Simulation of Business Systems
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Lecture - 12
Simulation Experiments using Arena

Good morning students welcome you guys back to the another session of Simulation of Business Systems. And last class we have seen how to build a single server simulation model using Arena, but we could not run the model completely because of the licensing issues. So, now, I have a complete licensed version of Arena in which I will demonstrate this to you guys once again, but today we will go a slightly faster because we already seen the details of it. And since it is a licensed version of Arena, you will get to see where much more details in that.

So, without delaying much let us get into how this is being done; as I said earlier if you look into the computer screen in your my in the windows, the start menu option you go to all programs and the scroll down in the list look for Rockwell software. Here is Rockwell software you click that, you will get to see what is under the Arena and factory activation stuff like that and you click Arena. And all these links are available Arena input analyzer output analyzer process analyzer etcetera that is we will be dealing with all of them later down the class, but first we click Arena and Arena software comes up you can see the screen by Rockwell automation.

And this is a licensed version of Arena. So, it will take little time for the license to verify it is a network licence it is an expensive software by the way. So, that is one of the reasons why; so, you now get to see that the interface is slightly different than what we saw in the last class, pretty much looks the same, but you will actually see lot more we only saw the basic processes in the last class.

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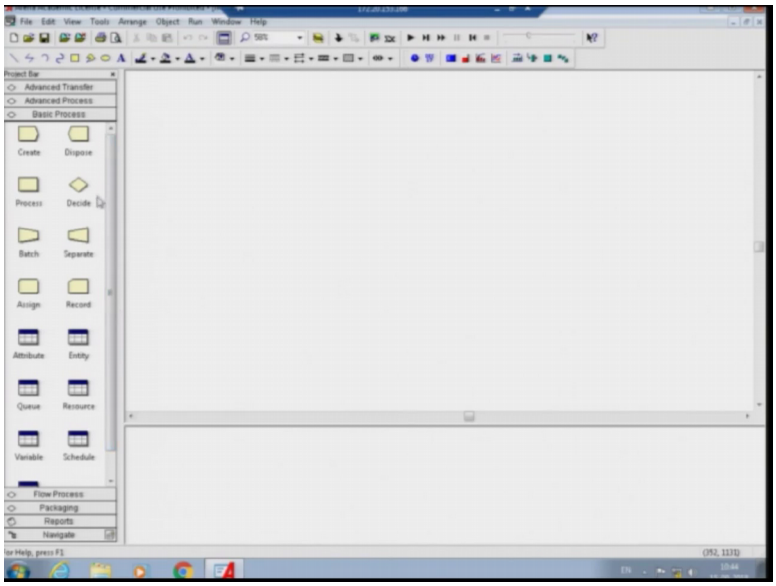

But here you can see that you have basic processes, then you have advanced processes, then you have advanced transfer, conveyor belt and stuff like that. Then you have flow processes where you can simulate continuous simulation models, then you have packaging systems, then you have different type of reports and stuff like that.

So, we were in the last class dealing with the basic processes things, but you can see that Arena come gives you Arena is simulation software package which provides you a graphical user interface to develop a simulation model. So, in this case you can see that the I said earlier this area the left hand side bar of this is the different module for models of Arena.

And these modules are divided into different categories; in the unlicensed version we only get the basic processes. In the licensed version you get advanced processes; advanced transfer, flow processes, packaging reports and navigation tool. Reports and navigations are also available in the basic one, but the packaging flow process advanced process, advanced transfer you require a complete license in that regard.

And this window this right hand side top area is our modelling window and the bottom is the details status details of each module. So, we are going to make the single server system where first we need to create the arrival of the system ok.

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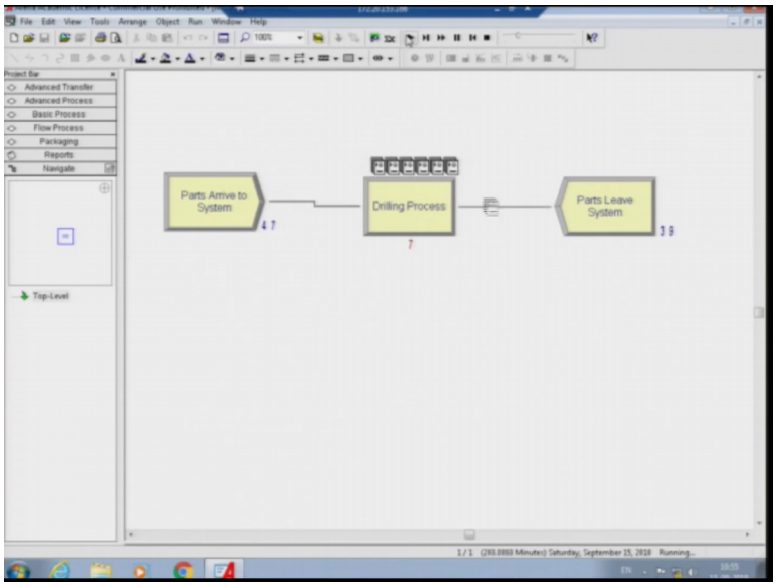

And we drag and drop the create here and we double click and this particular dialogue box opens and we are going to use this dialogue box to provide the details of the system. So, we say parts arrive to system and the name of the entity we made it as part last time.

