Read-Ahead for May 7, 2016
A General System Structuring Approach

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Introduction

Structural modeling blends the formal information associated with mathematics and logic together with empirical information associated with a specific real world problem to create an outline of the problem structure. Structural modeling has three components (see also Figure 1):

1. Basic structural modeling that is focused on specific, formal mathematical constructs;
2. Interpretive structural modeling that is focused on the characteristics and attributes of a given 'real world' problem; and
3. Structural integration modeling that places the information acquired from the real world problem into proper alignment with the applicable formal mathematics.

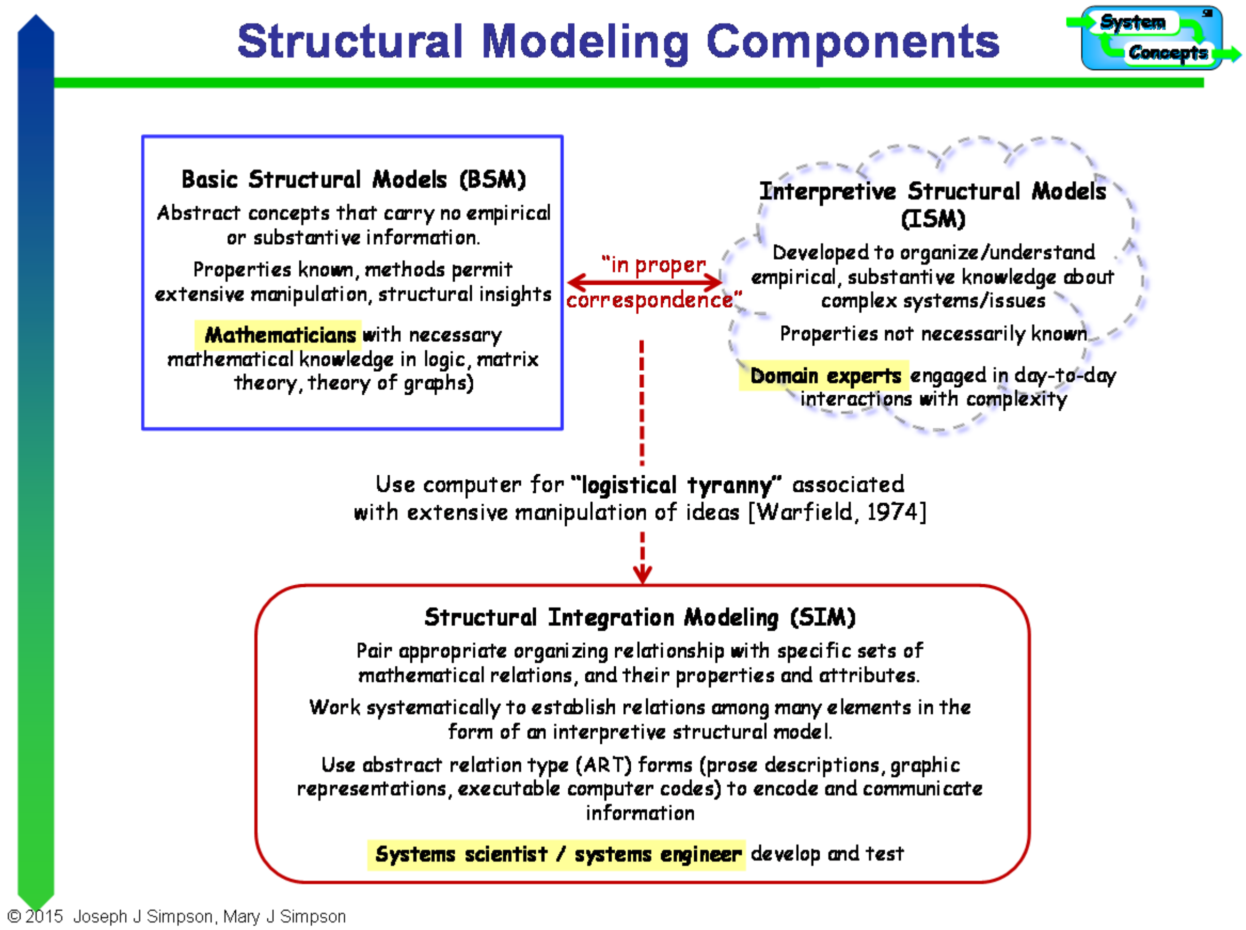

Figure 1 – Structural Modeling Components

This working paper outlines some of the specific types of information that are necessary to effectively implement structural modeling, as well as some basic process and work flow considerations needed to create an acceptable structural model.

