Oracle Reorder Point and Min-max Planning: Based on Outdated Concepts?

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0 Summary
The Inventory module of Oracle Applications Release 10.7 supports only 2 planning methods for independent demand: Reorder Point and Min-max planning. In the following both methods are evaluated from the viewpoint of a non-manufacturing (importer, wholesaler, distributor, retailer, etc.) environment. The functional limitations of such traditional approaches will be explained and compared with more progressive or trendy concepts such as Distribution Requirements Planning and Just-In-Time delivery. Kanban replenishment, a new functionality in Release 11, is not covered, because it is mainly a means of supporting pull-based inventory replenishment in manufacturing systems.

1 Reorder Point Planning

Reorder Point planning and its derivatives have been around since 1934, see [4], p. 40. A continuous review of inventories is always assumed. A fixed order quantity is usually suggested by the system whenever the inventory position drops to the reorder point or lower. Note that the inventory position includes on-hand and on-order stock (= planned receipts).

The Reorder Point (also known as *reorder level*) is equal to the safety stock plus the expected average sales (or usage) quantity within the replenishment lead time. From a physical standpoint, these two types of inventory levels are not separated. Safety stock, also referred to as *buffer stock*, is used to protect against the random fluctuations in demand and/or supply. It makes up inventory held to protect against forecast errors, changes in customer's orders, quality defects, or late shipments from the supplier of an inventory item. A graphical illustration (the traditional *saw-tooth diagram*) and a mathematical treatment of the system and its derivatives are provided in [7].

Reorder Point planning is equivalent to a common visual review system called *two-bin system.* This method uses two physical storage locations with stock of the same item. When one bin becomes empty, a replenishment order is placed to refill it while demand is filled from the second bin.

Reorder Point planning regards replenishment quantity as the main cost driver. But frequently the number of purchase order lines during the planning horizon is considered to be a more appropriate measure for cost behaviour, see [8], p. 87. Other weak points are related to rather strict assumptions needed to derive the basic mathematical model(s) for Reorder Point planning. The standard assumptions for Reorder Point planning are listed in the following:

- Inventory items are treated *entirely independent* of others, that is, possible benefits from joint reorder planning (as described in section 3, see below) are ignored or do not exist
- Planning horizon is rather long, usually 1 year
- Total sales (or usage) during the planning horizon is constant
- Demand rate is deterministic with constant mean and stable variability, that is, the item is in the mature stage of its life cycle
- Total demand can be fully covered, that is, no shortages are allowed
- Replenishment lead time is constant, that is, of zero or nonzero duration
- Inventory carrying costs per unit per year do not depend on the replenishment quantity, that is, semi-variable or semi-fixed (= stepped) costs do not occur by definition
- Acquisition cost per unit does not depend on order quantity, that is, quantity discounts for larger orders on unit purchase price and/or unit transportation cost are neglected
- Withdrawals from inventory take place in rather small quantities, that is, crossing of the Reorder Point can be recognised in time
- Purchase orders for inventory replenishment can be issued at any time, that is, no time and no quantity restrictions exist with respect to the reorder quantity

- The (suggested) purchase order quantity need not be an integer number of units, that is, there are no upper or lower limits as well as rounding rules on its size
- The entire purchase order quantity is delivered at the same time, that is, no partial shipments are allowed
- Permanent monitoring of the Reorder Point is mandatory , that is, a continuous stock-taking sub-system is required in practice for a continuous review system with or without manual override capability with respect to reorder quantity

Most of the standard assumptions listed above are also relevant for Oracle Reorder Point planning, but are not explicitly and completely mentioned in corresponding Inventory Reference Manual, see [5]. Knowing them precisely makes the assessment of applicability much easier for special categories of inventory items, for example:

- perishable, exquisite, style, and fashion items
- items with rapidly changing demand rate
- items subject to volume discounts and freight restrictions
- new and discontinued items
- extremely seasonal items
- high-value items
- damaged, obsolete, used and otherwise deteriorated items
- rare items which are difficult to replace
- heavy and bulky items (where drop-shipment is frequently more cost-effective than stocking; besides, drop-shipment of sales orders is a new function in Release 11.)

Oracle Reorder Point planning is intentionally not a completely automated system which allows no human intervention. It is generating replenishment proposals referred to as *purchase requisitions* using the so-called *Economic Order Quantity* (usually abbreviated as EOQ) and the safety stock as central inventory control parameters. Oracle offers only 3 options for calculation of safety stock for each item, see [5], p. 9-282:

- Manually entered safety stock quantities and the date for which each quantity is effective
- Percentage of forecasted demand for the item
- Service level and MAD. Service level represents the probability that a customer order can be filled from available inventory. MAD represents the mean absolute deviation of forecast errors. Safety stock quantity is calculated using an equation based on described input parameters.