And the time between arrivals we made it as random time between arrivals as you as I told you in the last session itself; it is simulated by or it is modelled by exponential time between arrivals. In the following classes where we talk about probability and statistics we will see why exponential distribution is used and what is the importance of exponential distribution for randomness?

And the value which is the time between arrivals the mean value we took it as 5 and the time units was made as minutes and entities per arrival is 1. Maximum arrivals is kept as infinite and first creation is 0.0, which means at the part arrives the first part arrives at t equal to 0 into the system. We do that all the things gets updated and as you can see they are also updated in the bottom portion of the screen.

So, the create module where the arrival the creation the arrival of the entity into the system the part into the system is created. Then we click the process module the on the basic processes drag and drop it to this area ok; we keep remember last time I showed you that you could use grid also if you want to you can see this you can use a grid if you want to or you can remove the grid and just it is a white background.

Ah I prefer white background because it grids kind of make my life eyes dizzy, but there are some people who actually like the grid process as well because, it allows things to be aligned properly. So, once we put the process module it is kind of it simulates the flow of the system. So, double click on this and we are going to we said last time that this is a drilling process. So, we are going to name it as drilling process and this is standard process and other option below this is submodel and you use submodel to actually built complicated submodels which we will see later in the class.

And the logic is not a delay, but we talked about the seize delay release. Seize delay release is a mechanism where a part come into the system and the logic is that if the machine is free. Then the machine the resource is seized by the; so, this is the first part seized part of it gets seized by the part then it gets delayed on the machine for how however, long the part have to spend on the machine until the process is completed. And once it is done the part is released from the machine the machine becomes free and the part released to the next thing or goes forward to do whatever it is in the system.

The minute you click the seize relay release; if it is just delay you see that nothing else works the bit; if you say seize delay release, it immediately gives you a provision for a resource. But before adding the resource there are 3 priorities that are available high medium and low; we leave it at medium for the time being. This is for the queuing system, so I will show you what is the queuing system associated with this then we click the add resource part and the name of the resource is the drill machine and there is only one unit of the resource because, it is a single server system there is only one drilling machine ok.

So, the minute you say a resource drill machine one it is added; then we there are multiple options for the delay type. Delay type means, how much time is being spent on the machine by the part? That is called as a delay, delay it is not just a delay the term is misnomer, but what is this happening is it is the value added processing time ok. So, the delayed time is the value added processing time.

So, here there are multiple options, there is constant, normal, triangular, uniform expression etcetera. The normally is implies the normal distribution if you click normal then the mean and the standard deviation options are provided. If you click triangular

then the minimum value, most likely value and maximum values are provided and if you click the uniform; then the minimum and maximum values are added etcetera like that.

So, to begin with we would start with a constant as we discussed in shown in the previous model. And we talk about it was minutes and this is a value addition process and it can also changes to non value added transfer wait and other things, but as of now because you are drilling a hole in the system it is a process step; so, you are adding value to it. And let us say we are saying that it takes 7 minutes to drill the hole in the part ok.

And then we also click the ensure that this box is checked which says report statistics and once you done with that you click then the drilling process comes into picture. And then there is a blue line that you see on the top which is a drilling process queue this queue associated with this drilling process. If you want to see the details of this queue then you click this queue and then immediately the drill process dot queue is shown.

And then you click the queue one this queue spreadsheet thing that is available in the basic process. You will see that the queue basic process is shown, where is the drill process dot queue it is a FIFO; which means First In First Out, you can change it into last in first out or lowest attribute value highest attribute value; which you if you remember this attribute values were chosen right here the priority; so, we can deal with that later.

So, the queue details are available and you click this and ensure that the queue statistics are reported. And if you click this way a multiple machines then you click this and say that this queue is shared. So, then the queue gets shared among the different machines available in the system ok. Once this is done, we go back to the last process of the system the parts arrived in the system then they go to the drilling process once the hole is drilled it gets it leaves the system.

So, we basically say parts leave system and we click ensure that this checkbox is there record entity statistics; which ensures that the statistics of the entity in the parts that are leaving the system is recorded properly. Once this is done what we do next is we have to make the connection or we have to tell Arena, how the parts will flow from one to another.

