Technical overview INCONTROL Software Simulation Platform

Introduction

Enterprise Dynamics® is a leading simulation platform to design and implement simulation solutions. It allows a problem solver to model virtually any problem and, by experimentation, look for a solution for a given problem or an answer to a specific question.

Most of the problems or questions for which simulation is used are:

- Capacity investigations
- Investment evaluations
- Time-to-Market vs. Costs evaluations

To be able to perform simulation studies, a good simulation platform is required. A good simulation platform does not only provide fast modeling capabilities and good visualization features, but it also provides the possibilities for the re-use of previous made models, segments of models, and components used in previously made models.

This document describes a technical overview of the Enterprise Dynamics Simulation Platform. The purpose of this document is to give the reader with little knowledge of simulation and Enterprise Dynamics a good understanding of how Enterprise Dynamics is built, and what are the key-factors that makes this simulation platform the right choice.

A good simulation study

Problem solving via simulation does not exist alone out of building a good model. This will not result automatically in good results. There is more to it, and a good simulation platform provides the user with supporting tools to get the job done.

A simulation study consists out of the following phases:

- Conceptualization
- Definition
- Data Collection
- Modeling
- Verification and Validation
- Experimentation
- Training
- Implementation

Most of the phases are executed one after another. However, Data Collection starts right after the Conceptualization phase, and is executed parallel. This is simply caused by the fact that the required data must be collected throughout an organization, and in a lot of cases has to be measured first.

The phase Implementation is added to the project in cases where simulation is really integrated in the operation, and where simulation is not used for design purposes alone. The rollout throughout a department or organization is an important phase to recognize because non-simulation experts will use the simulation solution.

The better the simulation platform aids in these steps, the more likely good results become. Table 1 gives an overview in the way a simulation platform can aid in the named project steps of a simulation study.

Project Phase	**Assistance**
Conceptualization	• Easy prototyping facilities to communicate between problem holders and problem solvers to get a good understanding of the boundaries of the problem.
Definition	• Re-usability of existing models and components. • Options to communicate and integrate with other (corporate) systems.
Data Collection	• Data analysis tools to filter out bad data, or to assist in the generation of functions to be used in the simulation model.
Modeling	• User-friendliness. • The availability of well-defined, strong simulation objects, which are easy to adopt and changed for the specific model at hand. • Strong debugging facilities to search and detect modeling errors. • Good documentation features to document the model, and specific changes when made. • *Functions accessible through keyboard shortcuts (nowadays important as part of anti-RSI measures).*
Verification and Validation	• Good reporting tools to be able to track the outcome of specific parts of the model. • Strong debugging facilities to search and detect modeling errors. • (3D) Visualization to be able to track the routing of specific parts/products/items through the model. • The ability to change parameters while a simulation model is running to be able to "play" with the properties of all simulation objects.
Experimentation	• Good reporting tools to be able to generate data reports with the results of specific experiments. • The ability to export data to external formats for further analysis. • Data analysis tools to analyze the results.
Training	• (3D) Visualization to be able to convey the message to the trainees. • Parameter changes should be easy to make to "play" different scenarios and to demonstrate the consequences of certain actions.
Implementation	• 3D Visualization to demonstrate the capabilities of a certain system in a more understandable way.

	• Modifiable user-interface to fit in the company language(s) and house-style. • Options to communicate and integrate with other (corporate) systems. • Good documentation.

Table 1: Assistance per phase

The Enterprise Dynamics architecture

The Enterprise Dynamics Simulation Platform is used in situations where speed, operational use, and user-friendliness are very important. This has led to a software architecture that is not only powerful, but also flexible to add new features, protocols, and simulation objects whenever required.

Enterprise Dynamics can be divided in three parts:

- The simulation engine
- The available (branch specific) atoms
- The user-interface

Figure 1 gives an overview of the three parts and how they react to one another.
The simulation engine binds all atoms together and makes it possible that the various objects can communicate with each other within a simulation model, or with external applications, databases and real-life systems. Whatever product is acquired, the simulation engine is always the same.