Decision on safety stock is important, because in large measure, safety stock determines customer service level and total inventory investment. The more difficult an item is to predict, the more safety stock is allocated through Reorder Point logic. Since most forecast errors occur in slow-moving items, an inventory policy that bases safety stock on forecast error is wrong, see [8], p. 75. Allocating a fixed total safety stock investment among all items of an assortment to minimise

- either expected total stockout occasions per year
- or expected total value of shortages per year

are much smarter strategies, see [7], p. 246. *Such aggregate considerations in fact devalue the concept of the Reorder Point planning with safety stock calculated for individual items.*

Oracle Reorder Point planning uses inventory forecasting information to calculate average demand. Two *naive* forecasting methods are available based on historical item usage: *Statistical forecasting* and *Focus forecasting*, see [5], p. 9-297, also [8] and [9].

Oracle Reorder Point planning creates *purchase requisitions* for all items that meet the reorder condition optionally constrained by minimum and maximum order quantities as well as a fixed lot size multiplier, see [5], p. 9-285.

Oracle Reorder Point planning calculates the Reorder Point (comprising safety stock) independent of EOQ, although efficient algorithms have been published for simultaneous calculation of both decision variables, for example see [6], p. 728 and [10], p. 291. Simultaneous calculation usually results in lower total cost in a pre-specified planning horizon.

Oracle Reorder Point planning does not consider possible price breaks and volume freight discounts when calculating the EOQ.

Oracle Reorder Point planning is based on the assumption that replenishment lead time is constant. More advanced models treat replenishment lead time as a probabilistic variable following a normal, gamma, uniform, or other distribution. Generally a more realistic Reorder Point quantity will be achieved.

When Oracle Reorder Point planning is used to calculate purchase requisitions, open customer orders are ignored. You could run corresponding planning report and miss items of which you have insufficient quantity to cover an open customer order. If the inventory position is not below Reorder Point, the item will not appear on the planning report at all. You can also have an item with an inventory position below the order point, and a large open sales order, but the suggested fixed order quantity is only sufficient to cover the independent demand forecast. If you convert these suggested quantities directly into purchase requisitions you will again be short, see [1], p. 2.

Another problem inherent in Oracle Reorder Point planning is related to visibility and comprehensibility. There are no Reorder Point or order quantity levels visible in the system anywhere. You must run the corresponding planning report to see these levels. At the same time, suggested order quantities are not exactly reproducible, see [1], p 2.

2 Min-max Planning

Besides Reorder Point planning Oracle Inventory covers Min-max planning. This approach again assumes continuous review of inventory levels. It is a planning method where the minimum is the reorder point and the maximum is the level the inventory is not to exceed. Order quantity is variable and is calculated by subtracting the inventory position (= on-hand quantity plus on-order quantity) from the maximum inventory level. When the result falls below the minimum quantity a reorder quantity up to maximum stock is suggested. The corresponding lot-sizing method is usually called *replenishment to maximum stock.*

The Min-max system is commonly used for low volume items (so-called "C" parts of an ABC inventory analysis). The main advantage of this system is its simplicity. A possible disadvantage is the variable order quantity. A graphical illustration and a mathematical treatment of the Min-max system and its derivatives are provided in [7].

In case of unit-sized withdrawals from stock, Reorder Point and Min-max planning are equivalent, that is, resulting in the same reorder quantity. Most of the standard assumptions for continuous review inventory systems therefore also apply to Min-Max planning, see section 1.

Oracle Min-Max planning does not take into account forecast demand during replenishment lead time when calculating the replenishment quantity, see [5], p. 9-280.

Oracle Min-Max replenishment quantity recommendations take order modifiers into account. This may change the initial order size calculated by the system , see [5], p. 9-280.

The major problem with present Oracle Min-max planning is that the minimum and maximum levels must be maintained manually by the users, see [1], p 1. This is very labour intensive when planning comprises many independent demand items and the system cannot react effectively to changing conditions. To counteract this, inventory managers may tend to maintain high minimum quantities to cover random usage fluctuations. Errors in the levels are often not discovered until the inventory is dangerously low or until a physical count (or cycle count) reveals inventory in excess. This type of manually maintained system is not at all acceptable from both, a manufacturing and non-manufacturing point of view.

