Lecture #34

Prof. John W. Sutherland

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MichiganTech

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Michigan Technological University

Lessons from Manufacturing Layouts

- **Processes**
  - Project
  - Batch
  - Job shop
  - Line Flow
  - Continuous
- **Equipment**
  - General purpose
  - Specialized

From Van Bennekom (2005)

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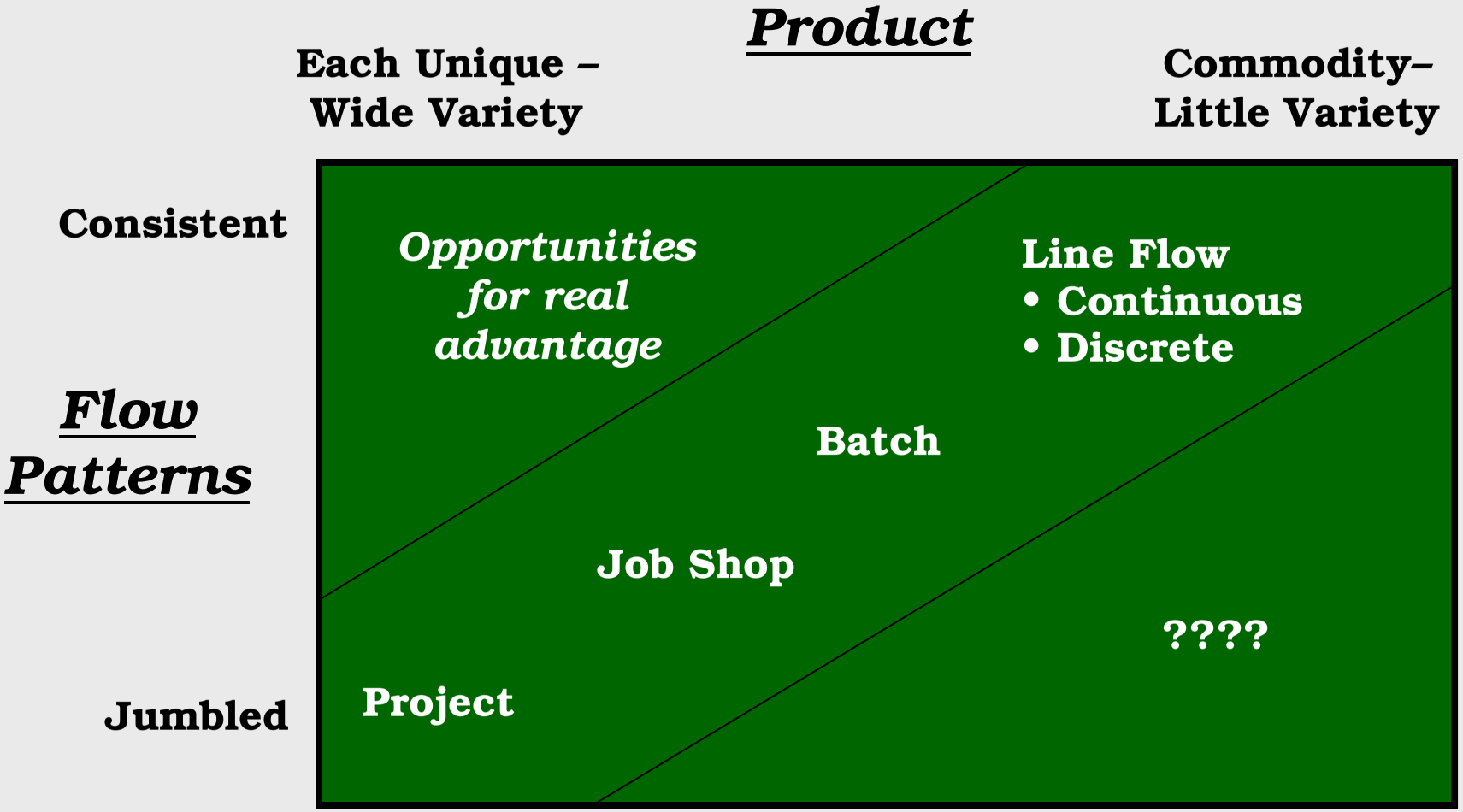
Process-Product Matrix



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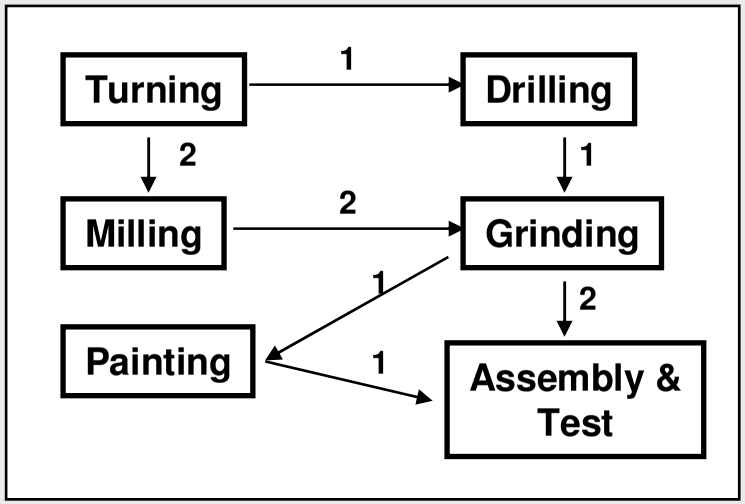
Facilities Layout

