Forecasting module

Documentation

V3.0

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1. Introduction

This document describes the forecasting module of frePPLe.

This module support the calculation of forecasted demand, their management and review of these values by planners and sales people, and the pre-processing of the forecast.

1. Functional overview

A forecasting process typically consists of the following sub processes.

1. Data loading
2. History correction
3. Baseline forecast generation
4. Forecast review and editing
5. Forecast profiling
6. Forecast consumption

a. Data loading

In a first step the input data are loaded into the frePPLe database. The key input consists of the following data elements:

- Items and their hierarchy.
- Customers and their hierarchy.
- Forecast, which defines a combination of a customer and an item where forecast calculations are stored and performed.
- Historical demand history

In most implementations these data elements are all loaded automatically through data interfaces from external systems. No manual intervention by the planner is then required for this step.

b. History correction

The demand history may contain some exception, one-off demands which are often called “demand outliers”. In order to avoid that such demand influence the calculation of the statistical forecast in the next step too much, the planner should review the recent demand buckets for such exceptional demands and correct them.

Here are some typical situations where such corrections are required:

- Exceptional demands, aka outliers
- Product revisions, sku1 -> sku2 -> sku3

Note that the calculation of the baseline forecast has a built-in threshold correction for demand outliers. This feature takes care of some demand outliers which weren’t corrected by the planner, but can never achieve the same quality as review and analysis by the planner.

c. Baseline forecast generation

In this step the system will apply statistical techniques on the demand history and extrapolate it into the future buckets. This generates automatically a **baseline forecast**.

These calculations are fully automated, and no planner intervention is required in this step.

The following time series forecasting techniques are implemented:

- **Moving average – constant forecast**
  This methods uses the average of the last N buckets as the forecast for each future period.
  FrePPLe will automatically use this technique if the time series doesn’t contain enough values to apply any of the techniques that follow.
- **Single exponential smoothing – constant forecast**
  This technique assigns exponentially decreasing weight on the previous demand

buckets: the most recent time bucket gets weight 1-α, the bucket before $(1-\alpha)^2$, the bucket before $(1-\alpha)^3$, and so on. The average of this weighted demand in these buckets is used as the forecast for each future period.
FrePPLe will automatically select the value of the parameter α to achieve the lowest deviation between the forecast and actual demand.

- **Double exponential smoothing – trending forecast**
  This method is similar to the previous one, but also computes a trending component.
  The algorithm will automatically tune the constant α and trend β parameters of this forecasting method to minimize the forecast error.

- **Holt-Winters multiplicative triple exponential smoothing – seasonal demand**
  FrePPLe performs a covariance check to detect seasonal patterns for each of the cycle lengths in the configured range.
  When a seasonal pattern is detected and sufficient historical data are available, frePPLe computes a forecast with the Holt-Winters multiplicative seasonal method. The constant α and trend β parameters are automatically tuned to minimize the forecast error. The seasonal parameter γ is fixed.

- **Croston's method – intermittent demand**
  Croston's forecast method will be used by frePPLe when the intermittence (ie the percentage of time buckets without demand) exceeds the configured threshold. The other methods, except from moving average, are then excluded.
  The algorithm will automatically tune the parameter α in the configured range to mimimize the forecast error.

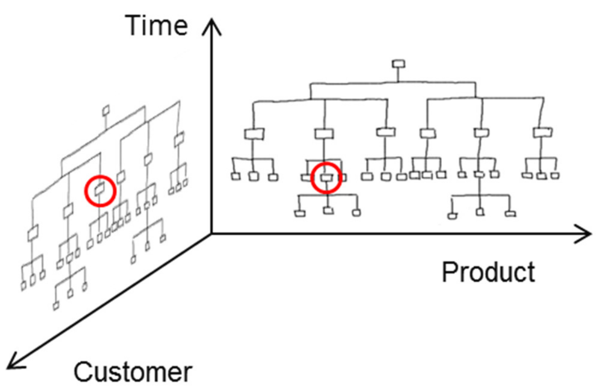
Each of these techniques is evaluated. The method which gives the lowest forecast error is automatically chosen to compute the baseline forecast. This evaluation is based on the symmetric mean percentage forecast error (SMAPE), where the forecast error in recent buckets is weighted more than the forecast error in older buckets.

d. Forecast review

The forecast calculation in the previous step was fully automated. In this step users will review these numbers and apply their extra knowledge about the expected demand.

