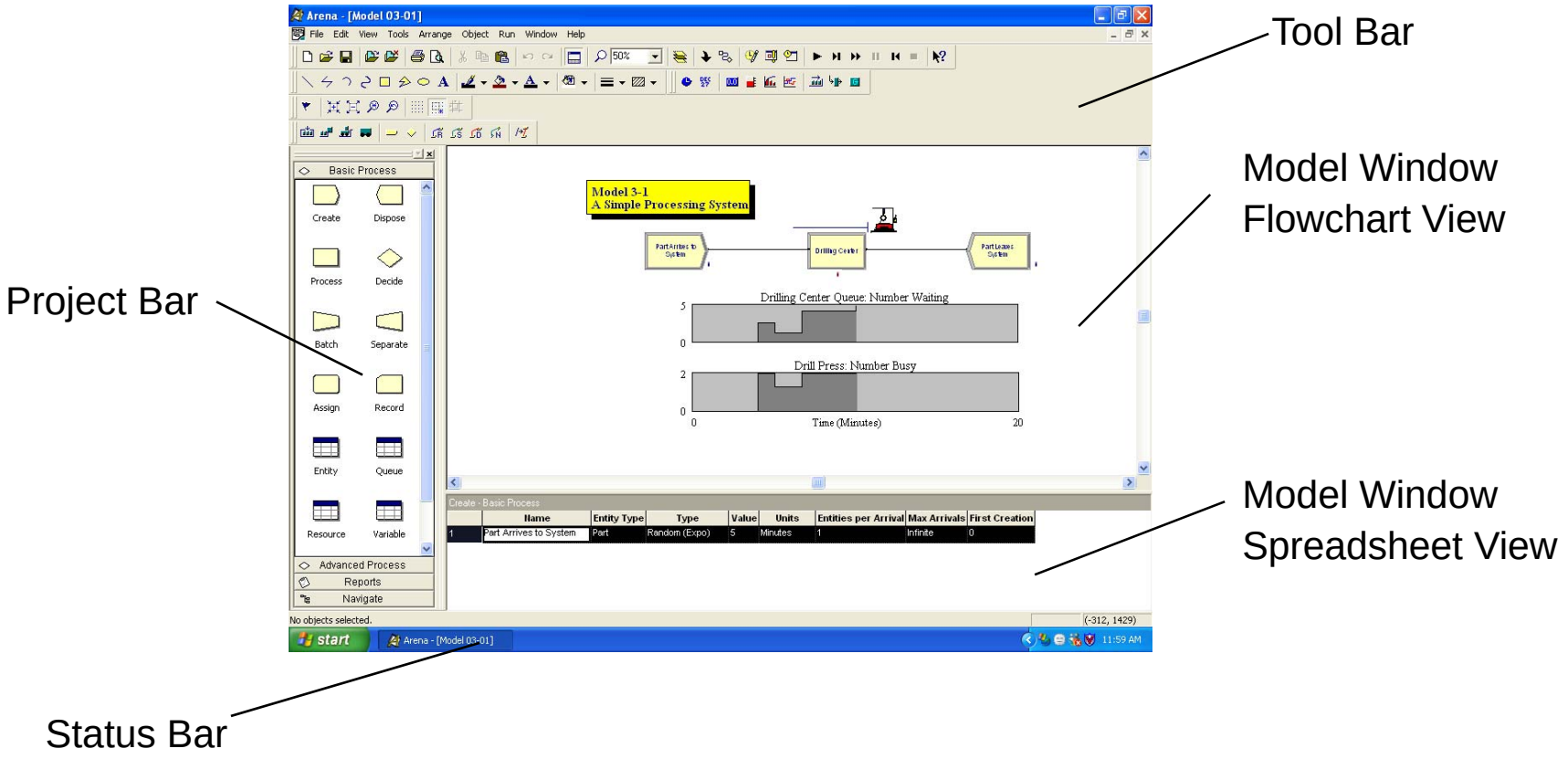
0405324: Stochastic System Simulation

Lecture 3: A guided tour through simulation

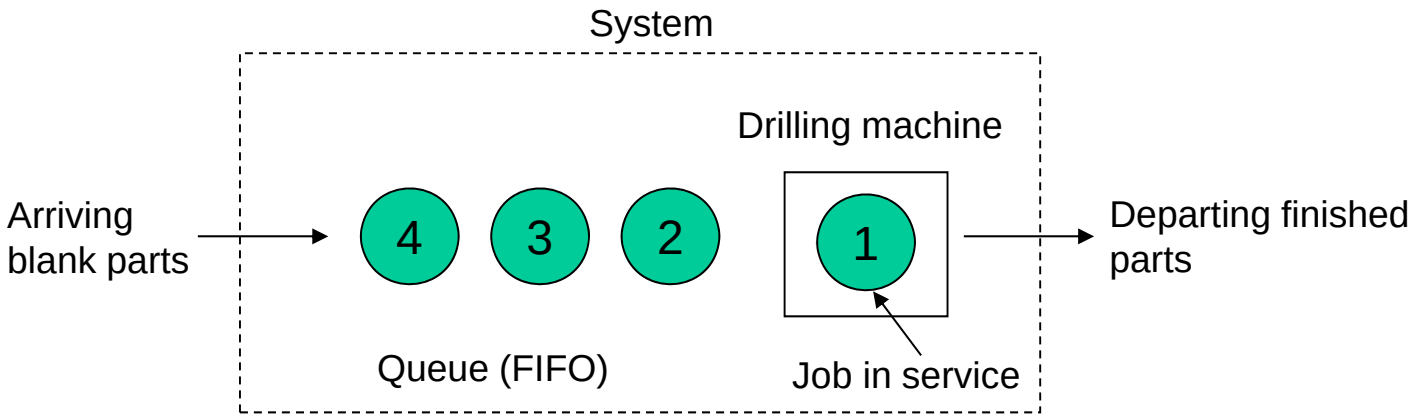
(To be covered by lab classes)

- **Please read Lecture 3-1 (Chapter 3 in Kelton)**

Exploring the ARENA window



The simple processing system in ARENA

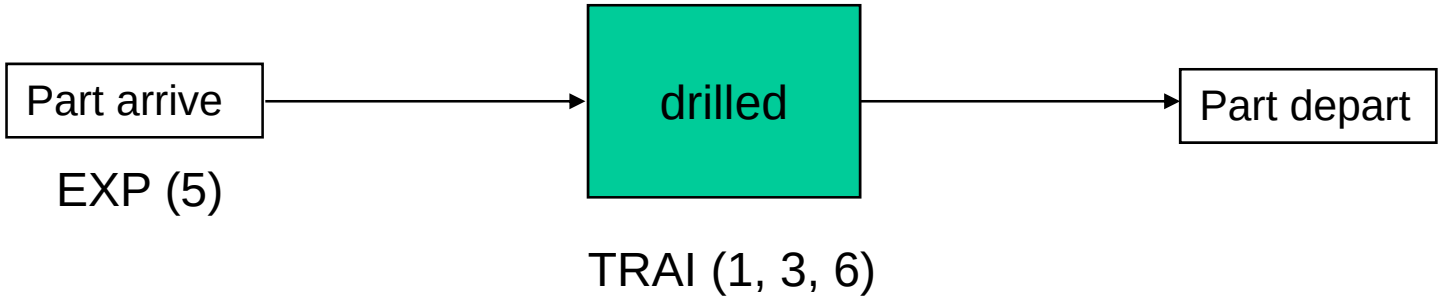


• **Model 03-01: Parts arrive at the drilling center at an inter-arrival rate characterized by an exponential distribution of mean 5 minutes [EXP (5)]. The arriving parts are machined at the drilling centre and exit the system after machined. The service time of the drilling centre is characterized by a Triangular distribution (1, 3, 6) [TRIA (1, 3, 6)]. Only one part comes to the drilling centre at any time and goes to the drill directly if it is free, otherwise wait in the queue. There is only one drilling machine in the drilling centre which is operated following the First In First Out (FIFO) discipline.**

Model the system in ARENA and run for 20 minutes. Find the machine utilization, number of parts in the queue, average waiting time per part in the queue. Make your recommendations to improve the performance measures.

