# Operations Management I

## Material Requirement Planning

Dong-Ho Lee

Department of Industrial Engineering
Hanyang University

# Material Requirement Planning

Introduction
Inputs, Outputs, and Procedure
Further Considerations

- Developer and Extensions
- Key Insight
- Prerequisites
- Basic MRP Procedure

- Special Topics
- Problems

Hopp and Spearman, 2008, **Factory Physics**, McGraw Hill. **(Section 3.1)**
Krajewski and Ritzman, 2005, **Operations Management**, Prentice Hall. **(Chapter 16)**

# MRP

## Introduction

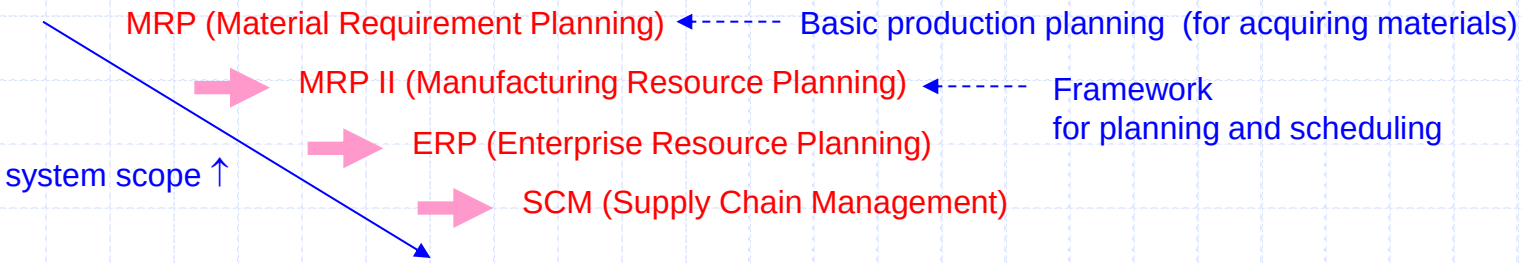
Developer and Extensions

- Developer
  - ✓ Josef Orlicky (IBM, early 1960s)

    Use of computer in production control

    → Tremendous boost in 1970s (MRP crusade)
    - ✓ APICS (American Production and Inventory Control Society)
    - ✓ Principal production control paradigm in the United States

- Extensions



# MRP

| | Independent demand | Dependent demand |
|---|---|---|
| Demand | Uncertain | Certain (relatively) |
| Estimation | Forecasting | Compute from independent demand |
| Methods | Inventory models | MRP |

## Introduction

Key Insight (1)

- Dependent demand inventory

  Raw materials, components, and subassemblies that are used in the production of the parent or the final products

  ✓ Prediction ← Concept of requirement (소요)
  (Material requirement plannng:MRP)

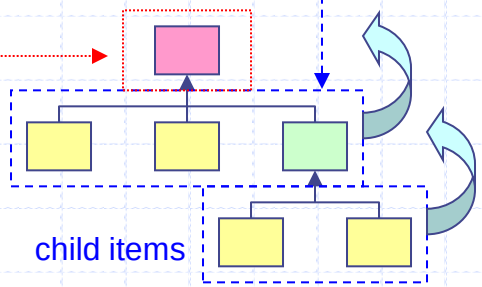
  e.g. demand of keyboards depends on the demand for computers

- Independent demand inventory

  Finished products, service parts, and other items whose demand arises more directly from uncertain market environment

  ✓ Forecasting ← Concept of replenishment (보충)
  (general inventory models)

  e.g. computers as final product



# MRP

## Introduction

Key Insight (2)

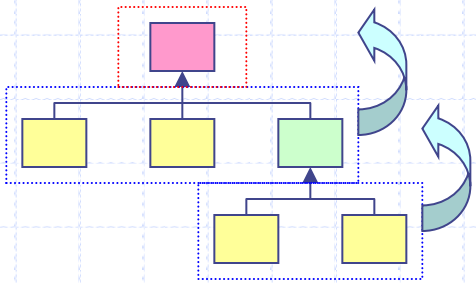
- Dependent and indepedent demands
  - ✓ MRP (Material Requirement Planning) ◄---- push system
    - ➢ Add the link between independent and dependent demand
    - ➢ MRP is used to coordinate orders from within the plant and from outside.

purchase orders

jobs

Two basic dimensions

- ➢ Timing
- ➢ Quantity

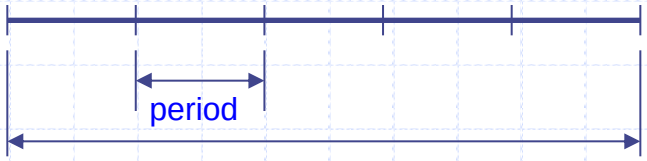


# MRP

## Introduction

Prerequisites (1)

Planning horizon and discrete time periods




- Bucket ◄----- period in the planning horizon

  Interval used to break time and demand into discrete chunks

  e.g. bucket length = 1 week (5 days)

  demand

| Mon | Tue | Wed | Thu | Fri |
|---|---|---|---|---|
| 250 | 300 | 200 | 100 | 150 |

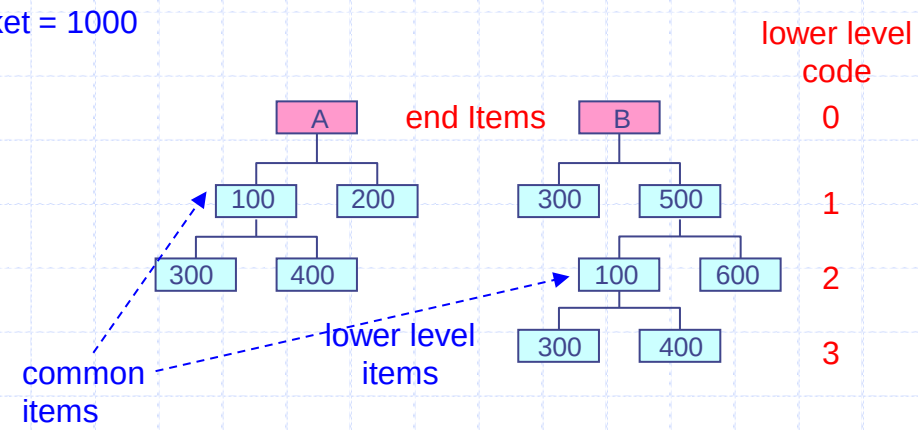
  demand of this bucket = 1000

- Bill of Material (BOM)