The review and correction of the forecast can happen at any level in the item and customer hierarchy. A sales manager might for instance be interested to review the forecast aggregated for all products by quarter in his region. A planner might want to review the forecast of each product in each month aggregated for all customers. The general manager will surely be interested in the total forecast across all items and all customers.

The forecast obtained at the end of this step is the **final forecast** that will be used for planning. The next 2 steps are automated calculations that bring the final forecast in a better structure for planning.



e. Forecast profiling

Forecasting can happen in coarser time buckets than required for planning. For instance the sales people could forecast in monthly buckets. Such monthly buckets might not too inaccurate for planning the production. In such cases the forecast for the month can be profiled into weekly buckets, according to some predefined weights.

The forecast profiling is an automated process, running at the start of the supply planning.

f. Forecast consumption

This step will subtract the orders already received from the total forecast. This is required to avoid double-counting the same demand.

The **net forecast** generated by this process is used as an extra demand stream by frePPLe's planning algorithm.

The logic is illustrated in this example:

- Input:
    - Net the customer orders from the gross forecast:
        - Gross forecast: 100
        - Orders already received: 20
- Output:
    - The demand to be planned consists of:
        - Net forecast: 80
        - Orders already received: 20

FrePPLe's netting algorithm can search previous and later time buckets, higher levels forecasts in the item hierarchy and higher levels in the customer hierarchy.

The forecast consumption is an automated process, running at the start of the supply planning.

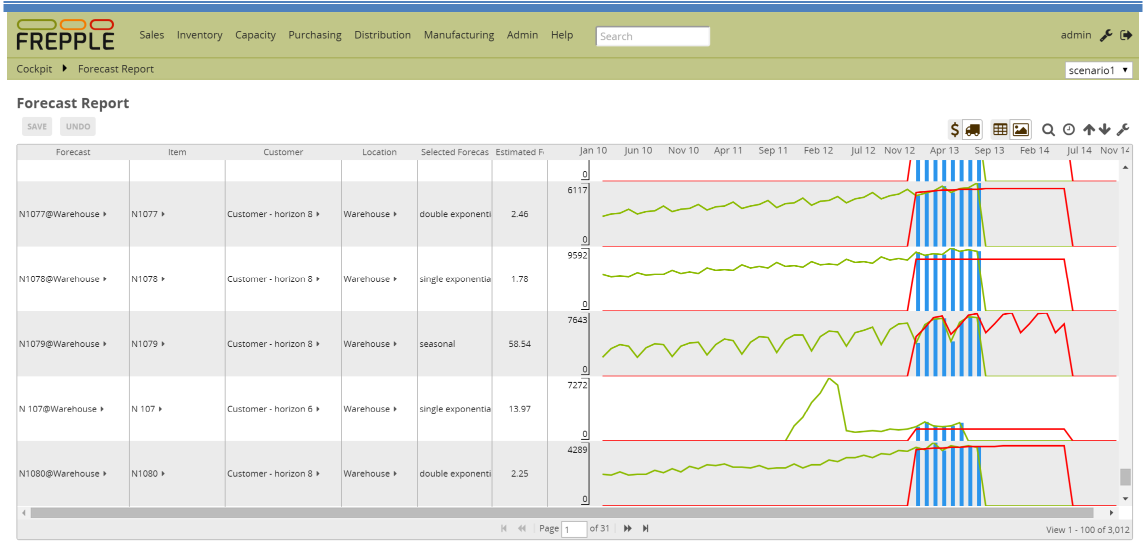
2. User guide

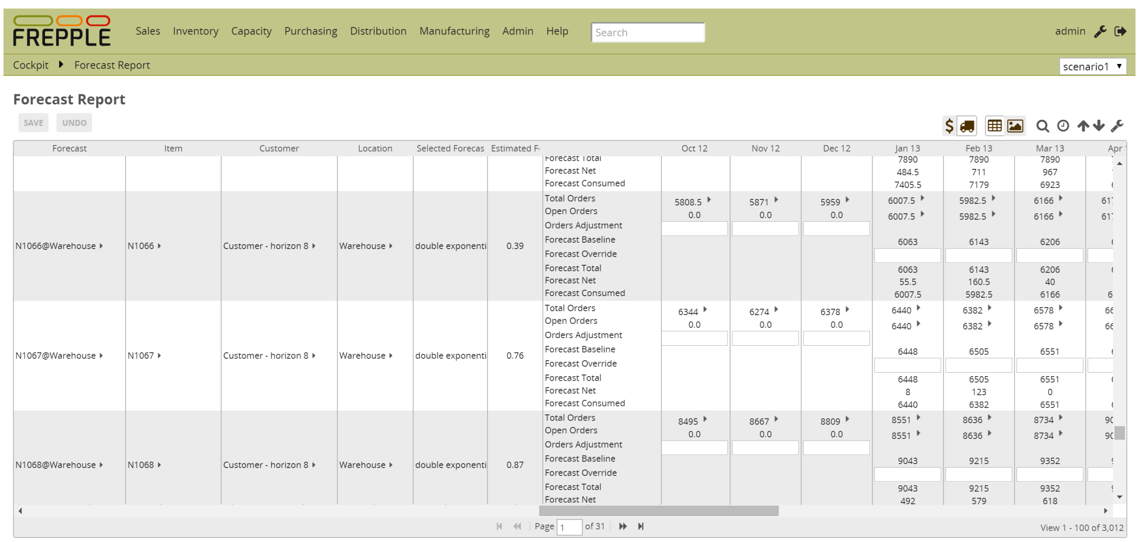
Two screens can be used to edit and review the forecast values

