Lattice representations and design descriptions

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Problem

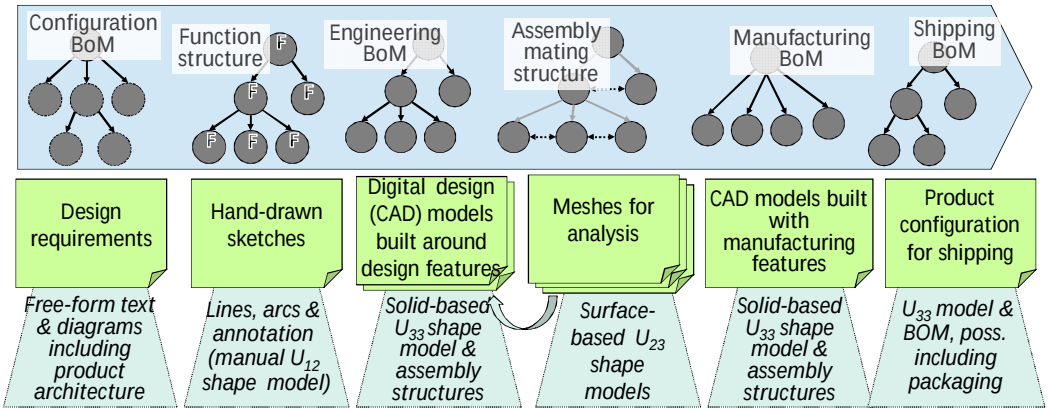
For a given design, designers work with multiple design descriptions and structures (including Bills of Materials (BoMs)) to support specific tasks. Multiple BoMs create significant data management problems that add cost, time and rework into development processes.

Engineering design goal

To explore the feasibility of methods & tools for engineers to create & work with the design structures they want, when they want them, on the fly, and associated with whatever information they wish to use

Research goal

To explore the potential of lattice theory as an approach to address this problem of multiple design descriptions by allowing design structures to be embedded in product information.

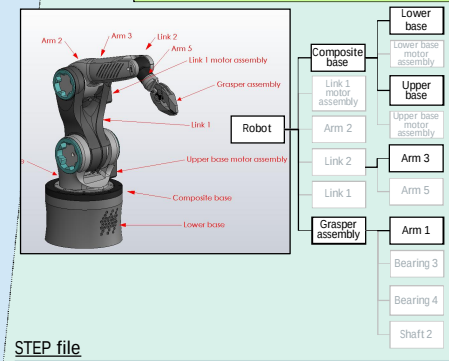


Why lattice theory?

- For a given collection of parts, there is a complete lattice that contains …
  … every possible combination of parts, *i.e., every possible BoM*
- Given two objects, *e.g., two BoMs,* there is
  - a unique biggest lattice (the supremum) that contains both and
  - a unique smallest part (the infimum) of both.
- We are currently working with lattices of parts; lattices can also be lattices of lattices

Results

Initial design descriptions



STEP file

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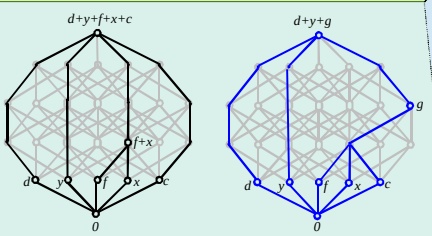
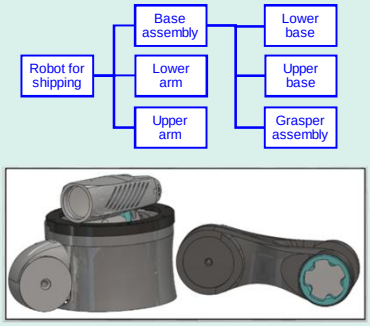
Lattices: Theory & Implementation



Part in D-BoM	Lattice node	Part in S-BoM
Arm 3	d	Upper arm
Arm 1	y	Lower arm
Upper base	f	Parts of base assembly
Lower base	x	
Grasper assembly	c	
Composite base	f+x	*Stripped down for shipping*
	g	Base assembly

Shipping design descriptions

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.NOT_KNOWN. ) ;
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....
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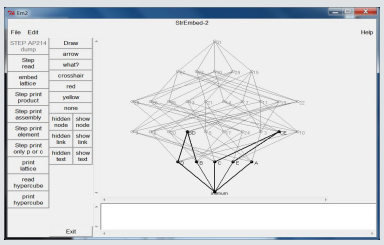
Extract Design BoM from CAD model

- The D-BoM (Hierarchy View in Solidworks) is extracted using the ISO10303-239 interface and imported into lattice editor (LatDraw).
- Currently: the CAD model needs to be constructed with care to ensure that the D-BoM is small enough to be imported into a lattice. A "full lattice" (maximum size - 2^5) is generated for the parts in the D-BoM.
- In the future: holophraxis & zoom facilities will allow engineers to select parts of interest from bigger lattices or to generate lattices, and lattices of lattices on the fly.

Select sub-structure to work with

- Represent the sub-structure of interest as a lattice embedded into the full lattice
- Embed different BoMs into this lattice
- Currently: infimum plus two tiers up implemented
- In the future: infimum to supremum implemented along with links to BoMs and so CAD models



Import 2nd BoM, e.g., a shipping BoM, back to CAD

- In principle this approach provides tools to facilitate the management and configuration of BoMs
- We are demonstrating the potential value of this to engineering design practice using qualitative data analysis tools such as NVivo
- The following research issues have been identified:
  - S-BoM changes assembly relationships in CAD
  - S-BoM requires new parts, e.g., packaging
  - Lattice generation is a 2^n problem; there is a need for appropriate implementation strategies

Conclusions

- It is feasible to use lattice theory to superimpose multiple BoMs (i,e,. parts related to each other through part-whole relationships) into physical design descriptions.
- Open questions related to mereology & part-whole relationships
- In moving across BoMs, there is potential to corrupt the shape model, e.g., the assembly mating conditions of some parts in the S-BoM are different to those in the D-BoM

Next steps

- Development of a full prototype is in progress
- Further software prototyping is needed to explore implementation & usability issues related to the size of lattices generated for even relatively simple parts.
- Further theoretical work is needed to consider embedding function structures into physical structures and the implications of embedding for the validity of associated CAD models.

Acknowledgements

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