  Relationship between end items and lower level items

- Master Production Schedule (MPS)

  Information concerning independent demand (end-items)

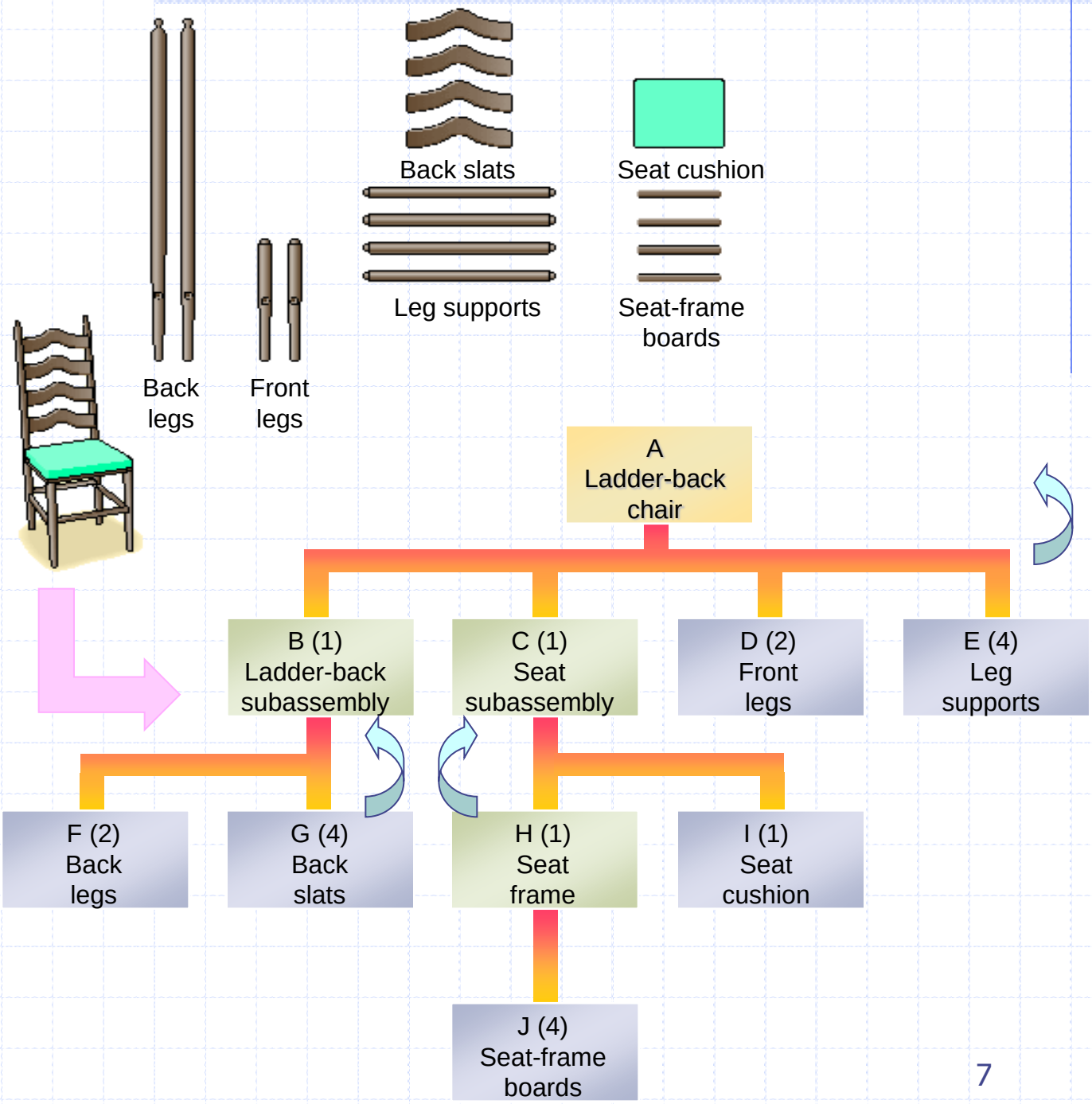


# MRP

- **Introduction**

  Prerequisites (2)

- Bill of Material (BOM)
  - Example



# MRP

## Introduction

Prerequisites (3)

- Master Production Schedule (MPS) – Example

| | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Ladder-back chair | 150 | | | | | 150 | | |
| Kitchen chair | | | | 120 | | | 120 | |
| Desk chair | | 200 | 200 | | 200 | | | 200 |
| Aggregate production plan for chair family | 670 | | | | 670 | | | |

# MRP

- End-items ← MPS
- Lower level items ← previous MRP operations

net requirement = {0, gross requirement – on-hand inventory – scheduled receipts}

## Introduction

Basic Procedure (1)

- Overview

For each level in the BOM, begining with end items, MRP does the following for each part

1) Netting

   Determine the net requirement

2) Lot sizing

   Divide the netted demand into appropriate lot sizes to form jobs

   - Wagner-Whitin algorithm
   - Lot-for-lot
   - Fixed order quantity (EOQ)
   - Fixed order period
   - Part-period balancing, etc.

3) Time Phasing

   Offset the due dates of the jobs with lead times to determine the start times

4) BOM explosion

   Generate gross requirements of any required components at the next level

# MRP

## Introduction

Basic Procedure (2)

- Example

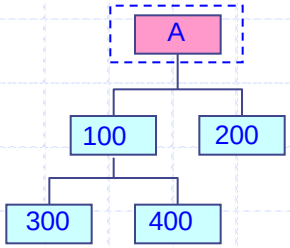
✓ Data

➢ Demand (planning horizon = 8 weeks) ◄---- master production schedule (MPS)

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |

➢ Initial on-hand inventory = 30 units
➢ No scheduled receipts
➢ Lot size = 75 units
➢ Lead time = 1 week

• Bill of material (BOM)




✓ Netting

Determine the net requirement (Initial on-hand inventory = 30 units)

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |
| Projected on-hand | 15 | -5 | | | | | | |
| **Net requirement** | **0** | **5** | **50** | **10** | **30** | **30** | **30** | **30** |

Projected on-hand
= on-hand inventory + scheduled receipts – gross requirement
= 30 + 0 – 15 = 15

Net requirement
= max { 0, gross requirement – on-hand inventory – scheduled receipts }
= max {0, 15 – 30 – 0} = 0

# MRP

## Introduction

Basic Procedure (3)

- Example

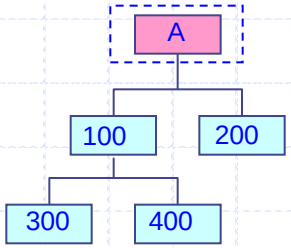
✓ Data

➢ Demand (planning horizon = 8 weeks) ◄---- master production schedule (MPS)

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |

➢ Initial on-hand inventory = 30 units
➢ No scheduled receipts
➢ Lot size = 75 units
➢ Lead time = 1 week

• Bill of material (BOM)




✓ Lot sizing (lot size = 75 units)

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross Requirements | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |
| Projected on-hand | 15 | -5 | | | | | | |
| Net requirements | 0 | 5 | 50 | 10 | 30 | 30 | 30 | 30 |
| **Planned order receipts** | | **75** | | | **75** | | **75** | |

75 = 5 + 50 + 10 + 10
20 units remain in period 5.

