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SYSTEM-LEVEL BASED IDM/DSM/DMM DATASET FOR MULTI-PROJECT CO-ORDINATION

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INTRODUCTION

For many product development companies a multi-project situation is reality driven by competitive environment: offering customers a variety of new, more complex, high performing yet flexible products at a shortest possible time and lowest cost. Customers' product complexity is however not an equivalent of the product development complexity and, while striving to deliver highly sophisticated products, development companies use various complexity management techniques in order to control and minimize it internally. High level of modularization, well-defined interfaces between the modules and components commonality & standardization are some factors contributing to complexity reduction. The benefits (according to Anderson, 1997) would be a capability to rapidly introduce incremental product improvements which can be called "new" products — that are really planned "variations on a theme," based on common parts and modular product architecture. Independent design of system components allows for clear definition of project boundaries and scopes within a project development portfolio, minimization of uncertainty and results in reduction of development cycle and ultra-fast time-to- market. However, according to Kentaro & Cusumano (1993) "…focusing on design modification is not advantageous strategy either in terms of the new product introduction rate or average platform design age".

According to Whitney, some products, like high power mechanical ones, as opposed to low power signal processor type products, would benefit from more integral design if technical performance is a priority. Technical constraints, such as light weighting, low power consumption etc. drive designers towards more integral architectures (adopted from Hölttä-Otto, 2005). Integral architecture is characterized by multiple dependencies between system entities (where entities could be functions, physical or non-physical elements), when interfaces are difficult to define clearly. Kentaro & Cusumano (1993) demonstrated that system-level co-ordination is required between different projects when composing and optimizing a project portfolio for complex products with integrated architecture. A practice of early enforcement of restrictions upon the project scope /requirements in order to avoid potential system-level dependency conflicts with other projects makes further development process less flexible and responsive to changing business requirements such as costs, product flexibility etc. Resolving system-based interdependency-related issue has traditionally been seen as system architect's task: "...architects' greatest concerns and leverage are still, …with the systems' connections and interfaces because (1) they distinguish a system from its components; (2) their addition produce unique system-level functions, a primary interest of the systems architect; (3) subsystem specialists are likely to concentrate most on the core and lest on the periphery of their subsystems (Maeir & Rechtin, 2002). Other players like development project group members and management in general have often limited access to dependency-based system views and use intuitive approach when dealing with dependencies., hence a transfer of knowledge is essential to be able to support flexibility in system-level project co-ordination.

The key idea is to develop an IDM (Information driven management approach)/DSM (Design or Dependency structure matrix) /DMM (Domain mapping matrix) Danilovic & Sandkull (2005), Danilovic & Browning (2007) based dataset that is system-level founded and yet easy to use for different stakeholders in multi - project development environment. It should provide them with a holistic view linking both technical constraints driving integral system design and business drivers allowing for more effective project co-ordination in product development. The potential application could be assessment of change - propagation effects of project technical decisions based on underlying (modular or integral) systems architecture on different product development and project management environment components and vice verse. One of the examples would be identification of the points for potential design transfer between the projects.

RESEARCH APPROACH

This research has been conducted in close collaboration with architects, engineers, project managers, business area managers and middle management. Data has been collected through interviews, a number of workshops and seminars. Results were presented at seminars for participants and their managers in order to share information, develop commitment to chosen approach and IDM/DSM/DMM methodology, to verify tentative results, elaborate on the quality of analysis, investigate if and how this approach can be introduced within the company.

RESULTS

The dataset has been created for base product groups, applications and product families. The dataset "kernel" consists of four component structure /architecture DSMs for each base sub system /application group and 12 inter-component DMMs, representing the dependencies between those groups. The sub-system DSMs includes a structural part and version part. The structural part is a result of clustering of systems components based on the level of dependencies between them; the version part visualizes how components differ between product families /platforms. The "kernel" data has been clustered into generic product structure DSM shown in Figure 5. A group of projects from project portfolio has been matched against the generic product DSM. For each project the level of change for each system component has been estimated, ranging from 0 (not in the scope) to 3 (redesign of component) as shown in Figure 6 and the project portfolio dependency
The process of forming a multi-project development portfolio with the help of system-level based data set could be illustrated as follows.

