Table of Contents

Go Back

The Time Machine

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The Time Machine is a *software* designed and developed as a support tool for decision-making, collective and collaborative discussion enactment and consent building.

The initial inspiration comes from the *Game of Future* designed by Gordon and Helmer in 1966 and from the "scenario technique" proposed by Godet (1984) of whom *The Time Machine* is in a certain sense a generalisation that, by offering a series of analytical tools, permits a detailed and transparent analysis of results.

1. The Structure of the Model

1.1. Events

The working hypothesis beneath the whole model is the idea that it is possible to "model" a system and its possible future developments/scenarios through a series of *events* that represent it. In other words, the system is defined as a collection of potential scenarios with a series of possible events. Therefore, the starting point for every model is a set of *events* each with respective *initial probability*.

Subsequently, the relations among events are defined. Generally, the information about relations among events answer – for each event E_x – on the following question: "If the event E_x occur, how does the probabilities of other events change?" These data are thus represented in a *relationships matrix* of a general form as illustrated by the Fig. 1.

Figura 1 – Relationships matrix *events* -> *events*

	E_1	E_2	E_3	…	…	E_{n-1}	E_n
E_1		p_{12}	p_{13}	$p_{1\ldots}$	$p_{1\ldots}$	$p_{1(n-1)}$	p_{1n}
E_2	p_{21}		p_{23}	$p_{2\ldots}$	$p_{2\ldots}$	$p_{2(n-1)}$	p_{2n}
E_3	p_{31}	p_{32}		$p_{3\ldots}$	$p_{3\ldots}$	$p_{3(n-1)}$	p_{3n}
…	$p_{\ldots 1}$	$p_{\ldots 2}$	$p_{\ldots 3}$		$p_{\ldots\ldots}$	$p_{\ldots(n-1)}$	$p_{\ldots n}$
…	$p_{\ldots 1}$	$p_{\ldots 2}$	$p_{\ldots 3}$	$p_{\ldots\ldots}$		$p_{\ldots(n-1)}$	$p_{\ldots n}$
E_{n-1}	$p_{(n-1)1}$	$p_{(n-1)2}$	$p_{(n-1)3}$	$p_{(n-1)\ldots}$	$p_{(n-1)\ldots}$		$p_{(n-1)n}$
E_n	p_{n1}	p_{n2}	p_{n3}	$p_{n\ldots}$	$p_{n\ldots}$	$p_{n(n-1)}$	

Where E_x is an event x: $x \in \{1, 2, 3, \ldots, n-1, n\}$
and $p_{jk} \in$ <-100, 100> is the probability variation of the event E_j if the event E_k occurs.

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Besides the events, there are the following founding entities of any model: *unforeseen events, causal factors* and *strategies.*

1.2. Unforeseen events

These are a type of entity rather similar to the events. Their peculiarity resides in the fact that they are to be considered, epistemologically, as exogenous to the system that is being modelled, as those forces that influence externally the system without being influenced themselves by the system.

Therefore, each unforeseen event is defined by a respective initial probability and the vector of values that indicates the variation of events' probability in case that specific unforeseen event occurs. The relationships matrix *unforeseen events -> events* is analogous, in its form, to that illustrated by the Fig. 1.

1.3. Causal Factors

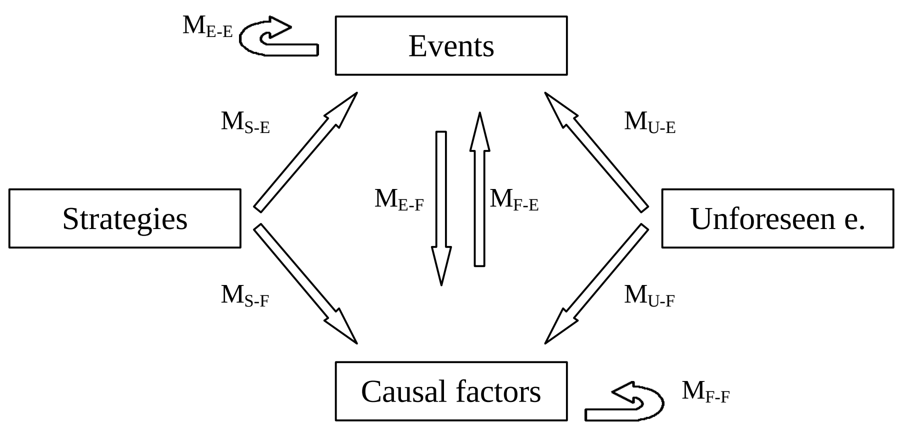
These are a particular type of entity that do not have an initial probability but a value expressed in adequate unit of measurement. Hence, a causal factor is a true quantitative variable that can influence the probability of events and values of other causal factors in case the initial value of that particular causal factor varies.