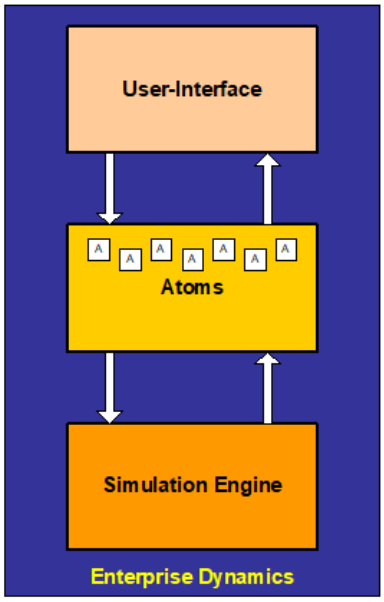

Figure 1: Architecture overview

Atoms mimic certain real-life objects and can be arranged (and be set with real-life parameters) to simulate a specific real-life process or system. The atoms are bundled in branch specific groups called Suites. Depending on the solution that is required, specific atoms are part of the product.

The third part is the user-interface that is merely a presentation of functionalities within a shell. However, this is a separate part in Enterprise Dynamics because it can be completely modified, independently from the other parts.

Object-oriented AND Event-oriented

Enterprise Dynamics is an object-oriented simulation platform. Simulation objects are defined with independent behavior. Communication between objects is realized, through the simulation language runner, via events and messages.

An object-oriented simulation platform has two major advantages:

- Independent objects can easily be re-used in other simulation models
- Behavior is defined on the object itself, and not in a different part of the model (which makes the model clearer to understand)

In an event-oriented language in many cases the entire possible behavior is programmed somewhere in the program. A selection must be made which part of the behavior is valid before the desired behavior can be executed. Not only does this lead to "spaghetti-code", but it also decreases performance.

With object-oriented software behavior is set on specific events. This can lead to small and fast simulation models.

However, object-orientation can demand some higher programming skills from the user. This could make the use of the software somewhat more demanding from an organization. And with a lot of object-oriented software, it really does have a large impact on the required skills!

To focus on problem solving, not programming, Enterprise Dynamics comes with the unique *Channel-concept*.

Channels are interconnections between simulation objects that are internally translated to tasks and messages to move objects and to communicate information. Channels are automatically added between objects to assist the modeler and limit the programming skills of the user. Using channels, a lot of models can be designed in an event-oriented approach, while internally the full power of object-oriented programming is active.

The atom concept

Everything within Enterprise Dynamics is called an atom. From a simulation object imitating a production machine to the operator that is using the machine. Hence, even a simulation model, and the simulation platform itself is considered an atom.

Each and every atom has certain properties that can be set during design and runtime and is able to act on events when they occur. The specific events on which an atom is reacting can be set during design and runtime as well.

Enterprise Dynamics comes with a lot of predefined atoms that are developed based on industry experience, but atoms can also be created from scratch. In some cases, existing atoms are not doing the job that is needed for a specific problem. Via the unique atom concept, it is very easy to create completely new atoms as well. Even these custom-build atoms have all the strengths of factory-build atoms, properties can be created and set during design and runtime, and all the events an atom can react on are available to create custom-build actions.

Example
One of the basic elements in simulation software is called a *Server*. A server act as an object that does something with an incoming part, product or item. For an insurance company it could represent the activity to evaluate a certain application, and it could represent a manufacturing step for a production company.

The *Server* has specific properties like:

- Cycle time.
- Mean time between failures.
- Mean time between repairs.

And the ability to execute specific actions whenever a certain event occurs:

- OnEntry.
- OnExit.
- OnCreation.

In all, Enterprise Dynamics supports 15 types of events per atom.

The ability to have full control over all the properties and events makes it possible to alter existing atoms to specific needs, and to build completely new atoms in the same way.

There are three big advantages of this unique approach:

- Flexibility. All atoms are completely modifiable to specific needs.
- Scalability. Only atoms and features that are required for the designed task at hand are made available, all other atoms and features can be disabled for the inexperienced users.
- Ease-of-use. All atoms have the same structure, and can be accessed, and modified in the same way.

Engine: Modular Design
The Enterprise Dynamics Simulation Engine is designed in modules. On top of the custom-build simulation language runner, all functionalities are offered in separate modules that communicate to each other, when needed, through the simulation language runner, see figure 2.

