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NEW VARIANT MANAGEMENT USING MULTIPLE-DOMAIN MAPPING

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1 BACKGROUND

With complexity being the major challenge for industry, Teseon supports technologically oriented businesses in the automotive industry, engineering industry, as well as the electrical industry in planning and developing their complex products. The range of services comprises assistance in accessing, understanding and taking advantage of complexity through consulting and software tool development.

2 EFFICIENT VARIANT MANAGEMENT – A VITAL CHALLENGE

Today's markets show an increasing individualized, dynamic and diversified character. Any company aiming at success in these markets has to offer a diversity of product variants as great as possible, externally recognizable to the customer. The company-internal management of these variants on the other hand has to be carried out as efficient and economical as possible. These circumstances represent a key challenge, especially for OEMs and suppliers in the automotive sector. Considering both, the viewpoints of marketing (e.g. constraints due to marketing strategies) and development (e.g. technically feasible possibilities of combination), is thus a central success factor to face this challenge.

Various strategies exist for controlling variants – e.g. building blocks, platform strategies, etc. The majority of methods, tools, and services available aim to represent the diversity of product variants and, following that, offer opportunities for optimization in tree structures (e.g. see [1]). However, the manageability, analysis, and optimization of variant trees is very limited, as the mere truncating of variant branches with low unit production numbers is only of limited use: the sum of these numerous branches constitutes an increasing proportion of business nowadays, known as the „long tail phenomenon" [2]. Additionally the integration of marketing and technical viewpoints cannot be represented in a variant tree. This leads to the fact that potentially available economies of scale (e.g. by using recurring parts) are not taken advantage of because correlations are not understood comprehensively.

3 VARIANT MANAGEMENT GOES MDM

The presented approach faces these issues and allows for the integrated management of variants, i.e. an integrated analysis and optimization of variants spectra. This unique possibility has not been offered by any solution up to now. Research at Teseon has shown that a "greater whole" is concealed behind the logic of variants – graph theory. This branch of mathematics investigates properties of graphs: nodes and edges, the relations between nodes. Many algorithmic problems can be dissolved using graph theory, amongst them the questions variant management deals with.

The methods of analysis in graph theory are now for the first time transferred to and applied in variant management. The case study is primarily set on businesses in the automotive sector, an industry with a high diversity of product variants.

The basic approach represents variants in matrix notation. Research has shown that this is possible using known algorithms of graph theory: a variant corresponds to a domain-spanning completely cross-linked cluster of feature combinations in a Multiple-Domain Matrix [3]. Thereby, each cluster contains features with one single value of each attribute.

A Variant corresponds to a domain-spanning completely cross-linked cluster:
Each feature of the variant is cross-linked to each other feature.