For that you can see there is this particular tool called connect, when you move the mouse over it shows that it is connect. You click that and you go to the place where you

wanted to move from and to. So, the green is the starting point, where the part will move. So, the parts arrive to the system and then they move from the arrival to the arrival create process to the drilling process ok.

So, you can see that if it is not in a straight line the system will adjust accordingly; however, it feels correct. Once it is done then you can do is that then you click the next one after the drilling; the part will move from the drilling to the parts leave system or it will departs system after the hole is being drilled. Once you do that then the logic of the system that parts will arrive or the create module creates a arrival simulates arrival of the parts into the system, then from there the parts move to the drilling machine.

If the drilling machine is free it will get a hole drilled, if it is not free it will wait in this queuing queue until the machine is free and it is turn comes up and then the hole gets drilled and from there it moves from the drilling machine to the part leave the system ok. I hope now you guys all understood this basic processes of this I am going slightly fast because we have gone in detail this whole modelling process in the previous lecture.

So, once this is done we have to do is we have to do the run setup of the system and I told you guys is that ensure that you go to run control and always compile on the go is checked and other things. And go to the replication parameters ensure that the dates are correct and time is correct ok. And then the warm up period time is given as hours you can just convert into minutes, replication length is infinite to be given you do not want it to run for infinite, but then you will have to wait until long time for it to get finish.

So, we will changed this into an 8 hour shift; so, 8 hour shift in minutes is each hour is 60 minutes. So, an 8 hour shift is 480 minutes and the 24 hours per day and basic time units said to be minutes. Once you set this up then you are ready for the simulation model to run, just remember that the number of replications is initially 1. And initialize between replication systems and statistics checkboxes need to be checked, the appropriate date need to be picked from the date picker, warm up period leaves it at 0 and change the time units to minutes.

Replication length make it as an 8 hour shift, which is 480 time unit remains in minutes that also leave it at 24 hours per day and base time units keep it as minutes and hit ok. And I will also show that how the simulation runs? Once we are ready with this what we do is; we run the simulation you can see that the parts arriving into the system the

simulation process continues it says 4 480 minutes. So, this is the simulation clock, it says simulation has run to completion would you like to see the results we say yes.

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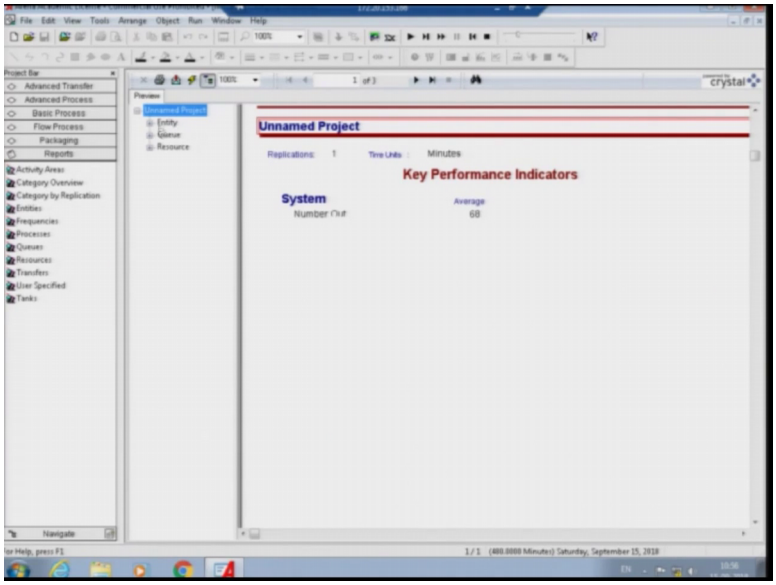

And remember that this was the place where we are having problem last time because, we could not see the reports. So, from here onwards we will go slightly slow because, you are probably going to see the report first.

So, first thing is we click the entity the unnamed project it says that one replication time units in minutes and we replicated the system to 480 minutes which is 8 hour shift and says number out is 68; 68 means 68 parts completed.