- Forecast report
- Distribution planning screen

a. Forecast report

The forecast screen is the screen supporting all of the process steps described in the previous section.





It shows the following data rows. Each row can be displayed in units or in value.

- **Orders total**
  This is a read-only row that is computed as the quantity available in the demand table.
- **Orders open**
  This is a read-only row that is computed from the data available in the demand table.
- **Orders planned**
  This row show how much of the order book has been met.
- **Orders adjustment**

This row can be updated by the planner to correct demand outliers.

- **Forecast baseline**
  This output row is the automatically computed forecast value by the system.
- **Forecast adjustment**
  In this row the planner can enter adjustments to the baseline forecast.
- **Forecast total**
  This is the sum of the forecast baseline and the adjustment.
- **Forecast consumed**
  This row shows how much of the forecast has been consumed by the order book.
- **Forecast net**
  This is the result of the forecast consumption. It represents the total forecast minus the demand that has already realized as customer orders.
  The sum of the rows “forecast consumed” and “forecast net” will always match the “total forecast” row.
- **Forecast planned**
  In this row the planner can enter adjustments to the baseline forecast.

b. Distribution planning screen

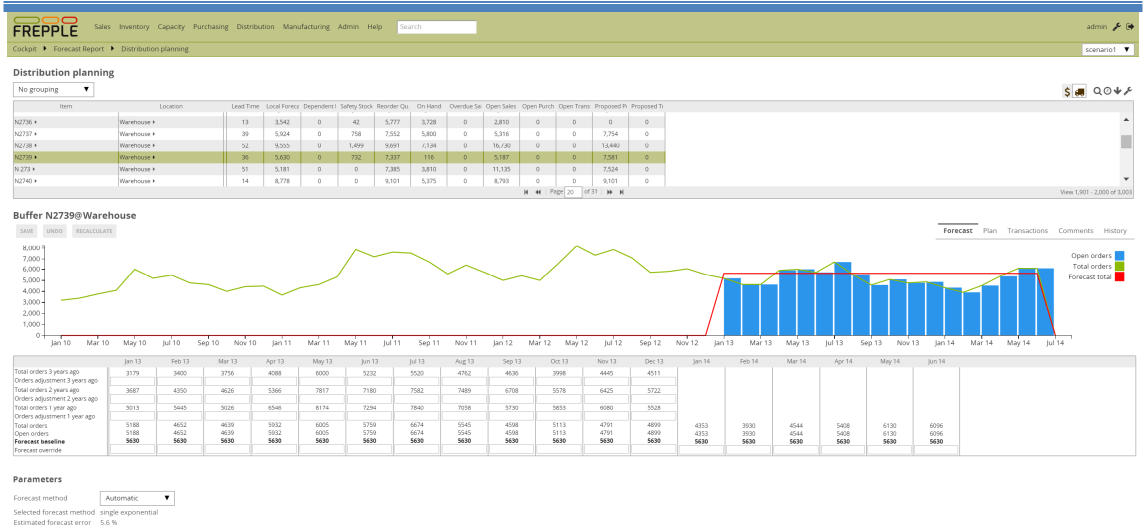
The distribution planning screen offers an integrated to review and update forecast and inventory planning parameters. In distribution intensive industries this is a main screen in the planner’s workflows.

The top part of the screen allows sorting and filtering on all item-location combinations. When selecting a row in the displayed list, the details are displayed in the bottom section.

The bottom section has different tabs. In the forecast tab, the planner can:

- Apply corrections to the historical demand.
- Override the forecasted value in future time buckets.
- Change the forecast method.