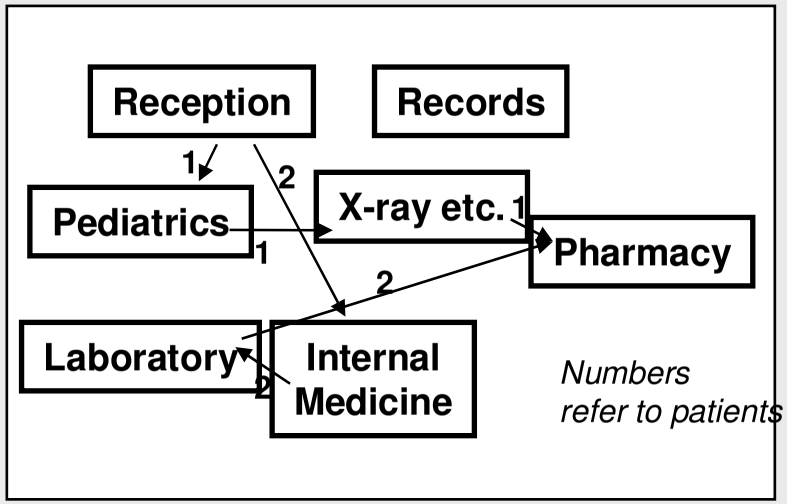
- **Fixed Position layout**
  - Huge and immovable
  - Ships, buildings etc.
- **Process Layout**
  - Focus on processes
  - Batch production, job shop
- **Product Layout**
  - Focus on one product
  - Assembly Line
- **Combination Layout**
- **Manufacturing Cells**
  - Focus on part families with similar characteristics

Process Layout

A typical job shop/batch production shop



A typical service operation



Numbers represent jobs or patients

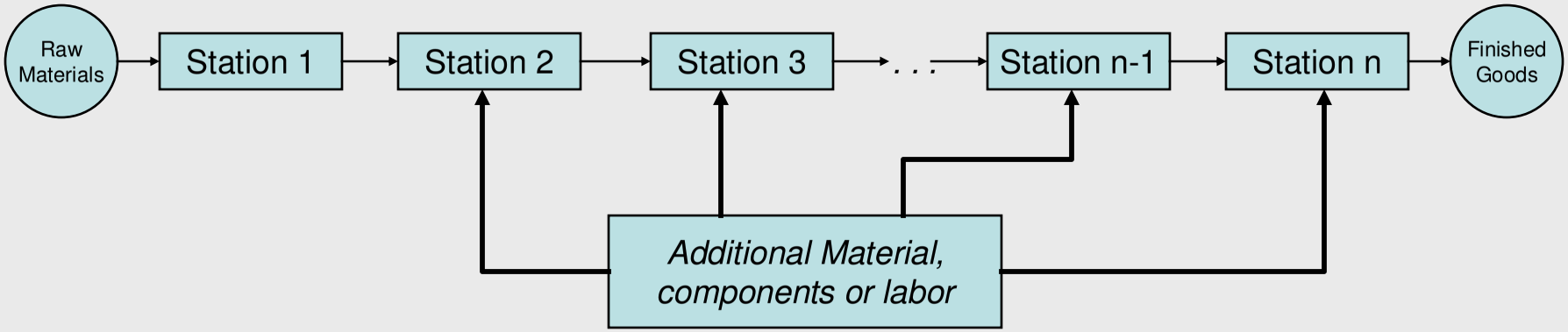
*Product travels to dedicated processing centers. Objective: Minimize Total load * Distance Traveled*

The arrangement should provide greater closeness rating.

