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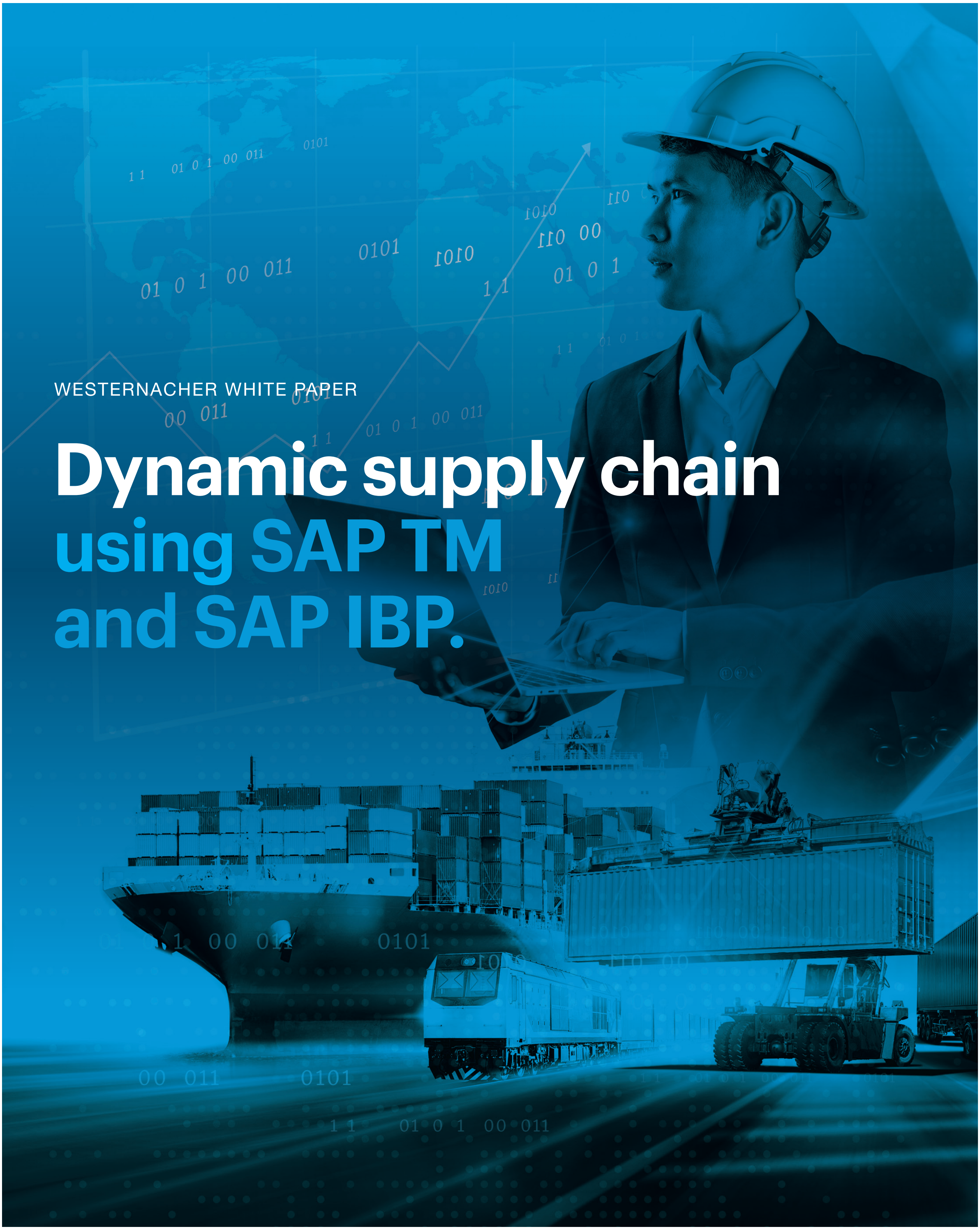
NONSTOP INNOVATION



WESTERNACHER WHITE PAPER

Dynamic supply chain using SAP TM and SAP IBP.

As has been seen throughout the pandemic, a lack of resilience, diversification, and risk management can easily lead to various supply chain issues. Whether congested ports or record freight rates, these issues can lead to a complete sputter and breakdown of the global supply chain. In a world where logistics operation has found itself to be rather reactive in nature, whether that be due to natural disaster, accidents on highways, etc., prescriptive analytics has found itself at the forefront of supply chain network design.

While a lot of businesses choose to combat any post-pandemic struggles, they find themselves in by simply increasing their pipeline inventory, this is not a long-term solution. As such, it is important to highlight various means of dealing with and preventing such issues, to mitigate effects from any unforeseen issues that can arise.

To ensure a prescriptive, compliant, and transparent supply chain, SAP provides cutting-edge innovation in its Transportation Management (TM) and Integrated Business Planning (IBP) modules. In this white paper, we will cover both modules, highlighting key features that can be attributed to the creation of a reliable, safe, and traceable supply chain network.

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Transportation network optimization.

A supply chain network consists of nodes and edges. The node can be either a distribution center or a destination. The edges are routes connecting the nodes. TM optimization uses a combination of algorithms to find the shortest route for completing a certain number of deliveries.

TM employs both the direct shipment model that is between a seller and a buyer, and the hub-and-spoke network that models the routes stemming from a distribution center (DC) to many destinations. The former would be the optimization of routes, drivers' time and the availability of handling facilities. The latter is more complicated as it deals with multiple nodes. The hub-and-spoke model simplifies the supply chain network if we only look at the larger nodes that represent the DC and ignore the smaller nodes that represent the final destinations. On the simplified network, we could have a line model that calculates the shortest route between two nodes. For example, a DC on the east coast and a DC on the west coast, while passing through several DCs on the way. If we zoom into the local supply chain network around a DC, we are facing a Traveling Salesman Problem (TSP) such as in last mile delivery – where a delivery truck starts from the DC in the morning, passing through many residential households, and returns to the DC at the end of the day.