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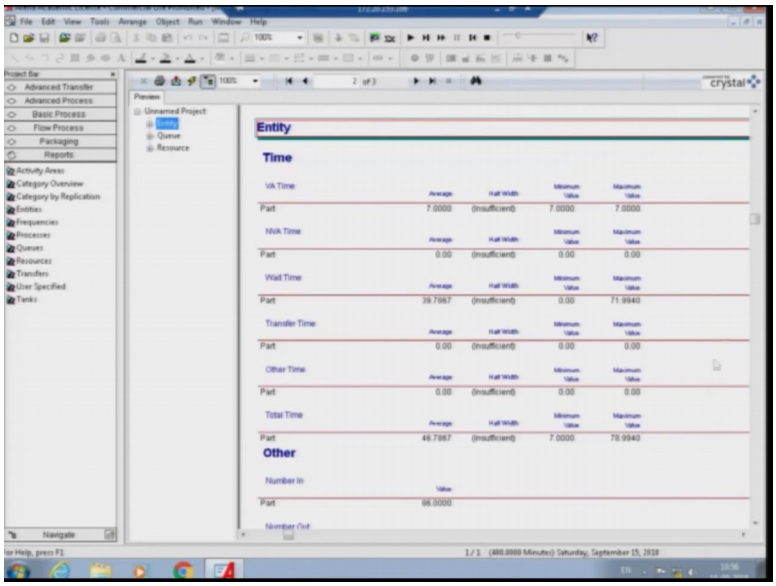

So, the minute you click the entity you will see a new thing comes into picture ok; the new thing basically says is that the value added time on an average is 7 ok. So, because we put it as constant you see that minimum and maximum values are 7. So, whatever you do the system, the every entity get the hole gets drilled at exactly at the 7th minute.

And non value added time is 0, because throughout it was working and wait time you can say that which is part wait in the system on an average for 39.78 minutes with the minimum value of 0, some parts would immediately get the hole get drilled and some would actually have waited for 71 minutes ok.

And this total time the total time of the part in the system which is the time in the system which I was telling to you which is another which like once you come into the system how long it takes before you can leave the system and it says 46 minutes. So, you come into the system and you have spend 46 minutes in the system; in which 7 minutes is drilling the hole the rest of the time is waiting ok. The minimum value is 7 which is the time taken to drill the hole and no wait and the maximum value is 78 ok. So, the minute you see the minimum value of total value added time minimum is 7 with a constant value you know that your model is working right. So, this is an example of validation validating the whether your model is doing the right thing.

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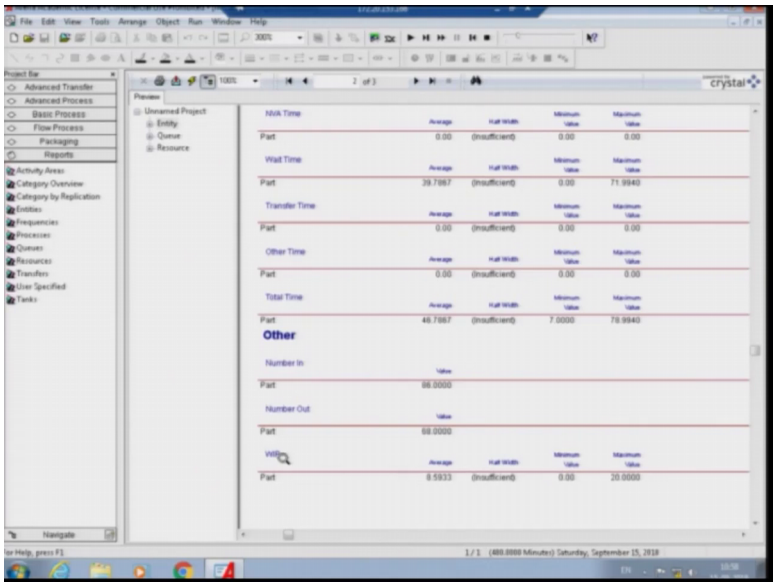

So, number of parts that are in is 86 number of parts that are out are 68. So, what happened is of the 86 parts that are come in, only 68 has left the system the rest of them are actually staying in system they are not left. So, when the simulation got over in an 8 hour shift even though 86 parts arrive to the system; you will only produce 68 if you follow a system like this. And WIP stands for Work In Process; work in process inventory system is a mechanism where we know how much of partially finished work remains in the system.

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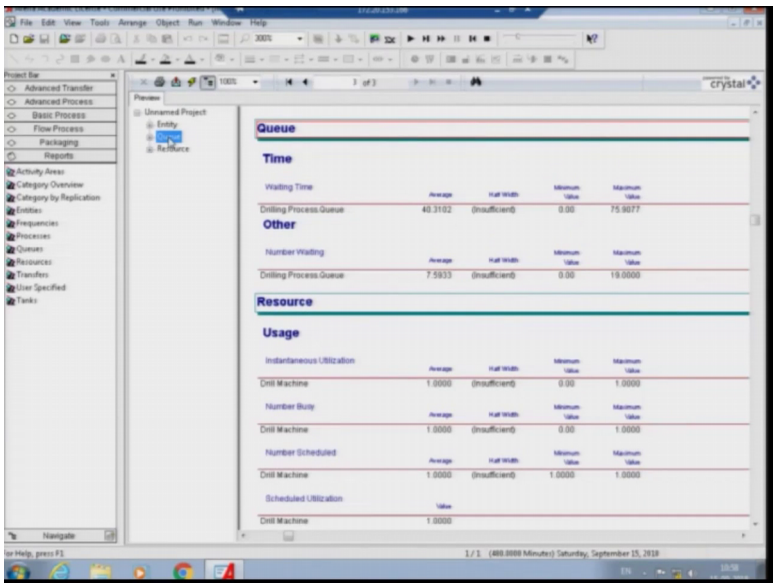

Now we talk about the second one which is the queue, which is the drilling process queue ok. So, the drilling process queue it says that on an average the waiting time in the queue is 40 minutes. So, you waiting in system for 40 minutes waiting in the queue for the machine to be free.

