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Original Article

Revolutionizing Forecasting with Unified Demand Forecasting for Supply Chain Retail by SAP Customer Activity Repository (CAR) using Machine Learning, Predictive Analysis, and AI

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Abstract *- In the supply chain of modern retail systems, accurate demand forecasting is vital for optimizing inventory, minimizing waste, and maximizing profitability. Traditional forecasting methods often struggle with the complexity and volatility of consumer behavior, leading to stockouts or overstock. This white paper details how SAP Customer Activity Repository (CAR) with Machine Learning (ML), Predictive Analysis, and Artificial Intelligence (AI) capabilities, can deliver the unified demand forecast which can be leveraged in SAP IBP. By leveraging real-time transactional data, external influencing factors, and advanced analytical models, retailers can achieve unprecedented forecast accuracy, enhance operational efficiency, and gain a significant competitive advantage. This paper will explore the methodologies, technical considerations, and tangible benefits of implementing such a transformative solution within the SAP ecosystem.*

Keywords *- Unified Demand Forecast, SAP CAR, Machine Learning, Predictive Analysis, Artificial Intelligence, Retail, Supply Chain, Inventory Optimization, Demand Influencing Factors.*

1. Introduction

The retail industry operates in an increasingly complex and unpredictable environment. Consumer preferences shift rapidly, product lifecycles shorten, and omnichannel strategies introduce new levels of intricacy to demand planning. Inaccurate forecasts lead to a cascade of negative consequences, including lost sales due to stockouts, increased carrying costs from excess inventory, markdowns, and diminished customer satisfaction. SAP Customer Activity Repository (CAR) provides a foundational platform for retail processes by centralizing real-time point-of-sale (POS) data and other operational information. However, the true potential of this rich data asset is unlocked when combined with the power of Machine Learning, Predictive Analysis, and AI. This integration enables a "Unified Demand Forecast" (UDF) that considers a multitude of influencing factors, historical patterns, and forward-looking trends to generate highly accurate predictions across all sales channels. This white paper will delve into how these advanced technologies within SAP CAR transform traditional demand forecasting into an intelligent, adaptive, and proactive process, driving significant business value for retailers.

2. Problem Statement: The Limitations of Traditional Demand Forecasting in Retail

Traditional demand forecasting often relies on historical sales data and statistical methods, which, while foundational, possesses inherent limitations in addressing the nuances of modern retail:

- Data Silos and Disparate Systems: Information pertinent to demand, such as sales data, promotional calendars, and supply chain constraints, frequently resides in disconnected systems. This fragmentation hinders a holistic view of demand.
- Inability to Capture Demand Influencing Factors (DIFs): Manual forecasting struggles to effectively incorporate the impact of various DIFs, such as promotions, holidays, local events, and even weather, leading to significant forecast errors.
- Challenges with New Product Introductions and Short Lifecycles: Products with limited or no sales history, common in fast-paced retail, pose a significant challenge for traditional statistical models. Hierarchical priors and reference products are crucial for these scenarios.
- Lack of Granularity: Aggregated forecasts often mask demand variations at the individual product-location level, leading to suboptimal inventory decisions. Retailers require forecasts at the most granular level (e.g., product-location-channel-day)
- Static Models: Traditional models are often static and

require frequent manual adjustments, making them slow to react to sudden market shifts or unforeseen events.

- Manual Adjustments and Bias: Human intervention, while sometimes necessary, can introduce bias and inconsistencies into the forecasting process, leading to sub-optimal outcomes.[5]

These challenges underscore the need for a more sophisticated, data-driven approach that can leverage vast amounts of information and adapt to evolving market conditions.

3. Capabilities of SAP CAR for Unified Demand Forecasting and Literature Review:

SAP Customer Activity Repository (CAR) is a key component of SAP's retail solution portfolio, serving as a central hub for transactional and master data. It provides the necessary foundation for advanced demand forecasting through:

- Real-time Data Aggregation: CAR collects and harmonizes data from various sources, including point-of-sale (POS) systems, e-commerce platforms, and master data from SAP ERP, providing a unified view of customer activities and product movements. This real-time capability is crucial for responsive forecasting.
- Unified Demand Forecast (UDF) Component: UDF, a module with SAP CAR, is a powerful modeling and forecasting tool. It combines strengths of various forecasting methods to supply predictive information to consuming applications such as SAP Allocation Management and SAP IBP. Below Figure 1, shows the configuration of UDF in SAP.