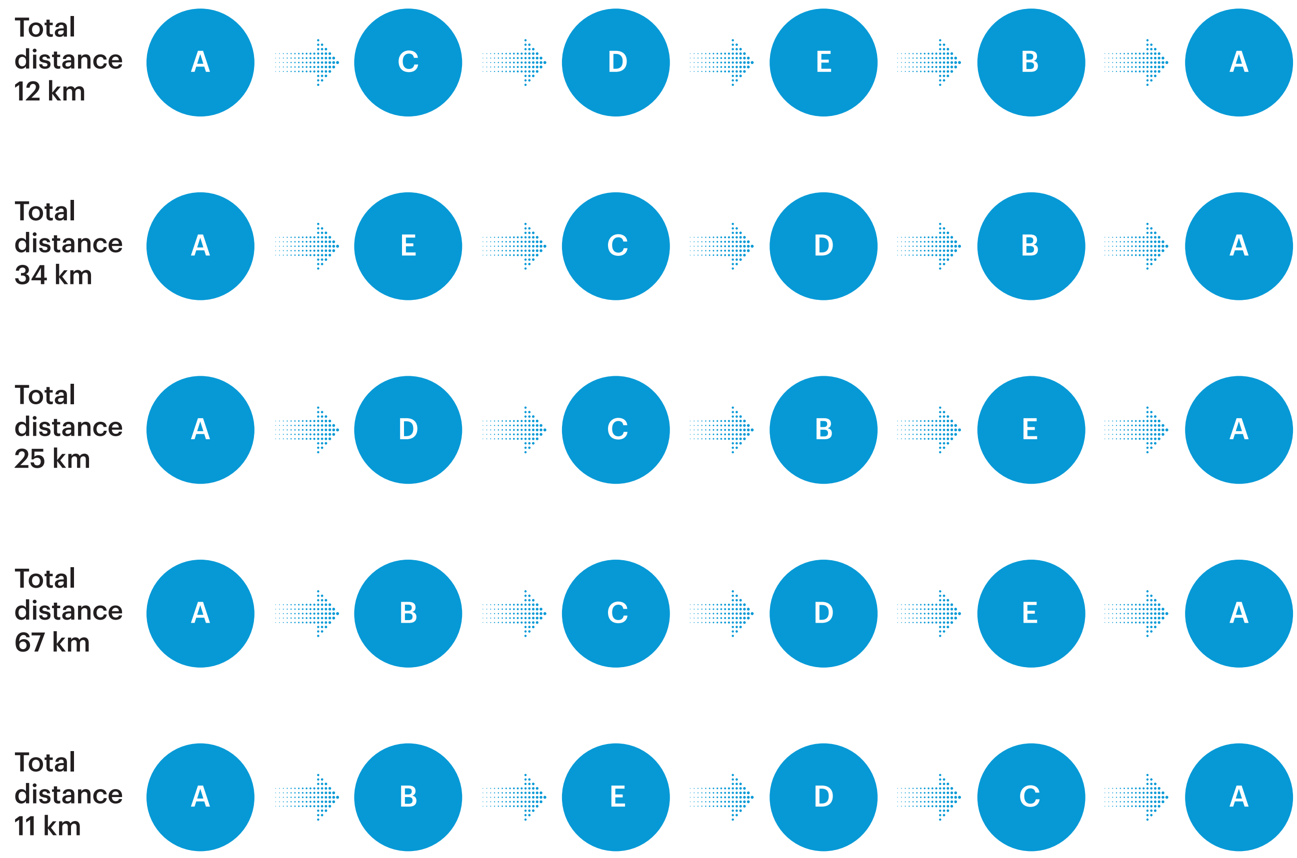
There are many ways to solve the route optimization problem in both line haul and TSP scenarios. One obvious way is the brute force method, which lists all the possible routes and picks the route with the shortest distance. However, the biggest challenge of the brute force method is that the computational burden would increase exponentially as the number of destinations increases. Thus, SAP TM uses a mathematical simulation called the genetic algorithm to solve the optimization problem.

The genetic algorithm does not go over all the possible routes, it starts with a few randomly generated routes[1]. For example, suppose we have 5 destinations and there are a total of 120 different routes (5! = 120), the algorithm randomly picks 5 routes as an initial population. Then, it calculates the total distances of each route and selects a subset of the population with overall shorter distances according to some threshold value. The subset are the fittest ones and they become the parents for the next generation/ iteration. The next generation of routes are generated by mutation and crossover. The mutation is represented by swapping two destinations within a parent's route. A crossover occurs when a child takes one portion of a parent's route and fills in the remaining slots with another parent's route. Again, the total distance of each child route is calculated, and the fittest routes are selected as parents for the next generation. The algorithm repeats this process until the route with the shortest distance within each generation converges to a steady value over time. This way, we can reach an optimal route much faster than using the brute force method. SAP TM ensures the speed and performance of its one-click optimization is based on this mathematical simulation.