Product Layout – Flow Shop

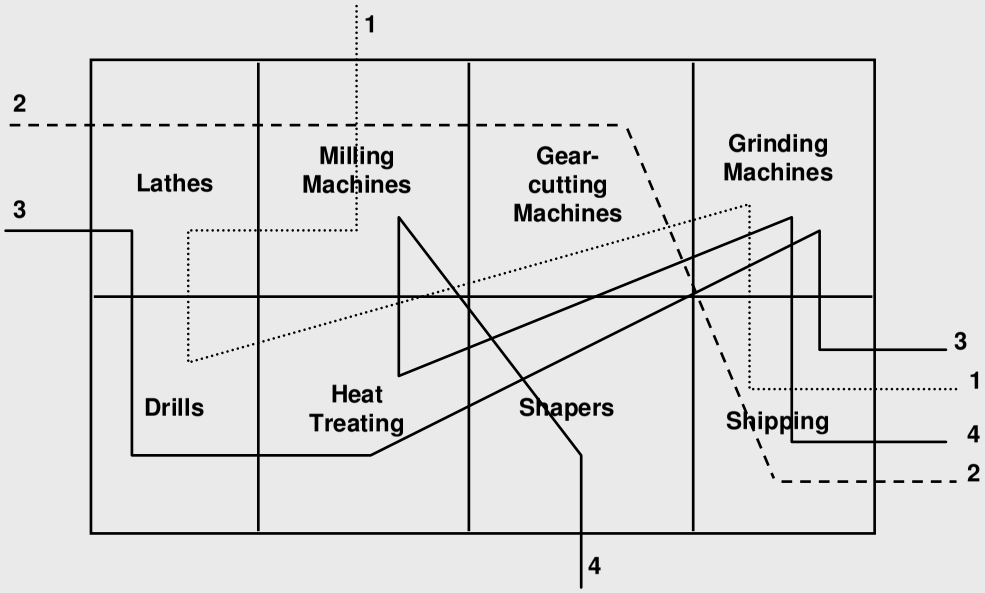
Can handle high volumes of the same product

Work moves through a fixed route

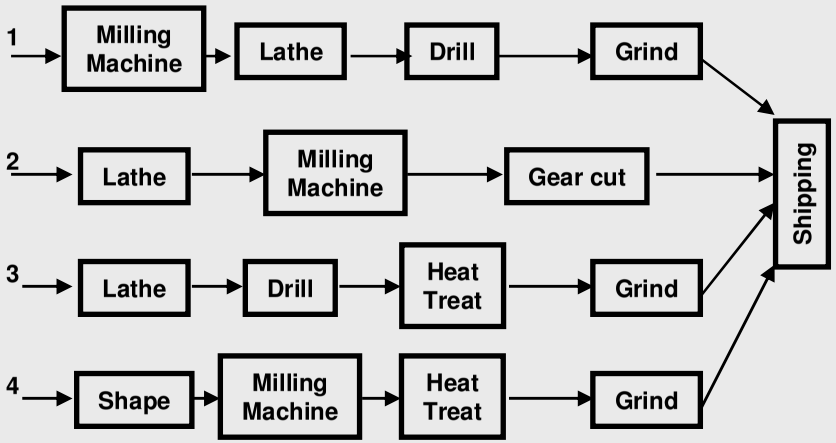


Total idle time at the stations should be a minimum.

Cellular Layout



Process Layout



Cellular Layout

Each part/product has its own cell or group of machines.

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Comparison of Layout Types

No.	Feature	Process Layout	Product Layout	Cellular Layout
1	Throughput Time	High	Low	Low
2	WIP Inventory	High	Low	Low
3	Flexibility - Volume	High	Low	High
4	Flexibility - Product Mix	High	Low	High
5	Utilization - Equipment	Low	High	High
6	Utilization - Labor	Low	High	High
7	Labor skills needed	High	Low	High
8	Type of equipment	General	Special	General
9	Prod. Planning & Control	Difficult	Easy	Difficult
10	Material Handling	High	Low	Low

