An Adaptive Structural Modeling Approach

SMC INCOSE
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Overview

Why it's important to do this:

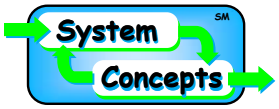
- Create logical foundation for systems structure
- Enables communications between humans and computers (develop a systems language)
- Develop the basis for a common testbed

Ongoing Status

- Static structure addressed 2013-2015
- Adaptive structure addressed 2016
- Start of detailed natural language relationship mapping to mathematical relations - May, June 2016

Building on the work of John N. Warfield

Structural Modeling Components



Basic Structural Models (BSM)

Abstract concepts that carry no empirical or substantive information.

Properties known, methods permit extensive manipulation, structural insights

Mathematicians with necessary mathematical knowledge in logic, matrix theory, theory of graphs)

"in proper correspondence"

Interpretive Structural Models (ISM)

Developed to organize/understand empirical, substantive knowledge about complex systems/issues

Properties not necessarily known

Domain experts engaged in day-to-day interactions with complexity

Use computer for "**logistical tyranny**" associated with extensive manipulation of ideas [Warfield, 1974]

Structural Integration Modeling (SIM)

Pair appropriate organizing relationship with specific sets of mathematical relations, and their properties and attributes.

Work systematically to establish relations among many elements in the form of an interpretive structural model.

Use abstract relation type (ART) forms (prose descriptions, graphic representations, executable computer codes) to encode and communicate information

Systems scientist / systems engineer develop and test

Logical Relation Properties

Hi-Level Logical Characteristics of Three Dyadic Relations - v1.1

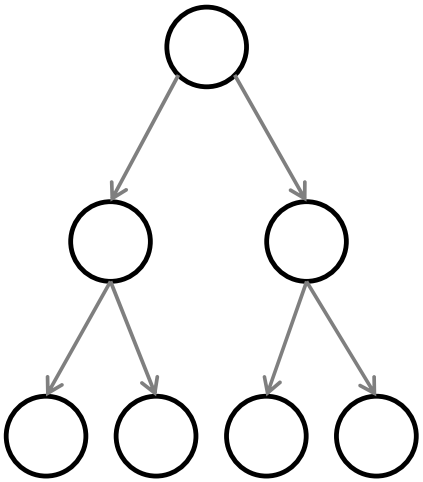
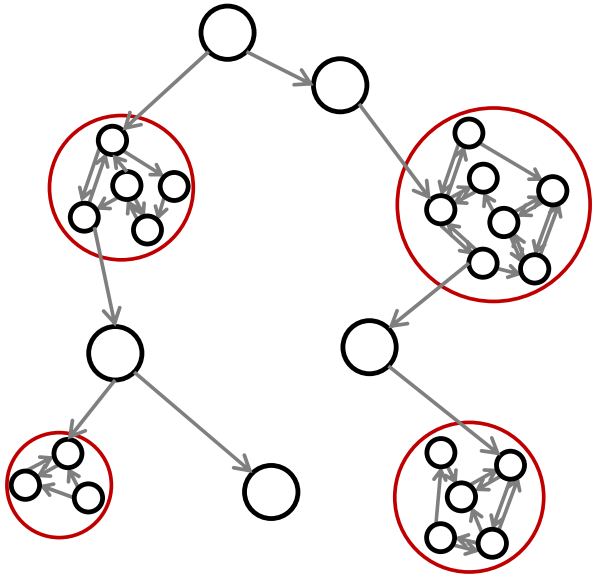
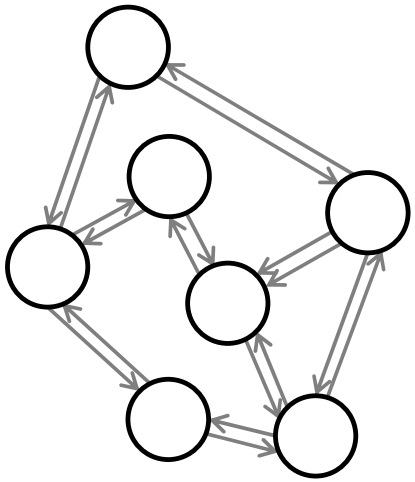
Reflexivity *Involves one individual*	*Symmetry* *Involves two individuals*	*Transitivity* *Involves three (or more) individuals*
Reflexive A relation, R, is reflexive iff any individual that enters into the relation bears R to itself. *Identical with; Divisible by	**Symmetric** If any individual bears the relation to a second individual, then the second bears it to the first. *Touching	**Transitive** If any individual bears this relation to a second and the second bears it to a third, then the first bears it to the third. *Greater than; North of; Included in
Irreflexive A relation, R, is irreflexive iff no individual bears R to itself. *Stand next to; Father of	**Asymmetric** A relation, R, is asymmetrical iff, if any individual bears R to a second, then the second does not bear R to the first. *North of; Heavier than; Child of	**Intransitive** A relation, R, is intransitive iff, if any individual bears R to a second and the second bears R to a third, then the first does not bear R to the third. *Father of; 2" taller than
Nonreflexive A relation which is neither reflexive nor irreflexive is nonreflexive. *Respecting; Killing	**Nonsymmetric** A relation which is neither symmetrical nor asymmetrical is nonsymmetric. *Likes; Seeing	**Nontransitive** A relation which is neither transitive nor intransitive is nontransitive. *Admiring; Fearing