The simple processing system in ARENA (cont'd)

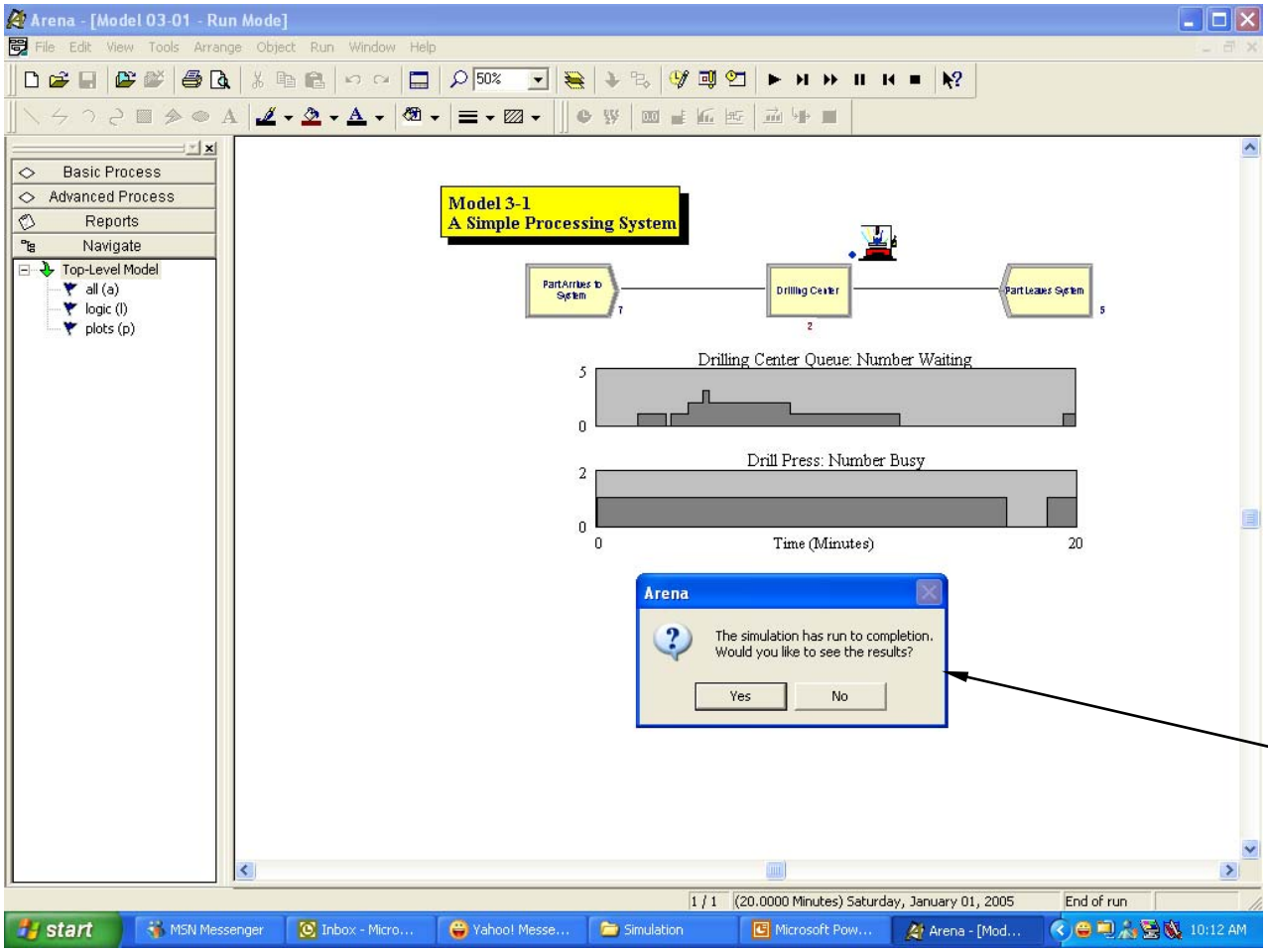
- The system can be represented by the following flow chart:



- The system can be modelled using three modules:
  - create
  - process
  - dispose