Service-scapes

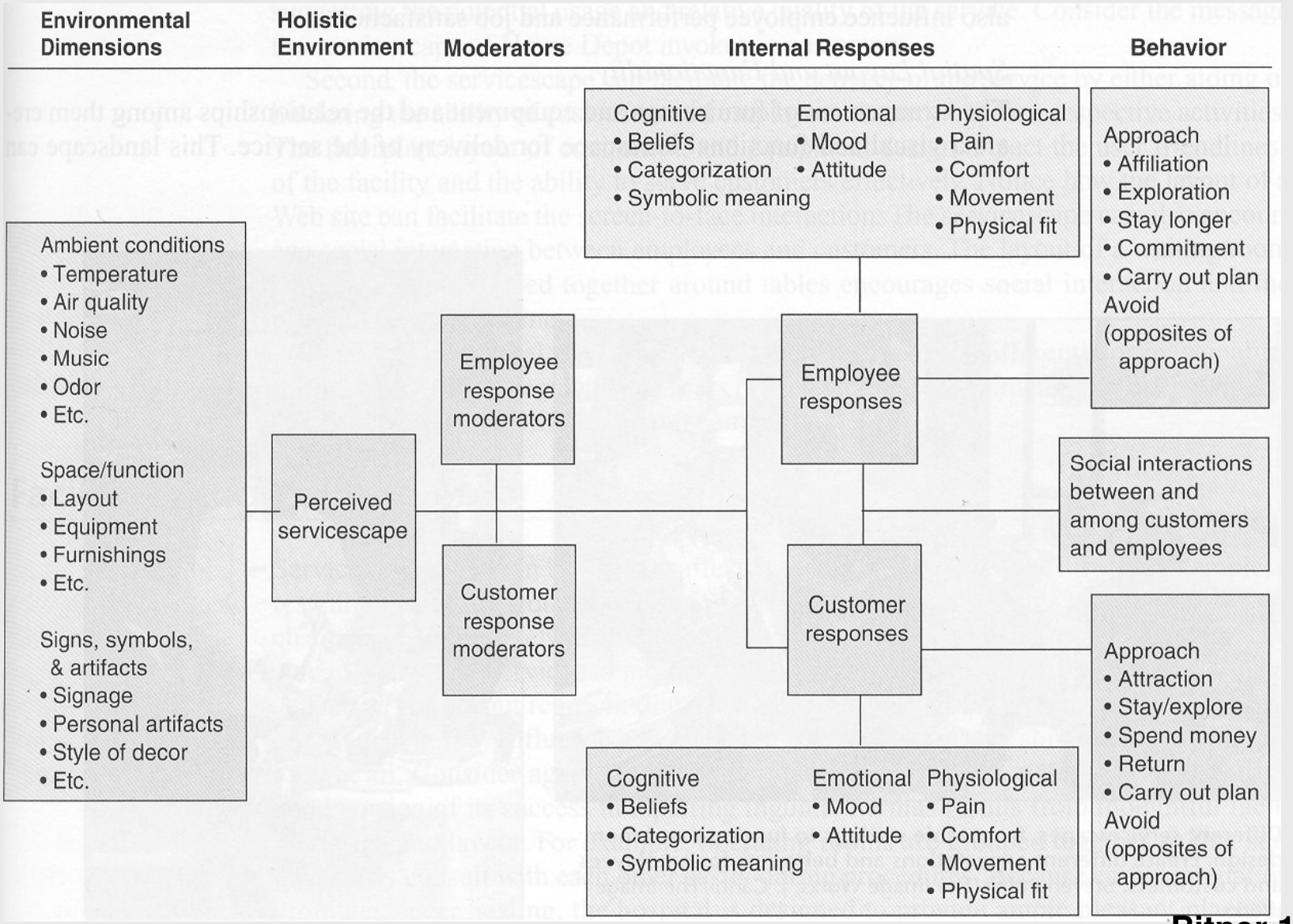
- The physical environment or service-scape of the supporting service facility influences both customer and employee behavior and should be designed with an image and feel that is consistent with the service concept to be provided.

Typology of Servicescapes

Who Performs in Servicescape	Physical Complexity of the Servicescape Elaborate	Lean
Self-service (customer only)	Golf course Water slide park	Post office kiosk E-commerce
Interpersonal (both)	Luxury hotel Airline terminal	Budget hotel Bus station
Remote service (employee only)	Research lab L.L. Bean	Telemarketing Online tech support

Bitner 1992

Service-scape Framework



Bitner 1992

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Environmental Dimensions of Service-scapes

- **Designing Physical Surroundings to Affect Employee and Customer Behavior:**
  - **Ambient Conditions: background characteristics such as noise level, music, lighting, temperature, and scent.**
  - **Spatial Layout and Functionality: reception area, circulation paths of employees and customers, and focal points.**
  - **Signs, Symbols, and Artifacts: selection, orientation, location, and size of objects.**

Facility Design Considerations

- **Nature and Objectives of Service Organization**
  - a fire station must have a structure large enough to house its vehicles, on-duty personnel, etc.
  - a bank must be designed to accommodate some type of vault
- **Land Availability and Space Requirements**
  - In an urban setting, buildings only can be expanded upward, e.g., McDonalds incorporating second-floor
- **Flexibility**
  - Adapt to changes in the quantity and nature of demand. “Designing for the future”

Facility Design Considerations

- **Security**
  - Modifications since 9/11
  - Scanners, surveillance cameras
- **Aesthetic Factors**
  - Nordstrom's vs. Eddie Bauer Factory Outlet
- **The Community and Environment**
  - Dry cleaner keeping hazardous chemicals out of the local environment.

Product Layout and the Work Allocation Problem

- Some standard services can be divided into an inflexible sequence of steps or operations that all customers must experience
- This is an example of a product layout most often associated with manufacturing assembly lines, where a product is assembled in a fixed sequence of steps
- The most obvious analogy is to a cafeteria, where diners push their trays along as they assemble their meal.

Product Layout and the Work Allocation Problem

- Staffing such a service requires allocating tasks among servers to create jobs that require nearly equal time.
- The job requiring the most time per customer creates a bottleneck and defines the capacity of the service line
- Several options are available:
  - Adding another worker to the job
  - Providing some aid to reduce the activity time
  - Regrouping the tasks to create a new line balance
    - "Line balancing problem"