*Examples

Adapted from *Predicate Logic* and *Handbook of Discrete & Combinatorial Mathematics*

Three System Structure Types

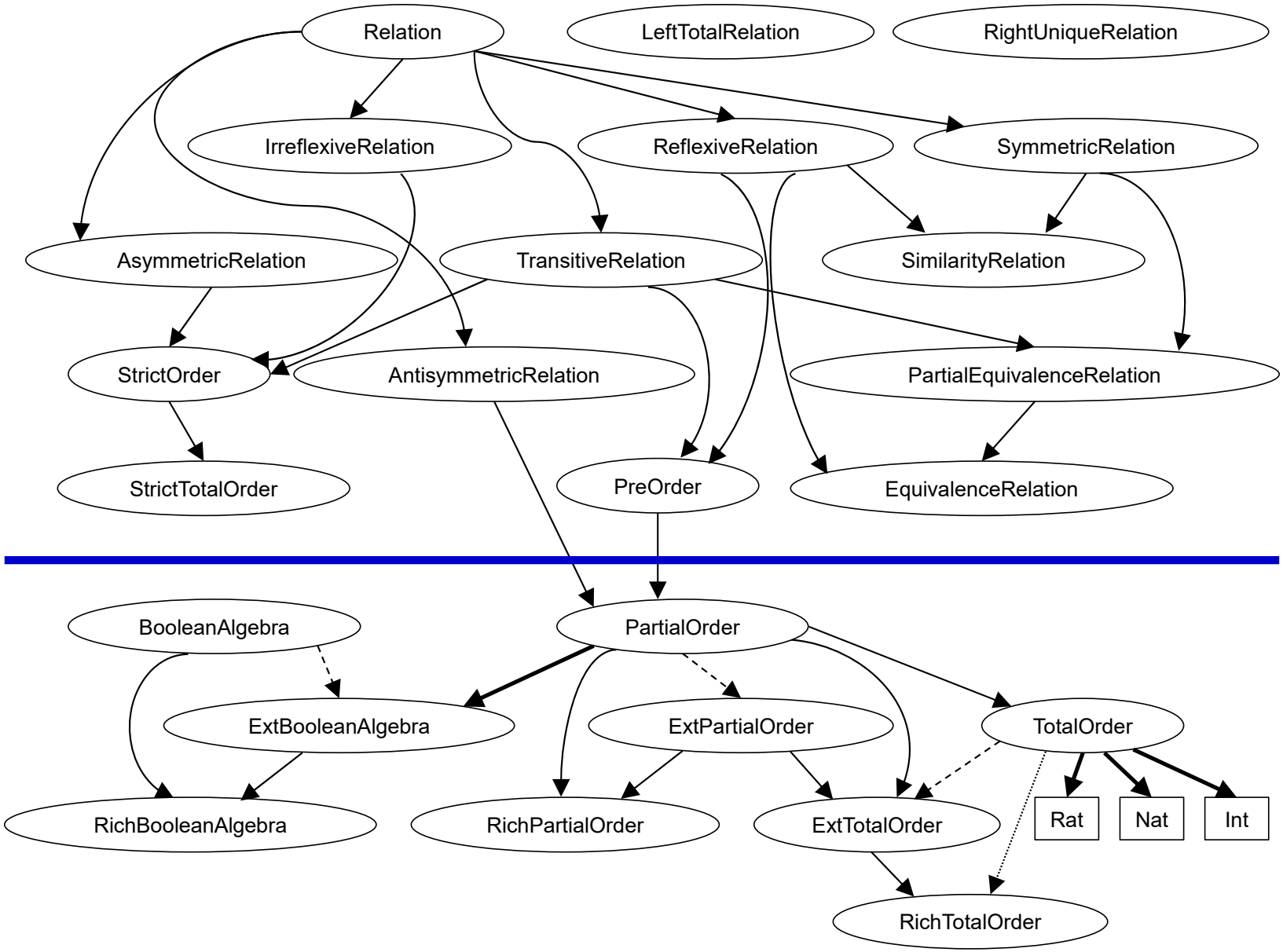
Organizing Properties of Symmetry

Asymmetric	Nonsymmetric	Symmetric
Hierarchy	**Combined Hierarchy & Network**	**Network**
		
• Use logic rules to discover structure in an efficient manner • Analyze structure	• Apply lattice and set partitioning rules to identify components • Apply other techniques as needed	• Analyze for highest value configuration • Filter out controlling structure • Analyze structure

