LECTURE 10
MRP&JIT

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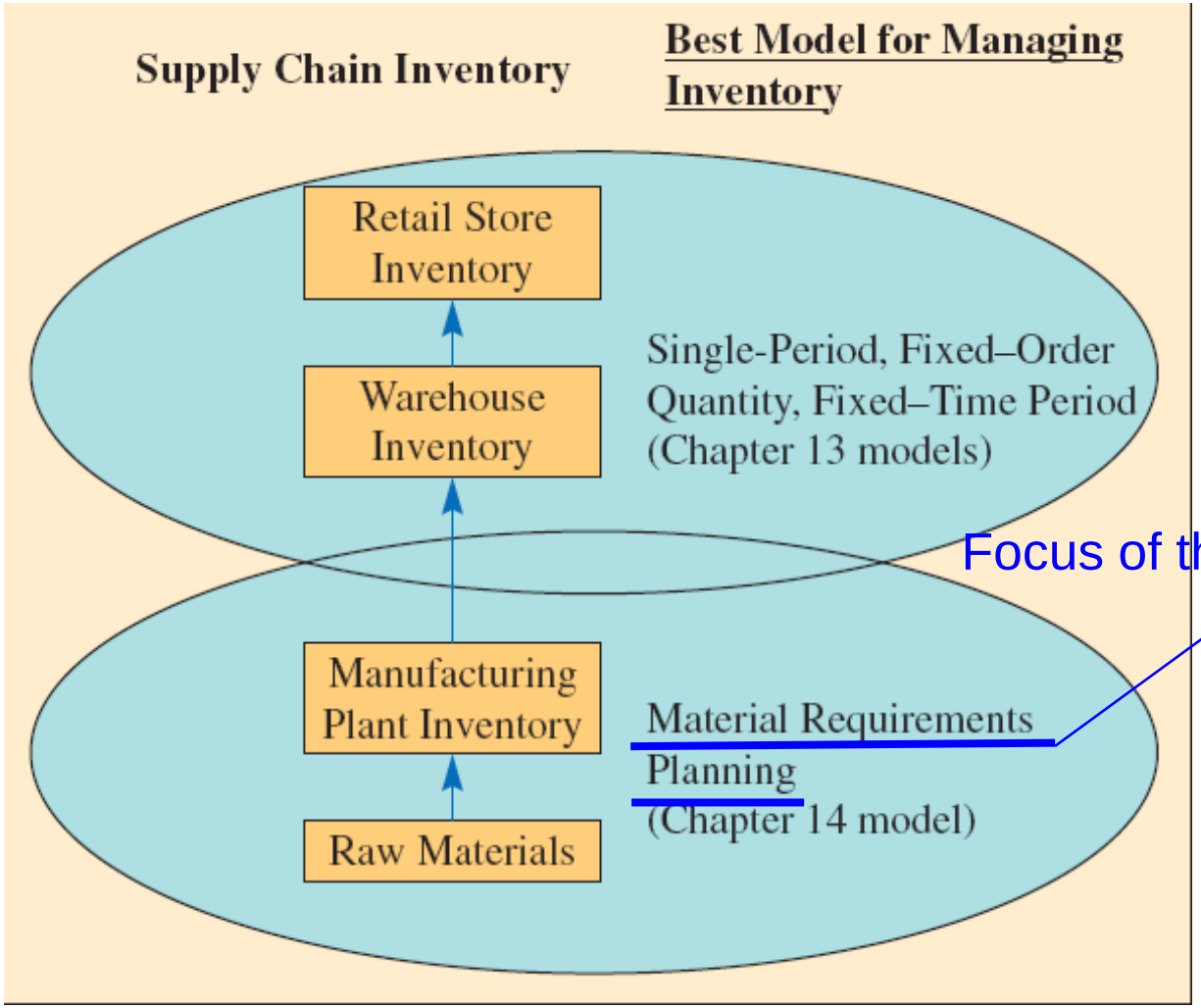
VARIOUS MODELS FOR INVENTORY MANAGEMENT



INDEPENDENT VERSUS DEPENDENT DEMAND

Independent demand refers to the demand for end products

(which originates outside of the system)

Dependent demand refers to demand for components that make up products

Example:

mountain bikes × 100

trekking bikes × 50 — Independent demand

mountain bike wheels × 200

trekking bike wheels × 100

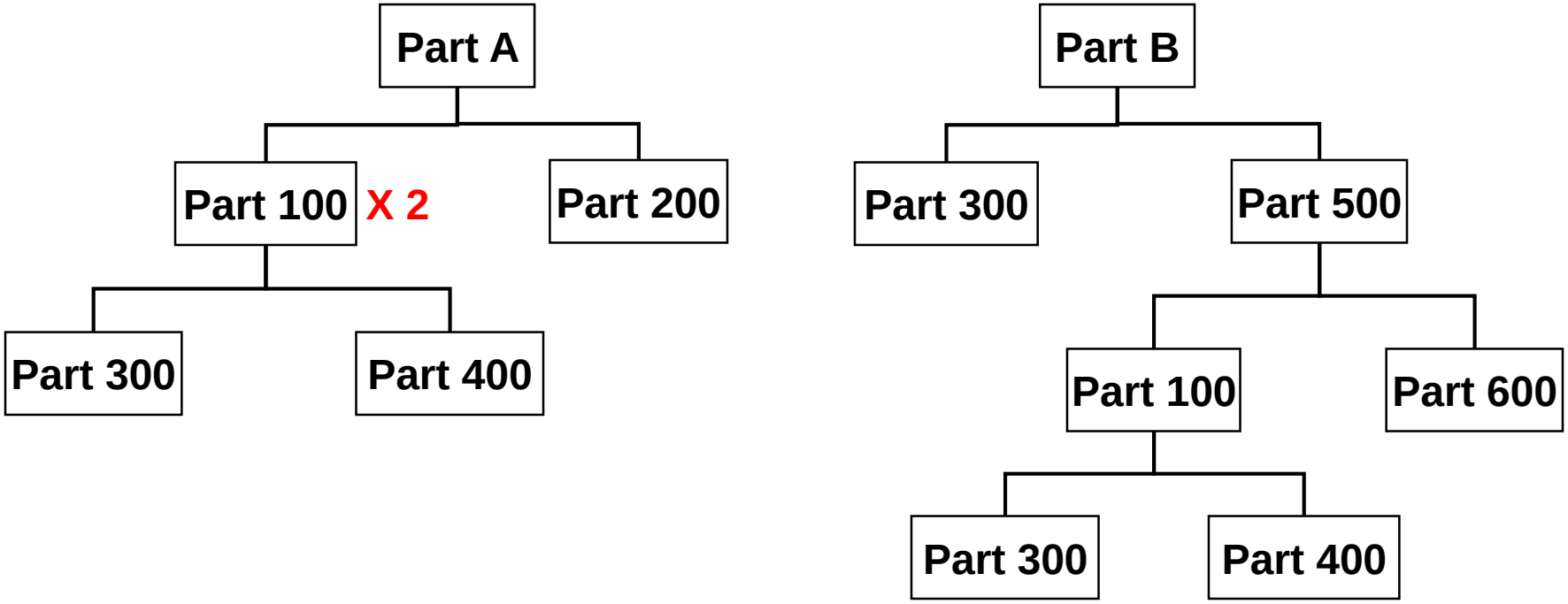
brakes × 300

Dependent demand

BILL OF MATERIALS (BOM)

Bill Of Material (BOM) - Relationship between products and components

Example:



→ Dependent demands of components can be determined by independent demands of products

BASIC IDEAS OF MRP

Work downward from demand information of end products (assumed to be know and deterministic)

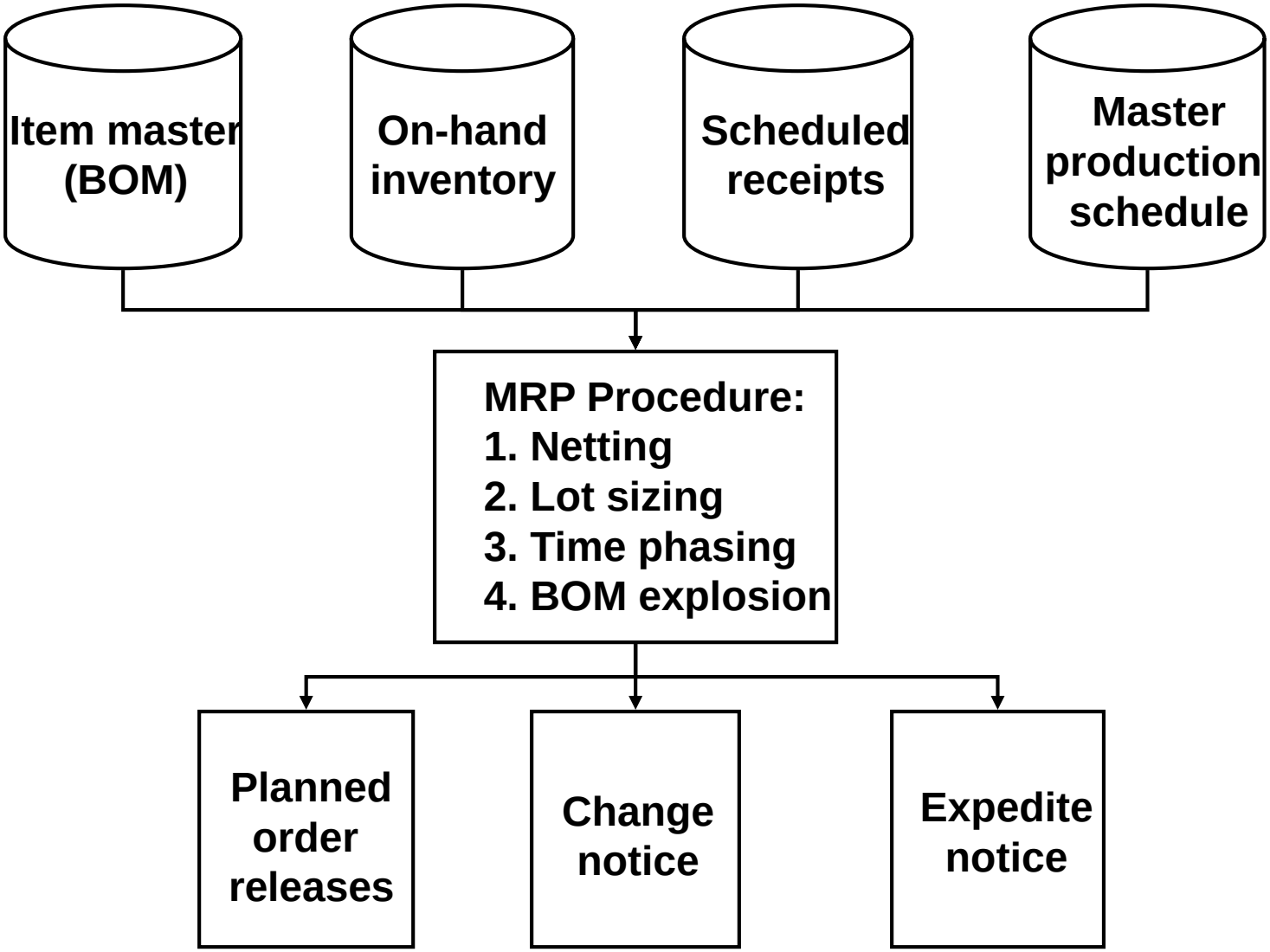
Translate that demand of products into that of components (from independent demand to dependent demand)

Based on the demand of components, determine the time and the quantity of production/ordering (dynamic lot sizing)

Not produce something until you need it. Have the components arrive just when you intend to use them

MRP is a push system as it computes schedules of what should be started and pushed into production based on demand forecast

SCHEMATIC OF MRP



MRP Input Data

MRP Procedure

MRP Output

MRP ILLUSTRATION – EXAMPLE DATA

Independent demand data (MPS)

MPS sometime is simply called "forecast"

Part A	1	2	3	4	5	6	7	8
Gross requirements (Weekly)	15	20	50	10	30	30	30	30

Part B	1	2	3	4	5	6	7	8
Gross requirements (Weekly)	10	15	10	20	20	15	15	15

MRP ILLUSTRATION – EXAMPLE DATA

Other data

Items	Current on-hand	Scheduled Reciepts (SRs)		Lot-sizing Rule	Lead time
		Due	Quantity		
Part A	20	1,2,4	10,10,100	POQ of 2 weeks	2 weeks
Part B	40	None		POQ of 2 weeks	2 weeks
Part 100	40	None		Lot-for-lot	2 week
Part 300	50	2	100	Lot-for-lot	1 week
Part 500	40	None		Lot-for-lot	4 weeks

MRP ILLUSTRATION – NETTING

Purposes:

- Calculate the net requirement
- Adjust the scheduled receipts (SRs) if necessary

Ideas:

- We first use the on-hand inventory to cover the gross requirements
- We then adjust the SRs and use the adjusted SRs to cover any unfilled gross requirements

That is, we can probably say, in a dynamic sense,

Net requirements = gross requirements

– on-hand inventory – scheduled receipts

MRP ILLUSTRATION – NETTING

Part A		1	2	3	4	5	6	7	8
Gross requirements		15	20	50	10	30	30	30	30
Scheduled receipts		10	10			100			
Adjusted SRs									
Projected on-hand	20								
Net requirements									
Planned order receipts									
Planned order releases									

MRP ILLUSTRATION – LOT SIZING

Purposes:

- Determine the quantities to produce to meet the net requirements by using appropriate lot sizes

Ideas:

- There are many different ways of determining the production quantities
- For example, lot-for-lot means whenever there is a net requirement, a production of the same size will be initiated
- Another example is period order quantity (POQ), which means each production will cover the net requirements of a given time duration

MRP ILLUSTRATION – LOT SIZING

Part A		1	2	3	4	5	6	7	8
Gross requirements		15	20	50	10	30	30	30	30
Scheduled receipts		10	10			100			
Adjusted SRs			20	100					
Projected on-hand	20	5	5	55	45	15	-15		
Net requirements							15	30	30
Planned order receipts									
Planned order releases									

MRP ILLUSTRATION – TIME PHASING

Purposes:

- Determine the start times to produce to meet the net requirements by taking into account lead time

Ideas:

- If the production lead time is fixed, we can compute directly the desired start times to produce

MRP ILLUSTRATION – TIME PHASING

Part A		1	2	3	4	5	6	7	8
Gross requirements		15	20	50	10	30	30	30	30
Scheduled receipts		10	10			100			
Adjusted SRs			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		

MRP ILLUSTRATION - BOM EXPLOSION

Purposes:

- Use the production quantities, start times, and the BOM to generate gross requirements of any required components at the next lower levels and repeat above steps until all levels are processed