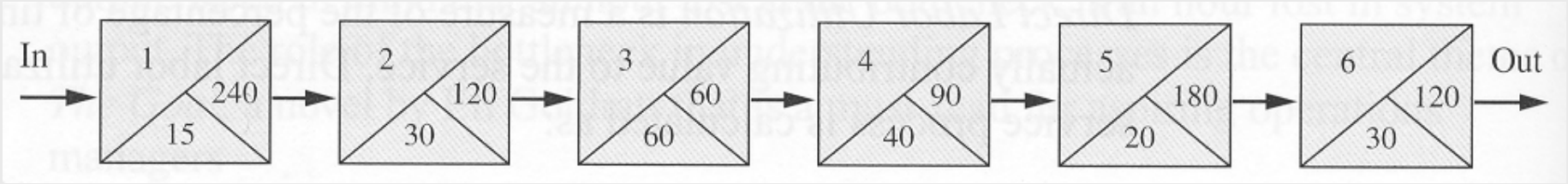
Driver's License Office

- A driver's license office is under pressure to increase its productivity to accommodate 120 applicants per hour with the addition of only one clerk to its present staff.
- The license renewal process currently is designed as a service line, with customers being processed in the fixed sequence listed in the table

Activity	Description	Cycle Time Sec.
1	Review application for correctness	15
2	Process and record payment	30
3	Check for violations and restrictions	60
4	Conduct eye test	40
5	Photograph applicant	20
6	Issue temporary license (state trooper)	30

Driver's License Office

- The process flow diagram for the current arrangement identifies the bottleneck activity as activity 3. which limits the current capacity to 60 applicants per hour.

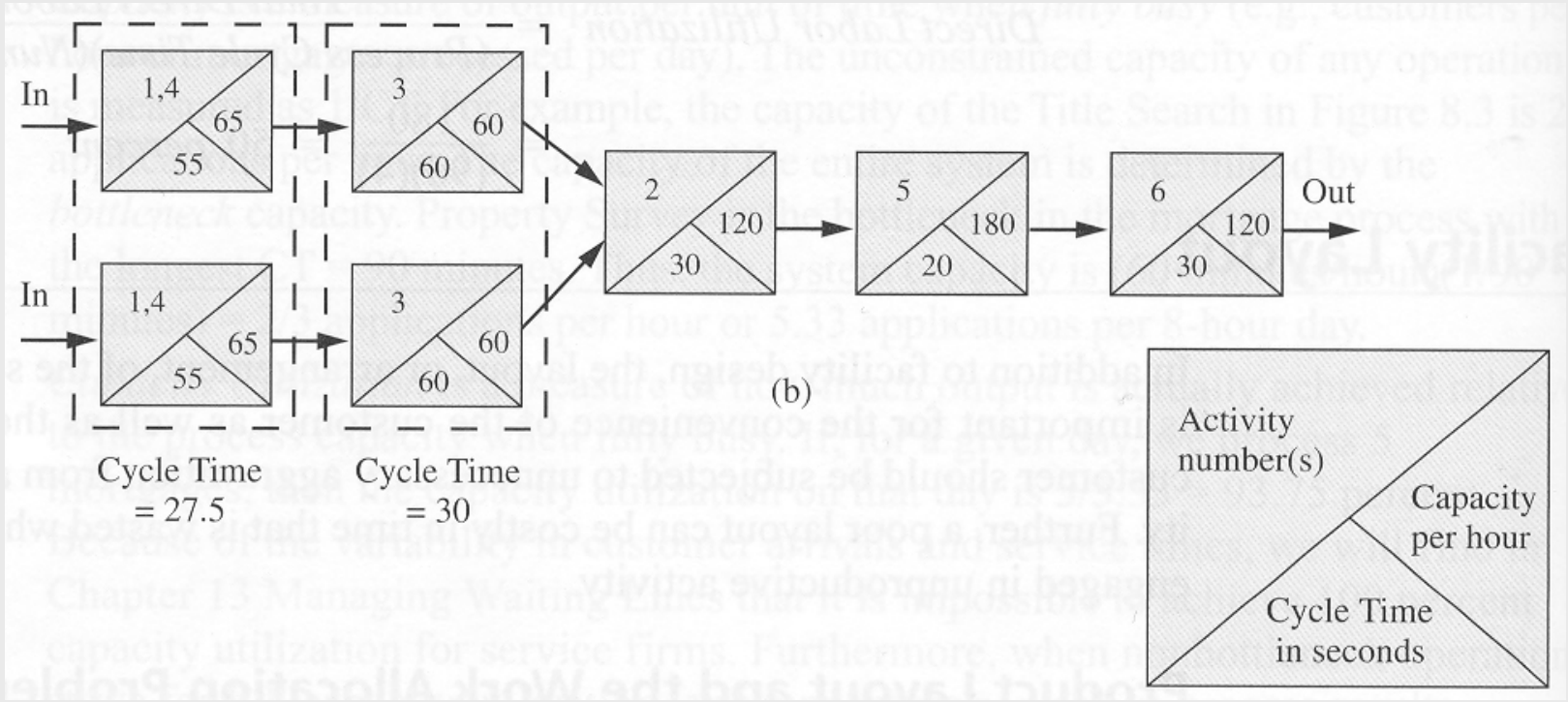


Driver's License Office

- By focusing only on the bottleneck, one might think that assigning the additional clerk to perform activity 3 would double the flow through the bottleneck and achieve the goal of 120 applicants per hour.
- However, the flow for this system would then be limited to 90 applicants per hour, because the bottleneck would shift to activity 4.