75 = 20 + 30 + 25
5 units remain in period 7.

# MRP

## Introduction

Basic Procedure (4)

- Example

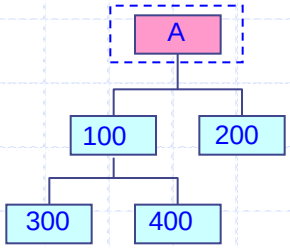
✓ Data

➢ Demand (planning horizon = 8 weeks) ⟵ master production schedule (MPS)

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |

➢ Initial on-hand inventory = 30 units
➢ No scheduled receipts
➢ Lot size = 75 units
➢ Lead time = 1 week

• Bill of material (BOM)



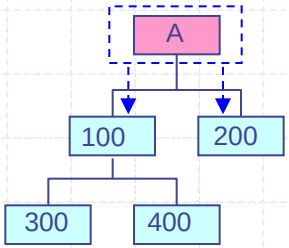

✓ Time Phasing

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross Requirements | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |
| Projected on-hand | 15 | –5 | | | | | | |
| Net requirements | 0 | 5 | 50 | 10 | 30 | 30 | 30 | 30 |
| Planned order receipts | | 75 | | | 75 | | 75 | |
| **Planned order releases** | **75** | | | **75** | | **75** | | |

lead time = 1 week

✓ BOM explosion

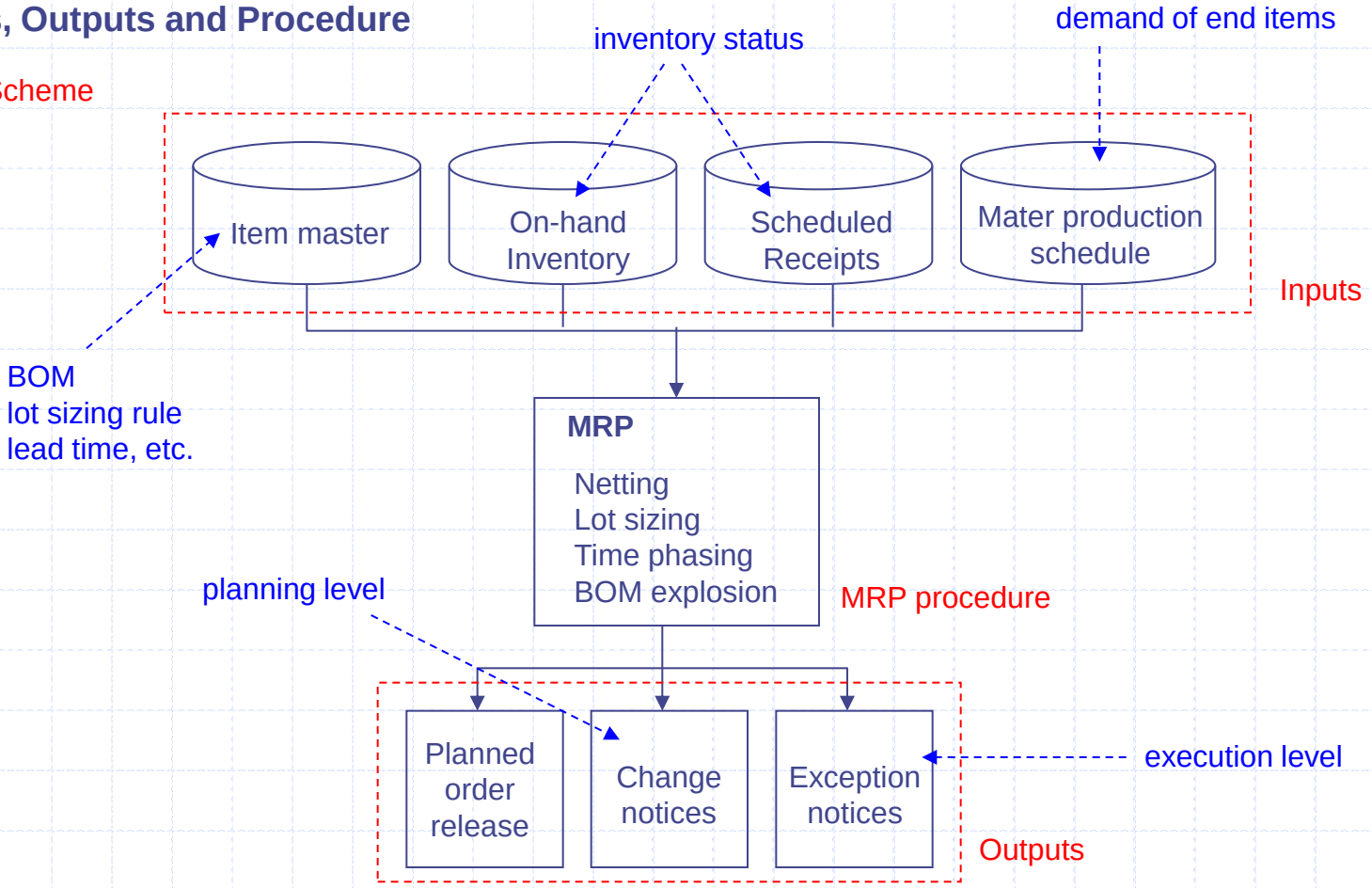
Generate gross requirements of items 100 and 200 (Items 300 and 400)



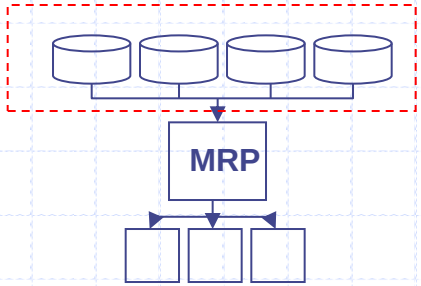
# MRP

- **Inputs, Outputs and Procedure**

Basic Scheme



# MRP




## Inputs, Outputs and Procedure

Inputs (1)

- Item Mater File
  - ✓ Description of part/product
  - ✓ Bill of material (BOM) data

    MRP accumulates all the demand of a part before it processes that part

  - ✓ Lot sizing rule (LSR)

    How the job will be sized?