The minimum value is 0, which means some parts did not wait maximum value is 75.90 or 91 minutes which means some parts actually waited for 75.91 minutes. So, number waiting which means how many this is the time the first waiting time is the queue always will have two statistics; the time how long you are waiting in the queue and how many people are waiting in the queue the number in the queue?

So the number waiting tells you the number in the queue. So, the drilling process queue on an average you will get 7.59 parts which means you will anywhere se between 7 to 8 parts waiting in the queue on an average. The minimum value 0; sometimes you will see the queue to be empty and the maximum value is 19 which means sometimes you will see a queue of 19 parts waiting in this system. Then, you talk about the resource utilization resource is the drill machine and instantaneous utilization it says is that 1. And if you look at it is the drill if you scroll down the report the scheduled utilization.

So, ideally speaking the drilling machine in this regard is 1to the utilization of 1 means 100 percent of the time you it is1 is multiplied by 100; then you will get the percentage. 100 percent of the time the drilling machine is utilized, which means once the process starts the machine continues to work there is no delay the machine is totally utilized continuous ok. So, that is the resource part of it you can also get the same thing by clicking the resource tab of this ok.

So, now that we have seen how the simulation works and how a report comes into picture? The next thing we do is we still have mean in the simulation mode; we need to stop the simulation mode. So, for that you go to the top and then see this button and when you move to the top of the button; it actually shows end when the mouse comes over it actually shows end. You press that the simulation get stopped so; that means, your the there is no simulation running.

So, now let us go back to the simulation model and the minute you close that one then you get the simulation model right here. So, the parts arrive in the system if you double

click you can say that on an average every 5 minute; the parts arrive into the system in a random manner and we have put in a time unit or constant time unit of 7 minutes.

Now, let me change it into a uniform distribution; a uniform distribution is I am going to change it as can anywhere vary between it is 4 minutes to 8 minutes ok. So, on an average the time between the minimum time it will take to drill a hole will be 4 minutes, the maximum time it will take to drill a hole is 8 minutes, but the distribution is uniform, uniform means that all values are equally likely between this. So, the probability of getting 5 is equal to the probability of getting 4.3 or the probability of getting 6.2 or probability of getting 7.9 etcetera ok. So, all values between the numbers of 4 and 8; the minimum value of 4 minutes and maximum value of 8 minutes are equally likely ok.

So, the average value the average in the uniform distribution is the minimum plus maximum divided by 2. So, in this case is 8 plus 4 divided by 2 is what we will have ok. So, that will be close to 6 minutes, so the average will be 6 minutes ok. So, if you want to make the average to be 7 minutes, then you have to make this as 10 and 4, 10 and 4 and all values equal likely. But before that before making it to turn let us keep it at 8 so, that the average is at 6 and let us see what happens. And you click this and the parts arrival everything remains the same, the run control it go there setup same 480 minutes.

So, what has happened here now is we change the average value of the simulation system. The drilling process the time taken to drill the hole is converted to a uniform process with all values be equally likely. And now we do that is and then we try to run the simulation you click this and once we wait for the simulation to be over; it is says a simulation is over it says 480 minutes completed in the bottom status bar; one replication is over, you click this and it says 77 units are completed; 77 parts were completed and their holed were drilled and they were out of the system.

So, let us click the entity and it says is the value at a time is on an average is 6.1379. So, I told you that the average in a normal uniform distribution is a plus b by 2 the minimum plus maximum divided by 2. So, that is 8 plus 4 by 2 it is 6, 8 plus 4 is 12 divided by 2 is 6. But you get a 6.13; so, we can see that because there is a variability because, it is a normal is a uniform distribution some variation will happen. So, the average is there the minimum value is 4.012 and the maximum value is 7.97.

So, the minimum and maximum value added time is between 4 and 8, which means that it is sampling from the right process that we are talking about. And you can say that on an average then reduce the parts were waiting for 19 minutes with a minimum of 0 and maximum of 50.78 ok. And the total time in that the part was spending in the system is 25 minute; 25.41 minutes, and the minimum value is 5.43 minutes and maximum value is 57 minutes ok.