Ideas:

- According to the low-level codes (LLCs), work from end items to lower-level items

End items: end products
Lower-level items: components that make up the products
Low-level code (LLC): the lowest level of a component from the products in BOM

MRP ILLUSTRATION - BOM EXPLOSION (PART B)

Part B		1	2	3	4	5	6	7	8
Gross requirements		10	15	10	20	20	15	15	15
Scheduled receipts									
Adjusted SRs									
Projected on-hand	40								
Net requirements									
Planned order receipts									
Planned order releases									

MRP ILLUSTRATION - BOM EXPLOSION (PART B)

Part B		1	2	3	4	5	6	7	8
Gross requirements		10	15	10	20	20	15	15	15
Scheduled receipts									
Adjusted SRs									
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		

MRP ILLUSTRATION – EXAMPLE DATA

Other data

Items	Current on-hand	Scheduled Reciepts (SRs)		Lot-sizing Rule	Lead time
		Due	Quantity		
Part A	20	1,2,4	10,10,100	POQ of 2 weeks	2 weeks
Part B	40	None		POQ of 2 weeks	2 weeks
Part 100	40	None		Lot-for-lot	2 week
Part 300	50	2	100	Lot-for-lot	1 week
Part 500	40	None		Lot-for-lot	4 weeks

MRP ILLUSTRATION - BOM EXPLOSION (PART 500)

Part 500		1	2	3	4	5	6	7	8
Gross requirements									
Scheduled receipts									
Adjusted SRs									
Projected on-hand	40								
Net requirements									
Planned order receipts									
Planned order releases									

*Indicate a late start. Not sufficient production time if produced at normal speed

MRP ILLUSTRATION - BOM EXPLOSION (PART 500)

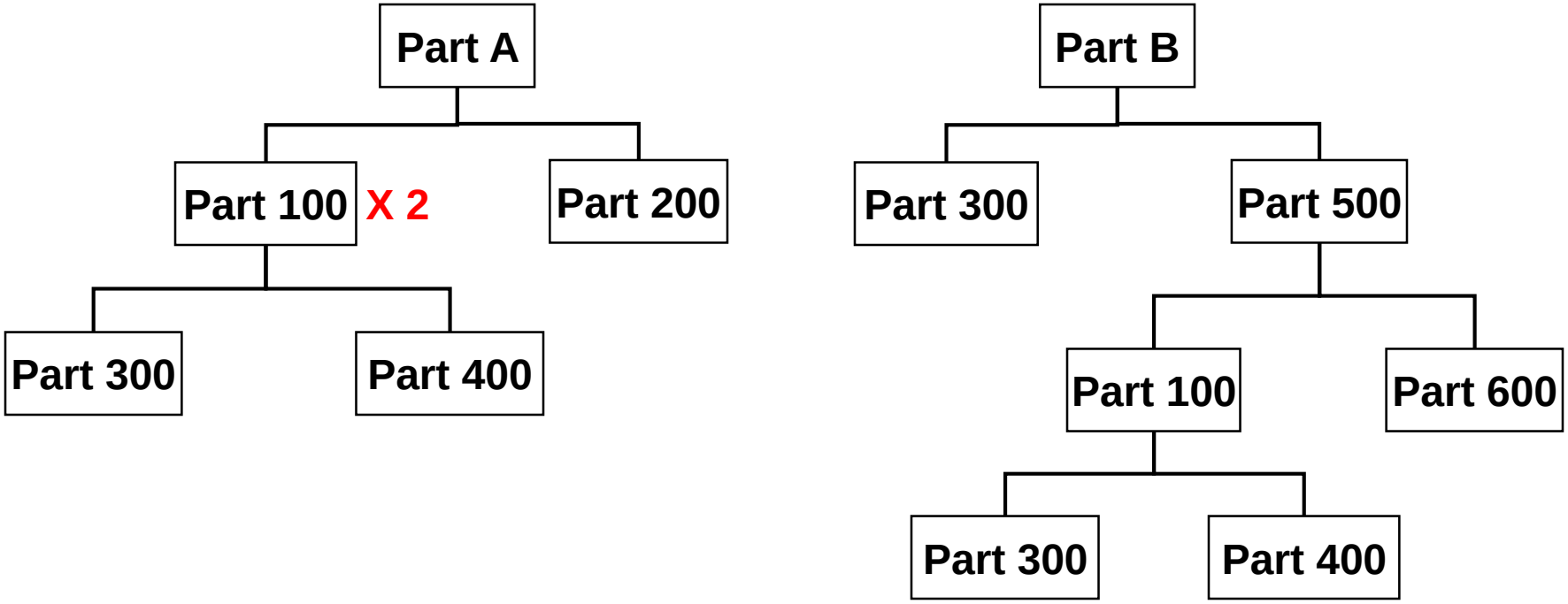
Part 500		1	2	3	4	5	6	7	8
Gross requirements			35		30		15		
Scheduled receipts									
Adjusted SRs									
Projected on-hand	40	40	5	5	-25				
Net requirements					25		15		
Planned order receipts					25		15		
Planned order releases		25*	15						

*Indicate a late start. Not sufficient production time if produced at normal speed

BILL OF MATERIALS (BOM)

Bill Of Material (BOM) - Relationship between products and components

Example:



→ Dependent demands of components can be determined by independent demands of products

MRP ILLUSTRATION - BOM EXPLOSION (PART 100)

Part 100		1	2	3	4	5	6	7	8
Gross requirements									
Scheduled receipts									
Adjusted SRs									
Projected on-hand	40								
Net requirements									
Planned order receipts									
Planned order releases									

MRP ILLUSTRATION - BOM EXPLOSION (PART 100)

Part 100		1	2	3	4	5	6	7	8
Gross requirements		25*	15		90		60		
Scheduled receipts									
Adjusted SRs									
Projected on-hand	40	15	0		-90				
Net requirements					90		60		
Planned order receipts					90		60		
Planned order releases			90		60				

MRP ILLUSTRATION - BOM EXPLOSION (PART 300)

Part 300		1	2	3	4	5	6	7	8
Gross requirements			125		90		15		
Scheduled receipts			100						
Adjusted SRs			100						
Projected on-hand	50	50	25	25	-65				
Net requirements					65		15		
Planned order receipts					65		15		
Planned order releases				65		15			

MRP ILLUSTRATION – MRP OUTPUT

Transaction	Part Number	Old Due/ Release Date	New 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 NERVOUSNESS

Sources of MRP nervousness

- Changes in demand for end items
- Late shipments
- Defective parts
- Machine breakdowns
- Horizon effects

Dealing with MRP nervousness

- Carry safety stocks
- Freeze production setup periods and change only production quantities
- Assess a schedule change cost or consequence
- Apply a rolling planning horizon
- Be flexible and use common sense

SUMMARY OF MRP

MRP is one basic philosophy of production control and is push production

MRP translates independent demands of products into time-phased demand of components and thus determines the production/ordering requirements on those components

A MRP system is usually complicated to develop, customize, and install, and the installed MRP system is often very nervous to many system factors

MRP II, ERP, and extended ERP/SCM are information systems that use MRP as an integral part

LEAN PRODUCTION

- **The most significant operations and supply management approach of the past 50 years is lean production.**
- **Lean production refers to a focus on eliminating as much waste as possible. Moves that are not needed, unnecessary processing steps, and excess inventory in the supply chain are targets for improvement.**
- **The basis of lean thinking came from the just-in-time (JIT) production concepts pioneered in Japan at Toyota.**

TOYOTA

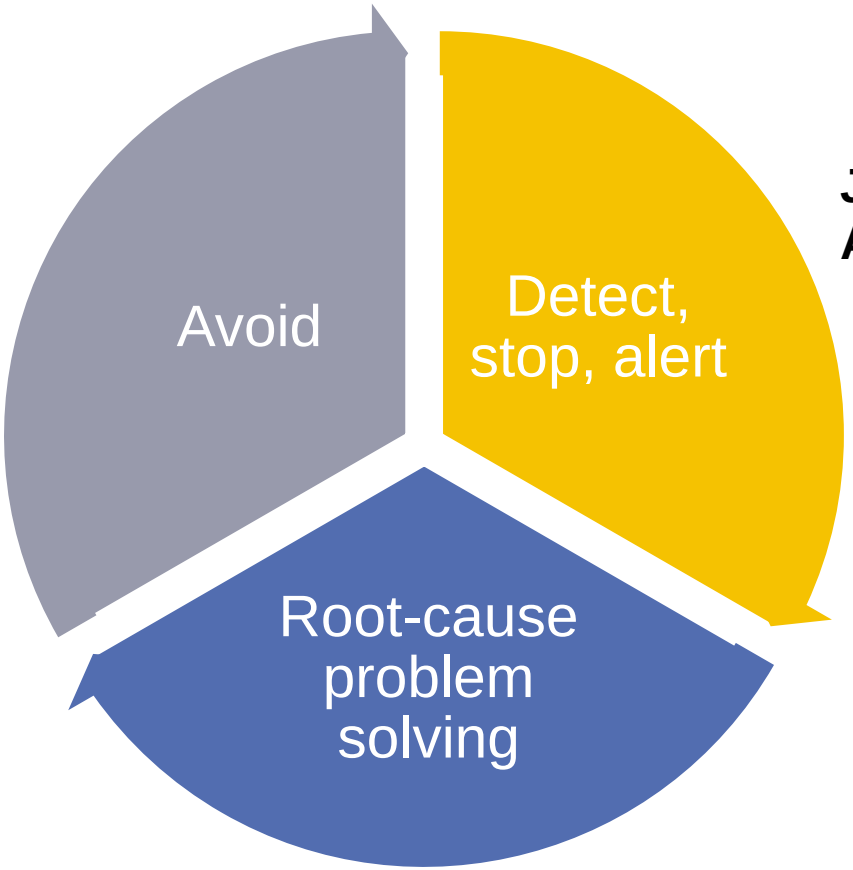
- **Originally manufacture looms**
- **Start making vehicles just before WW2**
- **One of largest car company in the world**
  - #1 in production 2012 (followed by GM, VW)
  - Market share growth
  - Profit
  - Quality
  - Environmental Leadership (hybrid technology)
- **Got there by operational excellence:**
  - Systematic elimination of waste
  - Operating system built around to serve demand

EFFICIENCY MEASURES USED BY WALL STREET

Management Efficiency Measures	Toyota	Ford	GM	Daimler Chrysler	Industry
Income per employee	**$40,000**	$8,000	$10,000	$8,000	$15,000
Revenue per employee	**$663,000**	$535,000	$597,000	$510,000	$568,000
Receivable turnover	**4.0**	1.5	1.0	2.2	2.1
Inventory turnover	**12.0**	11.5	11.7	5.9	11.0
Asset turnover	**.8**	.6	.4	.8	.8

TOYOTA QUALITY SYSTEM

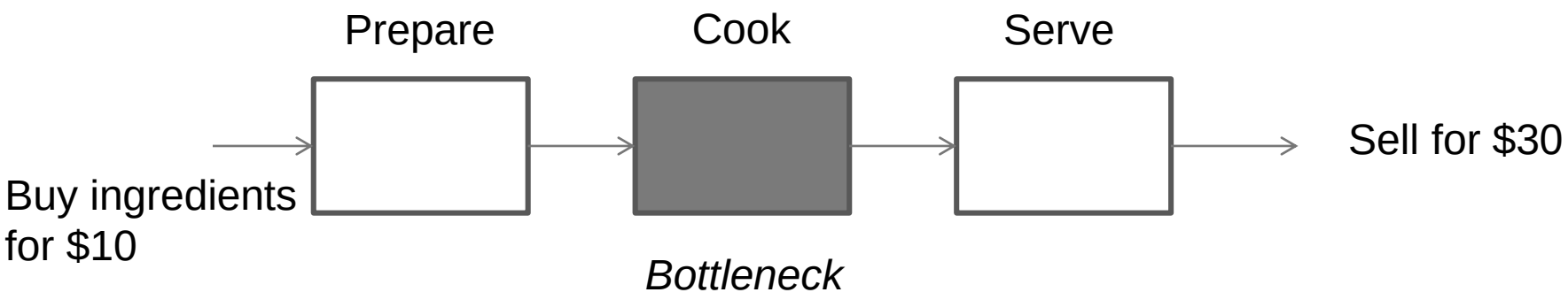
Poka Yoke
(Fool proof)



Jidoka
Andon cord

Ishikawa Diagram (Fishbone)

CATCHING DEFECTS BEFORE BOTTLENECK



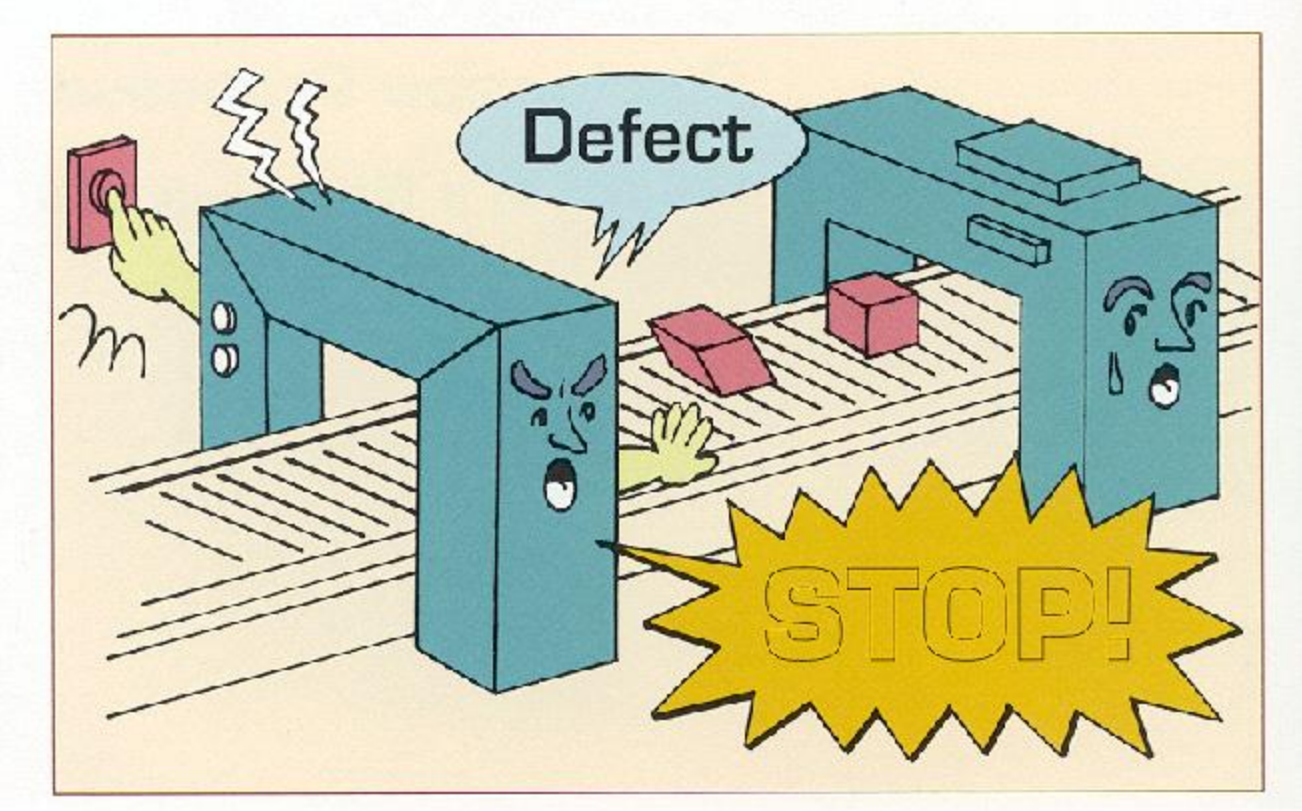
- **What is the cost of a defect?**
  - Defect detected before bottleneck
  - Defect detected after bottleneck