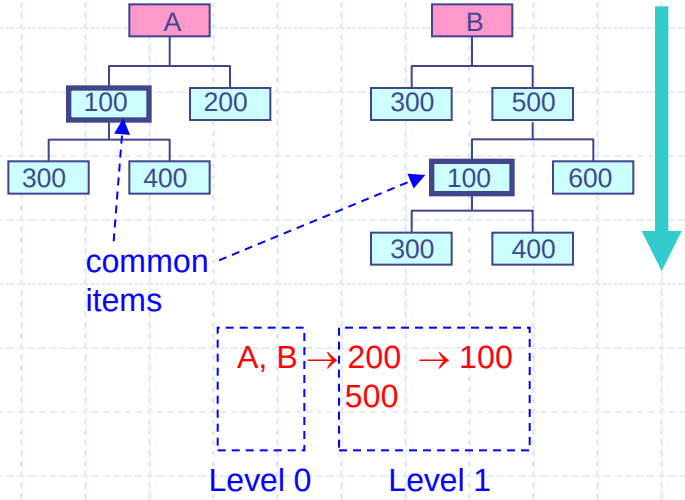
    balance the competing desires of reducing inventory (by using smaller lots) and increasing capacity (by using larger lots to avoid frequent setups)

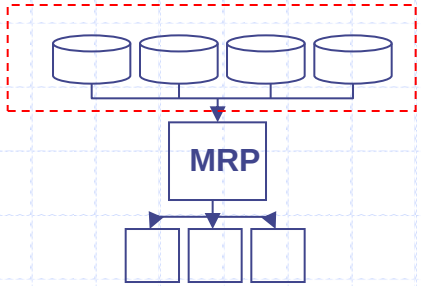
    e,g, EOQ, Wagner-Whitin, etc.

  - ✓ Planning lead time (PLT)

    PLT is used to determine job start times

    MRP – fixed (deterministic) ◄---------- Actual lead times vary and are never known in advance. (→ safety lead time)






# MRP

## Inputs, Outputs and Procedure

Inputs (2)

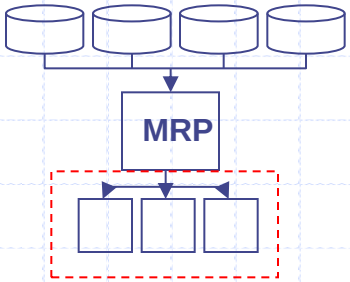
- Master Production Schedule (MPS)
  - ✓ Quantity and due dates of all parts that have independent demand (demand for all end items and external demand for lower-level parts)
  - ✓ Information
    - ➢ Part number
    - ➢ Needed quantity
    - ➢ Due date for each purchase order

    → gross requirements that initiate the MRP procedure
- Inventory Status File
  - ✓ On-hand inventory

    Information describing the part, where it is located, and how many are currently on hand
  - ✓ Scheduled receipts

    Planned order release that has actually been released (Identifier, due date, release date, quantity needed, and current quantity, etc.)

# MRP



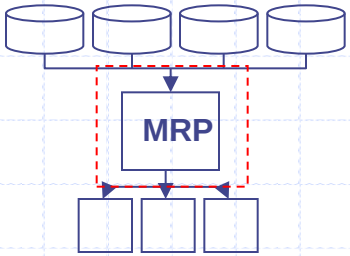

## Inputs, Outputs and Procedure

Outputs

- Basic
  - ✓ Planned Order Release (POR)
    - ➢ Basic MRP output representing production or purchase orders
    - ➢ Information (material requirements)
      - ▪ Part ID
      - ▪ Number of units required
      - ▪ Due date of the job
- Additional
  - ✓ Change Notices ◄----- planning level

    Modification of existing job
    (e.g. changes in due dates or priorities) ◄-------
    - Expediting: making due date earlier
    - Deferring: making due date later
  - ✓ Exception Reports ◄----- execution level

    Notify the users that there are discrepancies between what is expected and what is done




# MRP

## Inputs, Outputs and Procedure

Procedure (1)

- Overview

(1) Netting ◄----- net requirements (adjust scheduled receipts)

(2) Lot sizing ◄----- planned order receipts

(3) Time Phasing ◄----- planned order release

(4) BOM explosion

Notation

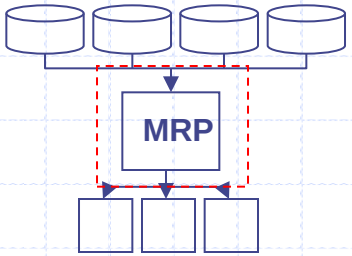
$D_t$ gross requirement (demand) for period t

$S_t$ scheduled receipt in period t

$I_t$ projected on-hand inventory at the end of period t
($I_0$ is the initial on-hand inventory)

$N_t$ net requirement for period t

Projected on-hand
= on-hand inventory + scheduled receipts – gross requirement




# MRP

## Inputs, Outputs and Procedure

Procedure (2)

- Netting

**Step 1**. (Adjusting the scheduled receipts)

Adjusts scheduled receipts by expediting (for late scheduled receipts) or deferring (for early scheduled receipts)

(1) Find the period when the first scheduled receipts should arrive and adjust scheduled receipts (expediting or deferring). ← change notice

$I_t = I_{t-1} - D_t$ Increment $t$ and continue to compute $I_t$ until it becomes less than zero

adjusted scheduled receipt

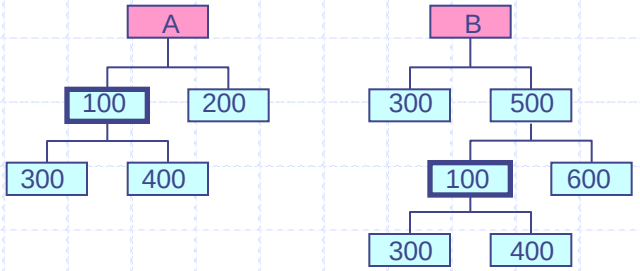
$I_t = I_{t-1} + S_t - D_t$ → (2) Modify the current on-hand inventory using the adjusted scheduled receipts. From the period obtained in Step (1), do Step (1) repeatedly until either we exhaust scheduled receipts or we have reached the end of the time horizon.