After a change you can hit the “recalculate” button to review the impact of the change. Once you’re confident with the change, you hit the “save” button to store the changes in the database.



3. Modelling and configuration

a. Input table Forecast

This table defines the item and customer combinations where either a) forecast is computed or b) aggregated forecast data is stored.

b. Input table ForecastDemand

This table is used for customers uploading forecast values that have been externally generated. Data loaded in this table will be merged into the internal frePPLe tables to store the forecast data, and after this merge the forecastdemand table is emptied.

Usage of this table is deprecated. It will be removed in a future release.

c. Output table ForecastPlan

This table stores all forecast results, both in quantity and in value.

d. Forecasting parameters

Forecast consumption

Net_CustomerThenItemHierarchy	1	This flag allows us to control whether we first search the customer

		hierarchy and then the item hierarchy, or the other way around.
Net_MatchUsingDeliveryOperation	1	Specifies whether or not a demand and a forecast require to have the same delivery operation to be a match.
Net_NetEarly	0	Defines how much time before the due date of an order we are allowed to search for a forecast bucket to net from.
Net_NetLate	0	Defines how much time after the due date of an order we are allowed to search for a forecast bucket to net from.

Constant forecast - Single exponential smoothing

Parameter	Default	Description
SingleExponential_initialAlfa	0.2	Initial smoothing constant.
SingleExponential_maxAlfa	1.0	Maximum smoothing constant.
SingleExponential_minAlfa	0.03	Minimum smoothing constant.

Constant forecast – moving average

Parameter	Default	Description
MovingAverage_order	5	This parameter controls the number of buckets to be averaged by the moving average forecast method.

Intermittent demand – Croston

Parameter	Default	Description
Croston_initialAlfa	0.1	Initial parameter for the Croston forecast method.
Croston_maxAlfa	1.0	Maximum parameter for the Croston forecast method.
Croston_minAlfa	0.03	Minimum parameter for the Croston forecast method.
Croston_minIntermittence	0.33	Minimum intermittence (defined as the percentage of zero demand buckets) before the Croston method is applied.

Trending forecast – double exponential smoothing

Parameter	Default	Description
DoubleExponential_dampenTrend	0.8	Dampening factor applied to the trend in future periods.
DoubleExponential_initialAlfa	0.2	Initial smoothing constant.
DoubleExponential_initialGamma	0.2	Initial trend smoothing constant.
DoubleExponential_maxAlfa	1.0	Maximum smoothing constant.
DoubleExponential_maxGamma	1.0	Maximum trend smoothing constant.
DoubleExponential_minAlfa	0.02	Minimum smoothing constant.
DoubleExponential_minGamma	0.05	Minimum trend smoothing constant.

Seasonal forecast – Holt-winters multiplicative method

Parameter	Default	Description
Seasonal_dampenTrend	0.8	Dampening factor applied to the trend in future periods.
Seasonal_gamma	0.05	Value of the seasonal parameter
Seasonal_initialAlfa	0.2	Initial value for the constant parameter
Seasonal_initialBeta	0.2	Initial value for the trend parameter
Seasonal_maxAlfa	1.0	Maximum value for the constant parameter
Seasonal_maxBeta	1.0	Maximum value for the trend parameter
Seasonal_maxPeriod	14	Maximum seasonal cycle to be checked.
Seasonal_minAlfa	0.02	Minimum value for the constant parameter
Seasonal_minBeta	0.2	Initial value for the trend parameter
Seasonal_minPeriod	2	Minimum seasonal cycle to be checked.

Overall parameters

Parameter	Default	Description
Calendar		Specifies the number of time series values used to initialize the forecasting method. The forecast error in these bucket isn't counted.
Skip	0	Specifies the number of time series

		values used to initialize the forecasting method. The forecast error in these bucket isn't counted.
SmapeAlfa	0.95	Specifies how the sMAPE forecast error is weighted for different time buckets.
DueAtEndOfBucket	1	By setting this flag to true, the forecast will be due at the end of the forecast bucket.
Horizon_future	365	Specifies the number of days in the future we generate a forecast for.
Horizon_history	10000	Specifies the number of days in the past we use to compute a statistical forecast.
Iterations	15	Specifies the maximum number of iterations allowed for a forecast method to tune its parameters.
loglevel	0	Verbosity of the forecast solver. Values are 0 (silent) through 4 (verbose debugging).
Outlier_maxDeviation	2	Multiple of the standard deviation used to detect and trim outliers.