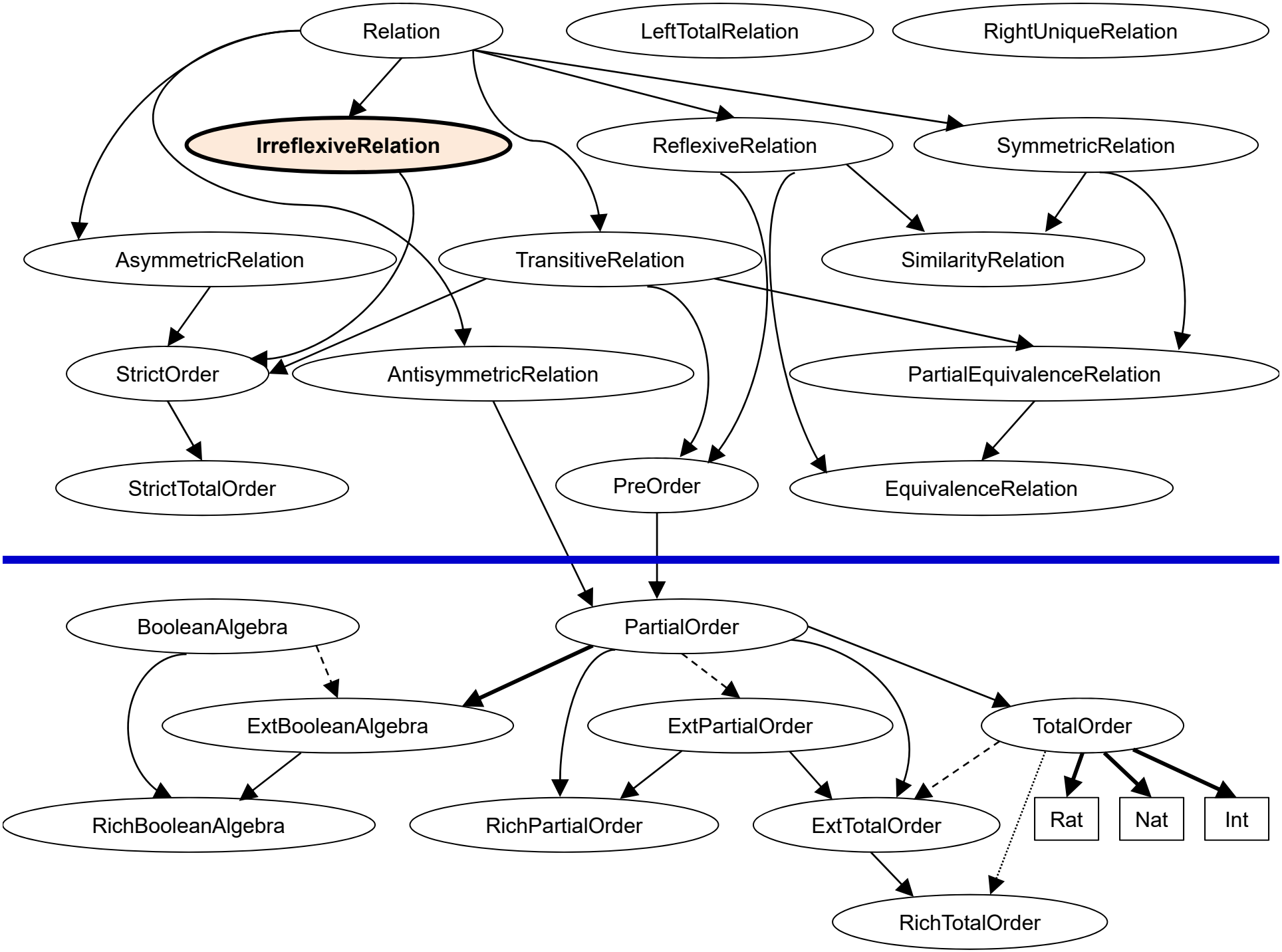
Permutation of Relation Properties

Permutations of Relation Properties, with Unique Identifiers					
RST-[1,1,1]	**R**eflexive, **S**ymmetric, **T**ransitive	RSI-[1,1,2]	**R**eflexive, **S**ymmetric, **I**ntransitive	RSN-[1,1,3]	**R**eflexive, **S**ymmetric, **N**ontransitive
IST-[2,1,1]	**I**rreflexive, **S**ymmetric, **T**ransitive	ISI-[2,1,2]	**I**rreflexive, **S**ymmetric, **I**ntransitive	ISN-[2,1,3]	**I**rreflexive, **S**ymmetric, **N**ontransitive
NST-[3,1,1]	**N**onreflexive, **S**ymmetric, **T**ransitive	NSI-[3,1,2]	**N**onreflexive, **S**ymmetric, **I**ntransitive	NSN-[3,1,3]	**N**onreflexive, **S**ymmetric, **N**ontransitive
RAT-[1,2,1]	**R**eflexive, **A**symmetric, **T**ransitive	RAI-[1,2,2]	**R**eflexive, **A**symmetric, **I**ntransitive	RAN-[1,2,3]	**R**eflexive, **A**symmetric, **N**ontransitive