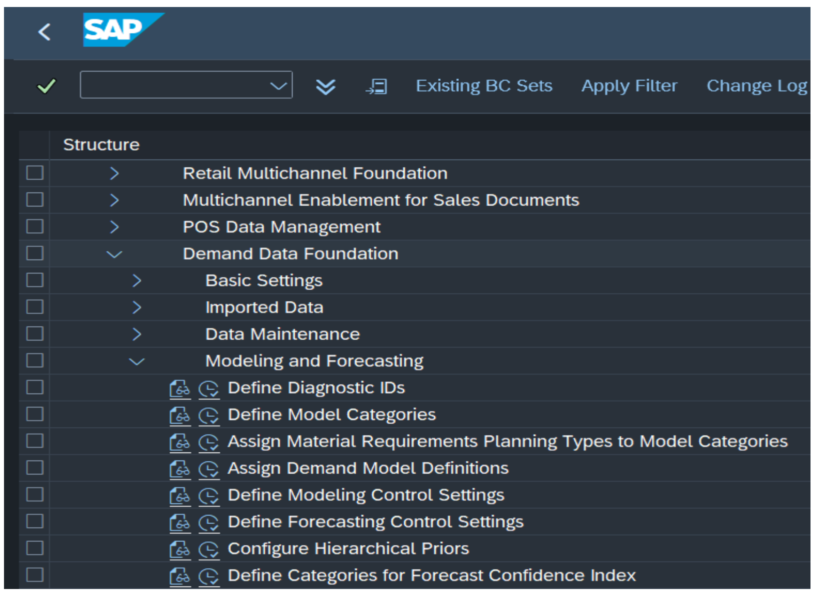

Figure 1: SAP CAR - UDF configuration in SAP

- Hierarchical Priors: SAP UDF uses Hierarchical Priors to enhance modeling of new lifecycle products or the like products that do not have sufficient history using Product/Location Hierarchy. In the case of new products that do not have historical sales, the system automatically uses the sales data of a reference product to identify a sales pattern that can be used to generate a UDF for the new product for a future horizon.
- Demand Influencing Factors (DIFs) Management: SAP CAR calculates the demand of each product-location and considers Demand Influencing Factors (DIFs) such as promotions, calendar events, seasonality, along with historic and forward-looking patterns to generate a UDF for multichannel (Retail stores and Distribution center forecasting. Promotions and offers are demand influencing factors (DIFs) that impact the forecast of a product. Planners use the Manage Demand Influencing Factors application Figure 2, in CAR to add promotion data by importing Promotions Data Matrix spreadsheet to CAR. DIFs such as Promotions, Black Friday, and Model Replacement are maintained at a product level and are applicable across all stores. The Local Events DIF is applicable at a location level.[4]
- Product and Location Hierarchies: Once an article/product is added in SAP S/4 HANA system, its corresponding reference article and hierarchy is also maintained in the same. Location Hierarchies are maintained directly in CAR. When a new store or Distribution Center (DC) is introduced, it is added in SAP S/4 HANA and interfaced to CAR. Once the store/DC is available in CAR, the new store/DC is assigned to a Location Hierarchy.

- Analyze Forecast and Adjust Forecast Applications: The output of UDF modeling and forecasting is available in the Analyze Forecast application, Figure 3. The Analytics team can use this app for scenario planning and modeling. The data is given by product and location ordered by the dates. Key metrics shown on the chart include Unit Sales (Actual), Model, System Forecast, and Adjusted Forecast. Planners can use it to review forecast output, and adjustments or corrections made to the forecast. Planners use the Adjust Forecast app to make adjustments or corrections to the forecast or to view details of a previously corrected forecast maintained in CAR. Planners may need to make forecast adjustments due to various reasons, such as promotional activity, store closures, or unplanned events.[2]