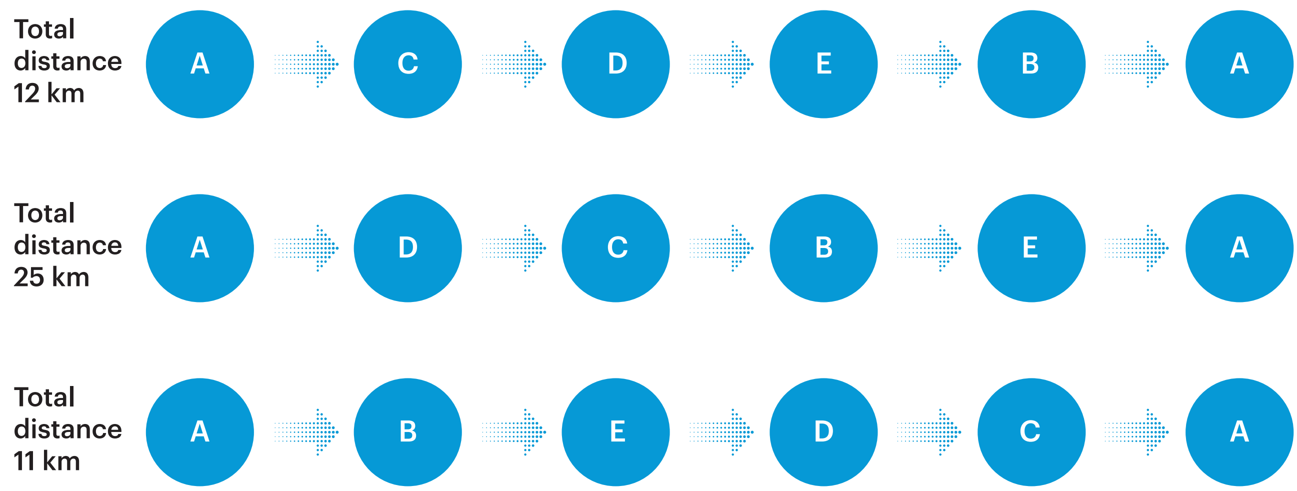
For example:

Suppose we want to find the shortest route starting from A and ending at A, while passing through other destinations B, C, D, and E. The diagram below shows the 5 randomly chosen initial populations:

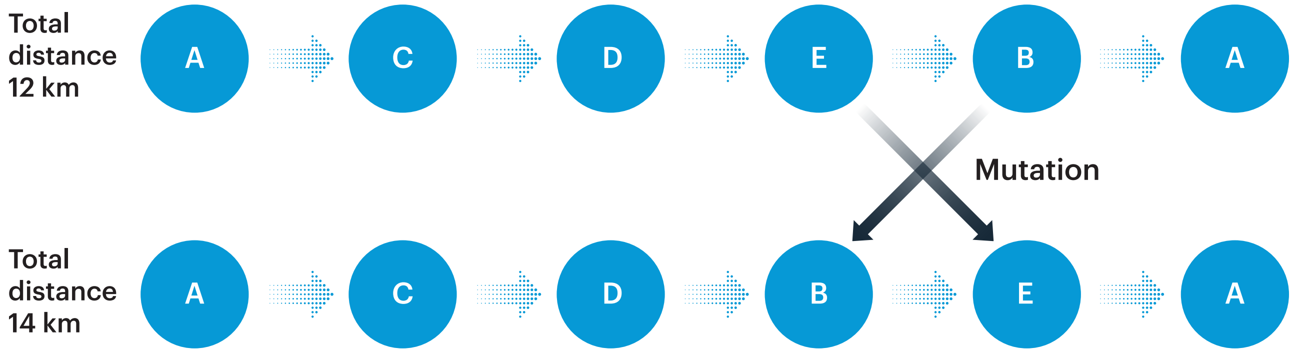
[1] Jake Tae, Traveling Sales Problem with Genetic Algorithms



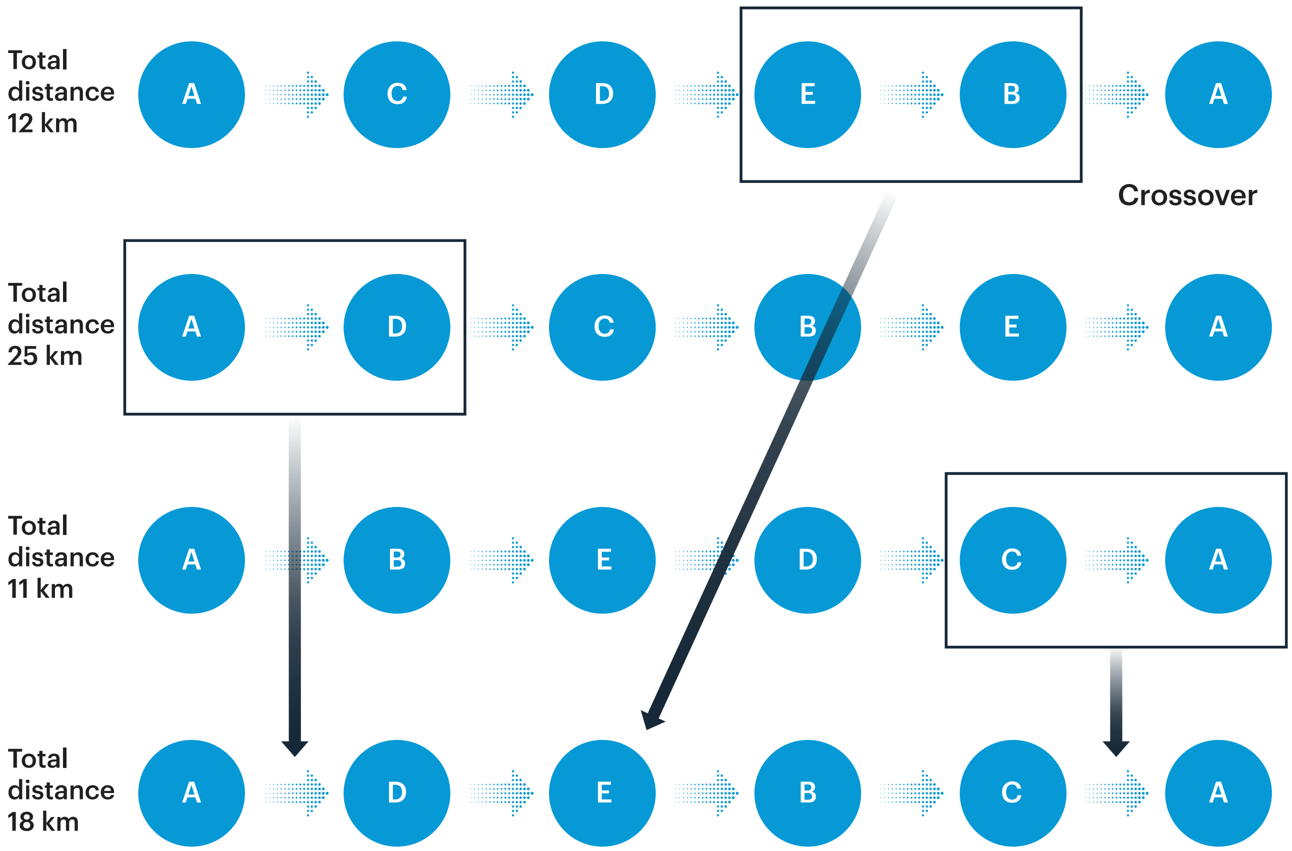
After calculating the total distance of the five routes above, we have 12, 34, 25, 67 and 11 km respectively. So, we set a distance threshold at 30, then we should only keep routes with distances of 12, 25 and 11 km, which are the following three routes and they become the parents of the next generation:



Then, we can start mutation and crossover. The route A → C → D B→E → A is an example of mutation of A → C → D → E → B → A because it swaps the position of B and E.



A crossover is made of portions of other chromosomes. A→D → E B→C→A is a crossover of all three chromosomes. It takes portion A→D from A→D→C→B→E→A, E→B from A→C→D→E→B→A and C→A from A→B→E→D→C→A.



In the next generation, we could have all combinations of mutations and crossovers and repeat the first again. Calculate the total distances of all routes and set a threshold to pick the fittest for the next generation's parents.

The above-described genetic model does not consider constraints, but what makes TM so powerful is that it expands the simulations into multiple dimensions with the considerations of different hard and soft constraints customized by the user for the actual calculation.

In addition, to genetic models, there is another widely used heuristic, the Clark Wright Saving Algorithm, that solves the TSP. Imagine in the least efficient scenario where every delivery truck just visits one destination in its trip, the total distance of visiting n destinations would be n times back-and-forth distance of a single trip. However, if we combine two destinations in each trip, the total distance we save would be one back-and-forth distance minus the distance between the two destinations. If the back-and-forth distance is larger than the distance between the location pair, we have achieved positive savings and increased the efficiency of the route[2].

Clark Wright works by sorting the savings for all pairs in descending order. Then, the algorithm creates a route between the pairs from the biggest savings to the smallest savings sequentially. If one point in the pair was already in another route, then the new route connects to the existing route. If both points in the pair are in previously planned routes, the routes will merge.

The simple logic behind the Clark Wright heuristic keeps the computation burden under reasonable limits with large destinations in the TSP scenario.

[2] https://web.mit.edu/urban_or_book/www/book/chapter6/6.4.12.html

Change control

Transportation stands at the tail of the supply chain, which means transportation professionals deal with changes and exceptions from both internal and external processes (change in delivery date, production delay, shortage of material, etc.), as well as environmental challenges (natural disasters, mechanical breakdown, etc.).

In the past, businesses have heavily relied on manual communication and decision making. With SAP TM[3], it is easier for supply chain professionals to manage larger and more complex supply networks through propagation capabilities. The system allows real-time changes in the supply network to be propagated to the upstream and downstream processes and make changes accordingly. This way, the supply chain is more resilient to disruptions. As technology advances this propagation helps to minimize supply chain latency.

Resilience

Whether it is a contractual obligation or strategic outsourcing, supply chain professionals aim to diversify their vendor portfolio to minimize risks. Using TM[4], businesses can manage a larger supply network in a much more efficient manner through predefined allocation and business shares. On one hand, when one of the carriers fails or when there is a peak demand, you can shift more business to another carrier. On the other hand, process owners no longer need to manually monitor whether each carrier has received enough business to maintain a strong logistics partner network.

Integration

TM can also be seamlessly integrated with IBP. The advantage of IBP is that it contains many advanced algorithms to predict demand and supply and optimize inventory. In addition, when TM is integrated with IBP, it also provides backward planning capabilities through simulations. The point here is setting up realistic shipping and delivery dates to maintain a high service level quality.

[3] This example is taken from Bernd Lauterbach, Stefan Sauer, Jens Gottlieb, Christopher Sürie, Ulrich Benz; Transportation Management with SAP; Rheinwerk Publishing, Boston MA 2019.

[4] This example is taken from Transportation Management with SAP 2019.

Inventory optimization.