REDUCING DEFECTS PAYS OFF:

Defects Found at:	Own Process	Next Process	End of Line	Final Inspection	End User's Hand
Impact on the Company					
	• Very minor	• Minor delay	• Rework • Rescheduled of work	• Significant rework • Delay in delivery • Additional Inspection	• Warranty costs • Administrative costs • Reputation loss • Loss of Market Share

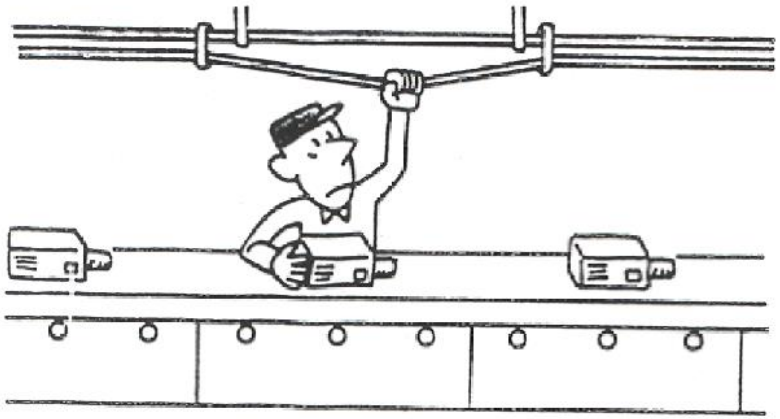
DETECTING DEFECTS AT TOYOTA

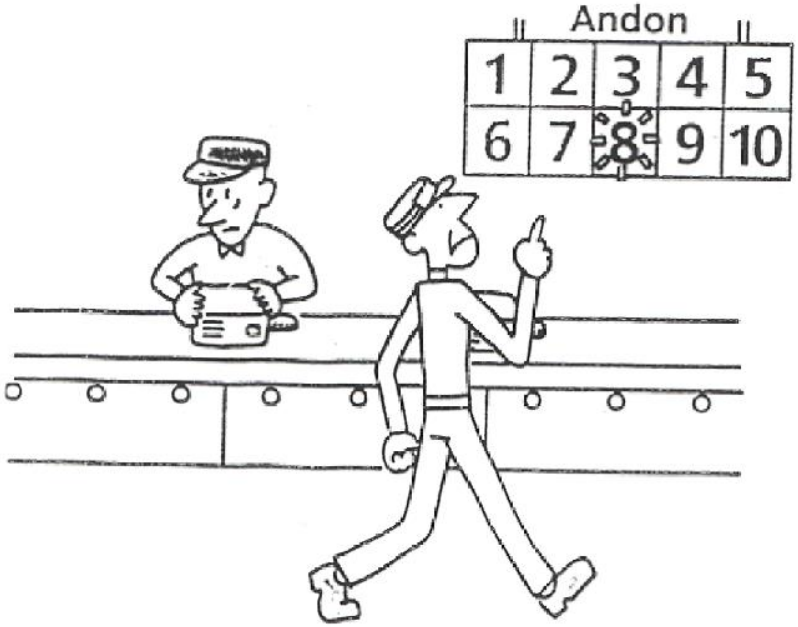
- **Jidoka: If equipment gets out of control, it shuts itself down automatically**



ANDON BOARD / CORD

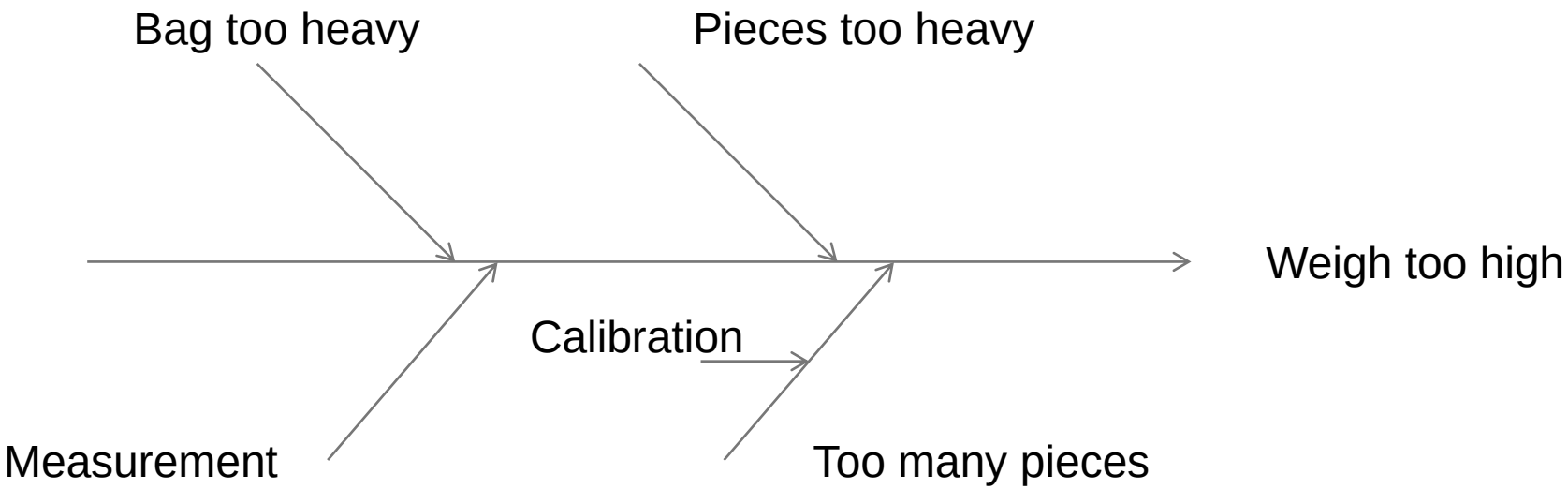
- Once worker observes a defect, he shuts down the line by pulling the andon cord
- The station number appears on the andon board





ROOT CAUSE PROBLEM SOLVING

- **Ishikawa Diagram**
  - A brainstorming technique of what might have contributed to a problem
  - Also called fish-bone diagram



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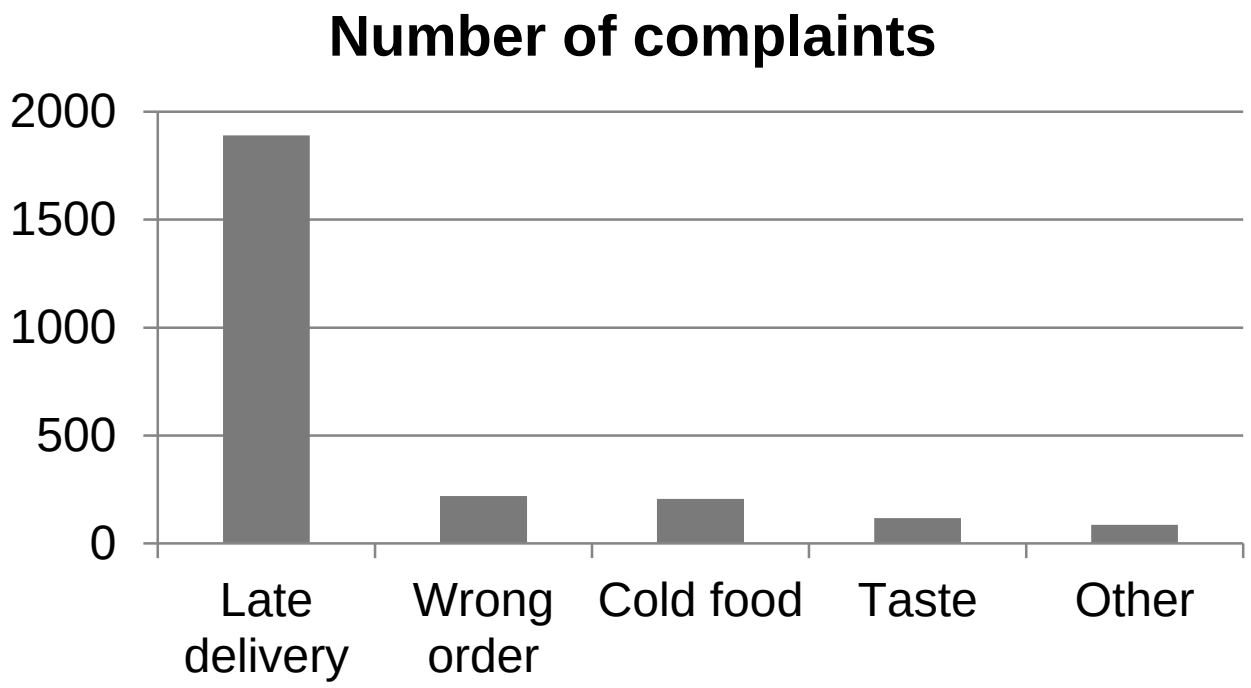
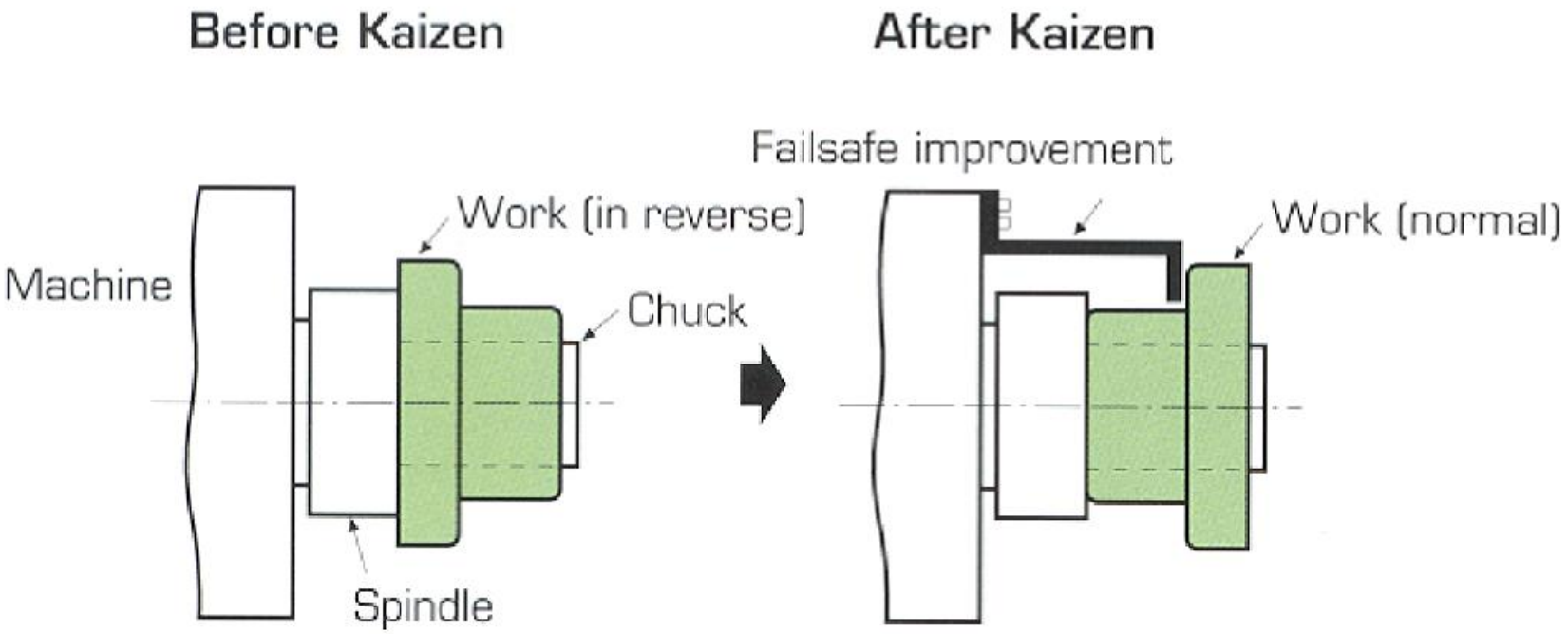
ROOT CAUSE PROBLEM SOLVING

- **Pareto Charts**
  - Break down a problem into the relative contributions of its components



POKA YOKE

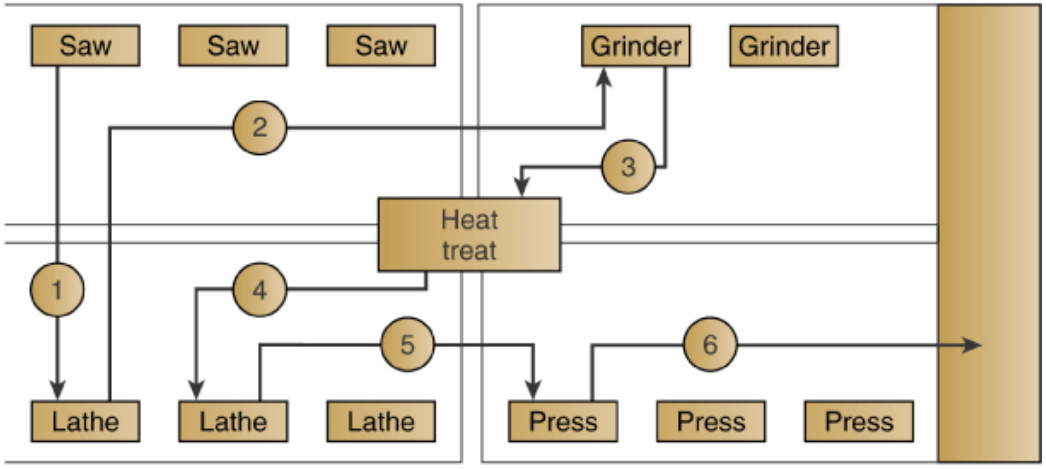

Before Kaizen
After Kaizen
Failsafe improvement
Work (in reverse)
Work (normal)
Machine
Chuck
Spindle