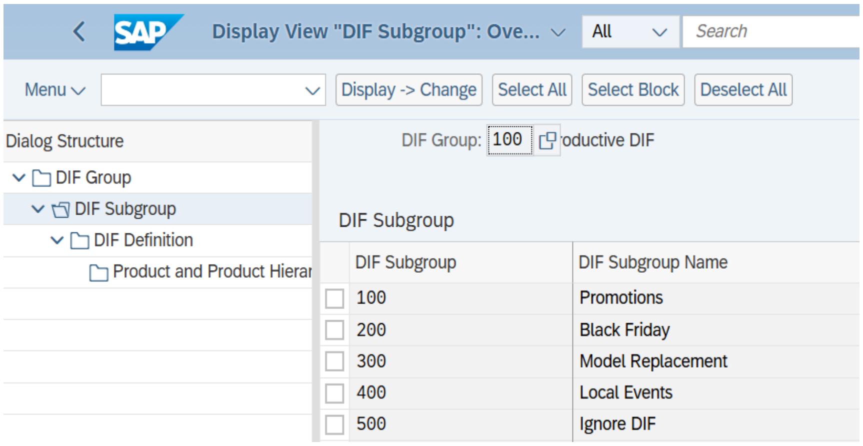

Figure 2: SAP CAR - Demand Influencing Factor app

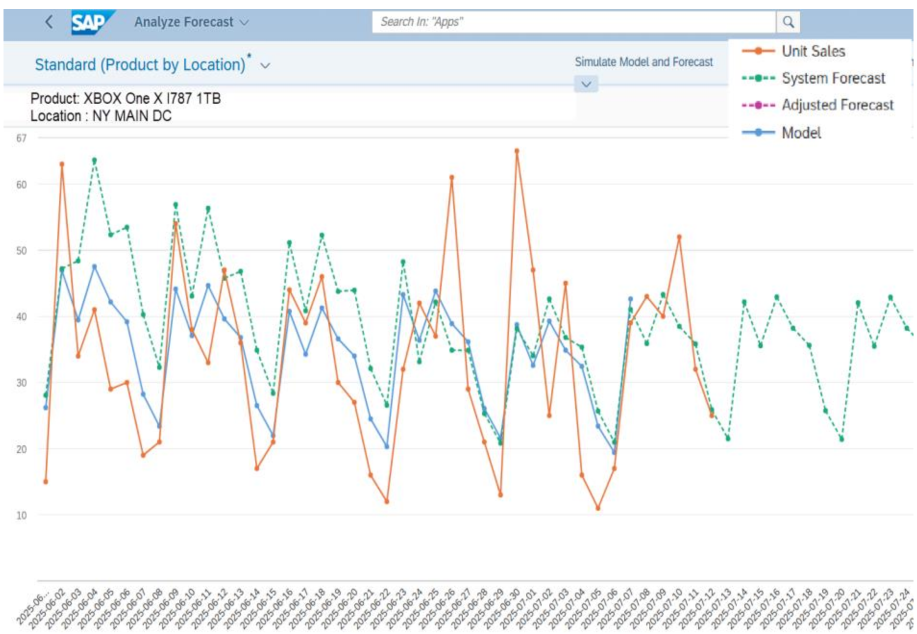

Figure 3: SAP CAR - Analyze forecast app showing Unified Demand Forecast

- Scenario Planning: Diagnostic scenarios can be modeled to simulate and fine-tune the demand plans. Diagnostic mode is available for diagnostic evaluations and forecast analysis. The Analytics team can leverage the schedule model and forecast process for scenario planning.
- Integration with SAP IBP: UDF forecast from CAR is sent over to IBP and is utilized for stock pooling or inventory segregation calculations. UDF Forecast generated in CAR is sent to IBP and utilized for buy plan and inventory optimization calculations.

4. Machine Learning, Predictive Analysis, and AI usage in SAP CAR UDF

The true innovation in retail demand forecasting lies in the intelligent application of ML, Predictive Analysis, and AI within SAP CAR UDF. These technologies empower the system to learn from data, identify complex patterns, and make highly accurate predictions, far surpassing traditional statistical methods.