**Step 2**. (Calculating the net requirements) ← The net requirements are used in the lot-sizing procedure.

$$N_t = \begin{cases} 0 & \text{for } t < t^* \\ -I_t & \text{for } t = t^* \\ D_t & \text{for } t > t^* \end{cases}$$

t* the first period with a negative projected on-hand inventory after all scheduled receipts have been properly adjusted.

# MRP




## Inputs, Outputs and Procedure

Procedure (3)

- Netting
  - ✓ Example

$I_3 = I_2 - D_3 = 5 - 50 = -45 < 0$

→ Adjust $S_3$ (expediting)

→ $I_3 = S_3 + I_2 - D_3 = 100 + 5 - 50 = 55$

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements ($D_t$) | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |
| Scheduled receipts ($S_t$) | 10 | 10 | | 100 | | | | |
| Adjusted SR | | 20 | 100 | | | | | |
| Projected on-hand ($I_t$) | 5 | 5 | 55 | 45 | 15 | -15 | | |
| **Net requirements ($N_t$)** | | | | | | 15 | 30 | 30 |
| Planned order receipts | | | | | | | | |
| Planned order releases | | | | | | | | |

Initial on-hand inventory ($I_0$) = 20

(deferring)

(expediting)

***t** = 6*

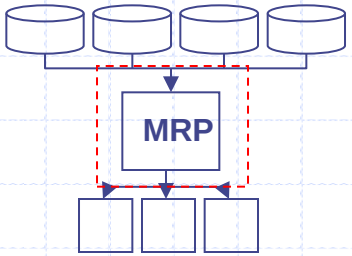
$I_1 = I_0 - D_1 = 20 - 15 = 5$

$I_2 = I_1 - D_2 = 5 - 20 = -15 < 0$

→ Adjust $S_2$ (deferring)

→ $I_2 = S_2 + I_1 - D_2 = 20 + 5 - 20 = 5$

# MRP




## Inputs, Outputs and Procedure

Procedure (4)

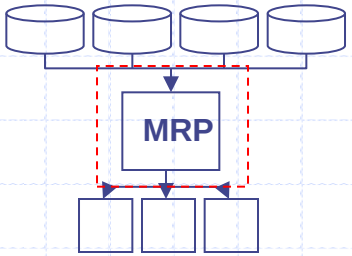
- Lot sizing

✓ Role

Net requirements ($N_t$) → planned order receipts
(dynamic lot sizing problem)

✓ Methods

- Lot-for-lot
- Fixed order quantity
- Fixed order period
- Part-period balancing, etc.




# MRP

## Inputs, Outputs and Procedure

Procedure (5)

- Lot sizing
  - ✓ Lot-for-lot (L4L)
    - ➢ Lot sizes (planned order recepts)

      Amount to be produced in a period is equal to that period's net requirement

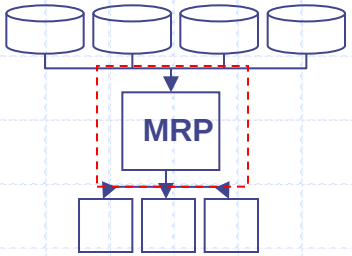
      $$POR_t = N_t,\ t = 1,2,...T$$

    - ➢ Practical reasons
      - Simple
      - Production smoothing

        ◄---- Not good for high setup costs

Example

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Net requirement | | | | | | 15 | 30 | 30 |
| **Planned order receipts** | | | | | | **15** | **30** | **30** |




# MRP

## Inputs, Outputs and Procedure

Procedure (6)

- Lot sizing
  - ✓ Fixed order quantity (FOQ)
    - ➢ Lot sizes (planned order recepts)

      Fixed amount to be produced in each period

      $$POR_t = \text{constant}, \text{ for some } t$$

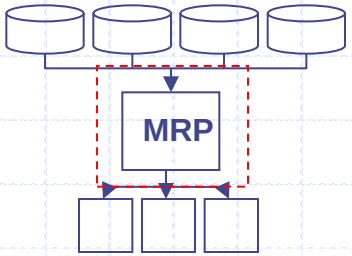
    - ➢ Methods
      - Lot size = production capacity
      - Economic order quantity (EOQ) based method

        ◄---- Modification

        Lot size = exact demand of one or more periods
        (choose the number of periods closest to the desired fixed lot size)

Example (Q = 50)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Net requirement | 15 | 15 | 60 | 65 | 55 | 15 | 20 | 10 |
| **Planned order receipts** | **30** | | **60** | **65** | **55** | **45** | | |




# MRP

## Inputs, Outputs and Procedure

Procedure (7)

- Lot sizing
  - ✓ Fixed order period (FOP)
    - ➢ Lot sizes (planned order recepts)

      Amount to be produced in a period is the sum of the net requiremens of P periods

      $$POR_t = \text{demand for } t, t+1, \ldots, t+P-1$$

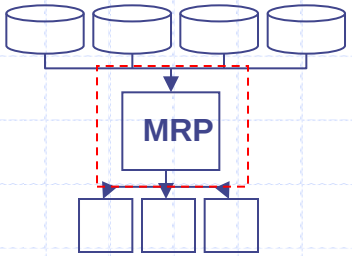
      P periods (fix)

      ◂---- lot-for-lot when P = 1
    - ➢ How to select P?

      e.g., using the EOQ formula

Example (P = 3)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Net requirement | | 15 | 45 | | | 25 | 15 | 20 | 15 |
| **Planned order receipts** | | **60** | | | | **60** | | | **15** |




# MRP

## Inputs, Outputs and Procedure

Procedure (8)

- Lot sizing
  - ✓ Part-period balancing
    - ➢ Basic idea

      Balance the inventory carrying cost and setup cost while satisfying the Wagner-Whitin property

      ◄----- EOQ: average inventory carrying cost = setup cost
    - ➢ Computation of inventory cost (using part-period)

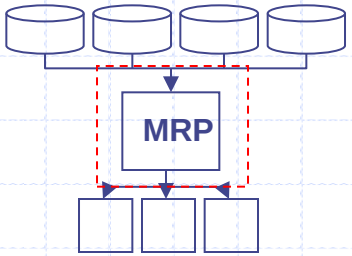
      inventory cost = number of part-periods × inventory cost