7 TYPES OF WASTE

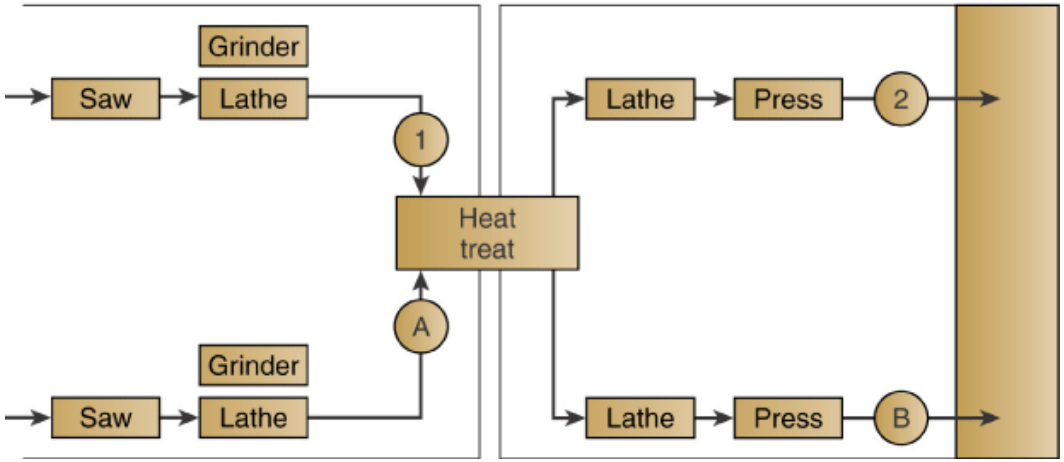
1. Defect (产品缺陷浪费)
2. Overproduction (生产过量)
3. Inventory (> need) (库存浪费)
4. Waiting (bad work sequence) (等待时间浪费)
5. Processing (not adding value) (工序浪费)
6. Motion (> minimum) (动作浪费)
7. Handling (运输浪费)

REDUCING WASTE

A. Process-oriented layout by department speciality



B. Group technology layout with manufacturing cells



HEIJUNKA (LEVEL/BALANCED PRODUCTION)

- **Monthly Production Requirement**

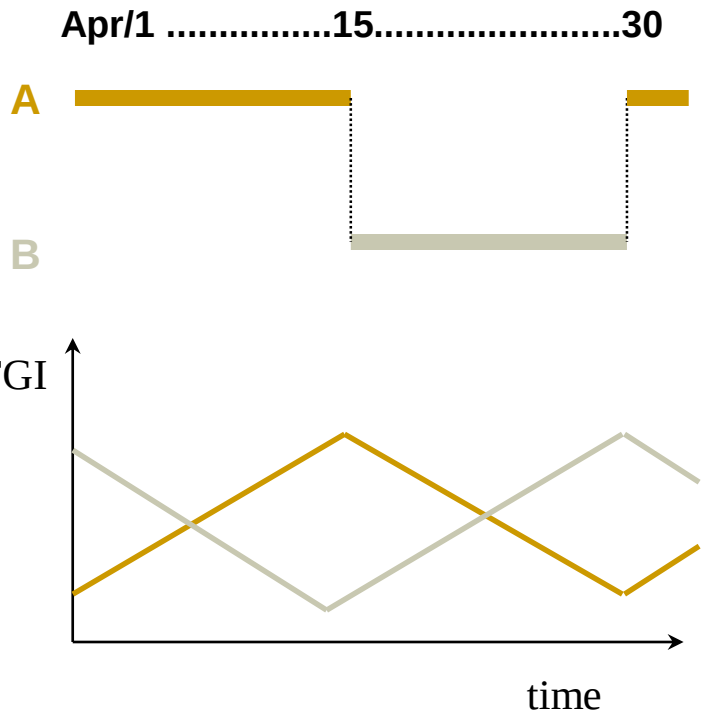
Model	Sedan (A)	Hardtop (A)
Quantity	3,000	3,000

How should production be scheduled for the month?

LEVEL/BALANCED PRODUCTION

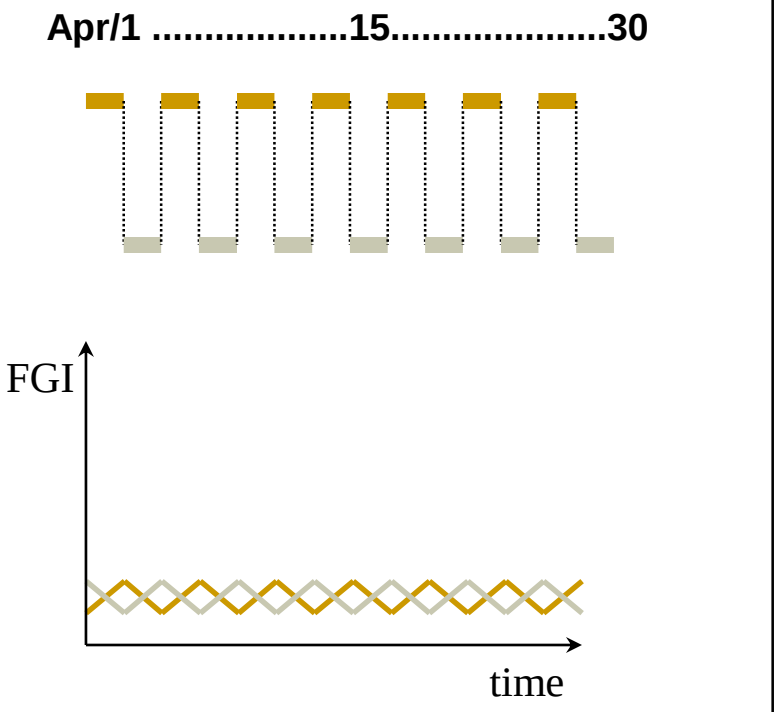
Batch Production Schedule

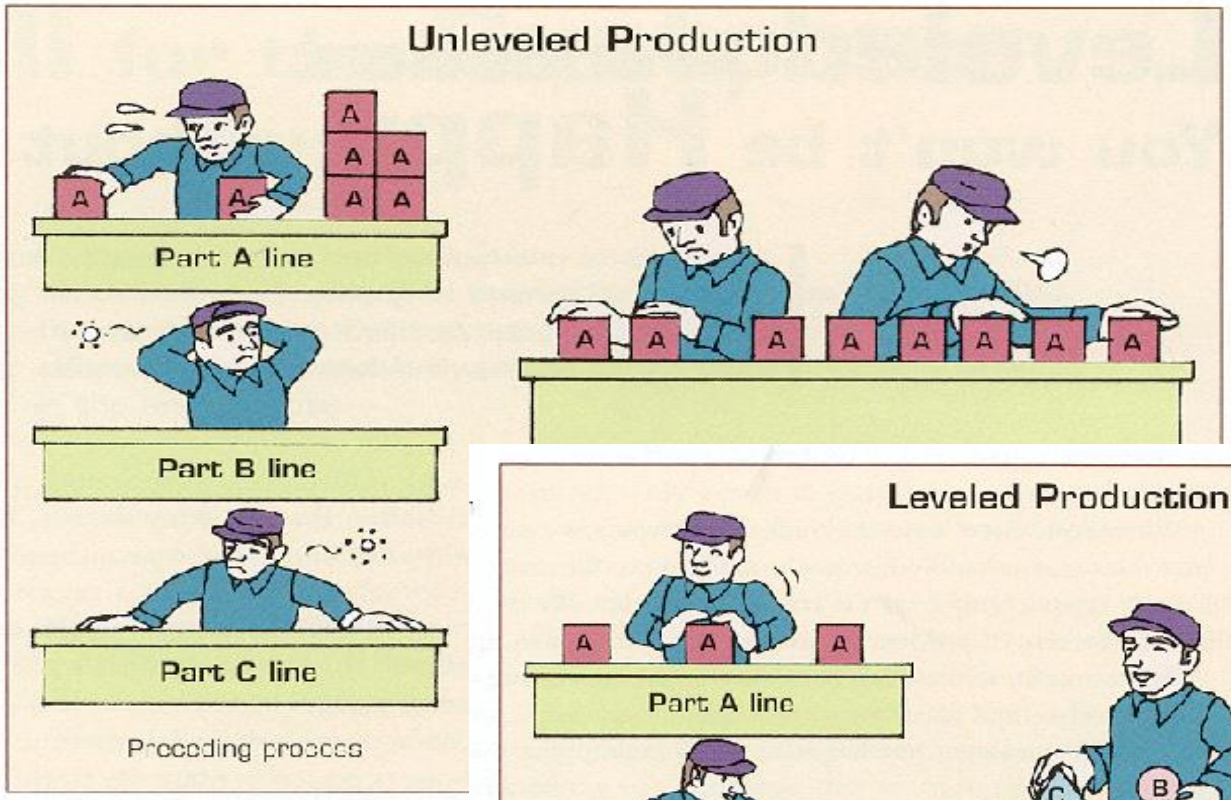
(AAAABBBB..)

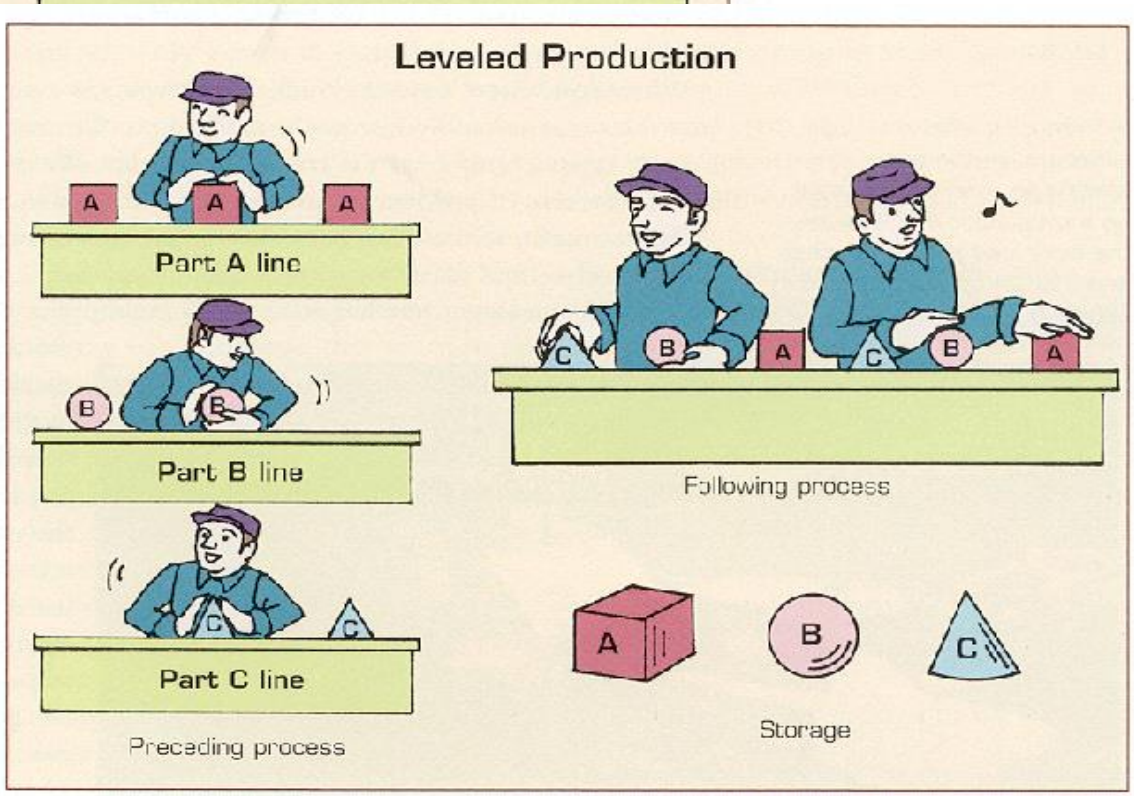


Mixed Production Schedule

(ABAB...)



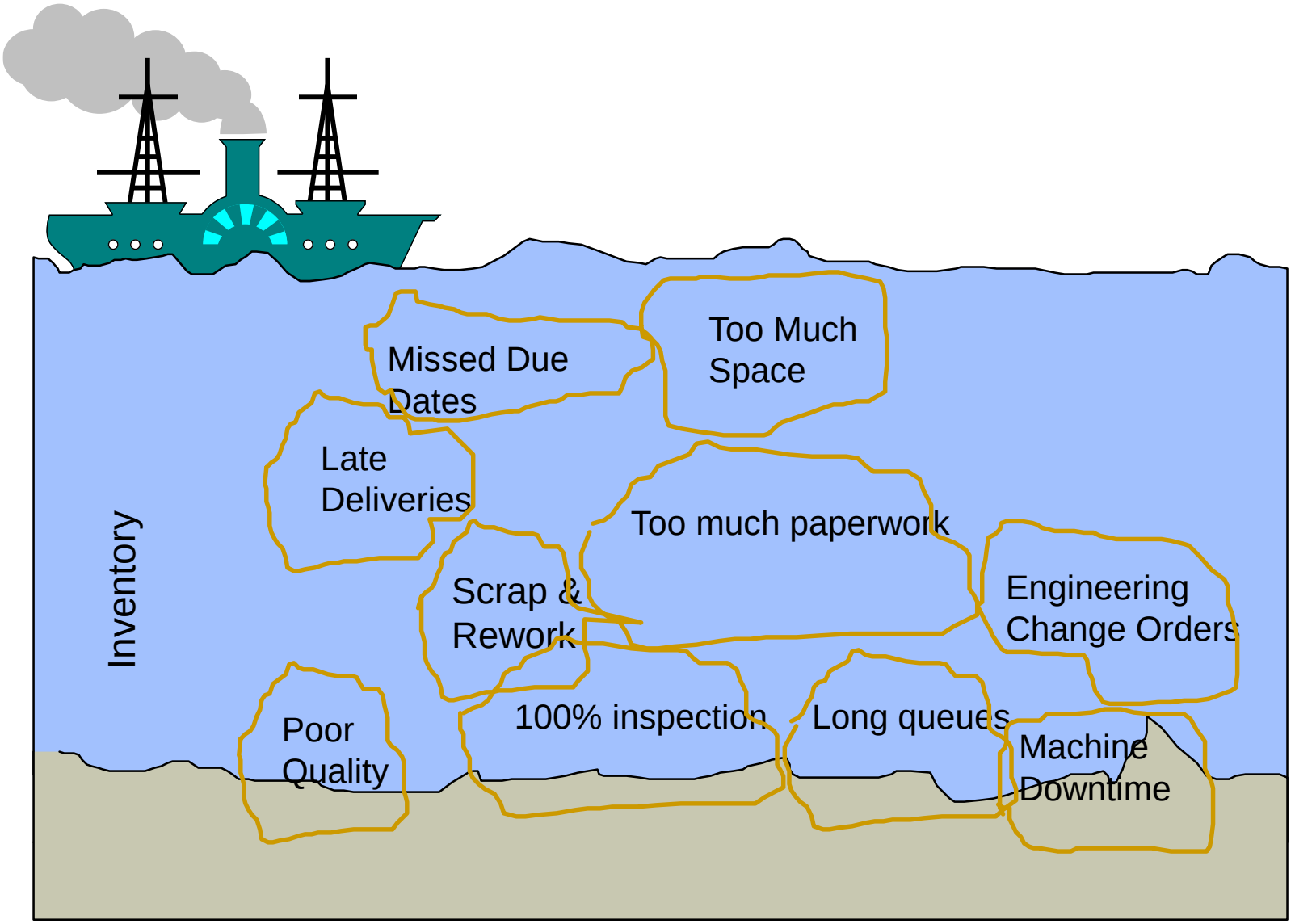

Unleveled Production
Part A line
Part B line
Part C line
Preceding process


Leveled Production
Part A line
Part B line
Part C line
Preceding process
Following process
Storage