- *Model the system in ARENA following the Step-by-step guide*

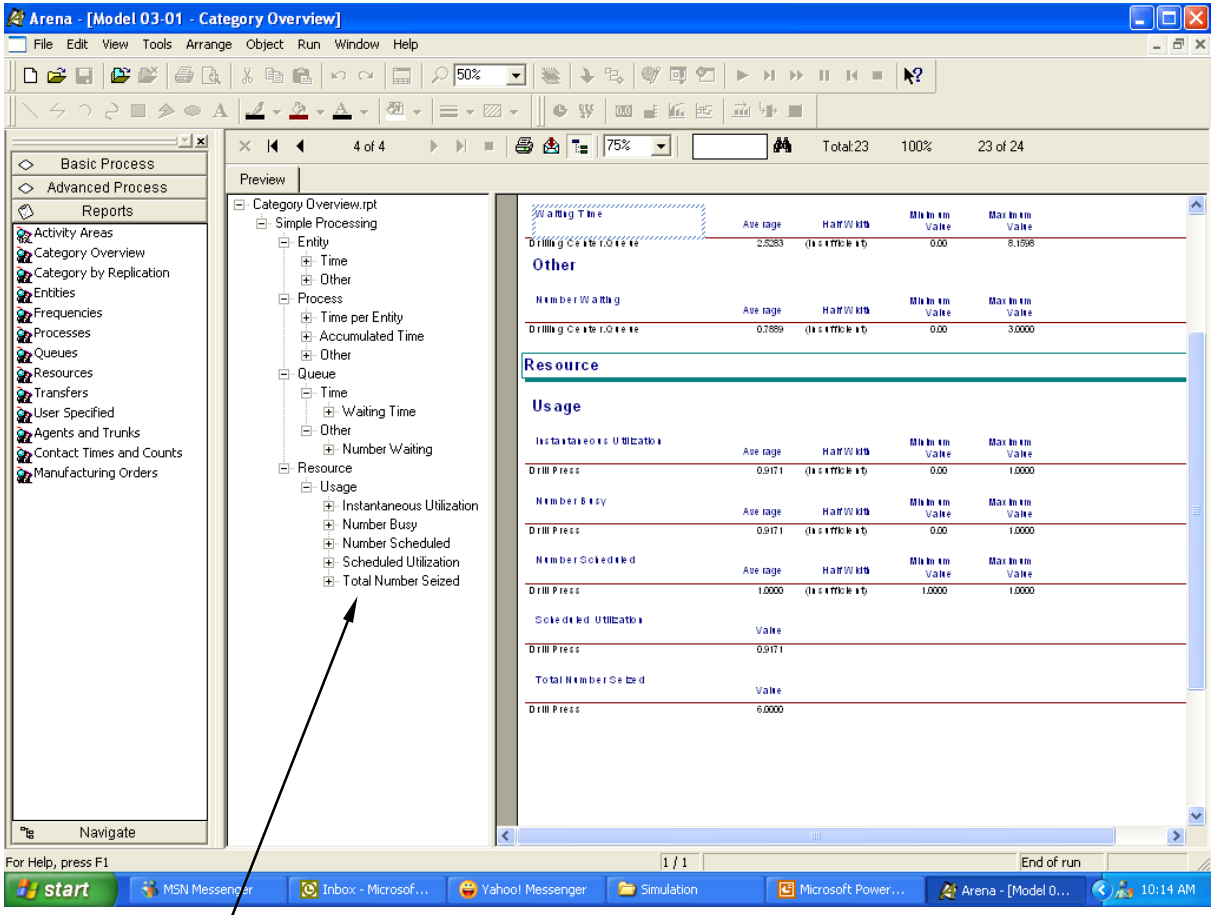
Output: The simple processing system in ARENA (cont'd)



ARENA box that shows the results

Output: The simple processing system in ARENA (cont'd)