      - ▪ Part-period

        Number of parts in a lot × number of periods they are carried in inventory

        e.g., 1 part carried for 10 period = 5 parts carried for 2 periods

        ⟶ 10 part-period (same inventory carrying cost)




# MRP

## Inputs, Outputs and Procedure

Procedure (9)

- Lot sizing
  - ✓ Part-period balancing

| Net requirement | | 15 | 45 | | | 25 | 15 | 20 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| **Planned order receipts** | | **60** | | | | **60** | | | **15** |

Example: A = 150, h = 2

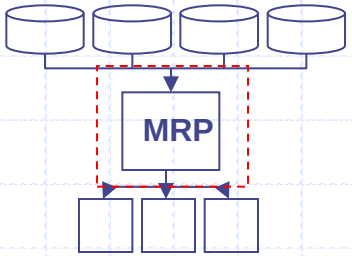
| period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Net requirement | | 15 | 45 | | | 25 | 15 | 20 | 15 |

Period 2

| Lot size | Setup cost | Part-period | Inventory cost |
|---|---|---|---|
| 15 | 150 | 0 | 0 |
| 60 | 150 | 45 | 90 (45 × 2) |
| 85 | 150 | 145 | 290 (145 × 2) |

Period 6

| Lot size | Setup cost | Part-period | Inventory cost |
|---|---|---|---|
| 25 | 150 | 0 | 0 |
| 40 | 150 | 15 | 30 |
| 60 | 150 | 55 | 110 |
| 75 | 150 | 100 | 200 |




# MRP

## Inputs, Outputs and Procedure

Procedure (10)

- Time Phasing (offsetting)

  Consideration of lead times (constant)

Examples

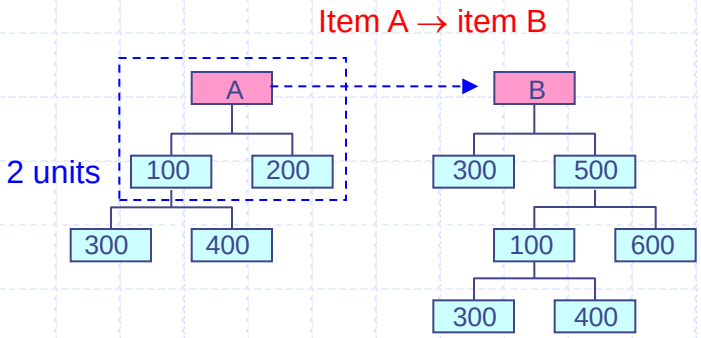
Lead time = 1 period

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Planned order receipts | | | | | | 45 | | 30 |
| **Planned order releases** | | | | | **45** | | **30** | |

Lead time = 2 periods

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Planned order receipts | | | | | | 45 | | 30 |
| **Planned order releases** | | | | **45** | | **30** | | |

# MRP




## Inputs, Outputs and Procedure

Procedure (11)

- BOM Explosion – Example

Item A (lot sizing: fixed order period (P = 2), lead time = 2 periods)

Initial inventory = 20

| Item A | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Gross requirements | | 15 | 20 | 50 | 10 | 30 | 30 | 30 | 30 |
| Scheduled receipts (SR) | | 10 | 10 | | 100 | | | | |
| Adjusted SR | | | 20 | 100 | | | | | |
| Projected on-hand | 20 | 5 | 5 | 55 | 45 | 15 | -15 | - | - |
| Net requirements | | | | | | | 15 | 30 | 30 |
| Planned order receipts | | | | | | | 45 | | 30 |
| **Planned order releases** | | | | | **45** | | **30** | | |

2 units of part 100 for Part A

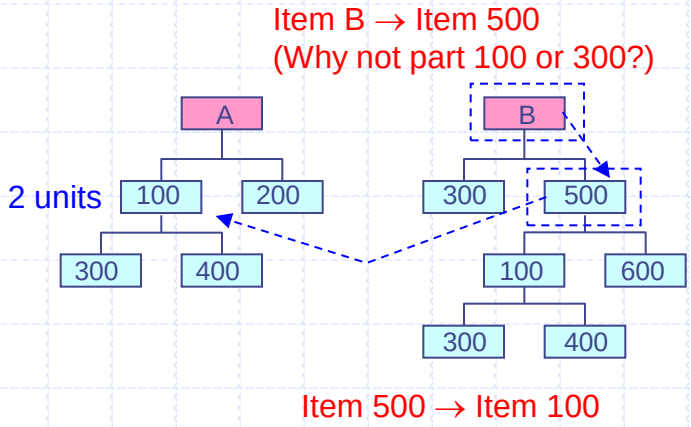
1 unit of part 200 for Part A

Planned order release generated for item A creates gross requirements for items 100 and 200.

| **Item 100** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Gross requirements** | | | | | **90** | | **60** | | |

| **Item 200** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Gross requirements** | | | | | **45** | | **30** | | |

# MRP




## Inputs, Outputs and Procedure

Procedure (12)

- BOM Explosion – Example

Item B (lot sizing: fixed order period (P = 2), lead time = 2 periods)

No scheduled receipts
Initial inventory = 40

| Item B | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | 10 | 15 | 10 | 20 | 20 | 15 | 15 | 15 |
| Scheduled receipts (SR) | | | | | | | | |
| Adjusted SR | | | | | | | | |
| Projected on-hand 40 | 30 | 15 | 5 | -15 | - | - | - | - |
| Net requirements | | | | 15 | 20 | 15 | 15 | 15 |
| Planned order receipts | | | | 35 | | 30 | | 15 |
| **Planned order releases** | | **35** | | **30** | | **15** | | |

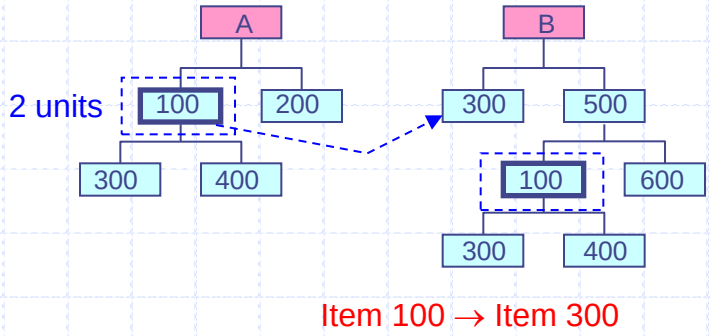
Item 500 (lot sizing: lot-for-lot, lead time = 4 periods)