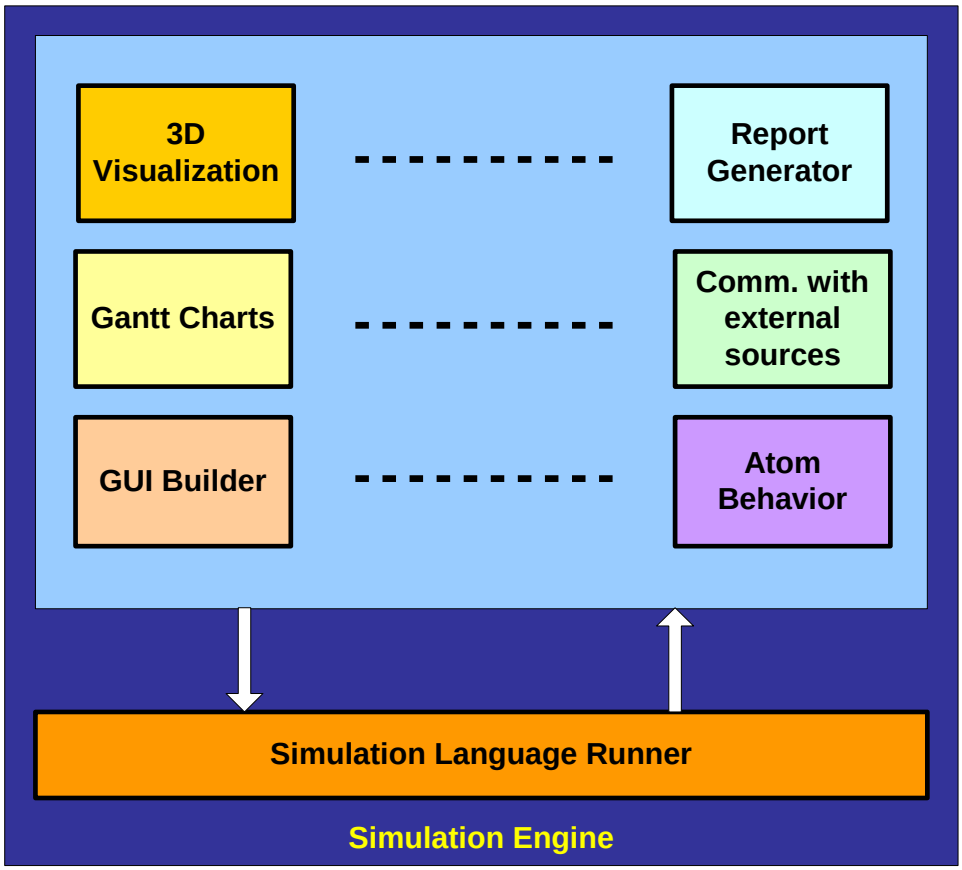

Figure 1: Schematic overview of the simulation language runner and some of the modules

There are three main advantages for this approach:

- New features can be added without re-implementing (parts of) the engine.
- Easier tracking-and-tracing of bugs.
- An existing feature can easier be replaced with an improved version, without disturbing existing libraries, and models.

Communication and control between modules is done via the simulation language runner in a standardized way through a limited number of access points. This limits possible errors through the interaction between modules.

Engine: 4DScript

The simulation language runner comes with a language that is very easy to learn and intuitive in its use. The name is **4DScript.** The name 4DScript is easy to understand. 4D stands for x, y, z to point at the position, and t for time. Script stands for the fact that it is a script language.

With 4DScript all well-known operations are possible that are available in modern programming languages. However, the true strength is the possibility to use the language for specific behavioral things that happen in real life. There are language words available to give simulation objects a speed, acceleration, and a rotation, and language words to batch objects, or to split objects in separate items.

Due to the good design of the available atoms, many users will hardly use any 4DScript command, but each option in an atom window is translated to 4DScript language.

4DScript, as a script language, interprets the language code when it is needed. However, simulation is all about speed, so optimization is made to interpret the code whenever it first appears. In practice this means, that the simulation run is as fast as any custom-build software that imitates real-life behavior.

For the experts
An interpreter language is on many occasions slower than a compiler counterpart. However, 4DScript is a hybrid form, in the middle between a compiler and an interpreter. This makes it versatile as an interpreter, but as fast as compiled software. During the time a model is loaded, it is already interpreted. Without any changes, the simulation language runner acts only as a loader for the interpreted model (just like

The main advantage is that changes can be made to the model during a simulation run. With custom-build software, a new compilation would be required. With Enterprise Dynamics the changed code is interpreted and reentered to the simulation runner. This approach results in two major advantages, the best of both worlds:

- Speed
- Flexibility

Atoms
Enterprise Dynamics comes with various atoms to be used in simulation models. These atoms range from abstract atoms to very specific detailed branch specific atoms, as well as additional atoms to assist in multiple tasks (like gathering data, communication with external sources, etc.).