Structural Modeling Contextual Artifacts

Structural modeling is designed to play a range of roles in the system discovery and design process. In this paper, the primary focus is on the discovery of an unknown systems structure. The presentation examples are organized around our previously cited *19-city example* which uses the 'north-of' natural language system structuring relationship. To effectively use the north-of natural language relationship to structure a system, two basic information items are needed. These items are:

- The logical properties associated with the ‘north-of’ natural language relationship.
- The number of cities allowed at each latitude.

This contextual information is collected and placed in the abstract relationship format. The logical properties associated with the ‘north-of’ natural language relationship are:

- Irreflexive. A city is not north-of itself
- Asymmetric. If City A is north-of City B,
  then City B is not north-of City A (City B is south of City A)
- Transitive. If City A is north-of City B, and City B is north-of City C,
  then City A is north-of City C

The number of cities allowed at each latitude is an important consideration during the empirical information collection phase.

Example 1. **Restrict the number of cities at each latitude to one.** This is the arrangement that was used in the first structural ordering web application. For only one city allowed at each latitude, and the property of asymmetry, the answer to the question, “Is City 1 north of City 5?” may be evaluated as follows:

- If the answer is *yes*, then it is known that City 1 is north of City 5, and due to asymmetry it is known that City 5 is south of City 1.
- If the answer is *no*, then it is known that City 1 is not north-of City 5, and due to asymmetry it is known that City 1 is south of City 5

With the answer to a single question, information is confirmed for both of these cities with respect to each other. Either answer provides the same information – as a direct result of the number of cities allowed at each latitude, and the asymmetric property of symmetry that applies to the relation ‘is-north-of’.

Example 2. **Allow multiple cities at each latitude** (lift the restriction for a single city at each latitude). This is the configuration addressed by the Adaptive Total Strict Partial Order (ATSPO) approach that is encoded into the current structural modeling web application software.

In this example, empirical information collection activity becomes more involved, and more structured questions are required to obtain information. Take cities 3 and 10.

Question 1, “Is City 3 north of City 10?” may be evaluated as follows:

- If the answer is *yes*, then it is known that City 3 is north of City 10, and due to asymmetry it is known that City 10 is south of City 3.

- If the answer is *no*, then there is insufficient empirical information to make a decision, since more than one city may be located at the same latitude. A second question (Question 2), needs to be asked at this point.

  Question 2, "Is City 10 north of City 3?" may be evaluated as follows:

  - If the answer to Question 2 is *yes*, then it is known that City 10 is north of City 3, due to the answer to Question 1 and due to asymmetry.
  - If the answer to Question 2 is *no*, then it is known that City 3 and City 10 are at the same latitude, due to the answer to Question 1 and the fact that more than one city can be at the same latitude.

The contextual information must include the organizing relationship, the organizing relationship properties, and information about valid system structural arrangements. In this specific case, the valid system structural arrangements are governed by the number of cities allowed at each latitude. These logical and empirical factors are used to create a valid system structuring approach. Different contextual information sets may drive different software application logic and user interfaces as demonstrated in the first two structural modeling web applications.

Abstract Relation Types Support Structural Modeling

Simpson and Simpson created the abstract relation type (ART) as a structured, standard format for the presentation and distribution of structural system information (Figure 2). The 19 cities problem uses the 'north-of' relationship to order the cities in the problem. ***The natural language relationship by itself, as discussed above, is insufficient to effectively structure the system.*** In the first 19 cities software application example, the real-world problem was also constrained to allow only one city at each level. This constraint created a strict order of the cities. In the second software application created to structure cities, the restrictions on the number of cities in the matrix and number of cities at each latitude were lifted. This second software application is called an Adaptive Total Strict Partial Order (ATSPO).

