

The University of Dublin



# **Applied Mereology**

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#### Motto

Image the whole, then execute the parts-

Fancy the fabric

Quite, ere you build, ere steel strike fire from quartz,

Ere mortar dab brick!

Robert Browning, A Grammarian's Funeral

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**Mereology: the term** 

Original coinage: *mereologia* Stanisław Leśniewski, 1927

Etymology Greek: *meros,* 'part' and *logos,* 'theory'

#### **Very Brief History**

- 1. Plato are some forms parts of others?
- 2. Aristotle several meanings of 'meros'
- 3. Scholastics
- 4. Brentano (1838–1917)
- 5. Stumpf (1848–1939) partial contents
- Husserl (1859–1938) independent parts (pieces) vs dependent parts (moments); idea of a formal theory (1901)
- 7. Leśniewski (1886–1939) first formal theory (1916)
- 8. Whitehead (1861–1947) theory of extension (1919)
- 9. Leonard and Goodman calculus of individuals (1940)
- 10. Simons Parts first monograph (1987)
- 11. van Inwagen special composition question (1991)12. Explosion

# **Principles of Formal Mereology**

Undefined notion: part (proper part)

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Def. COINCIDENCE
A coincides with B ::= A and B both exist and (A = B or any part of A is a part of B
and vice versa)
Def. INCLUSION
A is included in B ::= A is part of B or A coincides with B
Def. DISJOINT
A is disjoint from B ::= A and B both exist and nothing is included in both A and B
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EXISTENCE: If A is part of B then A and B both exist ASYMMETRY: If A is part of B then B is not part of A TRANSITIVITY: If A is part of B and B is part of C then A is part of C SUPPLEMENTATION: If A is part of B then there is a part of B disjoint from A

#### **Additional Principles**

EXTENSIONALITY: Coincident individuals are identical

Definition: COMPOSITION A collection of individuals m compose an individual A ::= Every one of m is included in A and no part of A is disjoint from all of m

UNIVERSAL COMPOSITION Every collection of individuals compose an individual

#### **Temporal Mereology**

For things which endure through time, to each principle insert at t – for a moment t or over T – for an interval T (except the identity predicate!)

TEMPORAL PART If O is an occurrent (event, process), and T is a moment or interval, then occurrent P is the T-temporal part of O ::=

P exists throughout T Every part of P exists at some time in T No part of P exists at any time outside T O exists throughout T Every part of O that exists at some time in T is a part of P

# **Mereological Follies and Speculations**

#### **Follies**

- 1. Compositional Universalism
- 2. Compositional Nihilism
- 3. Compositional Organicism
- 4. Mereological Idealism

#### **Speculations**

- 5. All things have temporal parts (perdurantism, 4-dimensionalism)
- 6. Set theory = mereology + singletons
- 7. There are atoms (simples)
- 8. There are no atoms ("gunk")

### **From Pure Theory to Application**

All talk about the parts of specific things is in a sense applied mereology (variables replaced by constants) Applied mereological statements are contingent They are domain-specific They typically use the part-concept unreflectively ... ... and have done so for thousands of years.

## **Disciplines in which mereological relationships feature**

#### **Theoretical**

Science	Example of parts
Mathematics	Sub-object of object
Physics	Particles of atom
Chemistry	Atom of molecule
Biology	Cell of organism
Geology	Stratum of deposit
Geography	Face of escarpment
Astronomy	Core of planet
Meteorology	Eye of hurricane
Sociology	Subgroup of society

# **Disciplines in which mereological relationships feature**

#### **Practical**

Discipline	Example of parts
Mechanical Engineering	Rotor of engine
Civil Engineering	Support of bridge
Architecture	Window of house
Anatomy	Organ of animal
Medicine	Stage of disease treatment
Genetics	Gene of genome
Dentistry	Root of tooth
Transport	Takeoff of aircraft
Sport	Over of cricket match

# **Mereonomy (Bill of Materials)**



### **Mereonomies are Needed**

Where **complexity** arises, through:

- Large Number of parts
- Large depth of part—whole relationships
- Large variety of part types
- Complexity of non-mereological relationships among parts such as relative position
- Variety and flexibility of part-relationships at different stages of design, planning, constructing, operating, maintaining and retiring an object

#### **Mereonomies overlook distinctions among:**

- 1. Physical Parts
- 2. Geometric Parts
- 3. Functional Parts
- 4. Salient Parts
- 5. Design Parts
- 6. Assembly Parts
- 7. Repair Parts
- 8. Retirement Parts
- 9. Ornamental Parts
- **10. Temporary Parts**
- 11. Permanent Parts
- **12. Essential Parts**
- **13. Optional Parts**

# **Example: Multiple Mereonomies (BOM) Problem**

- 1. Design Parts
- 2. Assembly Parts
- 3. Repair Parts
- 4. Retirement Parts

Large variations by between E-BOM, M-BOM etc.

#### The scale of the problem as of 20 years ago

Aerospace firm X manufactured in 1997 (and still does as of 2018) – among other things – aircraft, including a transport aircraft T first flown in the 1950s and an air superiority fighter F first manufactured in the 1990s.

When Firm X manufacturing engineers make a change to a part or assembly on the E-BOM with respect to that part/assembly on the M-BOM (i.e., they do something to distinguish the M-BOM from the E-BOM), they change the designation of the part number by prefixing it with what they call a "Planning Assembly Number".

These two queries were run against the database in July 1997 :

- 1. How many part/assembly records are there in the DB?
- 2. How many records with PA numbers are there? (That is: How many E-BOM/M-BOM divergences?)

#### The scale of the problem as of ca. 20 years ago

- 1. There are ca. 124,000 parts in the BOM DB
- 2. There are ca. 74,000 parts with PA numbers in the BOM DB.

NOTE: There are actually ca. 500,000 records in the BOM DB - the difference between 500,000 and 124,000 marks how many "relationships" there are among the 124,000 (i.e., instances of component vs. assembly; where used, version of, make from, etc.) **SO** 

3. There are 74,000 E-BOM/M-BOM divergences in the Firm X database.

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#### The scale of the problem as of ca. 20 years ago

Ancillary facts:

- 1. The BOM database is for ALL extant aircraft: i.e., T and F
- 2. Many of the T parts aren't in there. They are still only on drawings.

3. Just having a PA number (divergence designator) doesn't necessarily signify the existence of a STRUCTURAL divergence: of the 74k records, a significant number of them will be just quantificational divergences and other artefacts of planning for inventory.

# therefore

4. The E-BOM/M-BOM gap is (was in 1997, but it won't be a lot better now) **massive**.

5. Add all the other dimensions of variation in product structure

-- configuration by serial number/lot number/tail number / model / customer specifics, not to mention Engineering Revisions

– and ALL of the previous applies to processes as well – and we have a mess

#### **Solution**

Recognise the mess for what it is: conceptual confusion alongside engineering sept divisions and rivalry

Analyse the differences between different BOMs into commonly occurring cases One–Many discrepancies

Represent these mereological divergences in a suitable, transparent, manageable and manipulable way

Integrate the different engineering representations into a single database which accepts and manages the divergences and their relationships rather than separates them and forces discrepancies to be managed manually.

#### **Link Desiderata**

Link mereological facts with

Relative **location** of parts

**Processes** of design, manufacture, supply, assembly, operation, maintenance, variation, modification, malfunction, and retirement

#### **Lessons for IS Ontologies exploiting Mereology**

Do not be distracted by philosophical disputes in mereology Do be prepared to accept sensible philosophical advice on avoiding conceptual confusion (usually by making distinctions) Accept practitioners' and experts' views on what the "important" parts of a whole are (usually functional, not always) Judiciously (but critically) take on experts' terminology Be prepared to relativise mereonomies to stages in an entity's life-cycle (use temporal or stage relativisation) Be prepared for variation in several dimensions: time, change, role, version, variant, etc. Link the discrepancies and label them by type.



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# Thank you Go raidh maith azat