4.1. Machine Learning (ML) Algorithms for Forecasting:

- Time Series Forecasting: UDF leverages advanced time series algorithms to analyze historical sales data, identify trends, seasonality, and cyclic patterns. This includes techniques like ARIMA, Exponential Smoothing, and more advanced algorithms capable of handling intermittent demand.
- Regression Analysis: To understand the relationship between sales and various Demand Influencing Factors (DIFs), regression models can be employed. This allows UDF to quantify the impact of promotions, price changes, holidays, and external data like weather or local events on demand.
- Clustering: ML algorithms can cluster products or locations with similar demand patterns, enabling the system to apply learning from well-established products/locations to new or low-volume ones, especially valuable for new product introductions using hierarchical priors.
- Anomaly Detection: ML models can identify unusual deviations in sales data (e.g., unexpected spikes or drops) that might indicate data quality issues or unique events, preventing these anomalies from skewing the forecast.
- Self-Learning and Adaptation: Over time, ML models within UDF can continuously learn from new sales data and the actual impact of DIFs, automatically adjusting their parameters to improve forecast accuracy.

4.2. Predictive Analysis for Deeper Insights:

- Decomposition of Forecast Drivers: Predictive analysis tools within SAP CAR, such as the "Analyze Forecast" app, allow users to decompose the forecast into its contributing factors (e.g., base demand, promotional uplift, seasonality effect). This provides transparency and actionable insights into *why* a particular forecast is generated.
- Scenario Modeling ("What-If" Analysis): By adjusting DIFs or other parameters, predictive analysis enables planners to simulate various future scenarios (e.g., the impact of a stronger promotion, a store closure, or a competitor's launch).
- Probabilistic Forecasting: Moving beyond single-point forecasts, predictive analysis can generate demand probabilities, providing a range of possible outcomes and associated confidence levels. This helps in better risk assessment for inventory planning.
- Forecast Error Analysis: Continuous monitoring and analysis of forecast error are crucial for model improvement and fine-tuning.[3]

4.3. Artificial Intelligence (AI) for Enhanced Automation and Optimization:

- Automated Model Selection and Parameter Tuning: AI can automate the process of selecting the most appropriate forecasting model for each product-location combination and optimizing its parameters, reducing manual effort and human error.
- Cognitive Forecasting: AI can integrate unstructured data sources, such as social media sentiment, news articles, or customer reviews, to gain a more comprehensive understanding of potential demand shifts.
- Prescriptive Analytics: Beyond predicting demand, AI can suggest optimal actions. For example, based on the UDF, AI could recommend ideal safety stock levels, replenishment quantities, or promotional strategies to achieve specific business objectives.
- Integration with broader SAP Intelligent Enterprise: AI in CAR UDF can integrate with other SAP AI capabilities, such as those in SAP S/4HANA or SAP Business Technology Platform (BTP), to create a truly intelligent supply chain. For instance, embedded analytics within SAP MDG allow organizations to track key performance indicators (KPIs) such as duplication rates and data completeness. [1]

5. Use Cases and Benefits

Implementing ML, Predictive Analysis, and AI in SAP CAR UDF delivers a wide array of benefits across the retail value chain:

5.1. Enhanced Forecast Accuracy: This is the primary benefit, leading to:

- Reduced Stockouts: By accurately predicting demand, retailers can ensure products are available when and where customers want them, minimizing lost sales and improving customer satisfaction.
- Optimized Inventory Levels: Precise forecasts prevent overstocking, reducing carrying costs, obsolescence, and the need for markdowns.
- Improved On-Shelf Availability: Direct impact on customer experience and sales performance.

5.2. Improved Promotional Planning and Effectiveness:

- Accurate demand sensing during promotions leads to optimal inventory allocation and minimized post-promotion excess.
- Ability to analyze the actual impact of promotions on sales and refine future strategies.

5.3. Faster Response to Market Changes:

- Real-time data processing and adaptive ML models enable quicker adjustments to forecasts in response to

sudden shifts in consumer behavior or external events.
- Agile Supply Chain: More accurate forecasts translate into better upstream planning for procurement, manufacturing, and logistics.