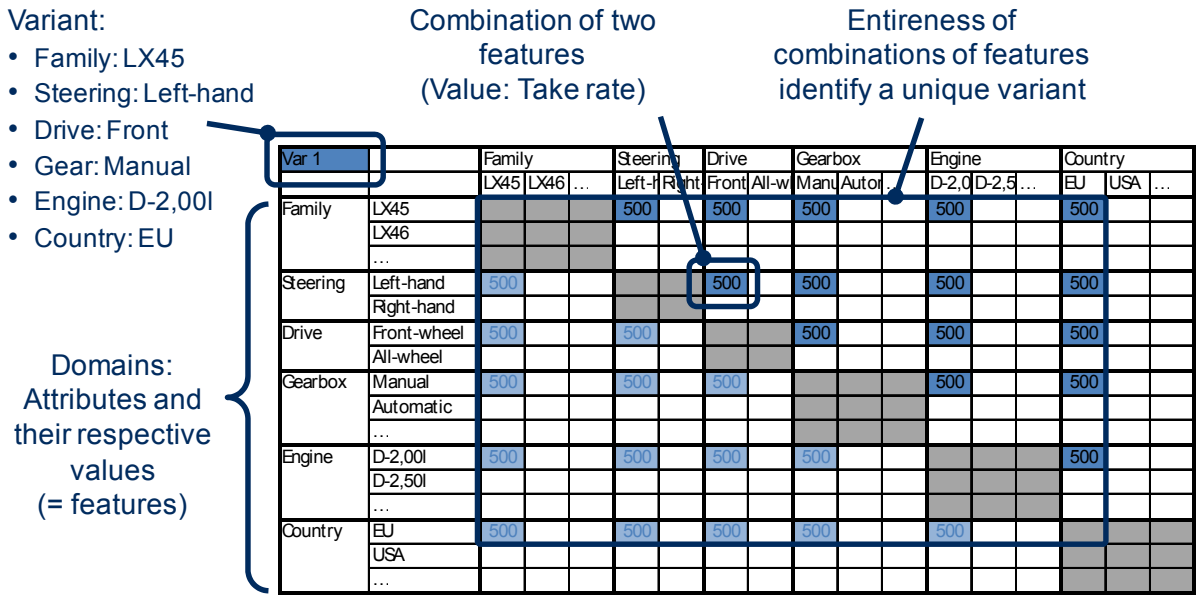

Figure 1. A Variant in Multiple-Domain Matrix notation

Thus if the range of variants can be transferred to matrix notation (see figure 2), the whole spectrum of analysis tools that graph theory offers can likewise be applied to variant management. The achievements that the DSM methodology [4] has developed can be applied to issues of variant management.

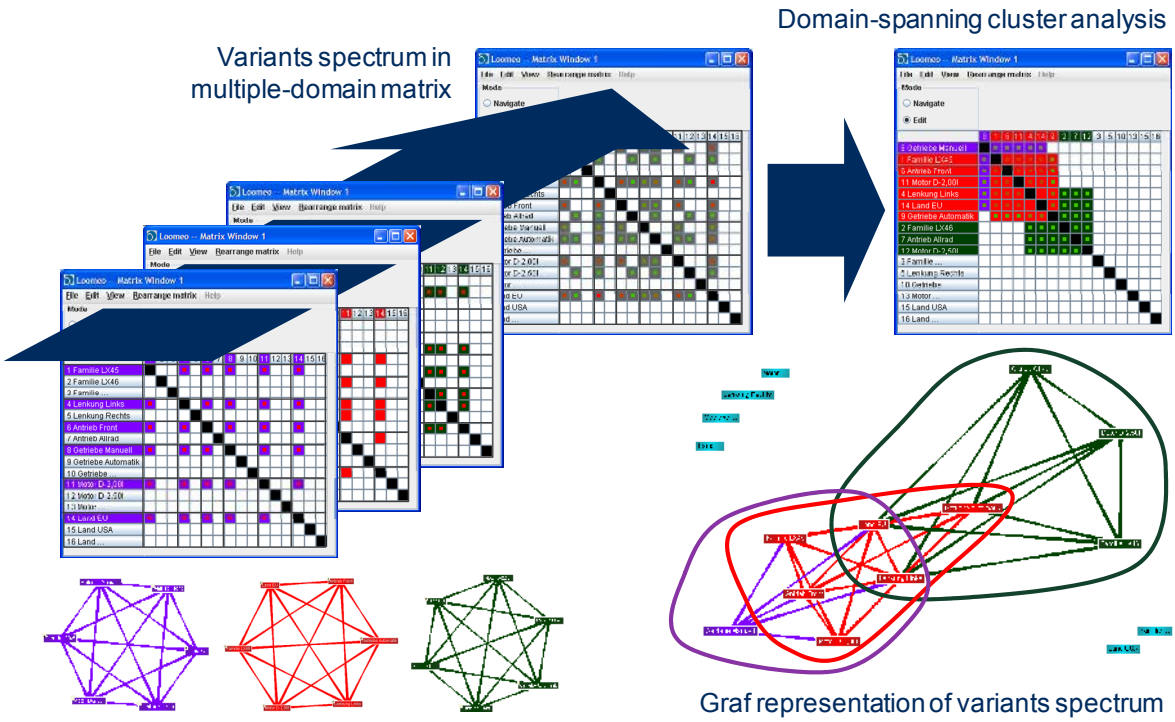

Figure 2. Variants spectrum

In combination with the Multiple-Domain Mapping approach previously developed and applied by Teseon it is additionally possible to establish links between the different points of view of sales/marketing (feature tree) and technology (variant tree) which was not possible until now.