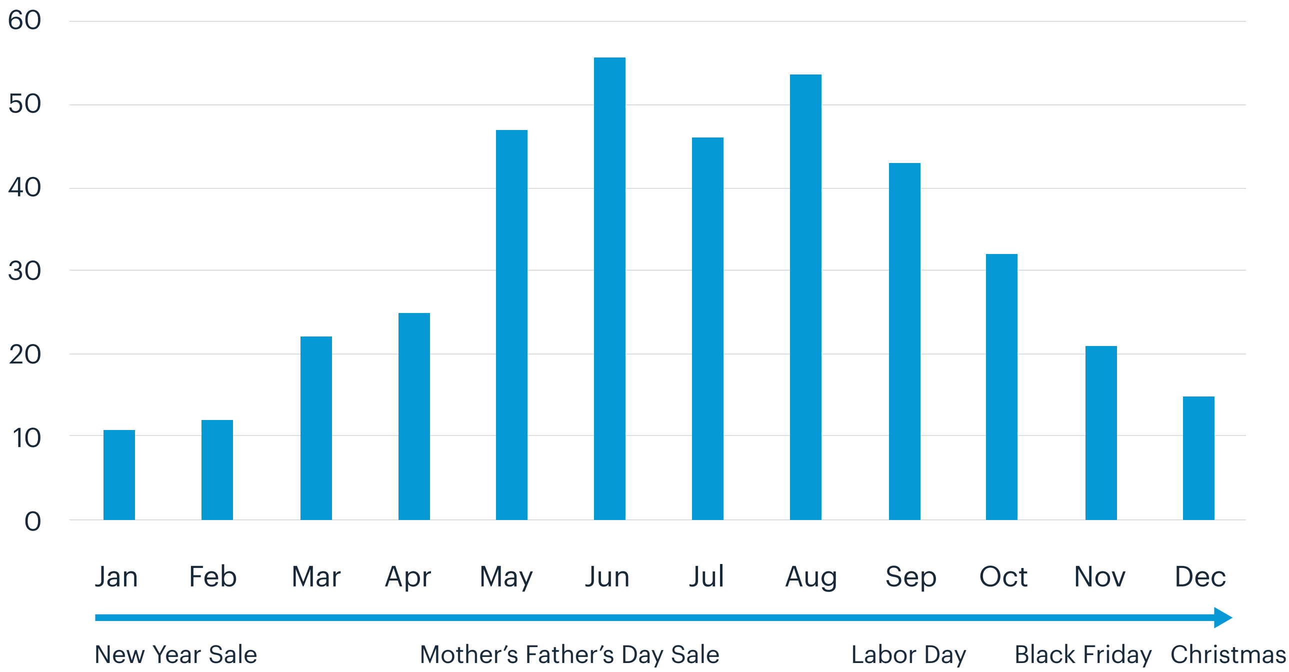
As the supply chain network becomes more complicated, we need to adopt a dynamic and product-centered approach to inventory optimization. We need more tailored inventory strategies for each product, and we also need to incorporate upstream and downstream shocks in the inventory calculation in real time.

For example, one of the most common factors is demand variation, from a high usage component to a specialized part, will have completely different demand patterns, thus a respective demand coefficient variation.

However, average supplier lead time also plays a huge role in inventory management. A product with an average lead time of one day will carry less inventory than a product with an average lead time of 3 days. Lastly, the location selection of regional warehouses, cross-docking centers, or distribution centers will also affect inventory holding decisions.

Below is an example of inventory for a seasonal demand consumer product that is heavily impacted by various seasonal promotions with more demand in the summer than in winter.

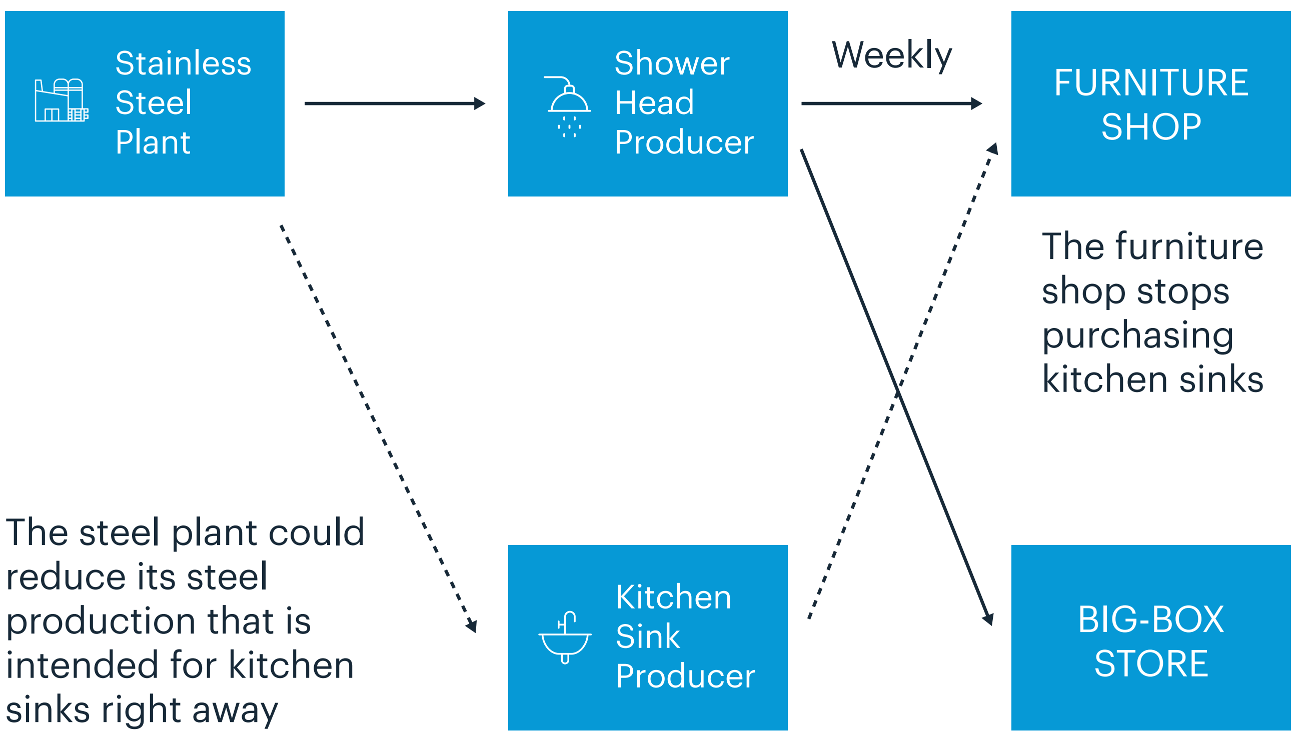
INVENTORY OF A CONSUMER PRODUCT IMPACTED BY SEASONAL DEMAND



As more factors are added to the mix, the complexity increases. In the business world, IBP can be used to drive customer segmentation and to set different target service levels for each customer. For customers that have a higher target service level, a higher inventory level is needed, and vice versa. In IBP, the target service level can be set in master data and the optimization algorithm would use them as constraints.