1.4. Strategies

Strategies are a particular kind of events that do not occur on the basis of their probability, but get "activated" directly by the user. They are to be interpreted as "actions" or "policies" at user's disposal in order to experiment their effect on the system.

To summarise, the entities that build up the model of *The Time Machine* as well as their respective relationships of influence are synthesised in the Fig. 2.

Figure 2. – The structure of the model



NOTE: Each arrow represents an influence and thus a relationship matrix; the matrixes are represented by the letter *M* and the indexes are indicating the direction of influence (E – Events, U – Unforeseen events, F – Causal factors, S – Strategies)

2. Execution of a Simulation

The modalities of the execution of simulation can be parameterised, but typically the following steps are followed:

2.1. Activation of Strategies Chosen by the User

The chosen strategies influence and modify the probabilities of events and values of causal factors as predefined in respective matrixes ($M_{S\text{-}E}$ e $M_{S\text{-}F}$, see fig. 2).

2.2. Unforeseen events activation

In this phase, the unforeseen events are “tested” – in random order – against their probability (*Monte Carlo* method). If an unforeseen event occurs, the probabilities of events and the values of causal factors vary as defined in respective matrixes ($M_{U\text{-}E}$ e $M_{U\text{-}F}$).

2.3. Causal factors activation

At this point, each change of value of a causal factor can – if so defined in $M_{F\text{-}F}$ and $M_{F\text{-}E}$ matrixes – modify respectively the values of causal factors and the probabilities of events.

2.4. Events Activation

Finally, each event is “tested” against its probability analogously as with unforeseen events. If an event occur, that can change the probability of other events, as well as final values of *causal factors*, as defined respectively by the matrixes $M_{E\text{-}E}$ and $M_{E\text{-}F}$.

In this manner, we have obtained a final scenario defined by:

- the final probability of events (or by a binary value “did occur”/”did not occur”);
- the final values of causal factors;
- the list of occurred unforeseen events;
- the list of implemented strategies.

It is important to mention that the software offers vast possibilities for parameterisation and personalisation of modalities, sequences and procedures of execution.

4. Analysis of Results

4.1. Visualisation and Analysis

Since the final results of a simulation depend on stochastic algorithms (e.g. Monte Carlo method), the software permits to easily reiterate the simulation and to analyse the series of results putting them in a perspective. In particular, the software provides the following results:

- all values of scenarios obtained iteration by iteration;

- the mobile mean values (which theoretically tends toward a mean value obtainable by an infinite number of iterations);
- minimum and maximum values;
- standard deviation of values.

4.2. Report Generation and Exportation of Data

For all aspects of simulation the respective *reports* can be generated and subsequently exported in a data format adequate for further analysis and elaboration.

5. As a Conclusion

Obviously, *The Time Machine* is a pure help for reflection, but it must not be underestimated for the fact that it can be easily activated and modified by the user, and that it provides an accurate and transparent analysis of the evolution of the system (as opposed to a “black box”); in should not be underestimated for the fact it can remind us that:

> "il serait dangereux de limiter la réflexion au scénario considéré comme le plus probable, car bien souvent ce dernier n'est en réalité que le moins improbable"
>
> (Godet 1984, p. 43.).

It is thus, a good example of that particular mix of empirism, modesty, attention on the qualitative, a prudent *calculemus*, attention for alternatives and counterintuitive effects, that seems an essential tool for a tool-box of a territorial plumber.

Bibliography

Godet, M. (1984), *Prospective e planification stratégiquei*, CPE, Paris

Back to the Top