IAT-[2,2,1]	**I**rreflexive, **A**symmetric, **T**ransitive	IAI-[2,2,2]	**I**rreflexive, **A**symmetric, **I**ntransitive	IAN-[2,2,3]	**I**rreflexive, **A**symmetric, **N**ontransitive
NAT-[3,2,1]	**N**onreflexive, **A**symmetric, **T**ransitive	NAI-[3,2,2]	**N**onreflexive, **A**symmetric, **I**ntransitive	NAN-[3,2,3]	**N**onreflexive, **A**symmetric, **N**ontransitive
RNT-[1,3,1]	**R**eflexive, **N**onsymmetric **T**ransitive	RNI-[1,3,2]	**R**eflexive, **N**onsymmetric **I**ntransitive	RNN-[1,3,3]	**R**eflexive, **N**onsymmetric **N**ontransitive
INT-[2,3,1]	**I**rreflexive, **N**onsymmetric **T**ransitive	INI-[2,3,2]	**I**rreflexive, **N**onsymmetric **I**ntransitive	INN-[2,3,3]	**I**rreflexive, **N**onsymmetric **N**ontransitive
NNT-[3,3,1]	**N**onreflexive **N**onsymmetric **T**ransitive	NNI-[3,3,2]	**N**onreflexive **N**onsymmetric **I**ntransitive	NNN-[3,3,3]	**N**onreflexive **N**onsymmetric **N**ontransitive