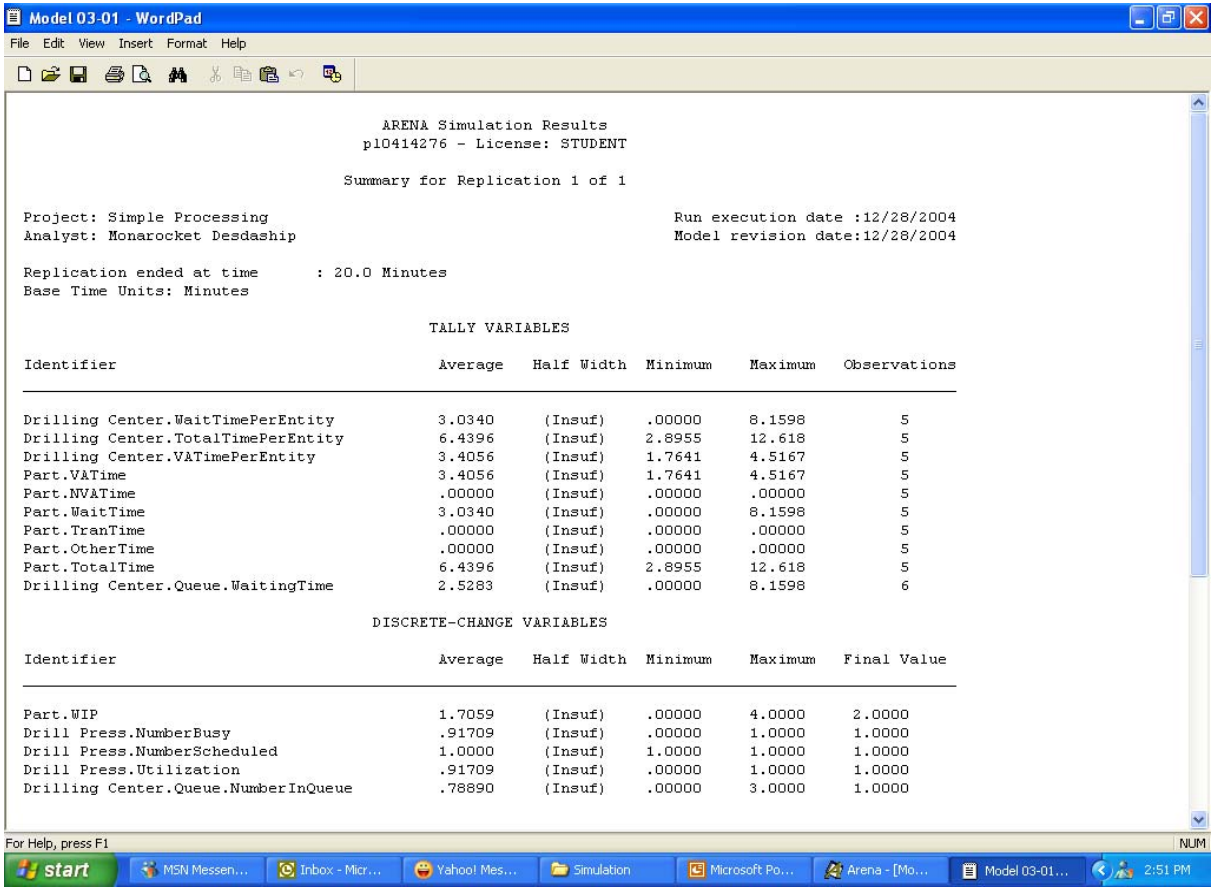
- Detail outputs (by clicking on the ***yes*** in the ARENA box)



Reports listed in the project bar

Summary of Output: The simple processing system in ARENA (cont'd)

- Run > Setup > Reports > ARENA Summary Report



- ARENA Summary Report file (Model 03-01.out) for Model 03-01

Try yourself

- **Modify** Model 03-01 **with all of the following changes**

  - Add a second machine to which all parts go immediately after exiting the first machine for a separate kind of processing (e.g. the first machine is drilling and the second machine is washing). Processing times at the second machine are the same as for the first machine (i.e. TRIA (1, 3, 6)).Gather all the statistics as before, plus the time in queue, queue length, and utilization at the second machine.

  - Immediately after the second machine, there is pass/fail inspection that takes a constant 5 minutes to carryout and has an 80% chance of a passing result; queueing is possible at inspection, and the queue is FIFO. All parts exist the system regardless of whether they pass the test. Count the number that fails and the number that pass, and gather statistics on the time in queue, queue length, and utilization at the inspection center. (try the *Decide* flowchart module).