In addition to single-stage inventory optimization, IBP can also execute global multi-stage inventory optimization, which propagates demand variability upstream to all nodes in the supply network and calculates the inventory needed in each node. If we optimize the inventory at each node separately, we may end up with a higher overall total inventory as compared to the global optimization for the same target end-customer service level. This is because global optimization could allow sub-optimal inventory in particular nodes if the global optimal is achieved. However, the summation of inventories resulting from single-stage optimization could be larger because the algorithm must achieve optimal inventory for each node.

For example, the graph below shows a stainless-steel plant that provides raw materials to two plants, one of them produces shower heads and the other produces kitchen sinks. The end retailers, a big-box store and a furniture shop, buy both shower heads and kitchen sink producers every week. Due to an unexpected fall in sales of stainless-steel kitchen sinks the first week of September 2023, the furniture shop has an overstock of stainless-steel kitchen sinks and stopped purchasing any more sinks for the rest of September. The steel plant has no way of knowing Kroger’s demand pattern changes until the sink producer relays the information. However, adopting SAP IBP, the change in the furniture shop’s demand pattern will immediately propagate to the steel plant’s incoming data stream, and trigger a recalculation of optimized inventory in real-time. It will prevent the steel from overproducing stainless steel that is intended for kitchen sinks.



IBP offers a platform for all parties to collaborate to responding to the unexpected events in supply chain in real time and adjust inventory quantities constantly.

The situation described in the above example could be quite common. Especially during the pandemic, some demand for products used in social events decreased suddenly while the demand for masks for hygiene products increased. This change impacts not only the immediate producers of those products but also the product-specific machinery manufacturers in the upstream. SAP IBP would help the upstream suppliers adapt to the change in end consumers' demand more quickly and cut unnecessary inventory. The quickness in response in inventory planning is especially important for the agriculture industry, where the produce is perishable, and storage is more costly. Tracking the demand variability in consumers would benefit those companies in the end.

In contrast to the consumer product example above, a piece of machinery used to produce advanced chips may be immune to seasonality and promotional events. Their inventory level would be more sensitive to upstream product's supply lead time and the sales of downstream products. Taking a step back, having the multi-echelon level inventory capability would also help a firm make decisions like the location of a new warehouse or distribution center. A firm would easily visualize the changes in demand multiple layers downstream and changes in supply multiple layers upstream on a map, and it becomes much more straightforward to make business decisions.

Managing efficient inventory is one of the key factors for a business to succeed and SAP IBP provides sophisticated and comprehensive technology support in inventory management. In addition to inventory optimization, IBP can also handle demand and supply planning. These predictive powers could help TM to better plan how many products to ship or store at each node in the supply network. The forecast provided by IBP can be leveraged in all aspects of the supply chain, whether it is tactical and driving inventory safety stock levels, warehouse floor mapping or transportation lane volume-based contracting – or strategic and driving large scale capital projects to improve efficiencies or determining a new facilities placement based on demand.

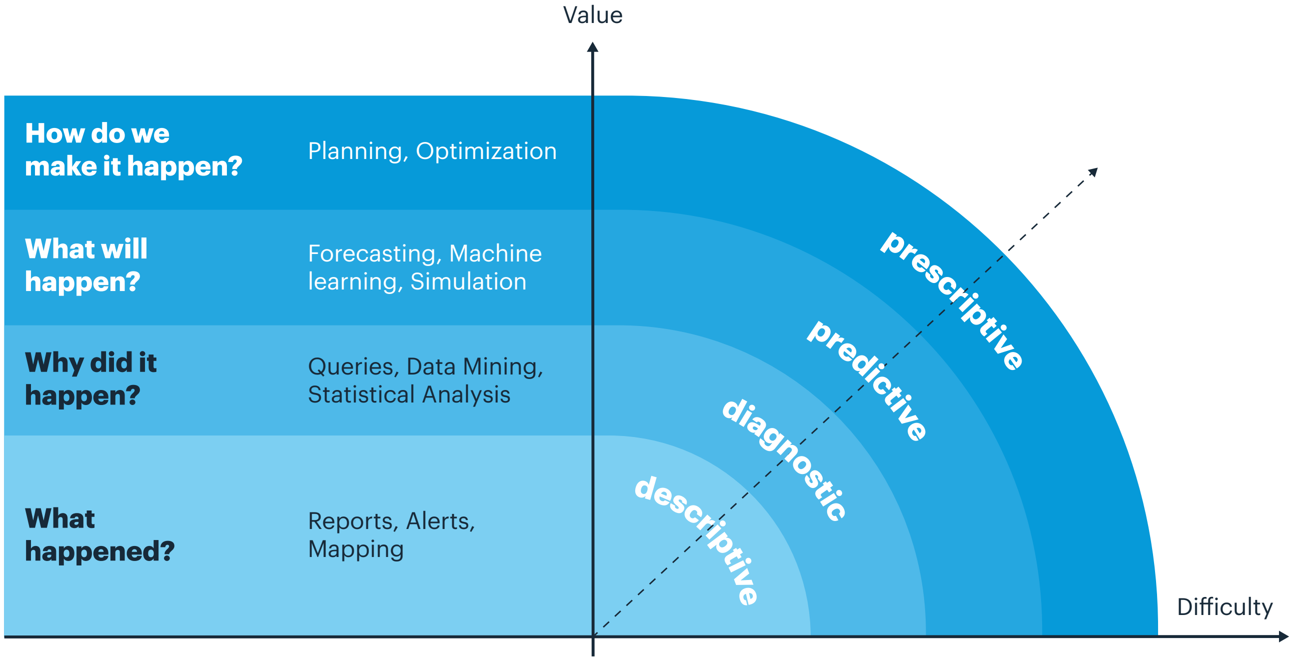
Establishing supply chain resilience through SAC intelligent insights.