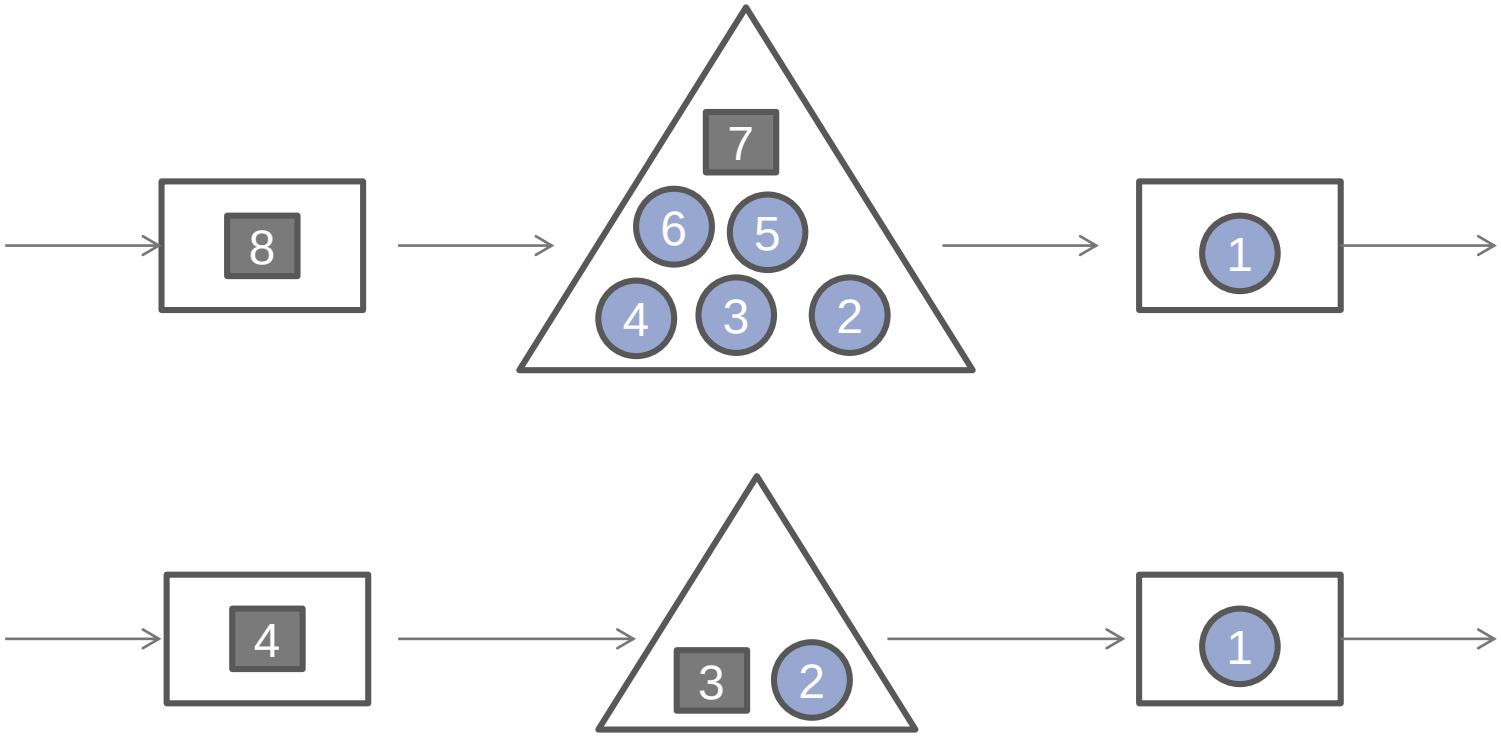
INVENTORY

- **Why we need inventory?**
  - To maintain independence of operations
  - To meet variation in product demand
  - To allow flexibility in production scheduling
  - To provide a safeguard for variation in raw material delivery
  - To take advantage of economic purchase order size

INVENTORY CAN HIDE PROBLEMS



INFORMATION TURNAROUND TIME



Inventory leads to longer ITAT

Good Unit

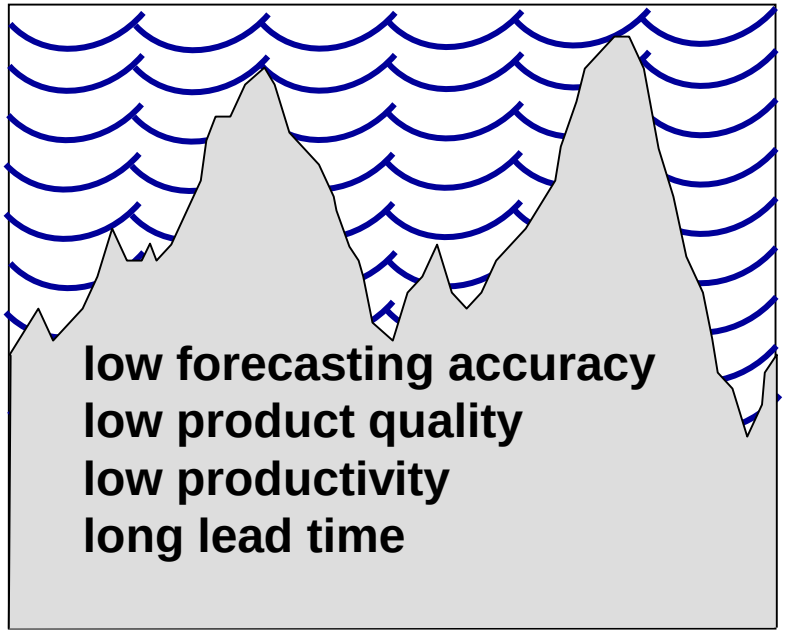
Defective Unit

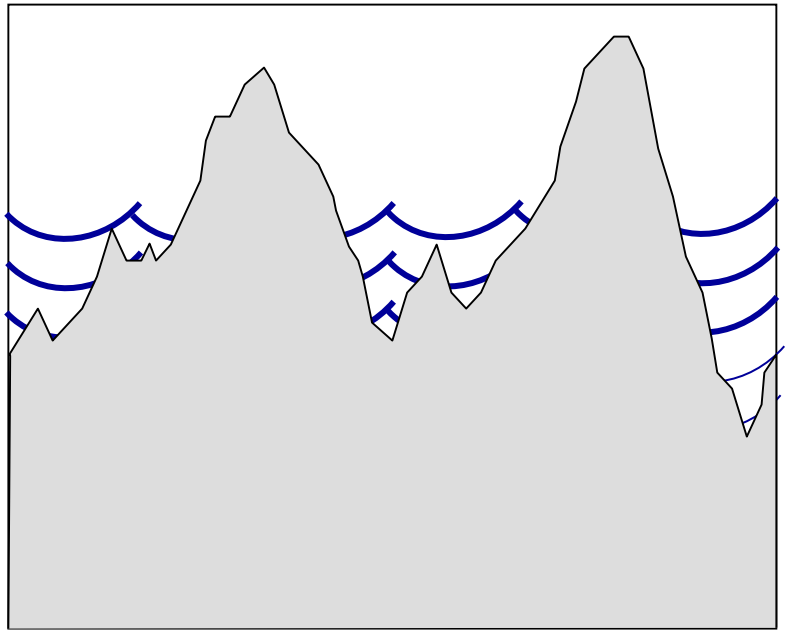
JUST-IN-TIME OPERATIONS

JIT = have exactly *what* is needed, in the *quantity* it is needed, *when* it is needed, *where* it is needed.

VMI = vendor managed inventory

PHILOSIHHY OF JIT: EXCESSIVE INVENTORY MASKS PROBLEMS





Excessive inventory masks problems (water covers rocks)

Reduced inventories reveal problem (rocks becomes visible)

HISTORY OF JIT

Origin of Just-in-time (JIT): The idea and the practice of JIT were initiated in 1970s at Toyota, the leading automobile manufacturer of Japan

Characteristics of Manufacturing Environment in Japan

- Limited working space
- Closeness to suppliers and consumers
- Small economy scale
- Relatively uniform taste of consumers
- Eastern culture (well organized, labor moral, etc.)

$\Rightarrow$ Improving productivity and reducing inventory become necessary and possible

GOALS OF JIT

Low level of inventory (ideal situation is zero inventory)

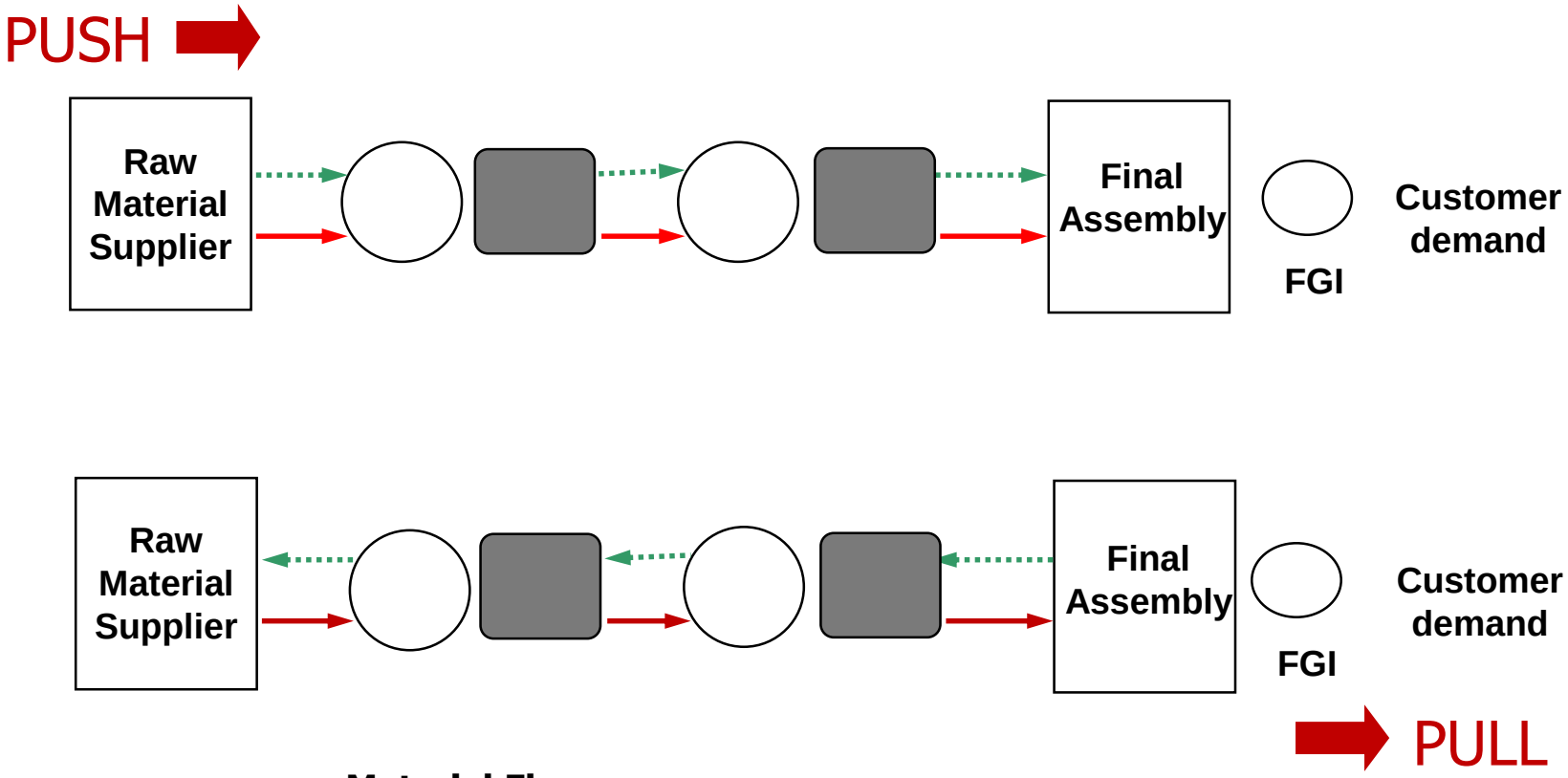
Low level of defective units or machines breakdowns

Low setup costs, and hence small batches

Parts are supplied from upstream whenever needed by downstream, e.g., multiple deliveries a day

Parts are produced as needed and thus sudden changes in demand are not desired

PUSH VS PULL SYSTEM



A REALIZATION OF JIT - KANBAN SYSTEMS

The Kanban system is a manual realization of the JIT idea and was initiated by Toyota (Kanban means card)

Two Kanban systems are often used in practice:

