, to balance service levels and costs?
The more details you consider in your model, the more opportunities for improvement you have. The more you wish to solve a problem at a finer granularity the more is the need to move from visualization to dynamic simulation.

This toolkit is critical for analysts striving to make their supply chains both lean and agile. However, all that doesn’t actually mean that dynamic simulation is better. Each tool is targeted at different kinds of problems: it cannot handle challenges suitable for analytical or more simple visual methods well, and vice versa. Visualisation identifies quick fixes whilst analytical methods allow you to handle large-scale problems and dynamic simulation addresses more details plus dynamics to go for deeper supply chain analysis. Each on the same data set but utilising a finer granularity.

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**Case Study – Hypothetical Case on a Postal Service Provider**

**Enhancing Supply Chain and Logistics Processes**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To analyse Postal service transportation network so as to identify main factors contributing to logistics cost</td>
<td>Data Analytics</td>
</tr>
<tr>
<td>2. To strategically redesign the supply network structure so as to reduce logistics cost while maintaining the current service level</td>
<td>Greenfield Analysis</td>
</tr>
<tr>
<td></td>
<td>Network Optimization</td>
</tr>
</tbody>
</table>

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**Factors Influencing Logistics Cost**

- Focus on reducing Transportation & Warehouse Fixed Costs

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**Choosing Optimum Number of DCs**

- Decreasing marginal return of investment for opening an additional DC
- Optimum number of DCs are likely to be 6 – 8 as there is a break in trend at no. 6 and 8

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**Optimum Network Configuration**

- 18% Cost of Transportation & Warehousing
Data Required to Drive Supply Chain Engines

The visualisation and supply chain engines will only function when a sufficient amount of data is channelled into the Urban Grid Logistics platform. For the simpler engines, easily collectable data at surface level is sufficient to power the engines. Whereas for complex functions, it will require a sophisticated network of data to drive the analysis, planning, and execution of tasks. The generic data requirement in the areas of the geospatial, company and other data sources and their increasing level of difficulty in data collection are illustrated below.

Geospatial data, which is used for logistics planning and asset sharing, is an important input to the geographic visualisation and simulation in the increasingly congested cities. Static data of infrastructure and locations are easily retrievable and widely used by many software in the market. The platform targets the dynamic geospatial data, which includes capacity utilisation, traffic conditions, and demographic changes in real-time.

When it comes to the collection of enterprise data, we are aware that companies are often reluctant to share their data in fear of data leakage and loss of competitive advantage. With our secured data repository and data exchange protocols, the enterprises can be enticed to share more data, which will eventually lead to company and industry-wide supply chain performance improvement.

The company data required in the platform are the infrastructure, network, customer, product, process, financials and real-time operational data. As companies adopt different technologies and information systems, collection and integration of these data are also key in the data-driven Urban Grid Platform. Complemented by the publicly available company publications and commercial data, the platform can smoothly process all data and instructions and generate the business-enhancing insights and actions.
Data play an integral role for these visualisation and supply chain engines. Simpler engines will function also with easily collectable data at surface level. More complex functions will instead require a sophisticated network of data to drive the analysis, planning, and execution of tasks.
Increasing Data Granularity Yields more Insights

Gradually increasing input data details in turn yield increasingly powerful output models. Proceeding with this logic, future platform versions will also incorporate intelligent AI-driven self-configuration tools.
SUMMARY AND KEY TAKEAWAYS
Conclusion

This paper aims to introduce the Digital Twinning Platform which is in the pipeline of The Logistics Institute – Asia Pacific. The Urban Grid utilises data to bring about leapfrogging transitions in the supply chain performance and capabilities of the companies across industries. The platform hopes to create a data-driven supply chain where information is shared across the entire supply chain to connect the various supply chain partners and provide end-to-end supply chain data access. At the same time, it will also incorporate value-adding decision supporting engines to improve utilization of resources, namely warehouses, skilled manpower, and transportation assets. The underlying data mechanisms will in turn create a shared environment where all supply chain partners hold a holistic industry perspective and integrate for more peer-to-peer sharing and multi-party collaboration.

In order to direct companies’ focus to planning, the platform is designed to include supply chain planning tools, ranging from visualization to dynamic simulation. Also, the platform will incorporate the business intelligence tools that transform data into actionable insights that allow a company to make strategic and tactical business decisions. Such visualization tools have proven to be indispensable in operations as they help to monitor day-to-day activities, perform analytics to improve logistics operations and respond to emergencies. Artificial intelligence and machine learning solutions are to be adopted by the platform to bring about greater operational intelligence and improved decision making which in turn boost profitability of the businesses.

With the multi-method grid for supply chain planning and analysis, it is hoped to provide a holistic industry-wide solution that leverages on digitalisation to improve supply chain collaboration, transparency and flexibility.
Key Takeaways

A wide-array of tools and technologies are readily available to address supply chain problems at all levels including strategic, tactical, and operational.

Organizations should embrace digitalisation to achieve operational excellence, supply chain transparency as well as boost their financial and service level performance.

Identification of problem statements remain a challenge. However, supply chain visualization can help to identify potential statement of problems, which then need to be addressed using more sophisticated tools such as analytical optimization, dynamic simulation, system dynamics and others, depending on the nature of the problem at hand.
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