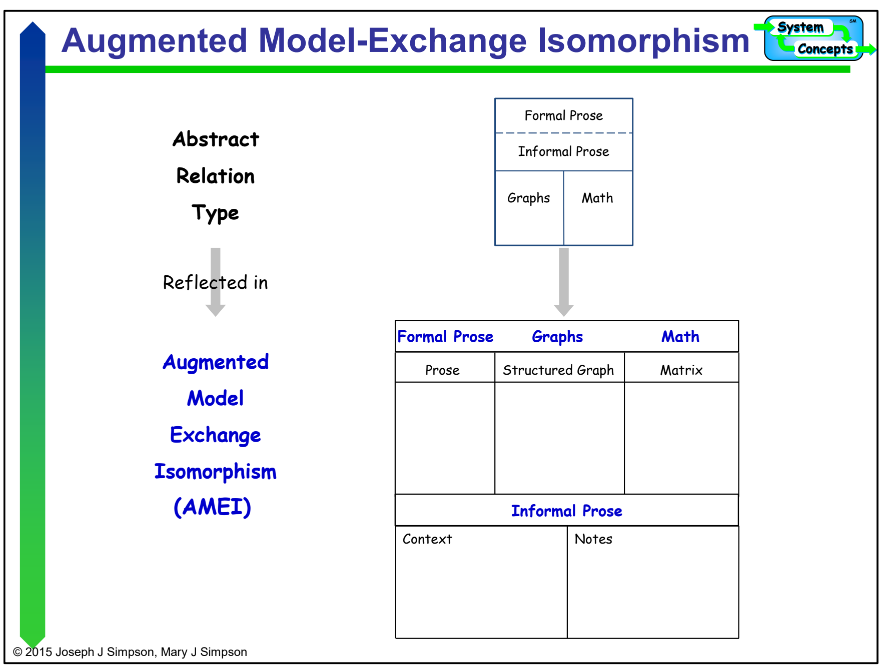

Figure 2. ART and the AMEI

The ART and the augmented model-exchange isomorphism (AMEI) both focus on the standard presentation of system structuring information. However, the AMEI is constrained to the primary topology of 27 logical property groups. These foundational logical property groups provide a mechanism to support effective, detailed technical communication about system structuring activities. Figure 3 shows the logical property groups that are the basis of the AMEI organization. From a system-structuring point of view, the logical property of symmetry is the governing property. The reflexive property group involves only one individual, and therefore does not provide significant system structure information. The transitive property depends on the existence of some type of symmetry connection; in the specific case of system structural modeling, the transitive property group only increases the efficiency in which the system structure may be discovered. In addition, the transitive property is the basis for the logical inferences used in typical structural modeling approaches. The system structure could be discovered by using only empirical information about the symmetry of the system. However, the approach that uses only empirical information would consume many more resources to discover the system structure.