The possibilities and methods of graph theory that are available and have proven to be valuable in numerous instances of application hold considerable potential when applied to variant management. A few of the advantages are listed in the following:

1. Using the matrix notation for variants enables an extremely high number of variants to be intuitively represented and processed.
2. The representation of variant spectra with strength based graphs enables connections between variants to be recognized intuitively. Transparency is established, which through its absence is one of the main causes for the existing problems in handling variant diversity.
3. Configuration rules, restrictions, and prohibitions, that are common when designing product portfolios can be represented very efficiently in the matrix.
4. The methods of cluster analysis enable the identification of core structures of variants and part numbers. This forms the basis for optimization of product programs.
   For instance when the variants available in a product range are represented with the methodology, further opportunities for optimization show, as the variant matrix contains all possible feature combinations. The entire product program that is possible in theory can be derived by the analysis of the completely cross-linked clusters.
5. Impact analyses enable transparency concerning the modification/deletion of variants, variant attributes, combinations of attributes, part numbers etc. Thus is avoided that e.g sales or marketing cause ramifications on the technological side that cannot be controlled. On the other hand the actual consequences for the product range perspective resulting from technical modifications become visible for the technology department.
6. Similarity analyses enable the identification of common features that can be exploited (carry over parts, economies of scale, …)

4 RESULTS

At the moment we are at the beginning of a fundamental change of variant management. The herewith presented approach provides the foundation for it. Teseon is currently discussing the method with manufacturers of the automotive industry. The interest in integrated variant management by means of Multiple-Domain Mapping is substantial, also due to results of the conducted surveys in cooperation with these companies. With proper implementation, they are given the possibility to increase their opportunities in the market considerably. They can offer a greater range of variants externally that are controlled and managed internally by means of marketing and development.

REFERENCES

[1] Schuh, G.; Schwenk, U.; *Produktkomplexität managen*. München: Hanser 2001.

[2] Anderson, C.; *The Long Tail: How Endless Choice is Creating Unlimited Demand*. London: Random House Books 2006.

[3] Maurer, M.; Lindemann, U.; Facing Multi-Domain Complexity in Product Development. In *CiDaD Working Paper Series 3;* 2007 1, pp 1-12.

[4] Browning, T.; Applying the Design Structure Matrix to System Decomposition and Integration Problems: A Review and New Directions. *IEEE Transactions on Engineering Management* 48 (2001) 3, pp 292-306.

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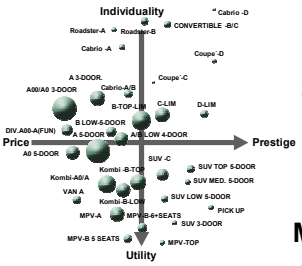
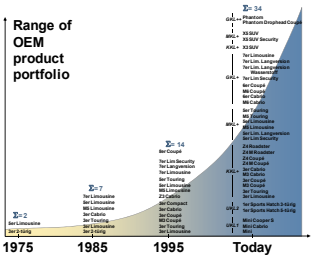
Efficient Variant Management – a Vital Challenge