A Hierarchy of Mathematical Theories



From John F Sowa's Ontology Summit, 18 Feb 2016, http://jfsowa.com/talks/intgerop.pdf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PartialEquivalenceRelation
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BooleanAlgebra
PartialOrder
ExtBooleanAlgebra
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TotalOrder
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RichTotalOrder

Mapping Irreflexive Relation to AMEI

Permutations of Relation Properties, with Unique Identifiers for Relation Oval - IrreflexiveRelation					
RST-[1,1,1]	**R**eflexive, **S**ymmetric, **T**ransitive	RSI-[1,1,2]	**R**eflexive, **S**ymmetric, **I**ntransitive	RSN-[1,1,3]	**R**eflexive, **S**ymmetric, **N**ontransitive
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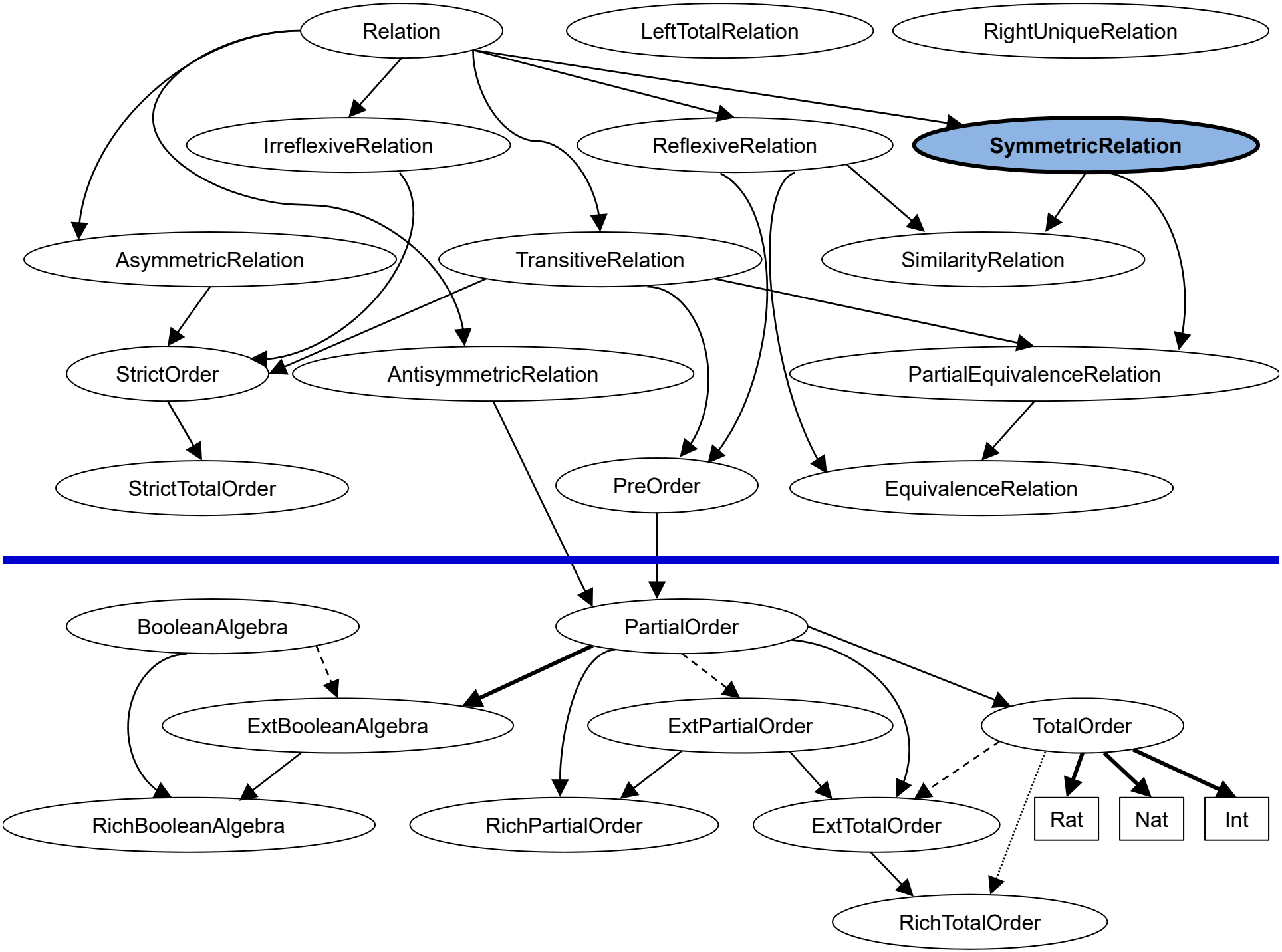
RNT-[1,3,1]	**R**eflexive, **N**onsymmetric **T**ransitive	RNI-[1,3,2]	**R**eflexive, **N**onsymmetric **I**ntransitive	RNN-[1,3,3]	**R**eflexive, **N**onsymmetric **N**ontransitive
INT-[2,3,1]	**I**rreflexive, **N**onsymmetric **T**ransitive	INI-[2,3,2]	**I**rreflexive, **N**onsymmetric **I**ntransitive	INN-[2,3,3]	**I**rreflexive, **N**onsymmetric **N**ontransitive
NNT-[3,3,1]	**N**onreflexive **N**onsymmetric **T**ransitive	NNI-[3,3,2]	**N**onreflexive **N**onsymmetric **I**ntransitive	NNN-[3,3,3]	**N**onreflexive **N**onsymmetric **N**ontransitive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Mapping Symmetric Relation to AMEI