3 Periodic Review System

In a periodic review system derivative usually called *Topping-up* system every T units of time a replenishment order is placed to raise the inventory position to the order-up-to-level S. The value of T is usually pre-specified and often dictated by external factors, such as frequency of full truckload shipment opportunities. The order-up-to-level S must be sufficient to cover demand through a disposition period of duration T + L. Figure 1 shows essential details of the Topping-up system.

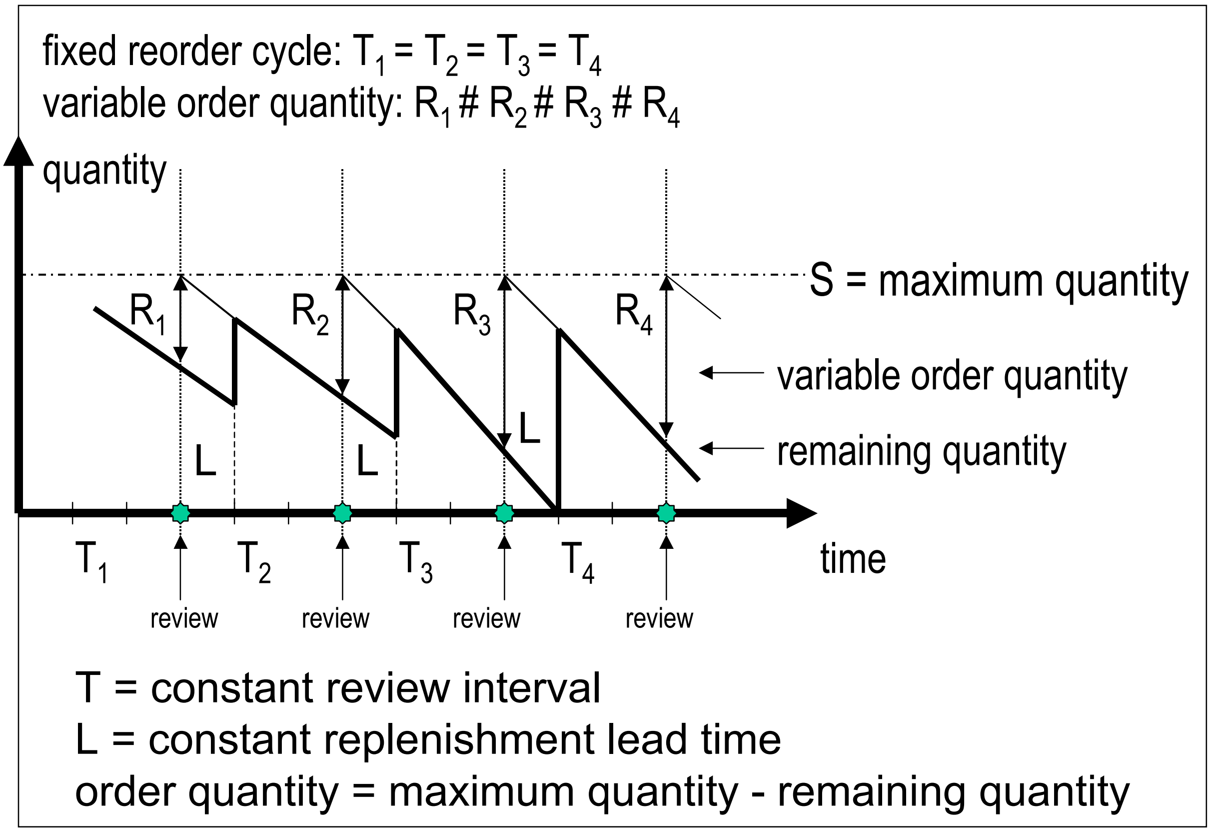

Figure 1: Periodic Review System: Illustration of the Topping-up System

The amount of safety stock carried for an inventory item in a periodic review system depends on the variability of demand (forecast error) and the desired level of one-time shipments.

The Topping-up system is used rather frequently in trading businesses where relatively short delivery times can be achieved by means of co-ordinated replenishment from a central distribution warehouse. The main disadvantage of the Topping-up system is that the inventory carrying costs are higher than in comparable continuous review systems.

Presently Oracle Inventory does not support any periodic review system (also called *fixed reorder cycle system*) and corresponding derivatives such as the briefly described *Topping-up* system.