Development of new market segments

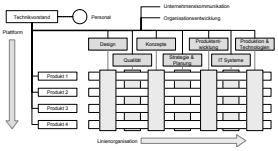
Steady increase in product variants



Market ⇄ **Product**

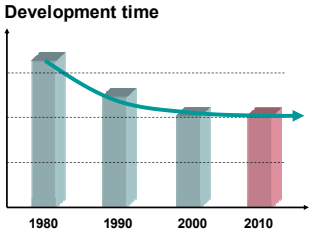
Complexity increases in all domains

Organization ⇄ **Process**



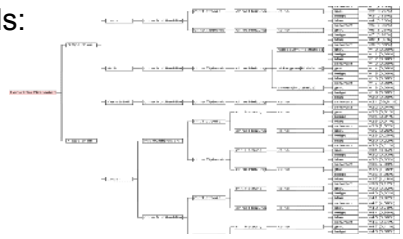
Increase in flexibility of organizational structures

Reduction of development time whereas development efforts rise



Variant Management – State of the Art

- Engineering development – methods and tools:
  - Implementation of software tools (configuration tools, variant tree software)
  - Rating methods for variant variety
- Organization:
  - Training of employees
  - Improvement of communication and coordination (interfaces)
  - Building up barriers for prevention of generating variants
- Processes:
  - Process modularization
  - Costing in accordance with the cause of cost, Activity-based costing
- Production:
  - Flexible production systems (e.g. reduction of set-up time),
  - Segmentation of production, pre-assembly
  - Variant formation in late phases of value creation chain
  - Purchased parts, find an efficient degree of company-internal value creation



Variant Management – Need for Action

System properties and behavior are not considered in many instances:

- Domain-spanning linkages
- Cause-and-effect chains
- Impact of specific activities on other domains (sales/marketing ⇔ technology)
- Dynamics

→ Holistic view on variant management is needed

→ Provision of transparency is needed

A Variant in Multiple-Domain Matrix Notation

All features of the variant are pairwise cross-linked

Variant:

- Family: LX45
- Steering: Left-hand
- Drive: Front
- Gear: Manual
- Engine: D-2,00l
- Country: EU

Domains: Attributes and their values (= variant features)

Combination of two features (Value: Take rate)

Entireness of feature combinations identify a unique variant

Var 1		Family			Steering		Drive		Gearbox			Engine			Country		
		LX45	LX46	…	Left-h	Right	Front	All-w	Manu	Autor	…	D-2,0	D-2,5	…	EU	USA	…
Family	LX45				500		500		500			500			500		
	LX46																
	…																
Steering	Left-hand	500					500		500			500			500		
	Right-hand																
Drive	Front-wheel	500			500				500			500			500		
	All-wheel																
Gearbox	Manual	500			500		500					500			500		
	Automatic																
	…																
Engine	D-2,00l	500			500		500		500						500		
	D-2,50l																
	…																
Country	EU	500			500		500		500			500					
	USA																
	…																

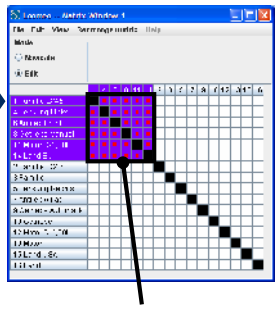
Variants – Completely Cross-Linked Clusters