And you can see that there were 86 parts that actually came into the system of which 77 were completed ok. So, number in the parts that came into this system were 86 and number out where 77 ok. And the work in process inventory remains at 4.31, minimum value 0 and maximum value is 10. You click the queue you can see that the drilling process queue on an average is 19.23 is the time minutes is the waiting time; minimum value is 0, maximum value is 50.

So, sometimes you will actually see 50.78 minutes of waiting time in the queue and the number waiting is now 3.31. And minimum value is 0 maximum value is 9 which means you at some point in time; you will actually see the queue with the number of 9 participating in the system.

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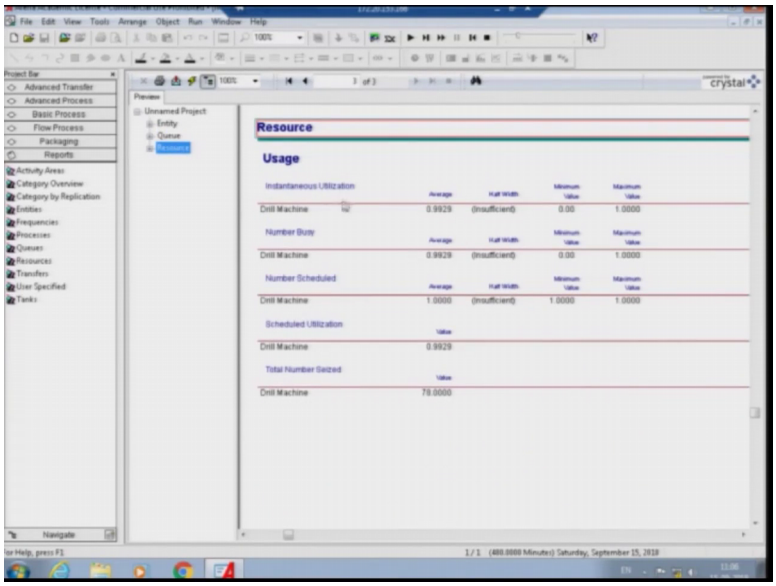

You click the resource it says that the resource utilization is 9929 which is 99.29 percentage or close to 1 percent, if the resource is fully used. And it say is 78 numbers seized, which means 78 parts went on to the drilling machine and the work was

completed. So, now, you see that some variability or some variation is shown in the system.

So, to avoid the variation one way to do it is let us actually go back to the drilling process and change this to constant and leave the time at 6 time units, which is equivalent to what we did earlier, but there is no variation in the system. We click this everything else remains the same we run the model and wait for the simulation to finish. The simulation clock is running here, finished the 480 minutes and you will actually see that the number out is 77.

But, if you look into the other parts, you can see that the value added time is 6, exactly 6 the other case you actually saw 6 point something slightly. Whereas, in a constant or a process where things are constant, there is no variation available the exact value is available. So, that; so such a system where this 6.000; it is not really possible in a typical trade system because, typical systems there is always variability and the minimum value is 6 and maximum value 6 means; there the another case it was 4 and 8 if you remember because, we are given the minimum and maximum limits and the value is varied between those limits here it is a constant so, there is no variation.

And you can also see that the waiting time is 19.3395 and the minimum and maximum value is 54.814 ok. If you note this times these values down and then if we can see that 86 entities came in and 77 were finished 4.72 was the work in process inventory and minimum and maximum values were 0 and 12 ok.

So, there are 12 parts there were waiting to be processed in the system work in process was shown that way. And if you look at the queue, it will actually say that 19 minutes on an average it was pending in the queue, the maximum value is 58 and the number waiting is 0 and 11; so, 11 entities you will actually see waiting in the queue ok. Now, it is with an average of 6 time units; the minute we stop the simulation, we close the report, we go back to drilling process and change from constant to uniform and make the values 4 and 8 only that change.

So, that the average is 6, 4 plus 8 by 2 will be 6; we do this and we run the simulation the same model that we run first. Once again; so, that I can show you the differences, we can see that the number out is 77 exactly same as the same as that of the other one. The value added time is slightly more 6.13; the minimum and maximum values which were 6 and 6

the previous time, there is a range is not being. The if you look into this the major difference would probably be in the queuing; you can actually see that number waiting is now at 9 whereas, the other case it was 11.

The difference here is because, in a constant all the time units are 6 6 6 6; you will get the consistent values of 6; in the uniform distribution at some point of time you get values close to 4. So, when the processing time values are close to 4, then the time spend on the system is actually lesser compared to the in the case of the constant. And yes, in some cases the time will be more than the constant also when the values are close to 7.9.