Automobile Driver's License Office

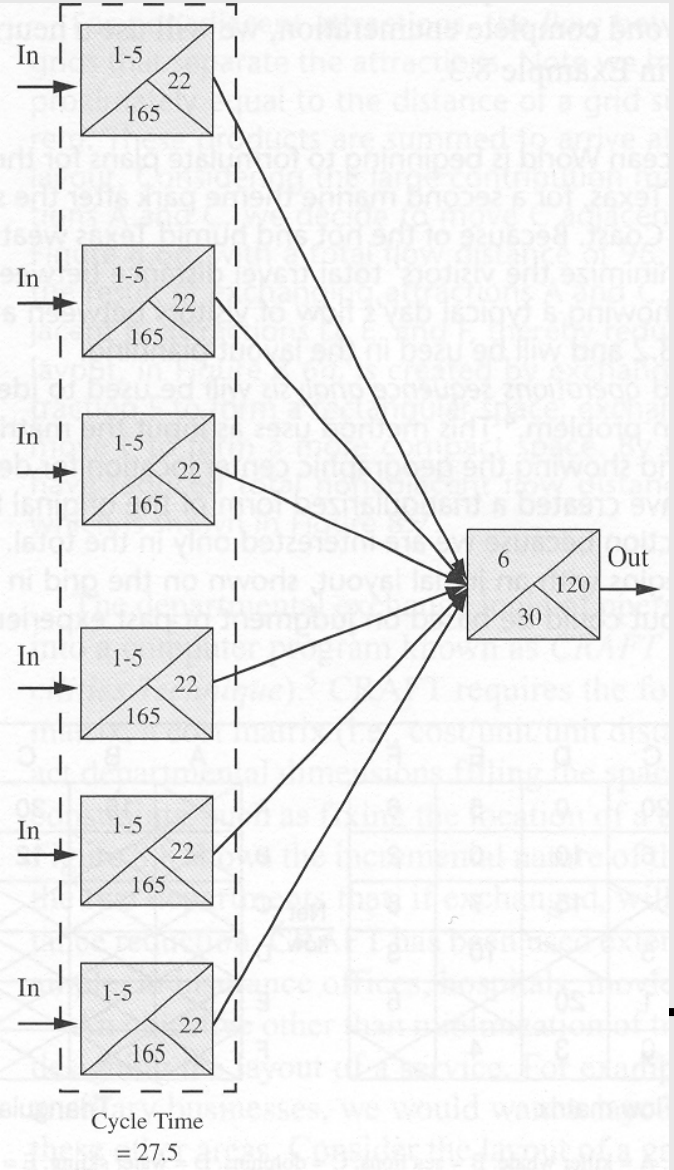
- **The proposed process design with 7 clerks can achieve the desired capacity of 120 applicants per hour because activities 1 and 4 have been grouped together to create a new job that better balances the work load among the staff**



Driver's License Office

- This example lends itself to a radical rethinking of the product layout. If money were available to invest in computers, additional eye-testing equipment, and cameras, then the entire process could be reengineered.
- Consider training each clerk to perform all five activities with a combined time of 165 seconds, or an individual flow rate of approximately 22 customers per hour.

Driver's License Office



- Now, an arriving customer would be faced with choosing from among 6 clerks working in parallel
- This system would be appealing to customers, however, because one clerk would handle all the transactions customers would be required to wait in between.
- Further, one would expect that the total time could be shortened because information would not need to be repeated as before
- Finally, staffing of the office would now be flexible because only the number of clerks required to meet anticipated demand need be on duty. This savings in labor could justify the investment in 6 work stations.

Process Layout

- A process layout: allows customers to define sequence of service activities to meet their needs -- provides some degree of customization
- From service provider's perspective, flow of customers appears to be intermittent – need for a waiting area in each department
- An example of a service process layout is a university campus with buildings dedicated to various disciplines – students go from bldg-to-bldg to attend classes.

Process Layout and the Relative Location Problem

- Relative location problem – how do we form the layout of the campus?
- For student/faculty convenience, departments such as engineering and physical sciences are placed in close proximity to each other, while perhaps economics and business administration are grouped together in another area.
- The library and administration offices located in a central part of the campus.

Example: Ocean World Theme Park

- The architect for Ocean World is beginning to formulate plans for the development of a property outside Waco, Texas. Because of the hot and humid Texas weather during the summer months, ways to minimize the visitors' total travel distance between attractions are being considered.

Example: Ocean World Theme Park

- **Data showing a typical day's flow of visitors between attractions:**

	A	B	C	D	E	F
A		7	20	0	5	6
B	8		6	10	0	2
C	10	6		15	7	8
D	0	30	5		10	3
E	10	10	1	20		6
F	0	6	0	3	4	

Flow matrix

Net flow →

	A	B	C	D	E	F
A		15	30	0	15	6
B			12	40	10	8
C				20	8	8
D					30	6
E						10
F						

Triangularized matrix

Description of attractions: A=killer whale, B=sea lions, C=dolphins, D=water skiing, E=aquarium, F=water rides.