5.4. Optimized New Product Introduction (NPI):
- Leveraging hierarchical priors and similar product data helps in forecasting demand for new products even with limited historical data.
- Reduced risk associated with new product launches.

5.5. Reduced Manual Effort and Operational Costs:
- Automation of forecasting processes frees up planners to focus on strategic analysis and exception management.
- Less time spent on manual adjustments and data reconciliation.

5.6. Enhanced Decision-Making:
- Provides deeper insights into demand drivers, allowing for more informed business decisions across merchandising, marketing, and supply chain.
- Supports better allocation decisions, ensuring the right products are in the right locations.

5.7. Increased Profitability:
- A direct result of reduced stockouts, optimized inventory, and improved operational efficiency.

6. Implementation Considerations
Implementing a unified demand forecasting solution with ML/AI in SAP CAR requires careful planning and execution. Key considerations include:

6.1. Data Readiness and Quality:
- Clean and Consistent Data: The success of ML/AI models heavily depends on high-quality historical sales data, master data (product, location, hierarchy), and DIF data. Data cleansing and standardization are crucial prerequisites.
- Data Integration: Ensuring seamless integration of data from various sources into SAP CAR is fundamental. This includes POS, e-commerce, promotional calendars, external data providers (weather, events), and master data from SAP ERP (SAP S/4 HANA).

6.2. Technical Architecture and Infrastructure:
- SAP CAR Deployment: Understanding the deployment model (on-premise, cloud, or hybrid) for SAP CAR is essential.
- SAP S/4HANA Foundation: SAP CAR often runs on SAP S/4HANA, leveraging its in-memory computing capabilities for fast data processing.
- Integration with SAP Analytics Cloud (SAC) / SAP Business Technology Platform (BTP): For advanced analytics, reporting, and custom ML model development, integration with SAC or BTP is often beneficial.
- Scalability: The solution must be scalable to handle increasing data volumes and forecasting complexity.

6.3. Machine Learning Model Selection and Tuning:
- Algorithm Selection: Choosing the right ML algorithms (e.g., gradient boosting, neural networks, ensemble methods) based on the specific demand patterns and data characteristics.
- Feature Engineering: Identifying and creating relevant features from raw data that can improve model performance (e.g., deriving lead times, promotional uplift factors).
- Model Training and Validation: Robust processes for training, validating, and back-testing models to ensure their accuracy and reliability.
- Continuous Learning and Retraining: Establishing mechanisms for ongoing model retraining and adaptation as demand patterns evolve.

6.4. Organizational Alignment and Change Management:
- Stakeholder Buy-in: Gaining support from various departments, including supply chain, merchandising, IT, and marketing, is critical for successful adoption.
- Skillset Development: Investing in training for supply chain planners and analysts to understand and utilize the new ML/AI-driven forecasting capabilities.
- Process Redesign: Adapting existing forecasting and planning processes to leverage the automated and intelligent capabilities of SAP CAR UDF.

6.5. Master Data Governance:
- Robust master data governance (MDG) is essential to ensure the consistency and quality of product, location, and hierarchy data, which directly impacts forecast accuracy. This includes maintaining article hierarchy in SAP S/4 HANA and location hierarchy in CAR.

6.6. Phased Rollout:
- Consider a phased implementation approach, starting with high-priority product categories or regions to demonstrate value and gather learnings before a full-scale rollout.

7. Conclusion
The convergence of SAP CAR with Machine Learning, Predictive Analysis, and AI represents a paradigm shift in retail demand forecasting. By moving beyond traditional statistical methods, retailers can harness the power of their vast data assets to generate highly accurate, granular, and adaptive forecasts. This not only optimizes inventory and reduces costs

but also significantly enhances customer satisfaction and overall business agility. The journey to unified demand forecasting in SAP CAR is an investment in the future of retail. While it requires a commitment to data quality, technological adoption, and organizational change, the profound benefits in terms of profitability, efficiency, and competitive advantage make it an indispensable strategic initiative for any forward-thinking retailer. By embracing these advanced capabilities within SAP CAR, businesses can truly revolutionize their supply chain and unlock their full potential in the evolving retail landscape.

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