A variant corresponds to a domain-spanning completely cross-linked cluster

Multiple-Domain Matrix representation of one variant

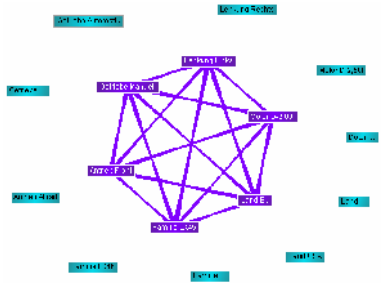
Domain-spanning cluster analysis

Consideration of Multiple-Domain Matrix as DSM



Completely cross-linked cluster

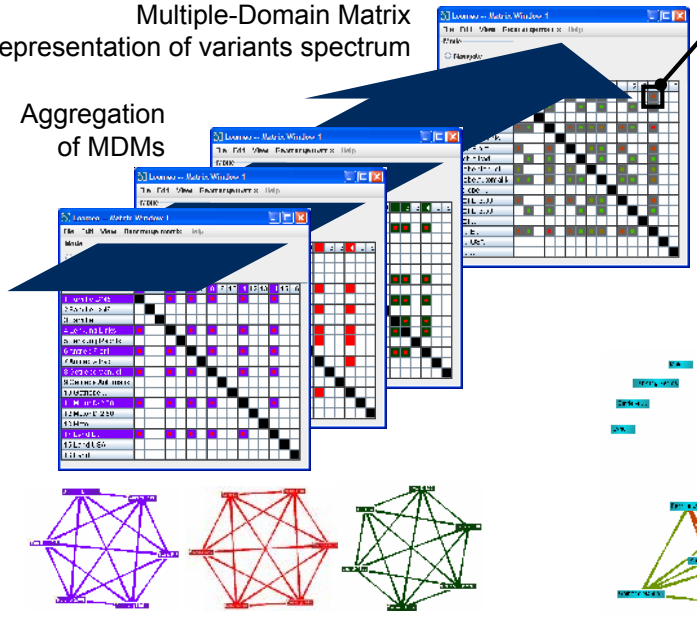
Graph representation of one variant



Variants spectrum in Multiple-Domain Matrix Notation

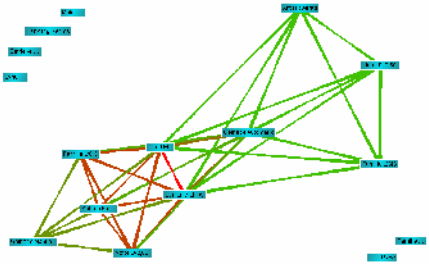
Multiple-Domain Matrix representation of variants spectrum

Aggregation of MDMs

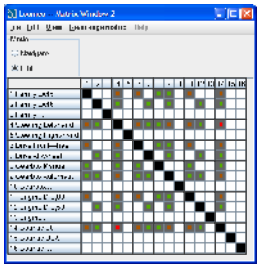


Various attributes of dependencies in Multiple-Domain Matrix:

- Affiliation to variants (variants denotation)
- Appearance of dependency (number of variants that include the dependency)
- Total take rate of dependency