As was shown throughout the pandemic, consumers' panic buying of goods can almost instantaneously lead to cleared-out shelves, something that displays the lack of resilience in many companies' supply chains. Even with prompt overnight action from the heads of the company, it is essential to not only maintain but also accelerate the transformation of your response.

So, what exactly contributes to the overall resilience of a supply chain? Two major key factors include visibility and vendor management.

Visibility as it pertains to the supply chain can generally be categorized into two sections: structural and dynamic visibility. Structural visibility helps a company get a snapshot of what supply chain operations look like at a certain point in time or period. This includes things like where supplies are, where manufacturing takes place, etc. Dynamic visibility deals with ways to monitor and respond to events taking place currently in real-time including things like how plants and warehouses are running, where products are across the supply chain, and where and when disruptions are occurring. With intelligent insight's ability to provide a deeper understanding and in-depth view of a company's global supply chain, we can see a direct impact in increasing the overall resilience of a supply chain. It is also important to note that you do not need perfect visibility to see this impact occur, but rather direct insight into more obvious risks pertaining to the business.

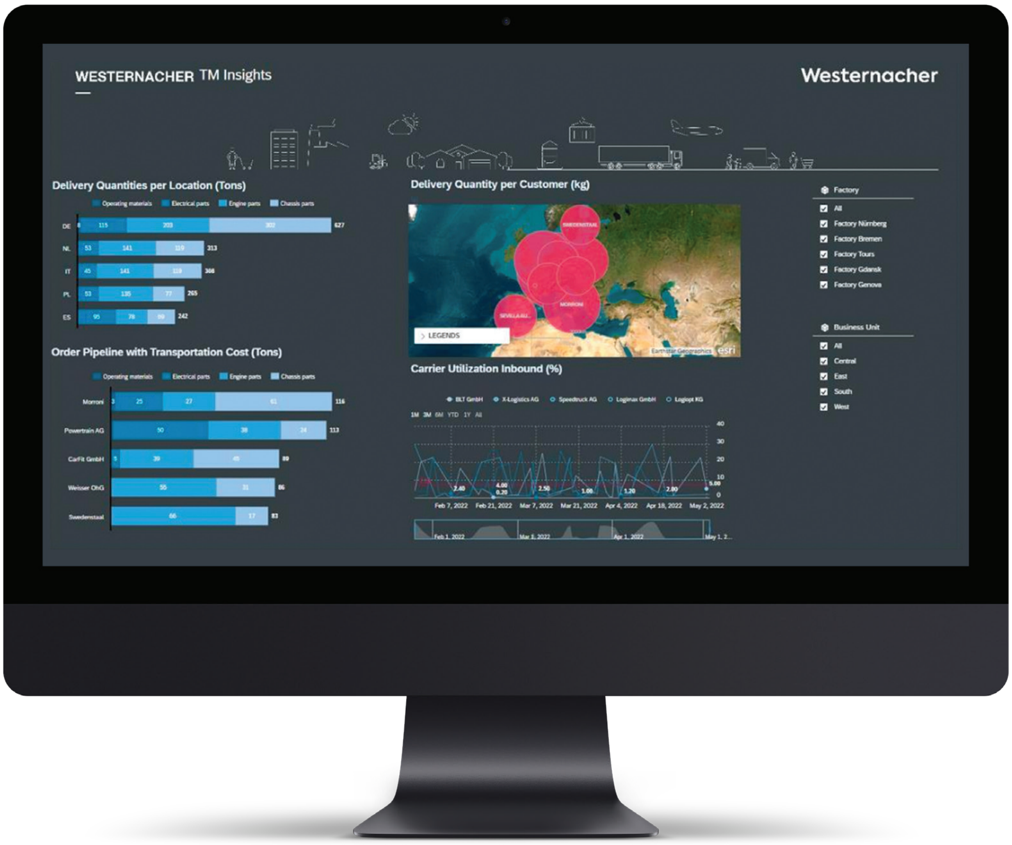
Vendor management is exactly what it sounds like – managing a network of vendors. This can be quantified as controlling costs, mitigating risks, ensuring service durability, and improving vendor relationships. The importance of this cannot be understated.



While some may think that vendor management is simple to begin with, it can quickly become extremely complex as a business continues to grow and more vendors are being used. SAP provides its customers with a way to define a Vendor Management System (VMS) to help organizations manage their relationships with external suppliers and vendors. In its simplest form, a VMS is a cloud-based software platform that provides enterprises with a way to find, engage and manage their external workforce – both suppliers and vendors. With a VMS, organizations can traverse through the various stages of vendor relationship management; vendor selection; risk assessment; contract negotiation; onboarding; managing performance and monitoring/ mitigating risk. With a well-defined VMS, companies are given the flexibility and agility in hiring vendors around the world, along with the ease of scaling up or down – essentially giving them the edge on the lesser prepared competition. We can see below how Intelligent Insight offers a multitude of metrics to display the performance of external vendors.