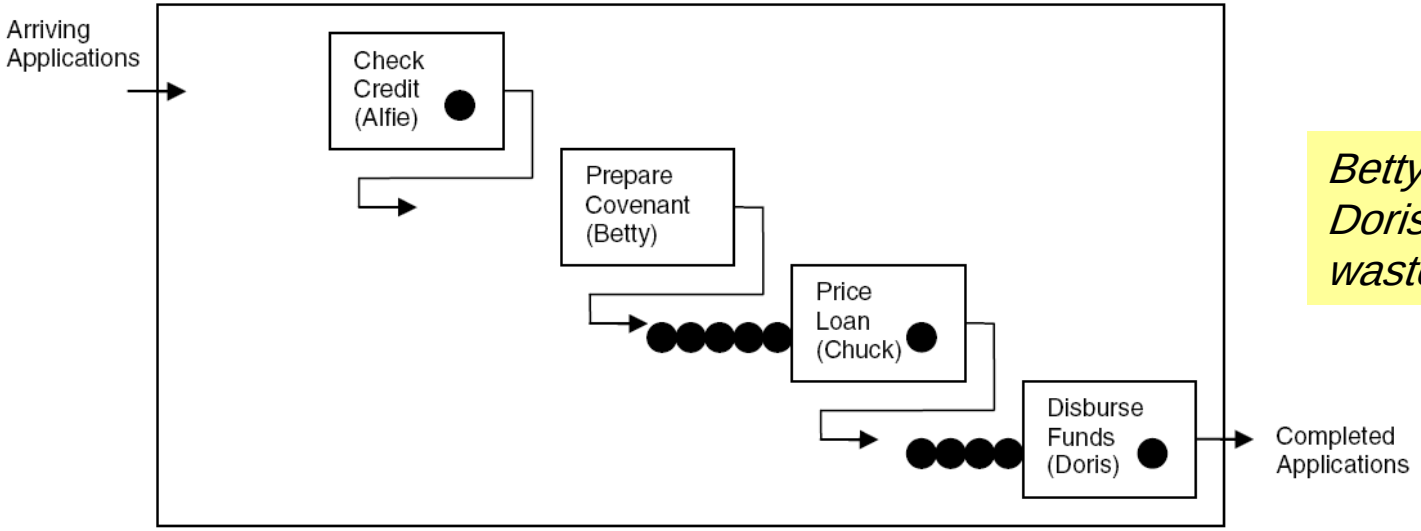
  - Include plots to track the queue length and number busy at all three stations. Configure them as needed.

  - Run the simulation for 480 minutes instead of 20 minutes.

Case Study: Specialized Serial vs. Generalized Parallel Processing

- **Loan applications go through four steps**
  - Check credit, prepare covenant, price loan, disburse funds
  - Each step takes expo (1 hour)
  - Applications arrive with expo (1.25 hour) interarrival times
    - First application arrives at time 0
  - Run for 160 hours
  - Watch avg, max no. applications in process (WIP); avg, max total time in system of applications
  - Four employees, each can do any process step
- **Serial specialized processing or generalized parallel processing?**
  - What's the effect of service-time variability on decision?

Case Study: Model 3-2, Specialized Serial Processing



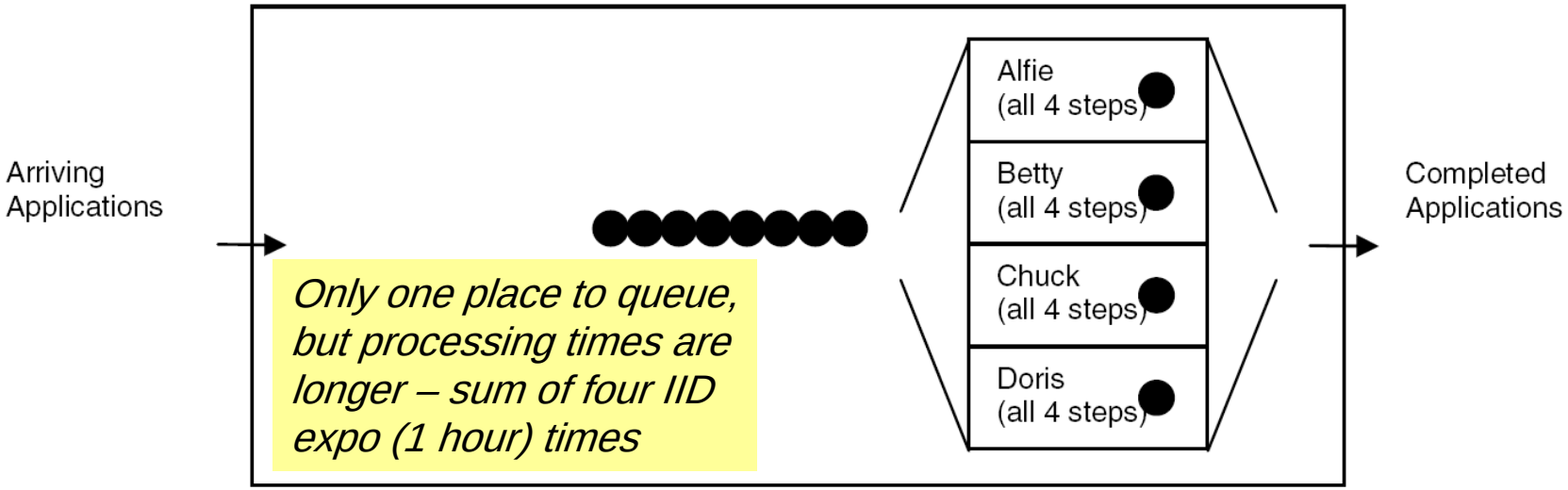
Betty's idle but Chuck and Doris are overloaded – wasted capacity?