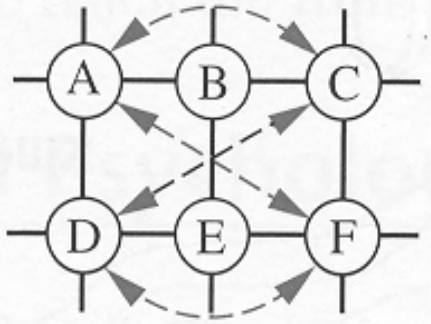
Example: Ocean World Theme Park

- A heuristic: operations sequence analysis – used to identify a good layout for this relative location problem
- This method uses as input the matrix of flows between departments and a grid showing the geographic center location for department assignments.
- The previous table has a triangularized form of the original flow matrix to sum the flows in either direction because we are interested only in the total.

Example: Ocean World Theme Park

- The heuristic begins with an initial layout

(a) Intial layout



Attraction Pairs	Flow Distances
AC	$30 \times 2 = 60$
AF	$6 \times 2 = 12$
DC	$20 \times 2 = 40$
DF	$6 \times 2 = 12$
Total	124

- Other flows only move a distance of 1 unit
- This initial layout is arbitrary but could be based on judgment or past experience.

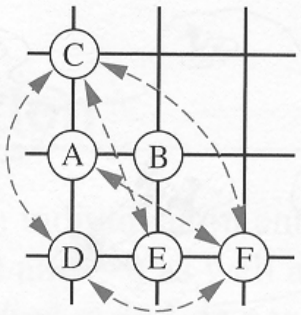
Example: Ocean World Theme Park

- Table suggests that attractions with high flow between them should be placed next to each other.
- Nonadjacent attractions, flow-distance obtained by multiplying flow by number of grids separating attractions.
- Assumed that diagonal separation is approx. equal to the distance of a grid side instead of using the Pythagorean theorem.
- These products are summed to arrive at a total flow distance of 124 for this initial layout.

Example: Ocean World Theme Park

- Considering the large contribution made to this sum by the separation of attractions A and C, we decide to move C adjacent to A to form the following layout:

(*b*) **Move C close to A**

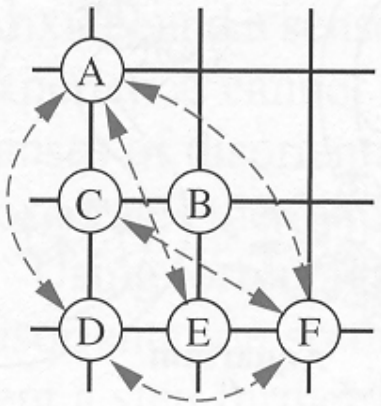


Attraction Pairs	Flow Distances
CD	$20 \times 2 = 40$
CF	$8 \times 2 = 16$
DF	$6 \times 2 = 12$
AF	$6 \times 2 = 12$
CE	$8 \times 2 = 16$
Total	96

Example: Ocean World Theme Park

- And then after exchanging attractions A and C, placing C adjacent to D, E and F.

(c) Exchange A and C

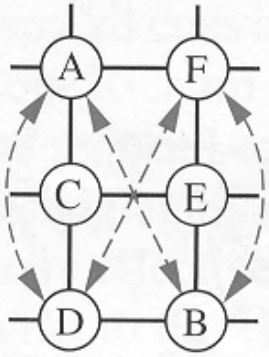


Attraction Pairs	Flow Distances
AE	$15 \times 2 = 30$
CF	$8 \times 2 = 16$
AF	$6 \times 2 = 12$
AD	$0 \times 2 = 0$
DF	$6 \times 2 = 12$
Total	70

Example: Ocean World Theme Park

- The final layout is created by exchanging B and E and by moving F to form a rectangular space; exchanging B and E keeps E and F adjacent as we move F to form a more compact space:

(*d*) **Exchange B and E and move F**



Attraction Pairs	Flow Distances
AB	$15 \times 2 = 30$
AD	$0 \times 2 = 0$
FB	$8 \times 2 = 16$
FD	$6 \times 2 = 12$
Total	58

Full Detail – JWS

	A	B	C	D	E	F	Dist-1
A	---	1	2	1	1	2	
B		---	1	1	1	1	
C			---	2	1	1	
D				---	1	2	
E					---	1	
F						---	
	A	B	C	D	E	F	Sum-1
A	---	15	60	0	15	12	
B		---	12	40	10	8	280
C			---	40	8	8	
D				---	30	12	
E					---	10	
F						---	

	A	B	C	D	E	F	Dist-2
A	---	1	1	1	1	2	
B		---	1	1	1	1	
C			---	2	2	2	
D				---	1	2	
E					---	1	
F						---	
	A	B	C	D	E	F	Sum-2
A	---	15	30	0	15	12	
B		---	12	40	10	8	266
C			---	40	16	16	
D				---	30	12	
E					---	10	
F						---	