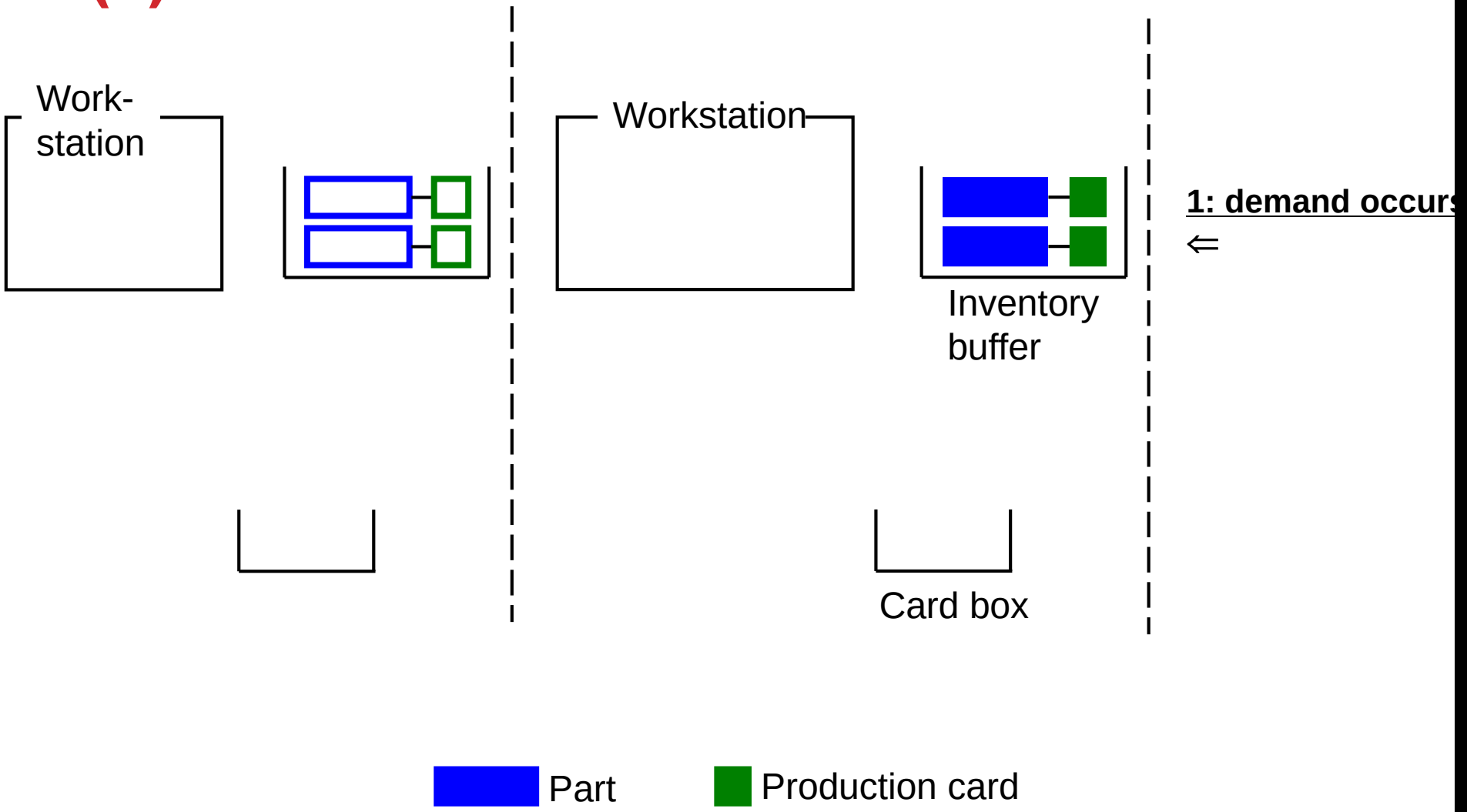
- One-card Kanban system, in which only production cards are used. It is suitable for the situation where workstations are close to each other
- Two-card Kanban system, in which both production and move cards are used. It is suitable for the situation where workstations are not close

In the Kanban system, the production of parts is authorized only with available production cards. So is the movement of the parts in the two-card system

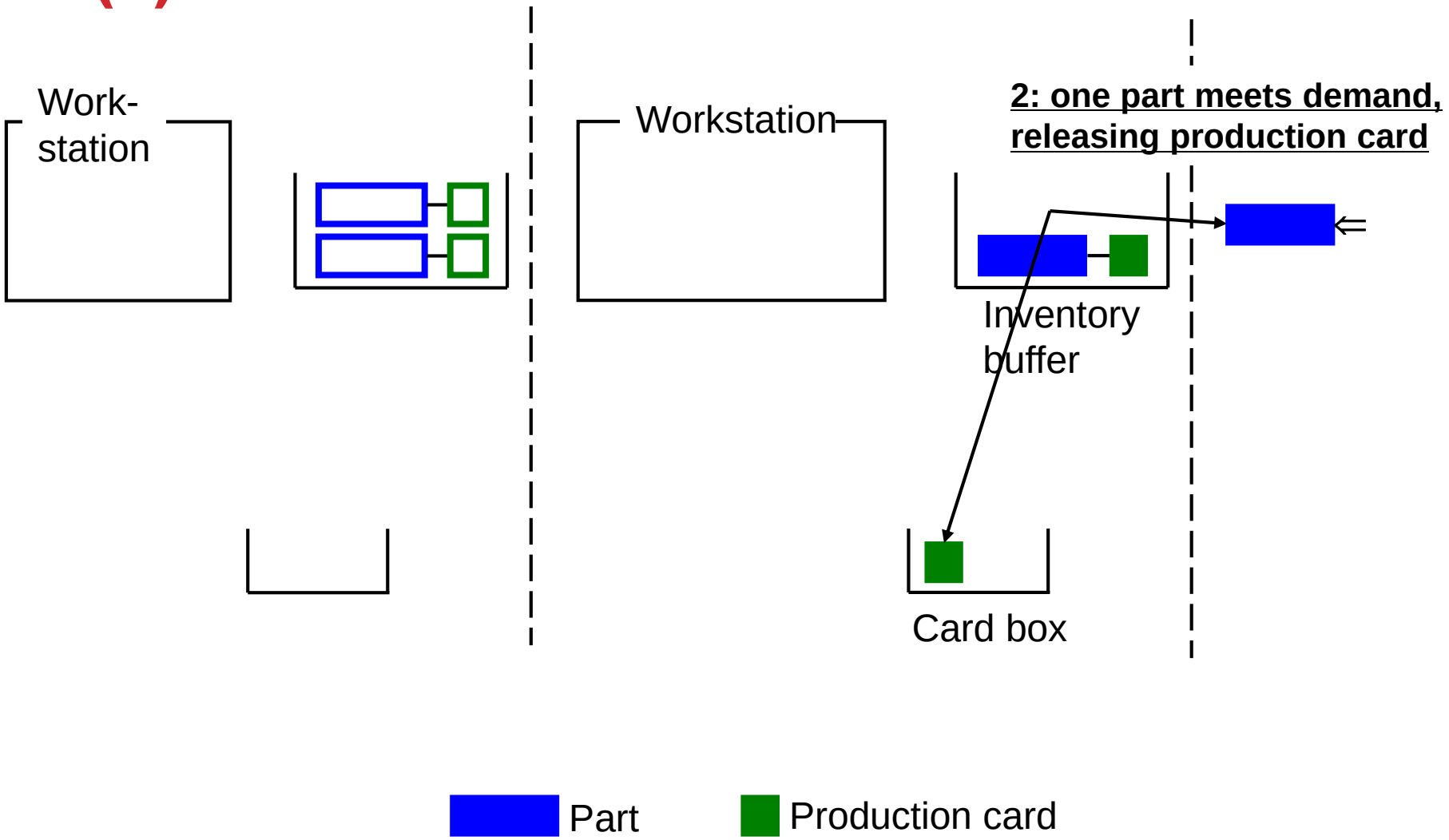
- The number of parts associated with a workstation is limited by the number of cards associated

DIFFERENT KANBAN APPROACHES

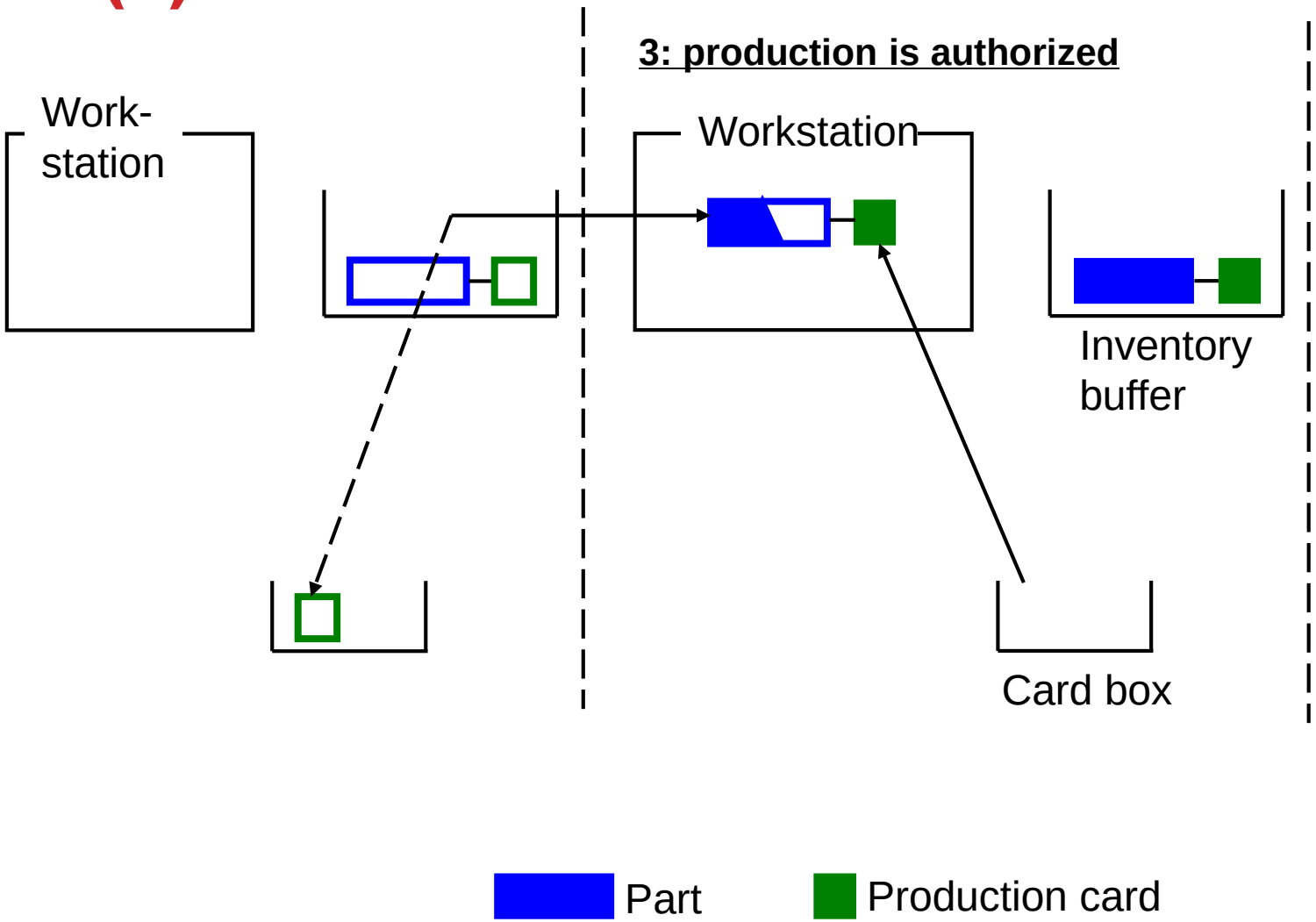
ONE-CARD KANBAN SYSTEM (1)



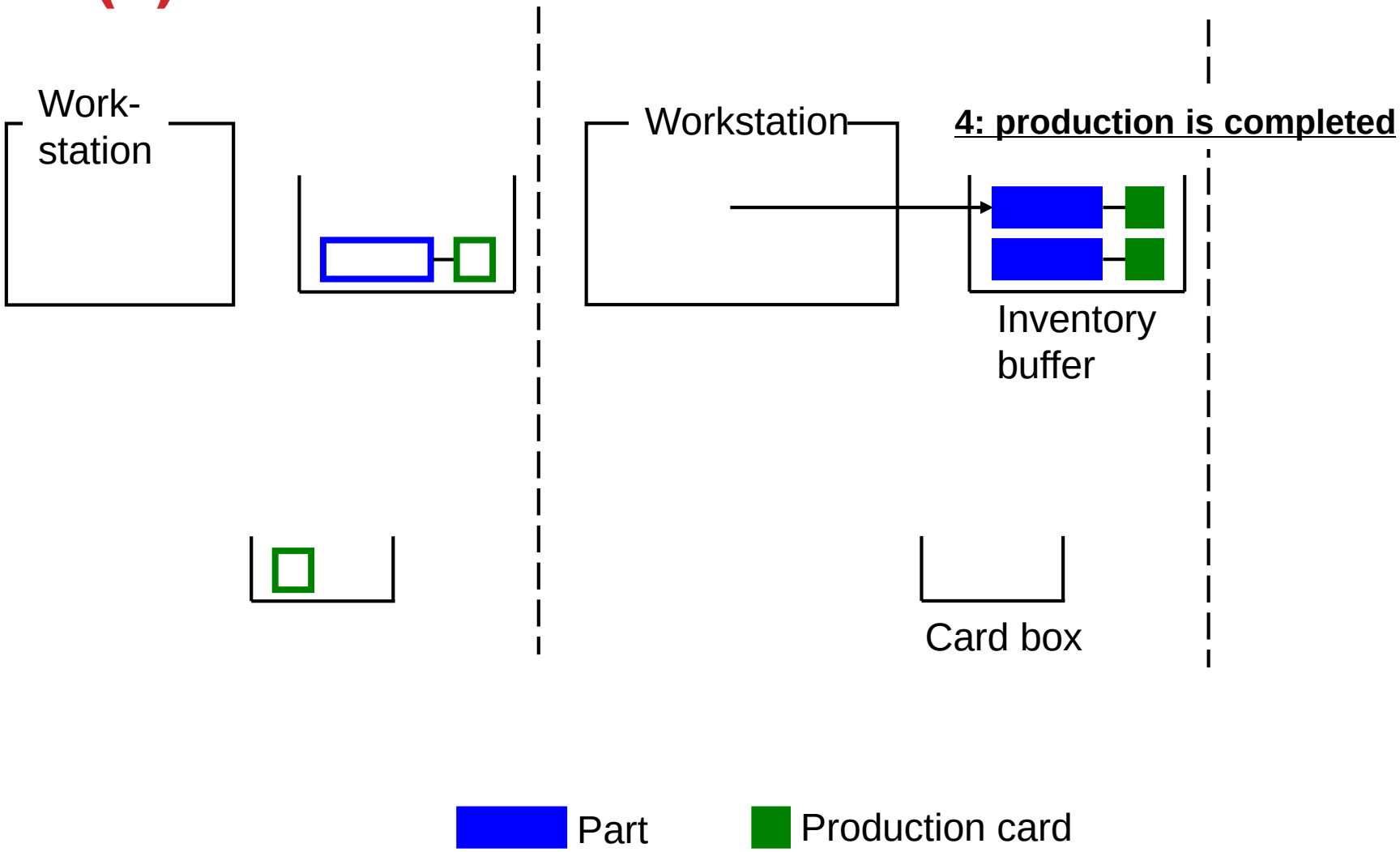
ONE-CARD KANBAN SYSTEM (2)