- **File `Model 03-02.doe`**
- **Create module – similar to Model 3-1 except expo mean, time units**
  - Set Entity Type to **`Application`**

Case Study: Model 3-2, Specialized Serial Processing (cont'd.)

- **Four Process modules – similar to Model 3-1**
  - Four separate Resources
  - Expo process time: Expression (via Expression Builder)
- **Dispose module similar to Model 3-1**
- **Default entity picture (report) is OK**
- **Default Resource animations almost OK**
  - Make Idle picture same as Busy
  - Select correct Resource name in Identifier field
- **Queue, Resource data modules OK**
- **Plot WIP – use Expression builder to find `EntitiesWIP(Application)`**
  - Fixed Y axis max = 25 to compare with next three models
- **Fill in *Run* > *Setup*, lengthen queue animations**

Case Study: Model 3-3, Generalized Parallel Processing



- **File `Model 03-03.doe`**
- **Create, Dispose, plot, *Run* > *Setup* almost same**
  - Just change some labels, etc.

Case Study: Model 3-3, Generalized Parallel Processing (cont'd.)

- **Replace four earlier Process modules with just a single Process module**
  - One Resource (**`Loan Officer`**), but four units of it
  - Still set Quantity to 1 since application just needs 1 officer
  - Delay type – Expression

    `EXPO(1) + EXPO(1) + EXPO(1) + EXPO(1)`
    - Why not **`4*EXPO(1)`**?
- **Modify Resource Animation for four units**
  - Open Model 3-2 Resource Animation to get Resource Picture Placement window, open Idle picture
  - Duplicate white square three times, realign; copy to Busy
  - In model window, double-click Seize Area, then Add three
  - Still not completely accurate animation (order) – need Sets

Case Study: Compare Model 3-2 vs. 3-3

Model	Total WIP		Total Time in System		Total Waiting Time		Number Processed	Avg. Utilization
	Avg.	Max.	Avg.	Max.	Avg.	Max.		
3-2 (serial)	12.39	21	16.08	27.21	11.98	22.27	117	0.78
3-3 (parallel)	4.61	10	5.38	13.73	1.33	6.82	135	0.87

- ***Caution*: This is from only one replication of each configuration, so there's output variability**
  - Are differences statistically significant? (Exercise 6-19)

Case Study: Effect of Task-Time Variability

- **Is parallel always better than serial under any conditions?**
  - Many aspects could matter
  - Focus on task-time variability
- **Now, each task time ~ expo (1 hour)**
  - Highly variable distribution

    P(task time < 10 minutes) = 0.15
    P(task time > 2 hours) = 0.14
    } *See text*
  - In serial config., just one large task time congests greatly
    - In parallel config. it would also congest, but probably not by as much since other three tasks are probably not all large too
- **Other extreme – each task time is *exactly* 1 hour**
  - Leave interarrival times as expo (1.25 hours)
  - Models 3-4 (serial), 3-5 (parallel) – alter Process modules

Case Study: Effect of Task-Time Variability (cont'd.)

	Model	Total WIP		Total Time in System		Total Waiting Time		Number Processed	Avg. Utilization
		Avg.	Max.	Avg.	Max.	Avg.	Max.		
Expo service	3-2 (serial)	12.39	21	16.08	27.21	11.98	22.27	117	0.78
	3-3 (parallel)	4.61	10	5.38	13.73	1.33	6.82	135	0.87
Constant service	3-4 (serial)	3.49	12	5.32	11.38	1.32	7.38	102	0.65
	3-5 (parallel)	3.17	11	4.81	10.05	0.81	6.05	102	0.66

- **For constant service, parallel improvement appears minor**
  - Maybe not even statistically significant (Exercise 6-19)
- **Some further questions**
  - In parallel, work is integrated/generalized, so would it be slower per task? (Exercises 3-13, 6-20)
  - Effect of worker breaks? (Chapters 4, 5)
  - Differences statistically significant? (Exercises 6-19, 6-20)

Continued in Lecture 3.1