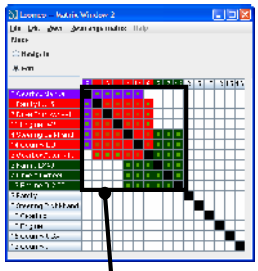


Variants spectrum in Multiple-Domain Matrix Notation



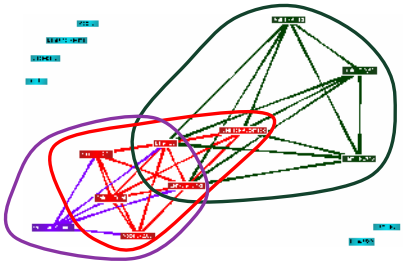
Domain-spanning cluster analysis

Consideration of Multiple-Domain Matrix as DSM



Overlapping of completely cross-linked clusters

Graph representation of variants spectrum

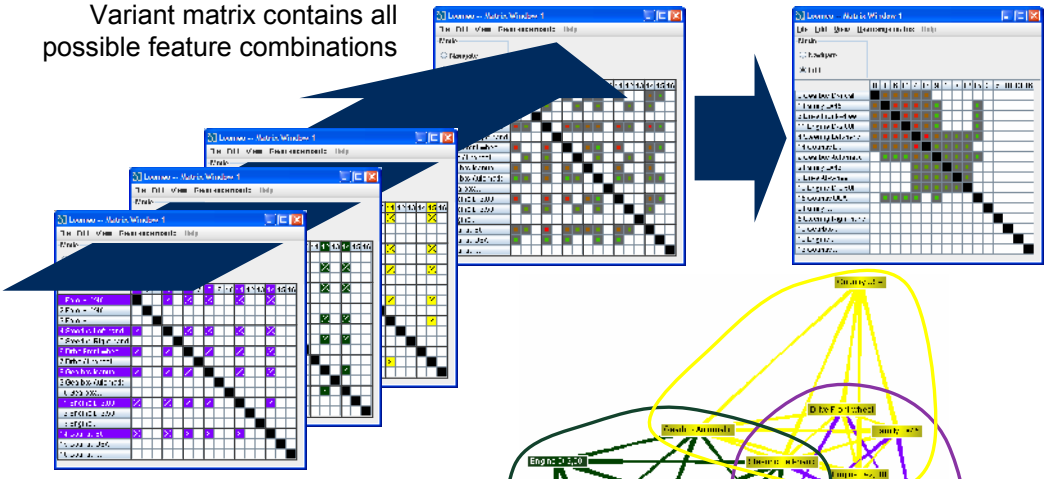


Application of Graph Theory to Variant Management

- **Multiple-Domain Matrix notation of variants spectra** → extremely high quantity of variants can be intuitively represented and processed
- **Strength based graphs** → Transparency enables connections between variants to be recognized intuitively
- **Configuration rules, restrictions, prohibitions** → efficient representation in the matrix
- **Identification of core structures of variants and part numbers** → basis for optimization of product programs
- **Impact analyses** → transparency concerning the modification/deletion of variants, variant attributes, combinations of attributes, part numbers etc.
- **Similarity analyses** → identification of common features that can be exploited (carry over parts, economies of scale, …)
- **Multiple-Domain Mapping** → linkage between different aspects of sales/marketing and technology is covered

Using Cluster Analysis for Product Program Optimization

Variant matrix contains all possible feature combinations



Three input variants form an existing variant spectrum

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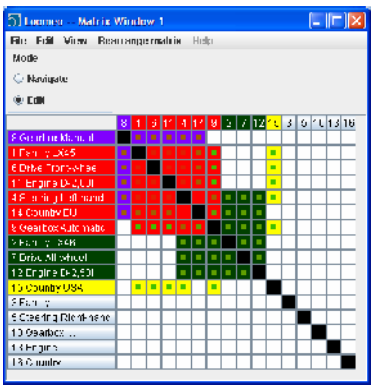
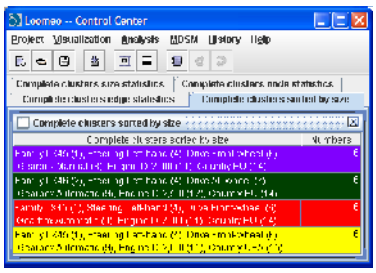
Using Cluster Analysis for Product Program Optimization

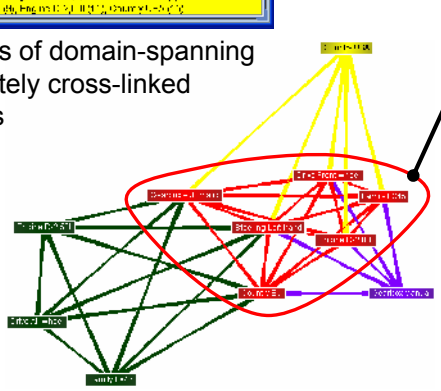


Variant matrix derived from an existing spectrum contains all possible feature combinations

→ Maximal product program can be derived

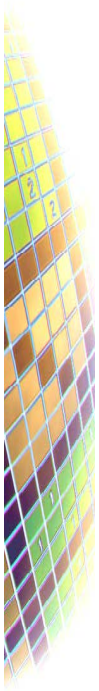


Analysis of domain-spanning completely cross-linked clusters



Identified cluster is not included in present variant spectrum but can be possibly build from existing feature combinations

Summary



- Multiple-Domain Mapping serves as an efficient basis for new variant management
- Variants spectra can be modelled by using Multiple-Domain Matrices
- Transfer of methods of graph theory to variant management becomes feasible
- MDM and graph theory open up great opportunities for variant management

→ The new approach offers a higher range of variants to be offered externally that can be controlled and managed internally