4 Joint Reorder Planning

Joint replenishment usually happens when items kept in the same inventory are ordered from one supplier. A joint purchase order comprises several inventory items to obtain volume and/or transportation discounts. Some of the benefits achieved from joint replenishment of purchased inventory items in these situations are listed in below:

- Transportation economies (for example, full truck load shipments)
- Reduced costs for sending purchase orders to suppliers
- Trade discounts based on order value and/or order quantity
- Accounts payables efficiencies achieved through reduction in paperwork

For manufactured items analogous benefits can be achieved.

A prerequisite for joint reorder planning is a periodic review system, see previous section. Corresponding inventory approach places purchase orders on a predetermined time schedule (daily, weekly, monthly, etc.). The actual purchase order quantity will vary from order to order based on how many units have been issued.

At present Oracle Inventory does not support replenishment planning methods based on periodic review of inventory levels, although joint reorder planning is an attractive approach for some trading businesses.

5 Combination of continuous and periodic review system

Combining the logic of Reorder Point planning with the logic of a periodic review system is possible in theory and practice. In addition to cyclic reordering, such a system will automatically generate a replenishment proposal as soon as the inventory position falls below the Reorder Point level. If this happens the system calculates the interval that starts from the point in time that the inventory position falls below the Reorder Point up to the availability date of the next regular planning run. This is used for the net requirements calculation. Suggested purchase order quantity must cover this time span. At the following regular planning date corresponding item is planned as usual.

It has been shown that, under fairly general assumptions concerning demand pattern and cost factors involved, the described system produces lower total costs than any other. However, the computational effort to obtain the best values of the three inventory control parameters,

- minimum stock level,
- maximum stock level, and
- review time

is more intense, see [7], p. 241. The system is therefore most suitable for so-called "A" items of an ABC inventory analysis.

Oracle Inventory does not support a combination of continuous and periodic replenishment planning for independent demand. Some competitive business software packages have this capability, for example SAP R/3.

6 Time-Phased Order Point Planning

This approach has been derived from well-known Material Requirements Planning (MRP) logic as a means to determine when inventory replenishment orders must be placed to ensure a continuous supply of goods.

Scheduled customer orders, demand forecasts or a combination of both are used to determine gross requirements at regular intervals for an item. Gross requirements represent the total demand for an item prior to accounting for corresponding quantity on hand and quantity on order (= scheduled to be received). The period split (day, week, month, etc.) for schedules and/or forecasts and the number of periods included in the schedules and/or forecasts is usually specified individually for each item, in other words, periods to be considered during requirements planning are determined by the user. The gross requirements quantities are used in the planning process to calculate net requirements for every period as follows:

- Gross requirements
- *minus* projected available on hand inventory (= quantity physically in stock)
- *plus* scheduled receipts (= orders released to supply sources in a prior planning period)
- *equals* net requirement

When there is a net requirement, then an order proposal is generated. The quantity stated in the order recommendation is calculated by the system according to a predetermined lot-sizing method. Depending on the method selected several net requirements quantities are pooled into one order quantity.

The replenishment lead-time offset is established by determining when an item is needed to satisfy a net requirement. This allows the system to schedule a planned order receipt in one time period and the planned order release in a prior time period. The time span between these two dates is the required lead time. Therefore, a planned order release includes a release date and a due date. The planned order release results in one or more purchase orders which are transmitted to suppliers. Of course, a supplier can only ship the ordered quantity punctually if he gets corresponding purchase order on time. Planned replenishment orders exist only within the system and can be modified or cancelled during subsequent planning runs if conditions change.

A simple numerical example for time-phased order point planning is shown below using the constants and variables listed in table 1.

Symbol	**Meaning**	**Dimension**	**Value**
	Variables		
t_{actual}	actual coverage date	business calendar date	to be calculated
$t_{planned}$	planned coverage date	business calendar date	to be calculated
$t_{arrival}$	requested arrival date	business calendar date	to be calculated
	Constants		
$t_{calendar}$	present planning date	business calendar date	100
T_{period}	length of planning period	workdays	10
$T_{delivery}$	delivery lead time	workdays	25
$T_{inspection}$	incoming goods inspection time	workdays	10
T_{safety}	safety stock time	workdays	5

Table 1: Meaning of symbols, variables, and given parameters for coverage calculation

10 workdays per planning period are assumed, see table 1. Available stock covers 4,5 periods, see table 2. Consequently 45 workdays are covered. Present date of the business calendar equals 100. Accordingly actual range of coverage date equals 100 + 45, that is, t_{actual} = 145.

planning period	P_1	P_2	P_3	P_4	P_5
projected available	1500	1200	1000	700	200
- forecast demand	300	200	300	500	400
= net requirements	1200	1000	700	200	-200

Table 2: Relevant quantities subdivided by planning periods

Expected total replenishment lead time equals 50 workdays, see table 1. Accordingly planned range of coverage date equals 100 + 50, that is, $t_{planned}$ = 150, see table 3.