No scheduled receipts
Initial inventory = 40

| Item 500 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | | 35 | | 30 | | 15 | | |
| Scheduled receipts (SR) | | | | | | | | |
| Adjusted SR | | | | | | | | |
| Projected on-hand 40 | 40 | 5 | 5 | -25 | - | - | - | - |
| Net requirements | | | | 25 | | 15 | | |
| Planned order receipts | | | | 25 | | 15 | | |
| **Planned order releases** | **25** | **15** | | | | | | |

**Late start**

# MRP




## Inputs, Outputs and Procedure

Procedure (13)

- BOM Explosion – Example

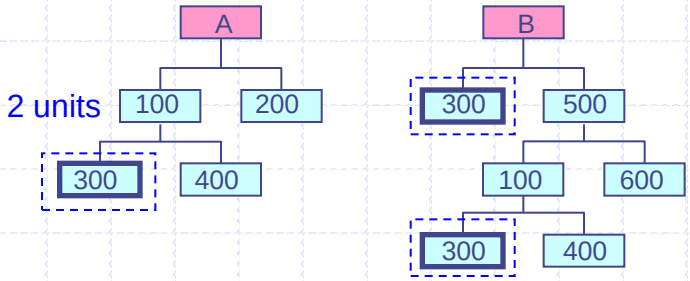
Item 100 (lot sizing: lot-for-lot, lead time = 2 periods)

No scheduled receipts

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Planned order releases (A) | | | | | **45** | | **30** | | |
| Planned order releases (500) | | **25** | **15** | | | 2 units | | | |
| **Item 100** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Gross requirements | | 25 | 15 | | 90 | | 60 | | |
| Scheduled receipts (SR) | | | | | | | | | |
| Adjusted SR | | | | | | | | | |
| Projected on-hand | 40 | 15 | 0 | 0 | -90 | - | - | - | - |
| Net requirements | | | | | 90 | | 60 | | |
| Planned order receipts | | | | | 90 | | 60 | | |
| **Planned order releases** | | | **90** | | **60** | | | | |

Initial inventory = 40

# MRP




- **Inputs, Outputs and Procedure**

Procedure (14)

- BOM Explosion – Example

Item 300 (lot sizing: lot-for-lot, lead time = 1 period)

| Planned order releases (B) | | 35 | | 30 | | 15 | | |
|---|---|---|---|---|---|---|---|---|
| Planned order releases (100) | | 90 | | 60 | | | | |
| **Item 300** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Gross requirements | | 125 | | 90 | | 15 | | |
| Scheduled receipts (SR) | | 100 | | | | | | |
| Adjusted SR | | 100 | | | | | | |
| Projected on-hand (50) | 50 | 25 | 25 | -65 | - | -15 | - | - |
| Net requirements | | | | 65 | | 15 | | |
| Planned order receipts | | | | 65 | | 15 | | |
| **Planned order releases** | | | 65 | | 15 | | | |

Initial inventory = 50

scheduled receipts (100 in period 2)

# MRP

- **Inputs, Outputs and Procedure**

  Procedure (15)

  - BOM Explosion – Example

    ✓ Summary of MRP output

| Transaction | Item Number | Old Due date Release Date | New Due Date | Quantity | Notice |
|---|---|---|---|---|---|
| Change notice | A | 1 | 2 | 10 | Defer |
| Change notice | A | 4 | 3 | 100 | Expedite |
| Planned order release | A | 4 | 6 | 45 | OK |
| Planned order release | A | 6 | 8 | 30 | OK |
| Planned order release | B | 2 | 4 | 35 | OK |
| Planned order release | B | 4 | 6 | 30 | OK |
| Planned order release | B | 6 | 8 | 15 | OK |
| Planned order release | 100 | 2 | 4 | 90 | OK |
| Planned order release | 100 | 4 | 6 | 60 | OK |
| Planned order release | 300 | 3 | 4 | 65 | OK |
| Planned order release | 300 | 5 | 6 | 15 | OK |
| Planned order release | 500 | 1 | 4 | 25 | Late |
| Planned order release | 500 | 2 | 6 | 15 | OK |

# MRP

## Further Considerations

Special Topics (1) ← Improving the performance of MRP

- Updating frequency
  - ✓ Frequent update ← Balancing (trade-off)

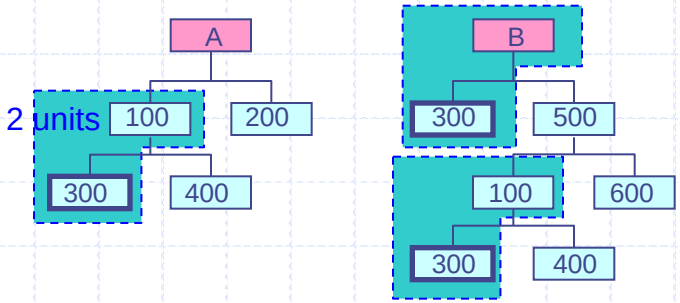
    Shop can be inundated with exception reports and constantly changing planned order release.
  - ✓ Infrequent update ←

    We can end up with old plans that are often out of date
- Firm Planned Order
  - ✓ Planned order release that held fixed
    (release regardless of changes in the system)

    ← The MRP procedure consider it as scheduled receipts.
  - ✓ Why

    Minimize schedule disruptions due to changes
    (useful for reducing system nervousness)

# MRP




## Further Considerations

Special Topics (2)

- Troubleshooting
  - ✓ Pegging

    Allows the planner to see the source of demand that results in a given planned order release

    Example

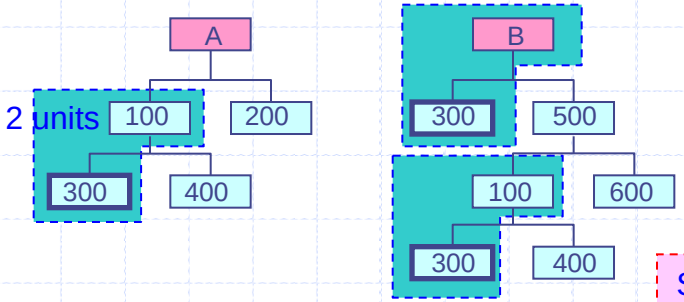
Item B

Item100 → Items A and 500

| Planned order releases (B) | | 35 | | 30 | | 15 | | |
|---|---|---|---|---|---|---|---|---|
| Planned order releases (100) | | 90 | | 60 | | | | |

| Item 300 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | | 125 | | 90 | | 15 | | |
| … | | | | | | | | |
| Planned order receipts | | | | 65 | | 15 | | |
| **Planned order releases** | | | **65** | | **15** | | | |

