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, the reciprocal of which is the "cube per order index" or COI) 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, …, 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 | | | | | | | | | | (0 … 3)	2(0) + 3 = 3	$\times$	21	=	63
$\frac{24}{4} = 6.00$	I/O | | | | A | A | A | A | | | | | | (-3 … 0 … 4)	2(3) + 4 = 10	$\times$	24	=	240
$\frac{7}{5} = 1.40$	I/O | | | | | | | | B | B | B | B | B | (-7 … 0 … 5)	2(7) + 5 = 19	$\times$	7	=	133
	I/O | C | C | C | A | A | A | A | B | B | B | B | B | (0 … 3 … 7 … 12)					436

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

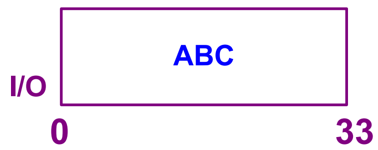
$$\left[\left(\frac{f_i}{M_i}\cdot d_j\right)x_{ij}\right] DSAP \subset \underset{\left(c_{ij}x_{ij}\right)}{LAP} \subset LP \subset \underset{\underset{TSP}{\cup}}{QAP}\left(c_{ijkl}x_{ij}x_{kl}\right)$$

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. 40×36 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:



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

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

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

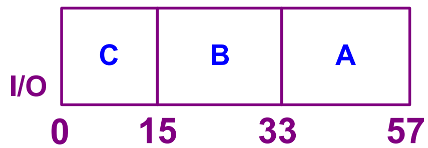
$$X = xL_{rand} = 3(11) = 33 \text{ ft}$$

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

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

Example 5: 1-D DSAP

- Dedicated:



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

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

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

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

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

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

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