$t_{calendar}$	$+ T_{period}$	$+ T_{delivery}$	$+ T_{inspection}$	$+ T_{safety}$	$= t_{planned}$
100	+ 10	+ 25	+ 10	+ 5	= 150

Table 3: Formula for calculation of $t_{planned}$

If $t_{actual} < t_{planned}$ a purchase order must be issued. This reorder condition is met because 145 < 150. Requested arrival date $t_{arrival}$ for the purchase order is calculated as follows:

t_{actual}	$- T_{inspection}$	$- T_{safety}$	$= t_{arrival}$
145	- 10	- 5	= 130

Table 4: Formula for calculation of $t_{arrival}$

Hence time-phased order point planning is a method that schedules each independent demand item to arrive at the proper point in time (that is, Just-In-Time) at the warehouse.

Order size is determined by making use of an appropriate lot-sizing method, for example periods of supply. This method establishes, primarily through experience, an order quantity that will cover a pre-specified period of time. Thus EOQ calculation can be replaced by shipments totalling multiple periods of actual and/or forecasted demand.

Presently Oracle Inventory does not support time-phased order point planning. This in turn means, that time-phased inventory planning can not be combined with dynamic lot-sizing methods such as the following:

- periods of supply
- period order quantity
- lot-for-lot
- part period balancing
- least unit cost
- least total cost

Lot-sizing methods for individual items with time-varying demand are further detailed in [7], p. 198.

7 Distribution Requirements Planning

Time-phased order point planning is closely related to Distribution Requirements Planning (DRP). In the mid seventies this planning method appeared on the scene to assist with problems related to physical distribution, see [4], p. 41. DRP involves meeting customer requirements and receiving and storing goods at the lowest cost possible for a pre-specified planning horizon.

Distribution Resource Planning is a scheduling system that extends DRP into the planning of key resources contained in a distribution system such as warehouse space, warehouse workforce, investment into inventory, and transportation capacity.

Distribution systems are usually classified as being either a push or a pull system. A push system moves the inventory from a central source of supply out to the field warehouses. Thus replenishment decisions are made centrally, based on forecasted and/or actual demand. This is in contrast to a pull system where replenishment decisions are made at the field warehouses. *DRP is most frequently used in conjunction with a push system of distribution inventory planning and control where all levels of the distribution system are owned by the same company.*

A significant number of trading companies who serve customers through a distribution network have substituted Reorder Point respectively Min-max planning in favour of DRP where emphasis is on order timing and quantity methods.

Oracle Inventory is suitable for representation of a company's inventory sites and business units as well as corresponding physical and logical units. In other words, definition of distribution structures can be defined without considerable restrictions. This is also true for inter-inventory transfer transactions within a distribution network.

- DRP (as needed for a push distribution system) is presently not completely available within the functional scope of the Oracle Inventory module.
- Oracle Reorder Point or Min-max inventory planning can be utilised for the purpose of a pull distribution system. But small customisations may be necessary for particular distribution networks, see practical case study outlined in [1].

8 Conclusions

From the perspective of trading businesses continuous review systems such as Oracle Reorder Point and Min-max planning are not old-fashioned. But their successful application heavily depends on the goodness of fit between the inventory planning model (and its underlying assumptions) on the one side and business reality on the other. For particular inventory item categories and non-linear cost behaviour (due to price breaks, freight restrictions, and the like) derivatives of the basic planning models are desirable.

Oracle Inventory does not support a wide choice of inventory planning models for independent demand. The ones available deserve some enhancements. The choice of lot-sizing methods is limited to EOQ and replenishment up to maximum stock level. But as more models and methods can be selected the approximation to business reality will improve.

More progressive or trendy concepts suitable for distribution inventory planning and distribution channel integration (frequently referred to as *inter-corporate logistics*, *quick response*, *continuous replenishment*, *supply chain management*, *partnership in merchandise flow*, *just-in-time distribution*, and *stockless materials management*) are *not* an integral part of Oracle Inventory Release 10.7.

9 Remark

No claim concerning the completeness and correctness of the statements in this article can be made. They represent purely the author's own understanding of Oracle Inventory Release 10.7.

Several people contributed to this article in various ways. These include Russel Hougthon, Stephan Seltmann, and Ian D. Spencer. To them all go my heartfelt thanks.

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