In conjunction with the creation of a VMS, SAP Analytics Cloud (SAC) Intelligent Insights offers organizations the same peace of mind when it comes to managing vendors; with the ability to drill down into relevant real-time data. To begin with, SAC TM Intelligent

Insights can be used to monitor both Inbound and Outbound Orders. With information such as delivery quantities per usage/customer/location, carrier utilization, and the order pipeline with transportation focus/cost, we can take a deep dive into specific metrics with the ability to drill down to the lowest level possible (specific couriers, countries, cities, etc.). With data pertaining to these metrics, we can create a dashboard that portrays important aspects of supply and demand determining the overall flow of goods in and out of the business. Paired with the ability to monitor both Transportation Execution and Financials at a vendor level, Intelligent Insight gives us a simple way to tackle building a strong network of vendors, as well as offer extensive visibility throughout various parts of the business. This also gives us the ability to display accurate information on carrier performance as a basis for future contract negotiations and the monitoring of service-level agreements. In theory, competition can establish a healthy environment in which success is bred. Intelligent Insights provides us with a way to accurately portray the success of each vendor in achieving their deliverables through easily accessible historical data.


WESTERNACHER TM Insights
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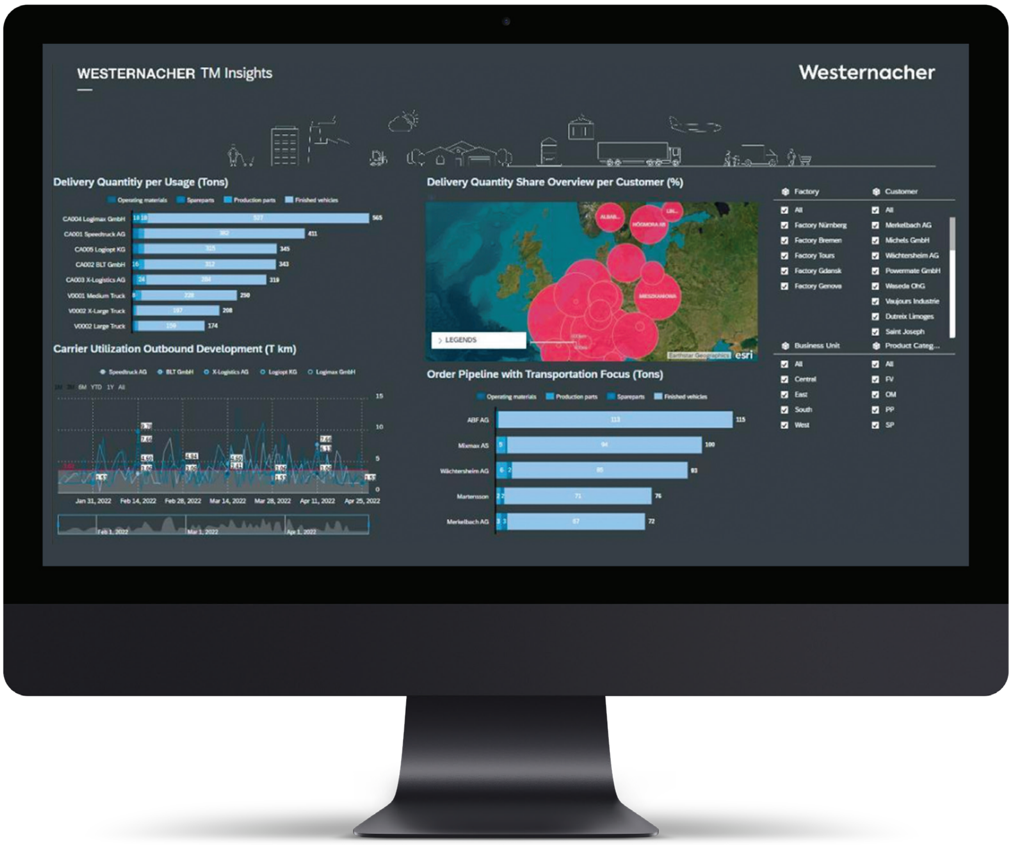
Delivery Quantities per Location (Tons)
Delivery Quantity per Customer (kg)
Order Pipeline with Transportation Cost (Tons)
Carrier Utilization Inbound (%)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Delivery Quantity per Usage (Tons)
Delivery Quantity Share Overview per Customer (%)
Carrier Utilization Outbound Development (T km)
Order Pipeline with Transportation Focus (Tons)

Supply chain transparency.

In the past, each individual business function owned its reporting and analytics units. However, nowadays it is a trend to integrate overlapping functions on a high level. Several SAP modules have supply chain management capabilities. For example, SAP Yard Management directly impacts warehouse operation, if the position of the trailer in the dock is incorrect then the forklift driver must make up for this bad position by adding extra lead time. It can also affect trailer outbound and inbound processes in TM.

SAP IBP is a module that is dedicated to integrating with TM and several other modules and building a real-time information hub involving transportation, finance, and upstream and downstream business partners. In addition, IBP has strong analytics and reporting capabilities that allow several planners to collaborate.

TM could integrate with IBP through a cloud interface and data service (CI-DS). The planners could conduct both inbound and outbound data integration within the app UI of the SAP IBP planner's workspace.

IBP could conduct what-if analysis using scenarios. For example, users could specify three possible scenarios in the future, such as the federal reserve will increase, keep, or decrease interest rates for the next month. Then, the cost rates or related prices may change under each scenario. We can run demand sensing algorithms according to each scenario and thereby prepare better for the future.

Summary.

As time progresses, the need for an ever-developing, seamless, and integrated supply chain network will continue to become more and more apparent to businesses wishing to streamline their processes. Both SAP TM and SAP IBP provide extensive modules to achieve this. With SAP TM, we are provided with a one-stop platform for all needs related to transportation network optimization and planning. With SAP IBP, businesses are provided with a platform to handle their inventory management, as well as a place to perform analytics and reporting. Not only do these modules provide an extended look into the inner performance of a company's supply chain network, but the seamless integration between SAP TM and SAP IBP through the collaborate Planner Workspace app allows different functional teams within the firm to easily work together. At Westernacher, we truly believe that the extensive, visual, and user-friendly view that these SAP modules provide will become an industry standard.

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