NGI101x - 4.4B - Discrete Modeling II

Hi, I am Alexander Verbraeck, professor of systems and simulation **a**nd I'm going to look with you to a number of discrete event simulation examples following up on the discrete event simulation module that you have looked at before. In this module I'm going to look at a number of differences between discrete event simulation software types and I'm going to look at three examples with you:

one on an airport, to look at logistics simulation

one on a large international supply chain

and one on barge transportation.

I will end with some conclusions and an outlook for discrete event simulation.

If we look at the types of simulation software available, there are actually two different types. One is programming languages that we can use to build simulation software.

Libraries are used to make the simulation software, but they're not so easy to use for end-users. Therefore, there are also a large number of general purpose simulation packages available on the market. Examples are Arena, Simio, Simulate, Plant Simulation, Enterprise Dynamics, Extend and AnyLogic, and there are many, many others, there are hundreds of different types of simulation software on the market.

Some of them are more suitable for some types of infrastructure models and others more suitable for other types of infrastructure models. If we look at the developments in the simulation packages, we see quite a number of fascinating things happening.

One is the use of libraries. We already covered that a little bit in the lecture on discrete event simulation modeling. Hierarchy is another one. Building models that can become more and more complicated. 3D animation is more and more the norm today for discrete event simulation packages. Furthermore, all kinds of input and output from and into databases, excel, statistical packages and all kinds of other input and output software

Link to optimization software and all kinds of extensions.

Lately a number of packages - among which AnyLogic - also offers multi-formalism modeling.

That means that we can mix discrete event simulation models, continuous simulation models and agent-based simulation models for the behavior of people in our models.

Let's look at our first case. A case for airport logistics. What we observed in a number of studies is that every time we had to build a model for solving problems at an airport we had to make a new model. We had to code it and we had to get the data. This means that it was a long process every time to build a model. Our challenge in this project was: can we construct a model out of building blocks? Small blocks from which we can build a model bottom-up?

Can we thereby tackle all kinds of airport problems in a much more generic way?

Our goal was to develop one set of simulation libraries for airport logistics, for airport design and for airport development. In the end, we created a set of library building blocks from which you can see here the highest level. So you see different concourses appears, different departure holes and at the bottom of the screen you can actually see all kinds of control blocks that control how people move between different parts of the airport, how the planes behave, when they land, what their flight schedule is, etc.

When we zoom in on one of these building blocks, for instance on one of the concourses, we see a smaller model; a couple of gates, a couple of walk areas, a couple of conveyor belts that help the passenger to go from or to the gate and from there to other parts of the airport.

So this is zooming in into one of the building blocks that you saw on the previous slide.

If we zoom in even more, for instance on one of the gates, we see that the gate consists

of a wait area, that means that people wait to be checked. Then they wait at the gate to get their boarding passes checked an through the bridge they can actually leave the model into the plane. Each of the building blocks that we saw on this particular slide, each of the gates, F1, F2, F3 etcetera, consists of a building block like this. These building blocks are very similar and are re-used in the model. The one thing that we did for this particular model is that we can parameterize the building blocks.

It means that we can set all kinds of properties of the building block to make them behave exactly the way it should be for this particular gate.

One of the interesting things is that we can also animate the model on the highest level.

It means we don't see all the individual gates and all the individual building blocks on the animation, but we actually see the concourse the way that anybody would see it.

We see that people move towards the gates, we see them walking, we see them using the conveyor belts and this means that we have a very, very good indication of how people move, how people walk and what they do.

We see it actually getting more and more busy - also at the wait areas- and it's only a matter of time until the first planes depart and we have actually people going out of the model. One of the most important things is of course the fact that we can also produce output from the model. Here we actually see the model that we've just watched in terms of the number of passengers at a certain desk row for checking in. We can also look at all kinds of other statistics. Statistics are one of the main reasons for creating simulation models, and especially discrete event simulation models. When we look back at this particular case, we see that we created one library for the passenger terminal logistics. We can very quickly model the infrastructure due to the fact that we have high-level building blocks.

The hierarchy helps is to reuse earlier efforts and to make sure that we don't have to invest time again in rebuilding building blocks that we made before. The models are still complex though and a lot of behavior is hidden. It still is difficult for people to create a good model from this. They need training. One of the other things that needs more focus is: input, output and scenarios. And that's what I will show in the next case study.

The next case study is about global supply chain management. Global supply change management is extremely complex. Goods coming from China being imported to Europe with all kinds of raw materials from all over the world, that are then again exported from Europe across the globe. Global supply chains. Many changes, with time as a very important factor, and extremely complex business relationships including competition.