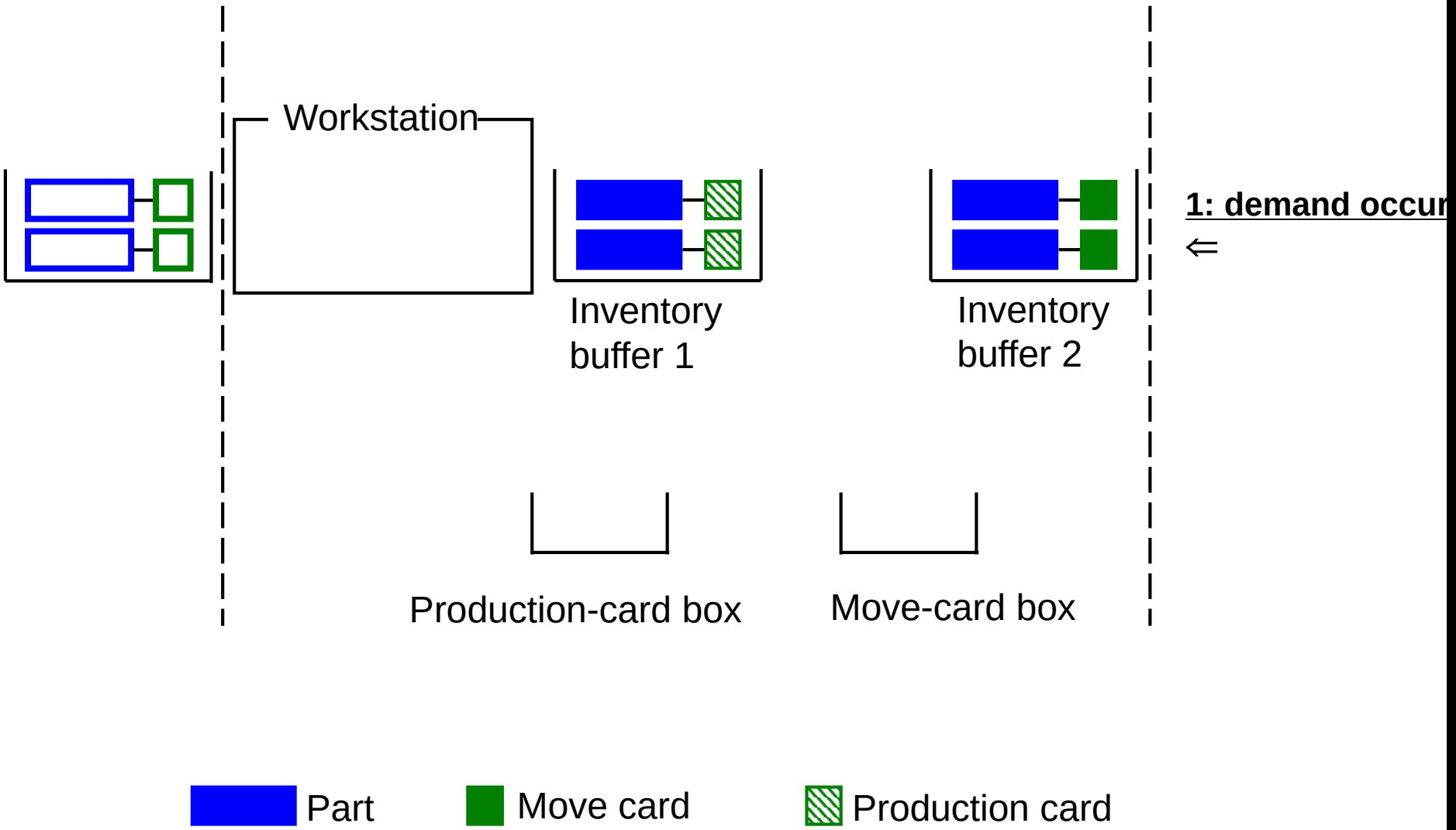
ONE-CARD KANBAN SYSTEM (3)



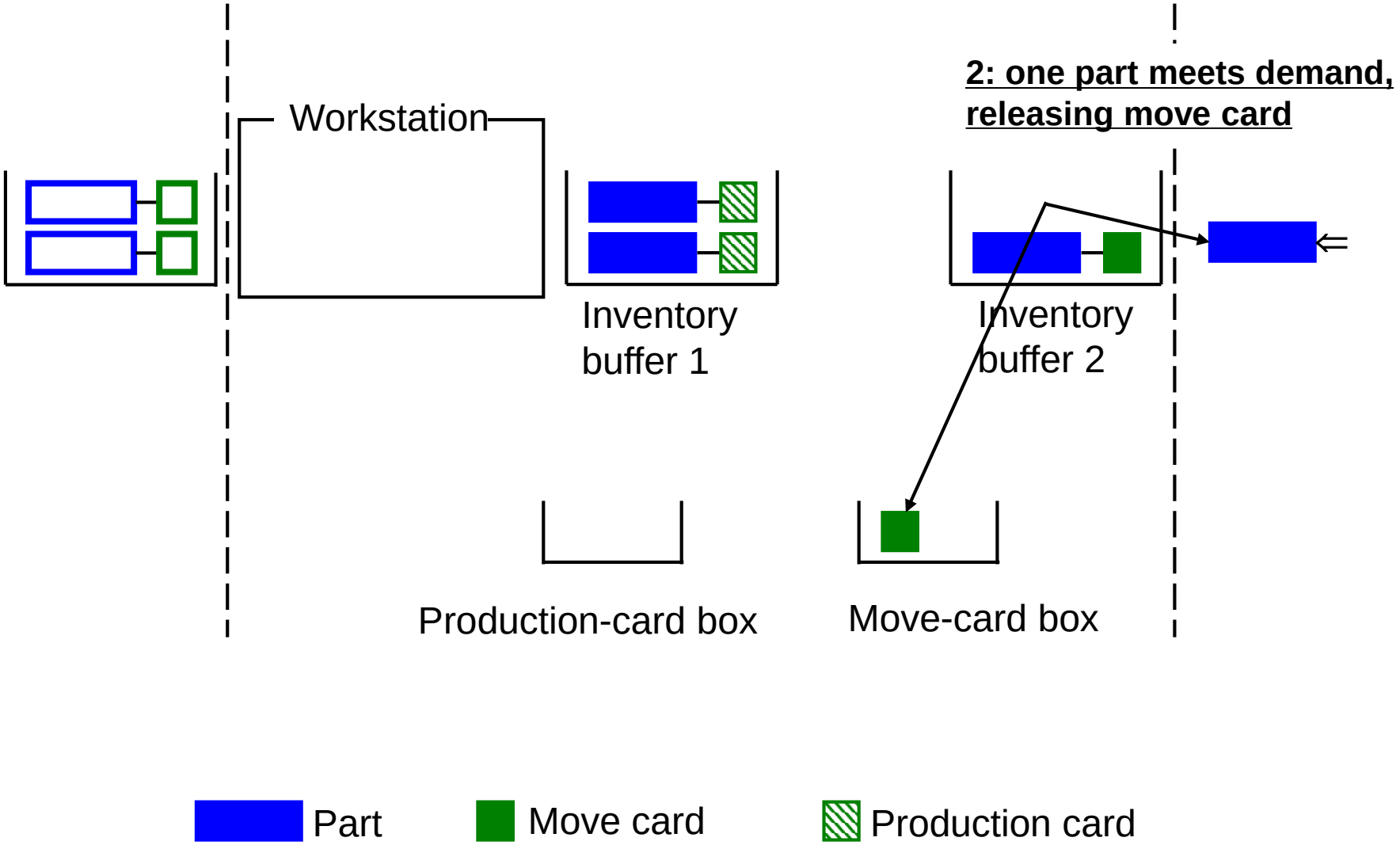
ONE-CARD KANBAN SYSTEM (4)



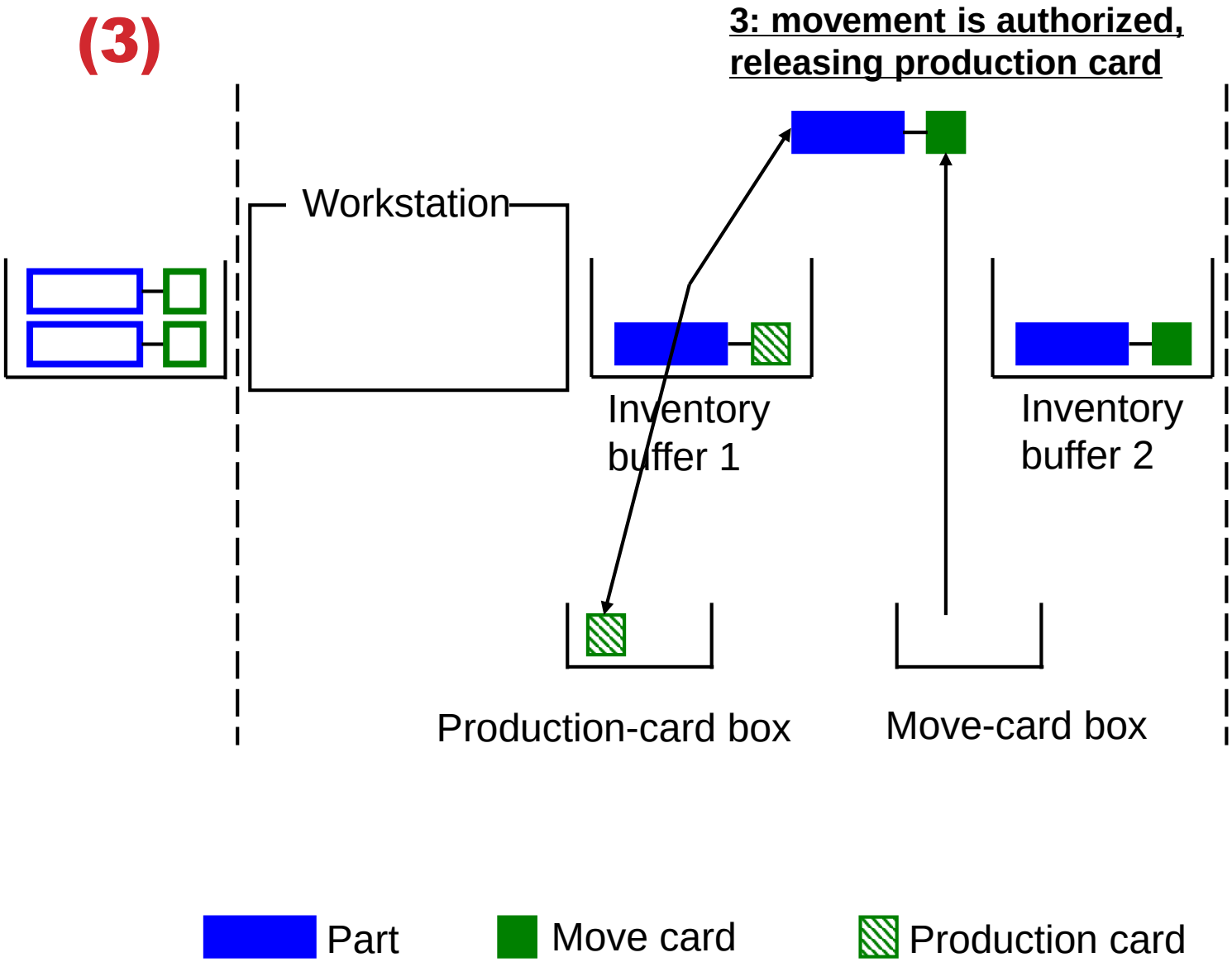
TWO-CARD KANBAN SYSTEM (1)



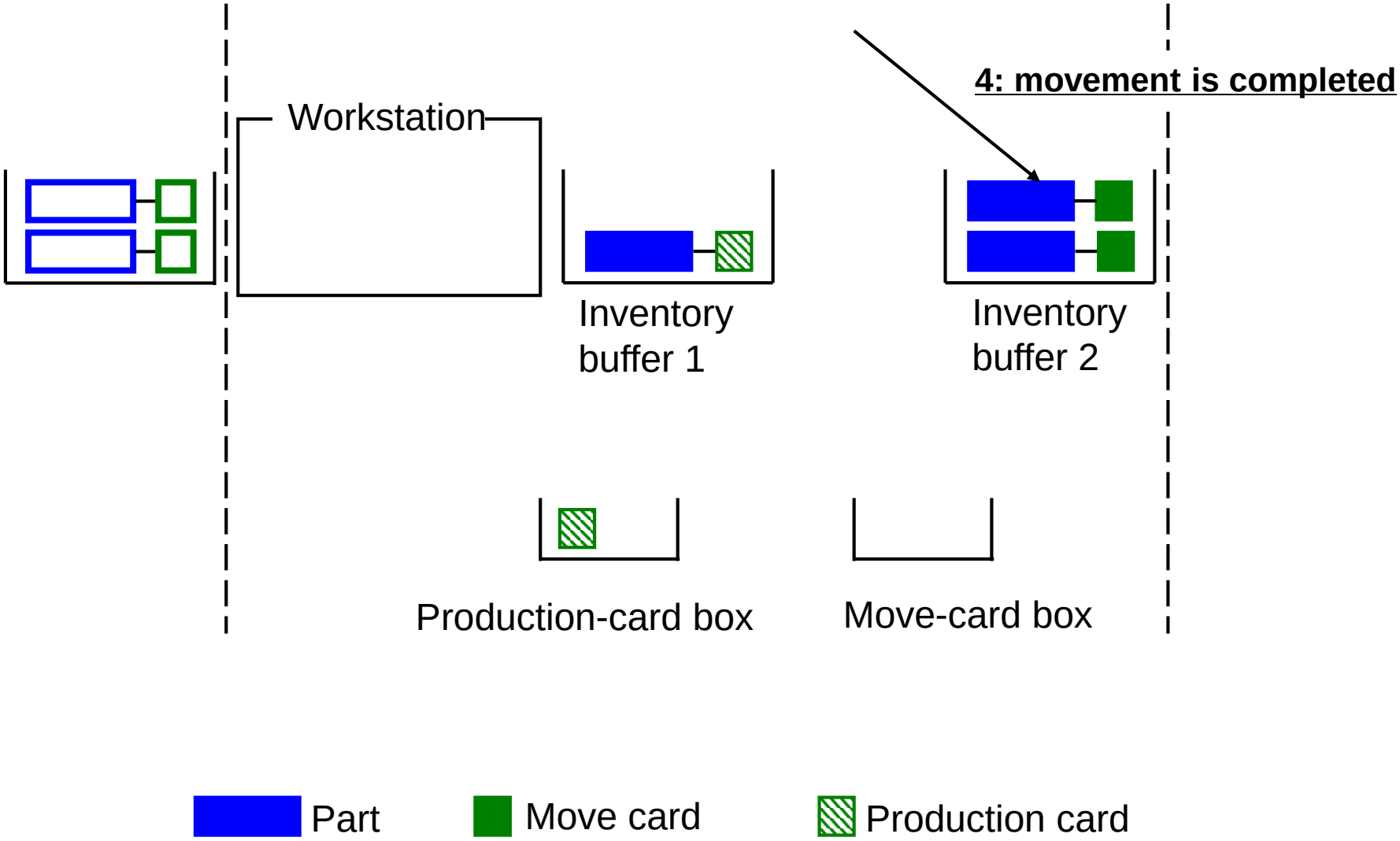
TWO-CARD KANBAN SYSTEM (2)