# MRP




- **Further Considerations**

  Special Topics (3)

  - Troubleshooting
    - ✓ Bottom-up replanning (based on pegging)

  Example

See if we can deliver 25 units of A when requested, the remaining quantity later

| Planned order releases (A) | | | | 45 25 | | 30 | | |
|---|---|---|---|---|---|---|---|---|
| Planned order releases (500) | 25 | 15 | | | | | | |

| Item 100 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | 25 | 15 | | 90 | | 60 | | |
| … | | | | | | | | |
| Planned order receipts | | | | 90 | | 60 | | |
| **Planned order releases** | | 90 | 50 | 60 | | | | |

satisfy requirements of item B or 100?
- if we select to satisfy item 100 (50)

| Planned order releases (B) | | 35 | | 30 | | 15 | | |
|---|---|---|---|---|---|---|---|---|
| Planned order releases (100) | | 90 50 | | 60 | | | | |

| Item 300 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | | 125 | | 90 | | 15 | | |
| Scheduled receipts (SR) | | 100 | | | | | | |
| Adjusted SR | | | | | | | | |
| Projected on-hand | 50 | 50 | | | | | | |

schedules receipts cannot arrive on-time.

Call vendor, place the order immediately, etc.

→ Bottom-up replanning (if they are impossible)

# MRP

## Further Considerations

Problems (1)

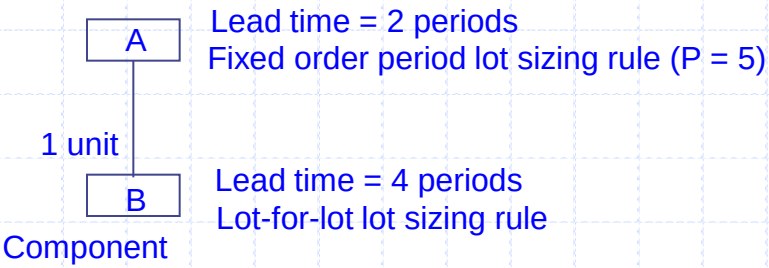
- Capacity Infeasibility ◄---------- capacity = maximum output of a production (service) system (measures by units or time)
  - ✓ MRP assumes infinite capacity
  - ✓ Problems when production levels are at or near capacity.
    - ----► Development of MRP II (manufacturing resource planning)
      - Rough-cut capacity planning (RCCP) for master production schedule
      - Capacity requirement planning (CRP) for detailed capacity assessment
- Long Planned Lead Times

  MRP uses the constant and long lead time (pessimistic).

  ➡ Large inventories
  Low customer service level

  ↑ Uncertainties in production systems
  1) Demand (quantity and timing)
  2) Processing time
  3) Machine breakdowns
  4) Quality problems, etc.

# MRP




## Further Considerations

Problems (2)

- System Nervousness

A small change in the master production schedule results in a large change in planned order releases.

Example

MRP calculations for Item A (before change in demand)

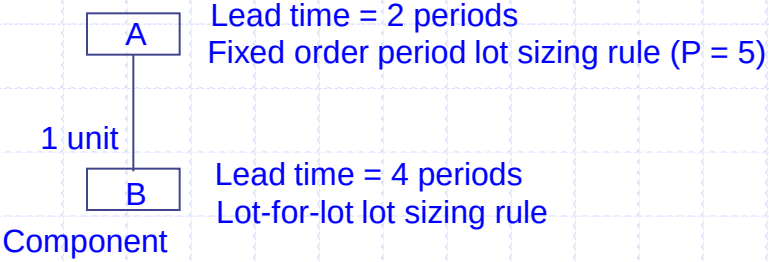
No scheduled receipts

| Item A | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Gross requirements | | 2 | 24 | 3 | 5 | 1 | 3 | 4 | 50 |
| Projected on-hand | 28 | 26 | 2 | -1 | - | - | - | - | - |
| Net requirements | | | | 1 | 5 | 1 | 3 | 4 | 50 |
| Planned order receipts | | | | 14 | | | | | 50 |
| **Planned order releases** | | **14** | | | | | **50** | | |

MRP calculations for item B (before change in demand)

| Item B | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Gross requirements | | 14 | | | | | 50 | | |
| Scheduled receipts (SR) | | 14 | | | | | | | |
| Adjusted SR | | 14 | | | | | | | |
| Projected on-hand | 2 | 2 | 2 | 2 | 2 | 2 | -48 | - | - |
| Net requirements | | | | | | | 48 | | |
| Planned order receipts | | | | | | | 48 | | |
| **Planned order releases** | | | **48** | | | | | | |

# MRP




## Further Considerations

Problems (3)

- System Nervousness

Example

**demand change: 24 → 23**

MRP calculations for Item A (after change in demand)

| **Item A** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Gross requirements | | 2 | **23** | 3 | 5 | 1 | 3 | 4 | 50 |
| Projected on-hand | 28 | 26 | 3 | 0 | | - | - | - | - |
| Net requirements | | | | | 5 | 1 | 3 | 4 | 50 |
| Planned order receipts | | | **Big change** | | 63 | | | | |
| **Planned order releases** | | | **63** | | | | | | |

MRP calculations for item B (before change in demand)

| **Item B** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Gross requirements | | | 63 | | | | | | |
| Scheduled receipts (SR) | | 14 | | | | | | | |
| Adjusted SR | | | 14 | | | | | | |
| Projected on-hand | 2 | 2 | -47 | - | - | - | - | - | - |
| Net requirements | | | 47 | | | | | | |
| Planned order receipts | | | 47 | | | | | | |
| **Planned order releases** | | **47** | | | | | | | |

**Late start (almost impossible)**

# MRP

## Further Considerations

Problems (3)

- System Nervousness
  - ✓ Methods to reduce system nervousness
    - ➢ Proper use of lot sizing rule

      Lot-for-lot reduces nervousness, but results in too many setups

    - ➢ Frozen zone (≡ time fence) ◄----- before MRP calculations

      Initial number of periods in the MPS in which changes are not permitted

      e.g.,

| Item A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gross requirements | 2 | 24 | 3 | 5 | 1 | 3 | 4 | 50 |
| Scheduled receipts (SR) | | | | | | | | |

frozen zone

    - ➢ Firm planned order ◄----- after MRP calculations

      Planned order release that held fixed
      (release regardless of changes in the system)