Dedicated Storage Assignment (DSAP)

- The assignment of items to slots is termed *slotting*
  - With randomized storage, all items are assigned to all slots
- DSAP (dedicated storage assignment problem):
  - Assign *N* items to slots to minimize total cost of material flow
- DSAP solution procedure:
  1. *Order Slots:* Compute the expected cost for each slot and then put into nondecreasing order
  2. *Order Items:* Put the flow density (flow per unit of volume) for each item *i* into nonincreasing order

$$\frac{f_{[1]}}{M_{[1]}s_{[1]}} \geq \frac{f_{[2]}}{M_{[2]}s_{[2]}} \geq \cdots \geq \frac{f_{[N]}}{M_{[N]}s_{[N]}}$$

  3. *Assign Items to Slots:* For $i = 1, \ldots, N$, assign item $[i]$ to the first slots with a total volume of at least $M_{[i]}s_{[i]}$

1-D Slotting Example

		A	B	C
Max units	M	4	5	3
Space/unit	s	1	1	1
Flow	f	24	7	21
Flow Density	f/(M x s)	6.00	1.40	7.00

Flow Density	1-D Slot Assignments													Expected Distance		Flow		Total Distance
$\frac{21}{3}=7.00$	I/O	C	C	C										2(0) + 3 = 3	×	21	=	63
	0			3														
$\frac{24}{4}=6.00$	I/O				A	A	A	A						2(3) + 4 = 10	×	24	=	240
	-3			0				4										
$\frac{7}{5}=1.40$	I/O								B	B	B	B	B	2(7) + 5 = 19	×	7	=	133
	-7							0					5					
	I/O	C	C	C	A	A	A	A	B	B	B	B	B					436
	0			3				7					12					

1-D Slotting Example (cont)

		Dedicated			Random	Class-Based		
		A	B	C	ABC	AB	AC	BC
Max units	M	4	5	3	9	7	7	8
Space/unit	s	1	1	1	1	1	1	1
Flow	f	24	7	21	52	31	45	28
Flow Density	f/(M x s)	6.00	1.40	7.00	5.78	4.43	6.43	3.50

		1-D Slot Assignments												Total Distance	Total Space
Dedicated (flow density)	I/O	C	C	C	A	A	A	A	B	B	B	B	B	436	12
Dedicated (flow only)	I/O	A	A	A	A	C	C	C	B	B	B	B	B	460	12
Class-based	I/O	C	C	C	AB	AB	AB	AB	AB	AB	AB			466	10
Randomized	I/O	ABC	ABC	ABC	ABC	ABC	ABC	ABC	ABC	ABC				468	9

2-D Slotting Example

		A	B	C
Max units	M	4	5	3
Space/unit	s	1	1	1
Flow	f	24	7	21
Flow Density	f/(M x s)	6.00	1.40	7.00

8	7	6	5	4	5	6	7	8
7	6	5	4	3	4	5	6	7
6	5	4	3	2	3	4	5	6
5	4	3	2	1	2	3	4	5
4	3	2	1	0	1	2	3	4

Distance from I/O to Slot

	C	C	B	
C	A	A	B	B
A	A	I/O	B	B

Original Assignment (TD = 215)

	B	B	B	
B	A	C	A	B
A	C	I/O	C	A

Optimal Assignment (TD = 177)

DSAP Assumptions

1. All SC S/R moves
2. For item *i*, probability of move to/from each slot assigned to item is the same
3. The *factoring assumption*:
    a. Handling cost and distances (or times) for each slot are identical for all items
    b. Percent of S/R moves of item stored at slot *j* to/from I/O port *k* is identical for all items

- Depending of which assumptions not valid, can determine assignment using other procedures

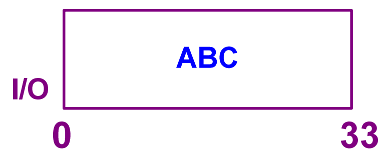
$$\underset{(c_i x_{ij})}{} DSAP \subset \underset{(c_{ij} x_{ij})}{LAP} \subset LP \subset \underset{\underset{TSP}{\cup}}{QAP} \left(c_{ijkl} x_{ij} x_{kl}\right)$$

Example 5: 1-D DSAP

- What is the change in the minimum expected total distance traveled if dedicated, as compared to randomized, block stacking is used, where
    a. Slots located on one side of 10-foot-wide down aisle
    b. All single-command S/R operations
    c. Each lane is three-deep, four-high
    d. 40 $\times$ 36 in. two-way pallet used for all loads
    e. Max inventory levels of SKUs A, B, C are 94, 64, and 50
    f. Inventory levels are uncorrelated and retrievals occur at a constant rate
    g. Throughput requirements of A, B, C are 160, 140, 130
    h. Single I/O port is located at the end of the aisle

Example 5: 1-D DSAP

- Randomized:



$$M = \left\lfloor \frac{M_A + M_B + M_C}{2} + \frac{1}{2} \right\rfloor = \left\lfloor \frac{94+64+50}{2} + \frac{1}{2} \right\rfloor = 104$$

$$L_{rand} = \left\lceil \frac{M + NH\left(\frac{D-1}{2}\right) + N\left(\frac{H-1}{2}\right)}{DH} \right\rceil$$

$$= \left\lceil \frac{104 + 3(4)\left(\frac{3-1}{2}\right) + N\left(\frac{4-1}{2}\right)}{3(4)} \right\rceil = 11 \text{ lanes}$$

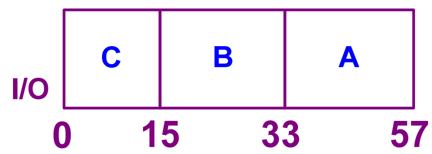
$$X = xL_{rand} = 3(11) = 33 \text{ ft}$$

$$d_{SC} = X = 33 \text{ ft}$$

$$TD_{rand} = \left(f_A + f_B + f_C \right) X = \left(160+140+130\right)33 = 14{,}190 \text{ ft}$$

Example 5: 1-D DSAP

- Dedicated:



$$\frac{f_A}{M_A}=\frac{160}{94}=1.7,\ \frac{f_B}{M_B}=\frac{140}{64}=2.19,\ \frac{f_C}{M_C}=\frac{130}{50}=2.6 \quad \Rightarrow \quad C>B>A$$

$$L_A=\left\lceil\frac{M_A}{DH}\right\rceil=\left\lceil\frac{94}{3(4)}\right\rceil=8,\ L_B=\left\lceil\frac{M_B}{DH}\right\rceil=\left\lceil\frac{64}{3(4)}\right\rceil=6,\ L_C=\left\lceil\frac{M_C}{DH}\right\rceil=\left\lceil\frac{50}{3(4)}\right\rceil=5$$

$$X_C=xL_C=3(5)=15,\ X_B=xL_B=3(6)=18,\ X_A=xL_A=3(8)=24$$

$$d_{SC}^{C}=X_C=3(5)=15\text{ ft}$$

$$d_{SC}^{B}=2(X_C)+X_B=2(15)+18=48\text{ ft}$$

$$d_{SC}^{A}=2(X_C+X_B)+X_A=2(15+18)+24=90\text{ ft}$$

$$TD_{ded}=f_A d_{SC}^{A}+f_B d_{SC}^{B}+f_C d_{SC}^{C}=160(90)+140(48)+130(15)=23,070\text{ ft}$$