Permutations of Relation Properties, with Unique Identifiers for Relation Oval - SymmetricRelation					
RST-[1,1,1]	**R**eflexive, **S**ymmetric, **T**ransitive	RSI-[1,1,2]	**R**eflexive, **S**ymmetric, **I**ntransitive	RSN-[1,1,3]	**R**eflexive, **S**ymmetric, **N**ontransitive
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NST-[3,1,1]	**N**onreflexive, **S**ymmetric, **T**ransitive	NSI-[3,1,2]	**N**onreflexive, **S**ymmetric, **I**ntransitive	NSN-[3,1,3]	**N**onreflexive, **S**ymmetric, **N**ontransitive
RAT-[1,2,1]	**R**eflexive, **A**symmetric, **T**ransitive	RAI-[1,2,2]	**R**eflexive, **A**symmetric, **I**ntransitive	RAN-[1,2,3]	**R**eflexive, **A**symmetric, **N**ontransitive
IAT-[2,2,1]	**I**rreflexive, **A**symmetric, **T**ransitive	IAI-[2,2,2]	**I**rreflexive, **A**symmetric, **I**ntransitive	IAN-[2,2,3]	**I**rreflexive, **A**symmetric, **N**ontransitive
NAT-[3,2,1]	**N**onreflexive, **A**symmetric, **T**ransitive	NAI-[3,2,2]	**N**onreflexive, **A**symmetric, **I**ntransitive	NAN-[3,2,3]	**N**onreflexive, **A**symmetric, **N**ontransitive
RNT-[1,3,1]	**R**eflexive, **N**onsymmetric **T**ransitive	RNI-[1,3,2]	**R**eflexive, **N**onsymmetric **I**ntransitive	RNN-[1,3,3]	**R**eflexive, **N**onsymmetric **N**ontransitive
INT-[2,3,1]	**I**rreflexive, **N**onsymmetric **T**ransitive	INI-[2,3,2]	**I**rreflexive, **N**onsymmetric **I**ntransitive	INN-[2,3,3]	**I**rreflexive, **N**onsymmetric **N**ontransitive
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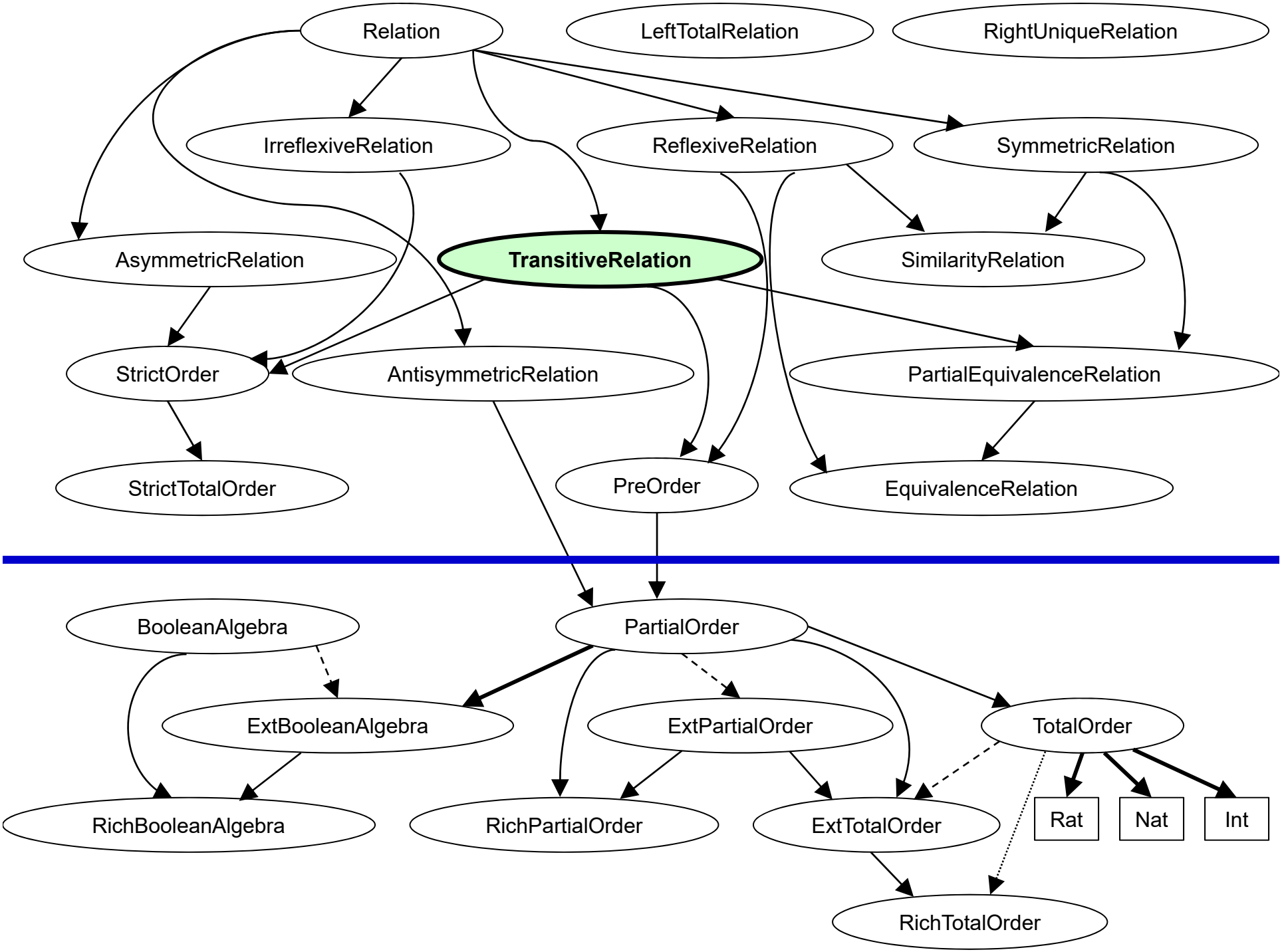
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Mapping Transitive Relation to AMEI