All the atoms that are part of Enterprise Dynamics are developed in close cooperation with branch specific experts. They have the knowledge to define the requirements of a good set of objects that are useful in a specific branch or for a specific solution.

Atoms have been developed with much real-life behavior, and the user has the possibilities to alter many parameters according to own specific needs. These atoms come complete with real looking 3D visualization.

However, the most important feature of Enterprise Dynamics is to change the behavior or appearance of these atoms itself. Alter existing atoms or create entirely new atoms is part of the standard functionality. Being able to define the correct behavior or appearance is what makes Enterprise Dynamics the leading simulation platform.

Atoms: Grouped by function
No matter which branch-specific solution is used, available atoms are always grouped by function. This makes it easier to determine which atoms are available that potentially are of use for the user for a specific model. Due to the high number of atoms that are supplied with each Suite, it would otherwise be hard to find the right atom within the pool of atoms.

However, as mentioned earlier, the user-interface is completely modifiable, and therefore the grouping can be changed if so desired. It is done to assist the user in finding the right atom quickly.

For users who create their own set of atoms, new groups can be added, or existing groups can be changed entirely. If a user creates models with the same set of atoms (pre-defined and/or newly created ones), the user is free to change the grouping so these atoms are the top-most set of atoms, which could speed up modeling.

Visualization
In a lot of cases, simulation is all about the determination of values within specific boundaries. However, a sheet with numbers, intervals and percentages is for most people hard to read. To convey the message, some other form is needed. Secondly some organizations use simulation for the sole purpose of demonstrating their own capabilities. Although they use the numbers internally, they want to demonstrate their products or services with a clear and easy to understand presentation.

Enterprise Dynamics comes with a high-end 3D graphic environment to visualize the simulation in an instance. This 3D graphic environment animates the simulation model with respect to the geometry entered, and is completely adaptable to visualize any real-life system.

The (3D) visualization in Enterprise Dynamics is part of the standard product and is generated immediately. Even changes made during a simulation run are updated at once. In this way the effect of the visualization or the changed geometry can be evaluated without starting all over again.

Most of the atoms supplied with Enterprise Dynamics offer more than one form of visualization. This makes adapting the visualization to specific needs easy to do and assist in creating astonishing presentations without any graphic designer skills.

Communication
In many occasions there is a need to communicate with databases, third-party software or even hardware. Some of the most experienced reasons are:

- A database contains data with real-life entry times of people that can be used as input data for a simulation model
- Some third-party software is used to write data to for analysis purposes (for instance Excel)

- Listening and responding to hardware is used to control a machine in a production line and to assist operators in specific tasks

Enterprise Dynamics is supplied with many features to communicate with external sources. No matter if it is a simple text-file, or a piece of hardware, Enterprise Dynamics can communicate with it!

To assist in the communication, Enterprise Dynamics comes with a set of supportive atoms that act as a wizard to set up the communication, and the desired response.

Analysis
Running a simulation model without good tools to analyze the results is only half the job done. Being able to analyze the results and the creation of clear reports is vital in a good simulation study.

Enterprise Dynamics comes with all the necessary tools analyze input and output data, as well as the features to create customizable reports. And if you prefer other analyzing tools, no problem, through the communication features and supportive atoms, an export to these tools is very easy to accomplish.

To assist in finding the right solution, Enterprise Dynamics is also equipped with tools to define scenarios and experiments. Scenarios and experiments are used to set a range of parameters and to run multiple simulation runs using these parameter settings. It assists the user in finding the right solution, as well as the statistical validation of the results.

Summary
Using Enterprise Dynamics is choosing for the leading simulation solution provider with more than 30 years of experience in simulation. Enterprise Dynamics is used by branch leaders to find the answers for capacity investigations, investment evaluations and time-to-market vs. costs evaluations.

Using Enterprise Dynamics as your simulation solution, you choose for:

- Speed and flexibility
- Object-oriented simulation software
- Branch specific expertise translated into powerful simulation objects
- State-of-the-art technology
- Instant 3D Visualization
- The ability to integrate simulation into your core processes
- Powerful data analyzing tools