But, in that process what happens is because all values are equally likely you can see that the number waiting the maximum value actually reduces ok. And the utilization also we can see it is the compared to the other one it is it is a slightly less utilization. And if you look in the resource also there is the number of units seized is 78; whereas, the number of units finished is 77. So, if you look into it parts out number out is 77, but 78 parts have seized which means when the simulation got over.

There is one part that is still on the machine that has not completed drilling the hole; so, it could not be released out. So, now, you see that you can actually utilize this simulation model to tweak different parts of the system; you can changing things if you want say instead of the 5 minutes, the parts are arriving what happen if the parts are arriving at 4.

So, let us for the time being let us change this back to constant and the time limit of 4; 6, we are not going to change this or let us maybe let us say let us make it into 5 and the for the time being which is same as the arrival takes 5 minutes to drill the hole and in every 5 minutes a part arrives. So, ideally speaking there should not be any queue things should process smoothly because a comes in finishes and goes by we will try to run the simulation in this one to see how that system works ok. And once the simulations over yes please show the results; it says that 81 parts got finished and it says that 86 entities came into the system and 81 got over ok.

So, why not all the entities got over, why was it that way ok? The answer lies in the problem that we used random exponential, where there is some that arrivals were random process. The way to solve this out would be make this into a constant make it 5; so, that there is no variability in the arrival also; you do that and you run the simulation you will get to see that there is no queue being shown here; nothing is waiting ever ok. You finish

this and let us see how the simulation runs 96 entities were completed ok. And if you look into it 97 parts arrived, 96 finished; 1 is waiting on the machine ok. And if you look into the queue the process queue the average waiting time in the queue is 0; nobody waited in the queue.

The drilling process queue on an average minimum value and maximum value is 1. So, means somebody just came in for merely a small fraction of time by the time the work got over and it actually left the queue ok. So, you can see that there is no queue ideally speaking, utilization is 100 percent and total parts seized is 97 ok. So, how many parts arrived? 97 arrived. How many left the system? 96; 1 is still on the machine ok.

If you look at the utilization of the resource the utilization is 100 percent and the resource is always busy. So, this model that I just showed you where the arrival is a constant of 5 units and service the drilling hole drilling part is also a constant of 5 minutes, you can think about it as the baseline system.

So, now if you say I have a baseline system where everything is constant; things arrived, things worked there is no variation in the system. Then I can say that I have no control over the arrival of the parts into the system. So, what I am going to do is instead of the constant; I am going to change it into random exponential which means it is a random with an average value of 5 minutes.

So, if I keep looking at the arrivals the long time I will get 5 minutes of arrival coming into the system. I do this and I do not change anything else; all I have changed is the constant which was like this to be changed to random exponential which means the arrival is random or the time between arrivals is exponential; it is no longer constants, there is a variation in the system.

You allowed to do this and then run the simulation model; you will see that unlike the previous case you will actually see queuing happening. And you can see that the place where 98 entities came into system in which 97 got completed we can see that only 81 is completed. So, the numbers have reduced from 97 to 81; if you look at entity it actually shows you that instead of the 97 arrivals, only 86 arrived because of the variation in the system.

So, in the 480 minutes where you could actually get 97 98 entities arriving into the or 98 parts arriving into the system; with the variation you can only get 86 parts arriving into the system. So, that is the first thing that you should be able to note in this scenario is that the parts arriving into the system can always give you a lower value when you put variability into the system.

So, all of us like to have a system without any variability, but that type of a system is not possible. So, if you look into this simulation model you can immediately see that the simulation provides you a very realistic mechanism to immediately model the variability of the system ok. So if you look into this 86 entities arrived in the system and only 81 finished. So that means, 5 are still waiting; waiting to be finished, that is the reason where we look into the queue, you will see that the number waiting in the queue on an average is 1.8 or 2 entities on an average waited in the queue. That is because of the variability in the arrival time; the arrival parts arriving into system became a variable process ok.

Same way, if you look into the drilling process queue this was 0, when the arrival time were constant. Now we can see its 10.17; that means, on an average you will see in a system like this where the arrival time is an average random process of 5; you time units you will see about 10 minutes of waiting time on an average in this scenario ok. And the minimum value is 0 and maximum value is 43; the earlier case you saw minimum and maximum to be 0 0 and here you see it to be 43. So, which means that the 43 minutes certain entities one specific part ended up waiting for 43 minutes in the system ok.

Same way the number waiting; how many were in the queue on an average 1.88 or approximately between one and two entities were waiting in the system or two parts were waiting in system. But, in certain cases the minimum value is 0 and the maximum value is 9 which means at some point of time; the number of parts waiting in the queue was equivalent to 9 parts ok. Similarly, the utilization you can see that only 84 percent of the time the machine is utilized.