TWO-CARD KANBAN SYSTEM (3)



TWO-CARD KANBAN SYSTEM (4)



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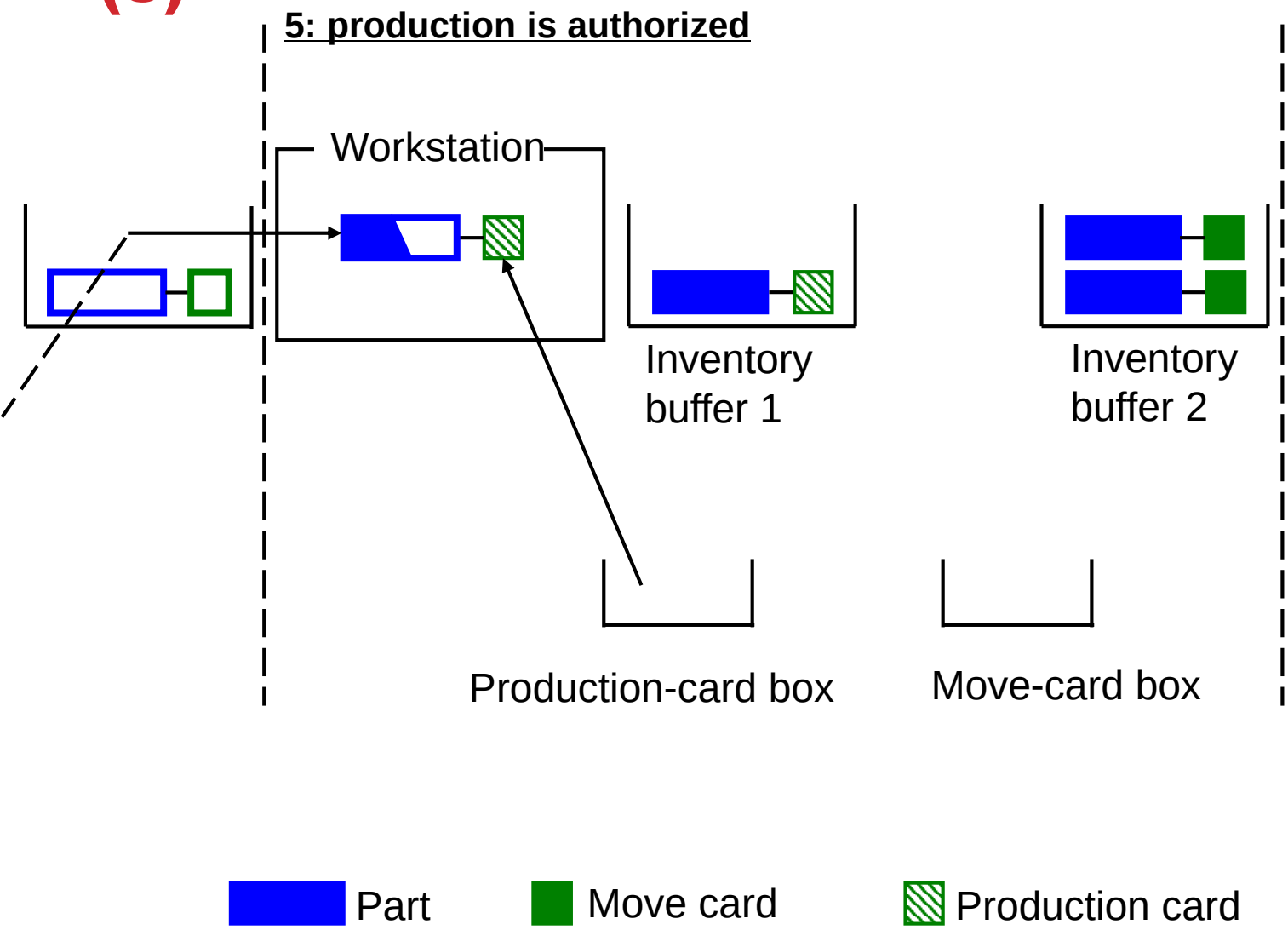

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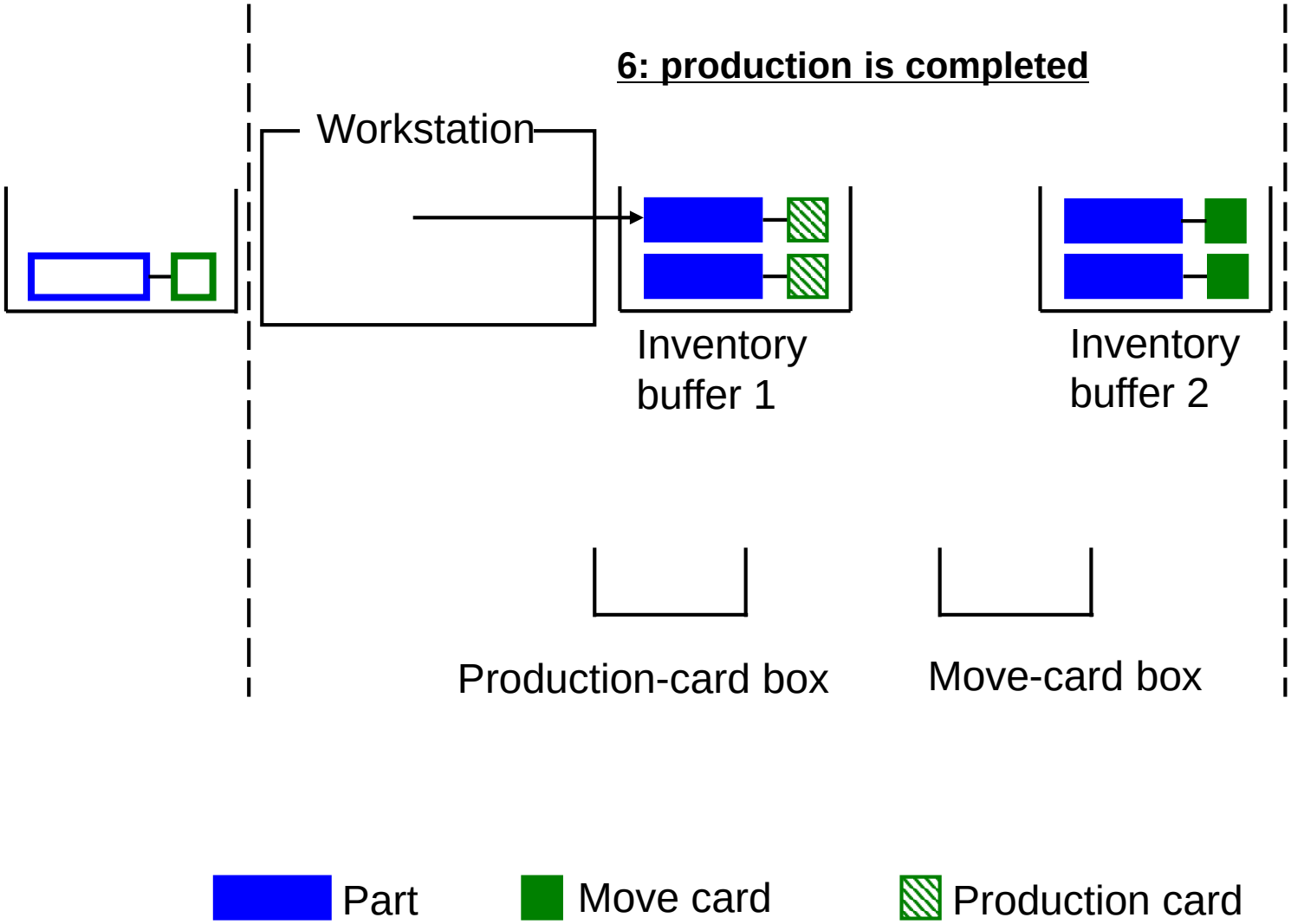


MRP VERSUS JIT PRODUCTION SYSTEMS

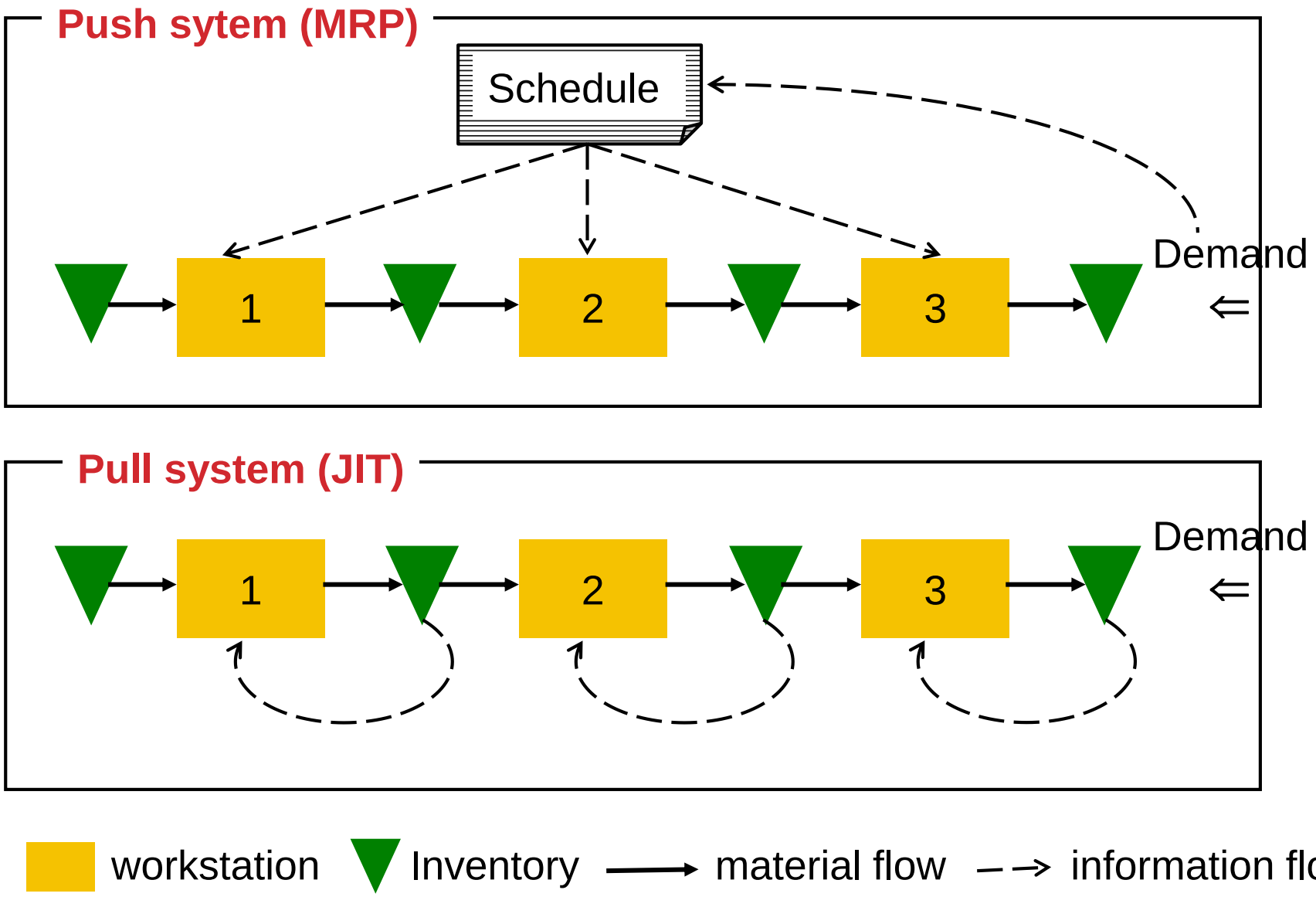
MRP

- Developed first in US
- Schedule-based
- Push system
- Often computer-based, may be complicated
- Typically with centralized control

JIT

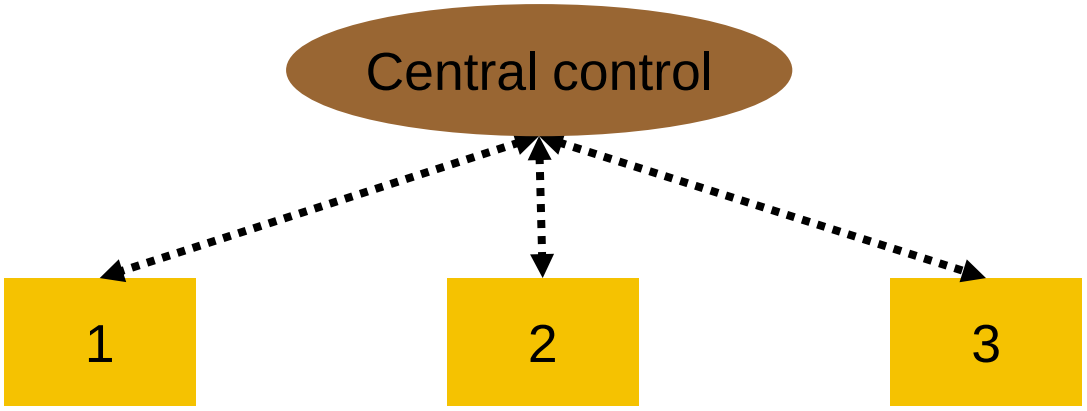
- Developed first in Japan
- Authorization-constrained
- Pull system
- Does not need computers, simple to understand
- Often with decentralized control

PUSH AND PULL PRODUCTION SYSTEMS



CENTRALIZED AND DECENTRALIZED CONTROL

Cenralized control



Decentralized control

SUMMARY OF JIT

- JIT is another basic philosophy of production control and is pull system
- JIT is less complex than MRP, but it works well only in certain environments
- The Kanban system is a manual realization of the JIT idea
- There are significant differences between MRP and JIT