Permutations of Relation Properties, with Unique Identifiers for Relation Oval - TransitiveRelation					
RST-[1,1,1]	**R**eflexive, **S**ymmetric, **T**ransitive	RSI-[1,1,2]	**R**eflexive, **S**ymmetric, **I**ntransitive	RSN-[1,1,3]	**R**eflexive, **S**ymmetric, **N**ontransitive
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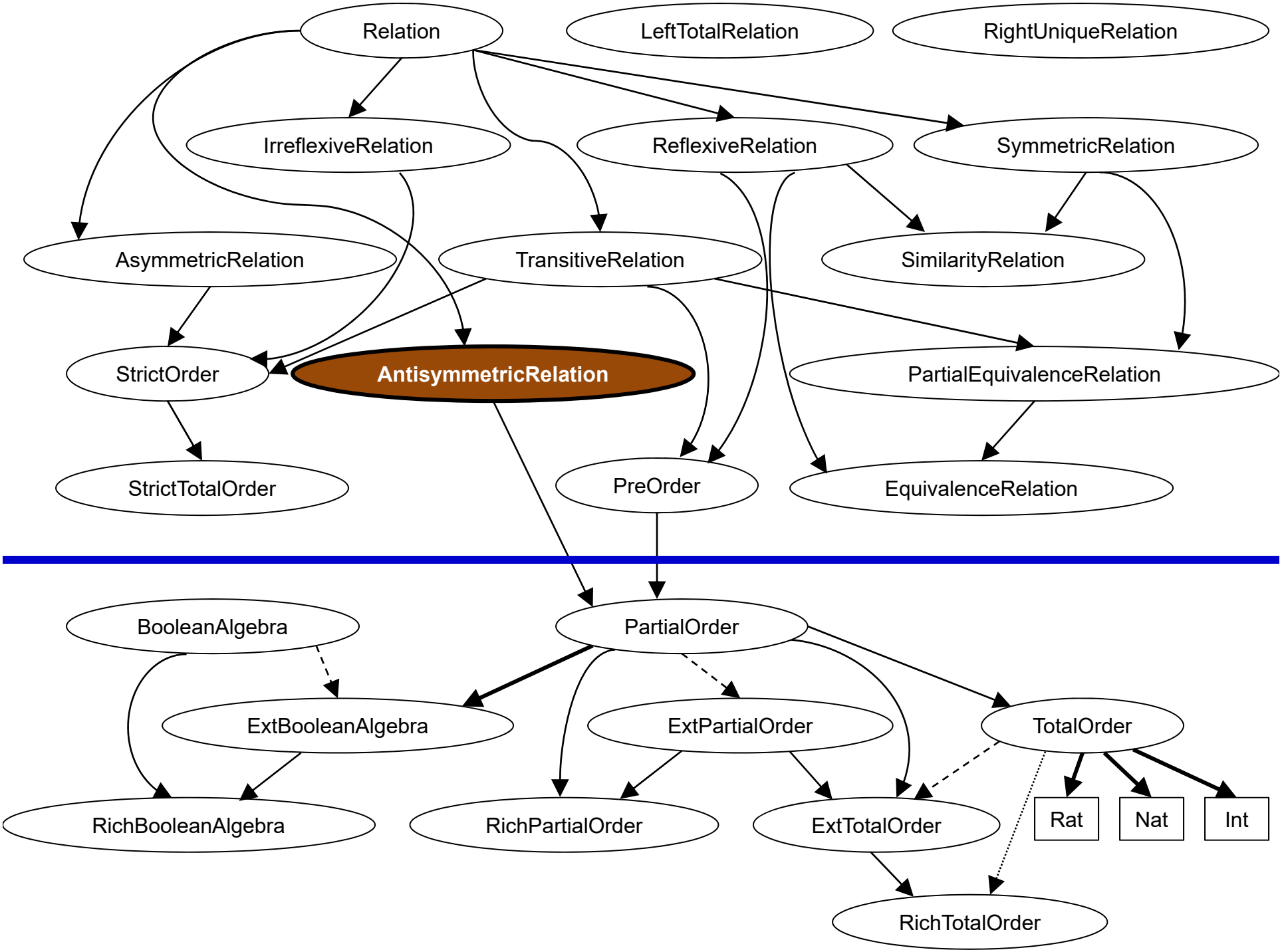
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Mapping Antisymmetric Relation to AMEI

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Summary

- Logical natural language relationship properties are a key to standard, repeatable system representations
- There is a need to address logical property groups that are important in natural language
- Significant progress is being made in this area
- If you are interested in our work, please let us know how you would like to participate

Questions

- A Good Question

  I understand the question, and have an answer.

- An Excellent Question

  I understand the question, have an answer, and have a backup slide.

- An Interesting Question

  I haven't a clue what you are talking about.