In the previous case you saw that the machine was utilised for 100 percent of the time; whereas, with the variation in the arrival process the parts following a random distribution or a exponential time between arrivals; the utilization of the machine has come down. Why the utilization has come down? Because, at certain point of time you

will not have any part arriving into the system; so, what happens is the machine weights idle for the part to come in.

And certain part of the times too many parts will come into the system at the same very in very close intervals. So, you will see queuing happening in the system ok; so, that is the other the one of the reason. So, the machine is utilized 84.66 percent of the time unlike the 100 percent utilization in the previous case. Now, I want to show you one last thing before we close this discussion. So, this is now an exponential 5 minutes time utilization this is constant of 5 minutes.

I want to change this to a exponential 5 minutes ok. So, I am going to change this to exponential 5 which means a 5 minute same as that of the arrival ok; I do this. And, so the way to do it is exponential is not available here constant is what we are doing 5 minutes instead of that you pull down to the expression. The minute you click the expression there is quite a lot of things that will come here, triangular and stuff like that you click expo mean and click this and change the mean value to 5. And ensure that the time units is 5 minutes it is value added everything else remains the same and you run the simulation and let us see how the system behaves now you are running in for 480 minutes it is completed.

Now, you can see that the average is further reduced to 77 ok. So, if you look at the entity you can see that 77 parts were finished in and if you look at the value added time its 5.536 minimum and value. So, some cases it actually was 29.6864; so, some parts to drill the hole it took 29 minutes which is crazy, but it is possible because the time taken to drill the hole is random process.

And if you look into it there were 80 parts that arrived into the system and 77 got finished ok. And on an average 3 of them 3 parts were waiting to be processed; if you look into queue you will see that on an average it took 16 minutes of waiting in the queue certain entities were 0, certain took 47 minutes to actually. So, now the waiting time has reduced compared to the previous case because, now the one case there was variability in the arrival the other case there was variability in the no variability in the drilling hole; now both of the parts have variability. So, now, we can see that things have behaved different and if you look at the resource utilization you see that 89 percent

utilization of resource which is slightly more than what the number that we got previously.

But anyway, now we can see that the variability increased variability in the system sometimes behaves craze you too much of a problem. Because on an example is if you look into this the entity time in the system; the value added time the previous time the average is 5.53 which means on an average it takes 5 and a half minutes to drill a hole.

But in certain cases it takes very small time close to 0 minutes to drill a hole whereas, certain times it takes close to 30 minutes to drill a hole. So, that type of a variability in the system is not acceptable because, then it is very hard for you to keep any promise of a delivery date or something like that. So, this is an example of a high variability system; so, when both the arrival and the service times when both of these were constants the arrive into the system and the drilling process were constant; then we were talking about a no variability system.

Then we introduced partial variability by making this as the exponential process and this remaining as a constant, the drilling remaining as a constant and we show the effect of a partial variability. Then we converted this also into a exponential distribution where we demonstrated the effect of complete variability in the system.

So, these kind of things that you are doing with the help of a simulation model is what we call as a simulation experiment. This is what I was talking to you earlier that you use the model to conduct an experiment. These kind of permutations and combinations or looking at different scenarios from the simulation model; evaluating the impact of variability, uncertainty, randomness all these kind of things in the behaviour of the system by slightly adjusting the parameters of the model is one of the very important added benefits of the simulation.

It I you might have see that we have taken some time to build this model using the GUI interface. But once the model is built conducting experimentations are very easy because all you are doing is changing few parameters. And immediately the system is able to show to you the changes in the time dependent behaviour of the system.

And you also seen how the simulation clock runs the time that was shown on the bottom it is not the real time, but it is actually the simulator time, we did not wait for an 8 hour

shift; instead that 480 minutes were simulated so, quickly that you could actually see what could actually happened, how many parts will come into the system, how many parts will leave the system, for how much time them drilling machine will be busy, what will be the average time to wait in the queue before the hole can be drilled?

What is the average number of a parts that will be waiting in the queue for the drilling machine to be made available, what is the average value of the value added time, what is the minimum value, what is the maximum value? All this aspects you are able to see. And there was also something called half width which we did not discuss the report was showing half width.

We will talk about half width because; you need to know probability and some statistics before understanding what the concept of half width. But anyway I hope that with this simple simplistic model that we have created so far using Arena; you will all be able to appreciate the utilization or simulation as a tool to study a simple system as a single machine system. Where a drilling machine was with this one drilling machine whose job is to drill holes and you can build a system out of it and study it and actually see the time dependent behaviour of the system.

So, this is an advantage of a simulation and I would like you guys both the detailed video of the previous one and this current video put together; you should be able to do something with Arena as of now. And what we will do is we will go back to the probability and statistics that you need to know to actually do the simulation experiments from the next class onwards and then we will go from there ok.

Thank you very much.