Chapter 1 Principles of Modeling in Information Communication Systems and Networks

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ABSTRACT

The authors present in this entry chapter the basic rubrics of models, modeling, and simulation, an understanding of which is indispensible for the comprehension of subsequent chapters of this text on the all-important topic of modeling and simulation in Information Communication Systems and Networks (ICSN). A good example is the case of analyzing simulation results of traffic models as a tool for investigating network behavioral pattarns as it affects the transmitted content (Atayero, et al., 2013). The various classifications of models are discussed, for example classification based on the degree of semblance to the original object (i.e. isomorphism). Various fundamental terminologies without the knowledge of which the concepts and models and modeling cannot be properly understood are explained. Model stuctures are highlighted and discussed. The methodological basis of formalizing complex system structures is presented. The concept of componential approach to modeling is presented and the necessary stages of mathematical model formation are examined and explained. The chapter concludes with a presentation of the concept of simulation vis-à-vis information communication systems and networks.

FUNDAMENTALS OF MODELS AND MODELING

A model is essentially the *re*presentation of an object, system or concept in a form different from that in which it occurs naturally. A model may likewise be defined as a tool, which helps in

the explanation, understanding or perfection of a system. Modeling can be described as the process of substituting a test object (the original) for its image, description, or substitute object known as a model and providing a behavior close to that of the original within certain reasonable limits of assumptions and uncertainties. Simulation is

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usually performed in order to gain knowledge of the properties of the original object by studying its model, rather than the object itself.

The use of models is justified in cases when they are simpler in comparison with the option of creating the original object, or when the original object is better left uncreated for whatever reason. In the words of D.K. Nordstrom (2012), "Models are one of the principal tools of modern science and engineering..." Scientists and engineers devote a lot of time to design, build, test, compare, and revise models (Frigg and Hartmann, 2009).

A model may be the exact replica of an object (*albeit* on a different scale and from a different material) or depict certain characteristic properties of the object in an abstract form; i.e. a representation of a real system or process (Konikow and Bredehoeft, 1992). A model is thus essentially an instrument for forecasting the effect of input signals on a given object, while *modeling* is a method of improving the reasoning efficiency and intuitive capacity of specialists.

All models are but simplified *re*presentations or abstractions of the real world. An *abstraction* contains within itself the major behavioral traits of an object, but not necessarily in the same form or as detailed as in the object. Usually a large portion of the real characteristics of the object of study is disregarded, while such peculiarities that idealize a real event version are chosen. As a result, most models are abstract in nature.

The degree of semblance of a model to its object is called *isomorphism*. Two conditions must necessarily be satisfied for a model to be considered *isomorphic* (or similar in form) to the original object:

- 1. Existence of exclusive correspondence between elements of the model and the modeled object;
- 2. Maintaining the exact relationships or interactions between these elements.

From the foregone, we see that a model is essentially a physical or abstract object, with properties similar to those of the original object under study in certain defined ways. The specification of models depends on the particular problem of study as well as the available resources. The general requirements for models are as listed below:

- 1. **Adequacy:** This refers to the level of accuracy in replicating the properties of the original object.
- 2. **Completeness:** The ability of the model to deliver to the receiver all necessary information about the original object.
- 3. **Flexibility:** The ability to playout different situations in the whole range of conditions and parameters.
- 4. The *complexity* of developing the model must agree with the existing time and software constraints.

According to Tedeschi (2006), the design of the tests for adequacy for a particular model should of necessity evaluate weaknesses to be addressed. He further contends that a combination of several statistical analyses vis-à-vis the original conceptual purpose of the model is essential for determining its adequacy.

Since modeling s the process of creating a replica of an object and the subsequent study of the object's properties through the created replica (a.k.a. model), entails two major stages:

- 1. Model design;
- 2. Model evaluation/validation and conclusion derivations.

Model validation is concerned with ascertaining that a model performance in satisfactorily accurate vis-a-vis model design objectives; it is all about building the model right (Balci, 1997). It is pertinent to note here that a uniform procedure 13 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the product's webpage: www.igi-global.com/chapter/principles-of-modeling-in-informationcommunication-systems-and-networks/79656

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