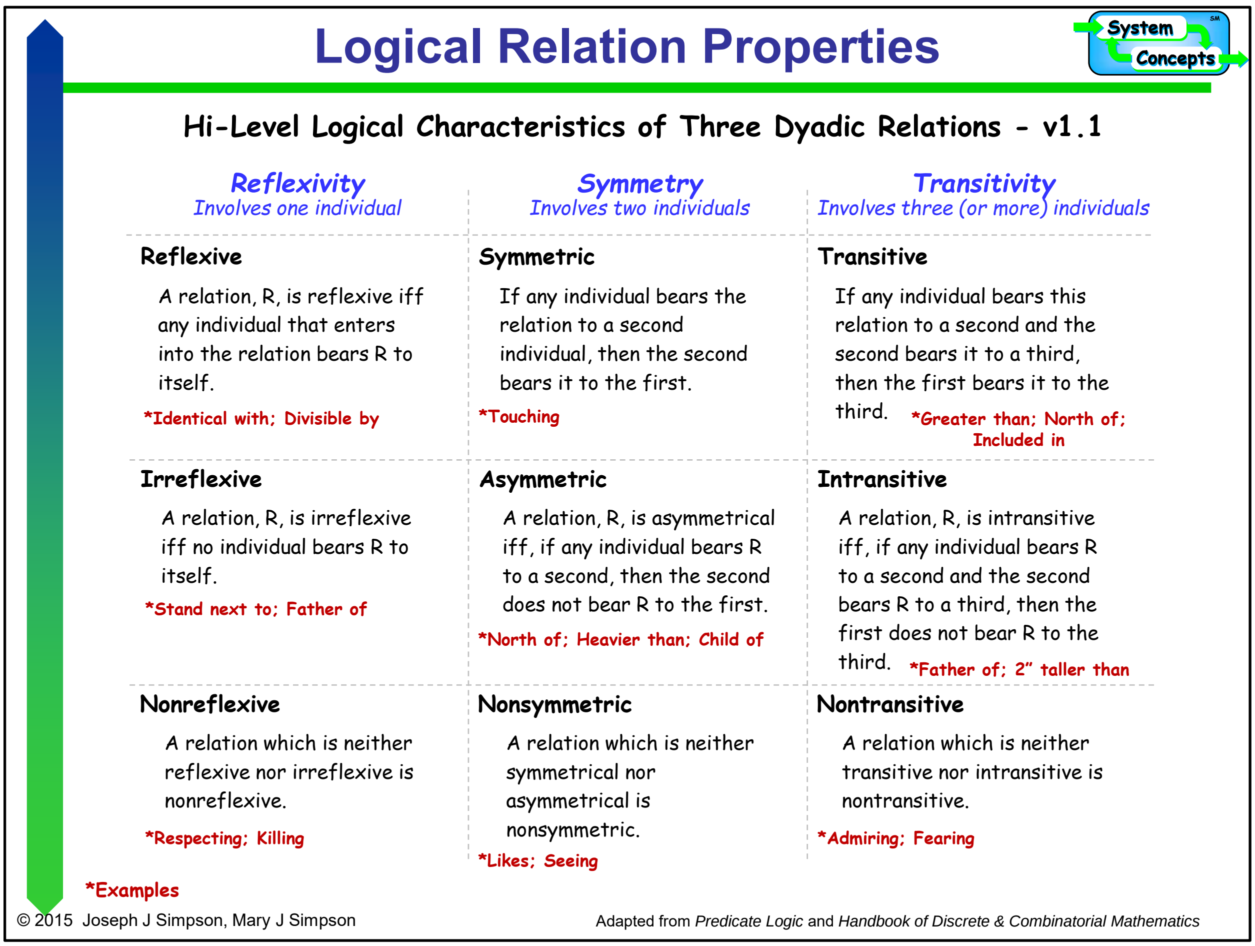

Figure 3. Logical Property Groups

The effective application of the ART and AMEI combination not only supports the creation of highly useful system structural analysis software applications, it also creates a sketch of an outline of the types of approaches that can be used in various cases. Using the information contained in the ART and AMEI, varying application and solution approaches may be evaluated and grouped into similar classes. Creating classes of solution approaches will greatly enhance the communication of system structural modeling information, and the application of these solution approaches.

The first two system structuring problems addressed by the structural modeling project have focused on the 'north-of' natural language system structuring relationship. This relationship has an asymmetric logical property. As indicated in the *Structural Modeling Contextual Artifacts* section, the asymmetric property plays a significant role in establishing the order of empirical data collection and processing. The next system structuring problem set will use a natural language system structuring relationship that has a symmetric logical property.

This new natural language system structuring relationship could be 'influences' or some other natural language relationship. The system analysis and evaluation software will have to be adjusted to correctly interact with a symmetric natural language system structuring relationship. Many of the historical applications appear to have natural language structuring relationships that have a symmetric property.

The change ***from an asymmetric to a symmetric*** natural language system structuring relationship will drive the reevaluation and design of the system structuring software. It appears that there will be more than one type of system structuring software approach. Further, it appears that the proper software approach will depend on the type of logical symmetry property associated with the natural language system structuring relationship for a given context.