More Detail from JWS

	A	B	C	D	E	F	Dist-3
A	---	1	1	2	2	2	
B		---	1	1	1	1	
C			---	1	1	2	
D				---	1	2	
E					---	1	
F						---	

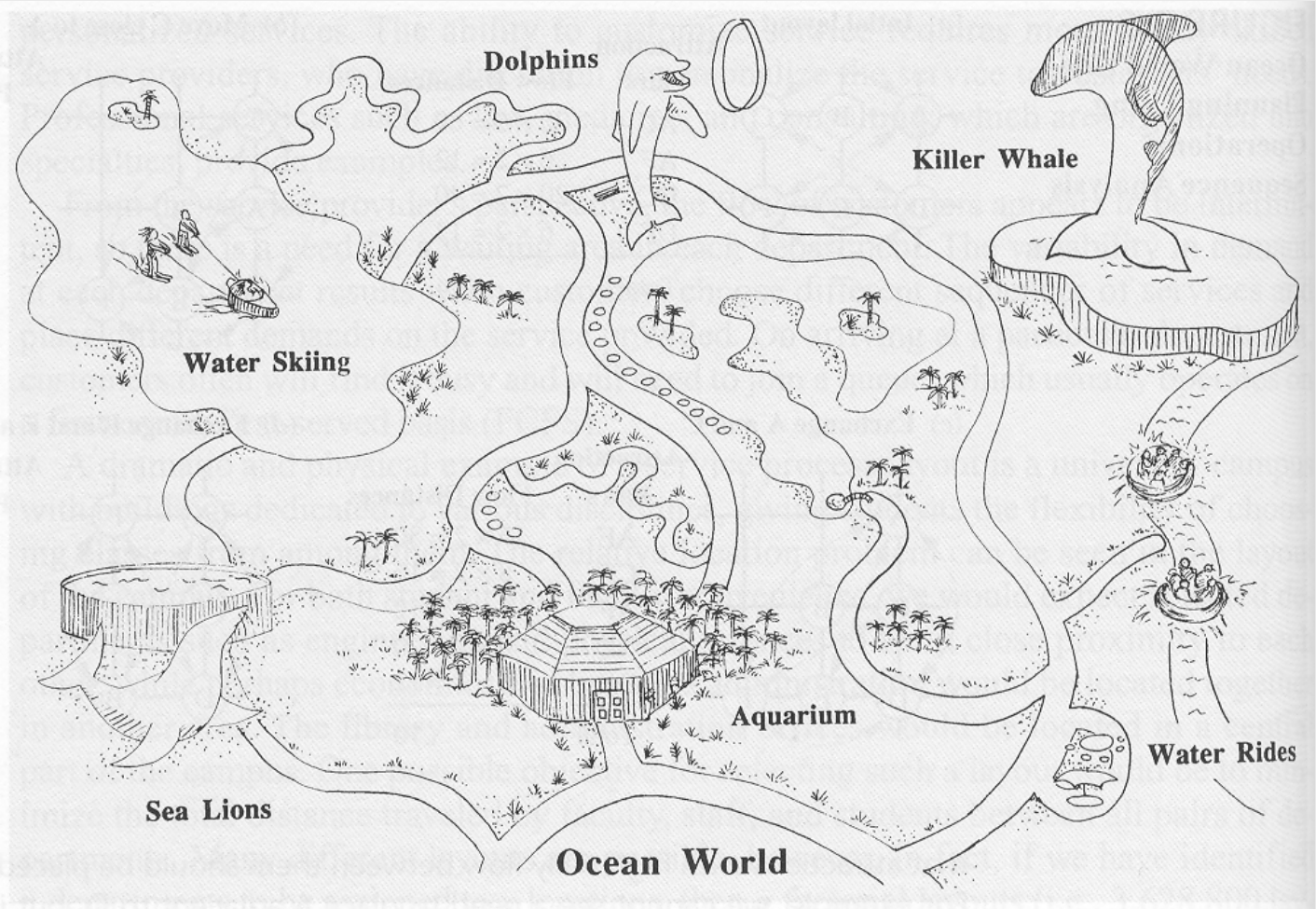
	A	B	C	D	E	F	Sum-3
A	---	15	30	0	30	12	
B		---	12	40	10	8	253
C			---	20	8	16	
D				---	30	12	
E					---	10	
F						---	

	A	B	C	D	E	F	Dist-4
A	---	2	1	2	1	1	
B		---	1	1	1	2	
C			---	1	1	1	
D				---	1	2	
E					---	1	
F						---	

	A	B	C	D	E	F	Sum-4
A	---	30	30	0	15	6	
B		---	12	40	10	16	247
C			---	20	8	8	
D				---	30	12	
E					---	10	
F						---	

Example: Ocean World Theme Park

- **Final site plan:**



Environmental Orientation Considerations

- Need for spatial cues to orient visitors
- Formula facilities draw on previous experience
- Entrance atrium allows visitors to gain a quick orientation and observe others for behavioral cues
- Orientation aids and signage such as “You Are Here” maps reduce anxiety

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