We really want to compare alternatives in all kinds of different scenarios and the question is: how can you parameterize those scenarios?

What you see on the screen here is a very simple model at the top in terms of the weights represented. The model at the bottom, however, shows the background of the particular model, the way it is being built, and we can see that it is extremely complicated.

The question is: How can we make this more simple for the users. How can we create a flexible set of models for demonstration and teaching of these very, very complicated global infrastructures?

This is a view of the way a model looks: We see the fact that on the left side we have initial suppliers, we have on the right hand side all consumers and customers and in the middle the focal company we want to look at. And this focal company we want to learn more about in a lot of our studies.

This is an example of a teaching case that we built based on the library again of all kinds of building blocks in which we compared two different strategies. On the top, I made the stock supply chain and on the bottom I made the order supply chain.

The difference between these supply chains is whether we pull or we push the orders.

Are the orders pushed from the left hand side, you actually push your product to the markets. Are the orders pulled from the left hand side means, that you actually work in the other direction.

It leads to a very different way of sending information, receiving information and sending for instance products. Again in this particular example, the output is of the utmost importance.

We see a lot of different graphs that we can create with this particular model and they provide a lot of insight into what happens in the different parts of the supply chain.

We can look at inventory positions, we can zoom-in to individual companies and we can look at all kinds of information that are important to test the effect of the decisions we've just made.

We extended these particular models to gaming. It means that the same models that you saw the previous slides are at the core of a number of supply chain games that we created to play with students. This is an example of a screen of a global supply chain game that we actually played globally with students and in the material on the MOOC you can actually find more information about this. Students play a relatively simple business case in many different parts of the world.

And underneath are exactly the same building blocks of discrete event simulation

that you saw on the previous slides.

With this, we provided a flexible solution for supply chain management. The side by side comparison that you saw in the animation provides all kinds of insight for the users.

We focused very much on the output here, contrary to the models that you saw in the first case study. In this particular case we used Java libraries to build the models to have full flexibility in the way we could build them.

Finally, serious games have been developed with discrete simulation models as the core, which aligns very much with decision making as human decision makers do and they can enter their decisions into the game.

Our final case study is about a barge transportation.

In this particular case our challenge was: can we create micro simulation models with a lot of detail that we can use to support decisions 10, 15 or 20 years ahead. Long term policy studies.

The question was: are these models fast enough and would they be usable in this particular setting? In this particular case we created the micro level simulation model for barge transportation in the Netherlands usable in policy setting that can be used 10 to 20 years ahead. The model itself is based on a geographical information system and uses a lot of different databases to support the model background. The data itself - barge transportation, terminals, waterways, volumes - are based on all kinds of measurement and statistical data and also on official records.

When we slow down the simulation time a little bit, you can actually see individual ships sailing and the moment I click on one, you can see the information about the ship, the number of containers it contains, where it's coming from and where it's going to.

Each individual containers is modelled for this particular simulation mode, several millions a year!

And still the model actually completes a year of simulation in about one minute.

One of the advantages of discrete event simulation.

We can also see information about the terminals. This means that we can look at the

stack positions in the terminals, how many containers are stored, how many key cranes and other types of cranes do they have and we can look at all kinds of other information. One of that is the locks and bridges; I just clicked on one of the pointers on the left hand side to turn on the information on bridges and locks. The locks and bridges can also be questioned and queried and we can see for instance whether certain types of ships would be able to sail those particular locks and bridges.

This helps us to take all kinds of infrastructure decisions for the future, where we can for

instance look at the effect of investing in extension of locks, or making bridges higher so we can actually sail with larger ships. We can also look at the effect of widening or deepening certain waterways or canals. And all these things can be done with one simulation model that we used in quite interactive settings.

On the right hand slide, you see one of the settings that we did. A setting with Rijkswaterstaat in the Netherlands (part of the ministry of Infrastructure and Environment) where we looked at the use of these micro simulations in decision making settings and where we studied the effect of all kinds of infrastructure changes towards the future. We really were able to support long term decision making with these particular models. This discrete event simulation formalism took care of creating very fast models. Participants could use the models and were fully engaged in the sessions (by the way the sessions that we did lasted one to two days in which all kinds of infrastructure decisions were tested).

Thank you very much for your attention and I hope that you will learn a lot more about discrete event simulation using the materials that are available on this MOOC. Thank you very much.