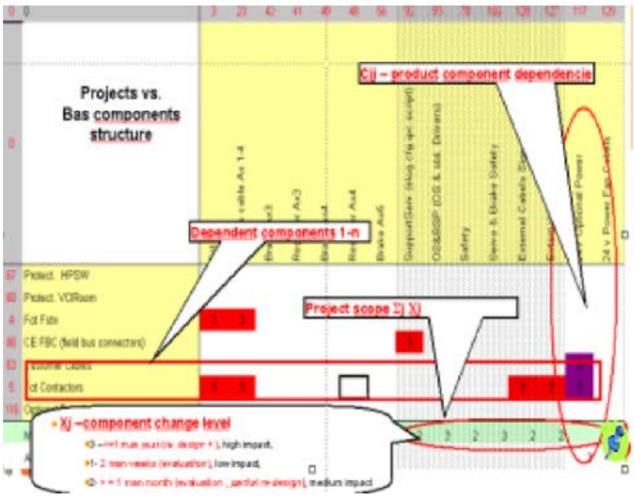

Figure 1. Project system-level dependencies DMM analysis (extended)

1. The company is targeting customers'/ marketing requirements with product portfolio (DMM, marketing requirements vs. product offering)
2. The requirements/market segments with no match in product portfolio could be identified, demonstrating strategically available development opportunities.
3. Opportunities are broken down into development project candidates forming a project portfolio. DMM Marketing requirements vs. projects.
4. Projects' scopes are identified and matched with the products component structure in DMM/DSM projects vs. generic product structure, based on information about critical components in DMM Marketing requirements vs. product structural components. Projects are

targeting requirements, requirements /functions are represented by components, hence project scope is to include functional components in it's scope.

5. Project dependency level and hence potential design transfer opportunities are identified. Projects scope embraces components; components are interdependent and hence are the projects in DSM projects vs. projects. Dependant project clusters are derived from DMM/DSM projects vs. generic product structure.
6. Changing the dependencies within a project scope would give a different scenario of intra-project complexity, being quantified as dependency index. The final dependency plan or matrix has to be balanced against targeted marketing requirements. For example, if dependency is eliminated or excluded from the project scope, in order to reduce project complexity is this project still targeting the market requirements?
7. The required competence could be matched with each project dependency cluster, creating a project portfolio information network.
8. The dataset could be extended to include competitive analysis on all levels, GPD analysis etc.

The most challenging issue during the analysis was to find a correct aggregation level of presenting a product structure. The level which would allow architectures, functional organization specialists as well as project mangers to have a common ground for discussing dependencies–related issues. Presenting interdependencies between software, mechanical and controlling systems was another challenge: a need for a state of the art approach, proposing an adequate numerical representation /classification of dependencies between mechanical, controlling and software systems, reveling the nature of different levels of integration between them.

Finally, after the project was finished management decided to adopt IDM/DSM/DMM approach as a standard procedure in analyzing projects and multi-project situations, creating repeatable and consistent approach to making complexity of multi-project multi- project development environment more digestible (adopted from Parsons, 2006).

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9TH INTERNATIONAL DSM CONFERENCE

SYSTEM-LEVEL BASED DATA SET FOR MULTI PROJECT CO-ORDINATION

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The multi-project situation in product development

•Multi-project situation is driven by competitive environment

•New, more complex, high performing yet flexible products at a shortest possible time and lowest cost

•Reduction of complexity via commonality & standardization & modularization etc. to reach faster ultra-fast time-to- market

• Compromising between integrated and modular design to get an affordable high performing solution

•Design transfer and concurrent engineering, data set-based design.

The multi-project situation

- A practice of early enforcement of restrictions upon the project scope /requirements in order to avoid potential dependency conflicts with other projects makes further development process less flexible and responsive to changing business requirements such as costs, product flexibility etc.
- Resolving system-based interdependency-related issue has traditionally been seen as system architect's task: ”... architects greatest concerns and leverage are still, …with the systems' connections and interfaces because
  - (1) they distinguish a system from its components;
  - (2) their addition produce unique system-level functions, a primary interest of the systems architect;
  - (3) subsystem specialists are likely to concentrate most on the core and lest on the periphery of their subsystems, viewing the latter as (generally welcomed) external constraints on their internal design (Maeir & Rechtin, 2002).

The multi-project situation

- Other players like development project group members and higher executives have often limited access to dependency-based system views and intuitive approach to dealing with dependencies. "Our product development philosophy is based more upon administration excellence than technical excellence, and it's getting worse.” (Michael Kennedy, 2003) Product Development for the Lean Enterprise,Toyota) … Product managers are not seen as direct contributors to delivering value to customers.

- The system-level co-ordination is required between different projects when composing and optimizing a project portfolio for complex products. The transfer of knowledge between major players is essential to be able to support the system-level project co-ordination.

Research question

- How to establish a system level based co-ordination data set between multiple projects allowing to make development process more flexible and adaptable to changing requirements?
- What kind of structure would the co-ordination data set have and which components its going to include?
- Who is going to use the data set?
- Which level of aggregation should be used to make co-ordination meaningful for those involved into development process ?
- How to measure a system-level co-ordination ?
- How would the process of forming a multi-project development portfolio, with the help of system-level based platform, look like?

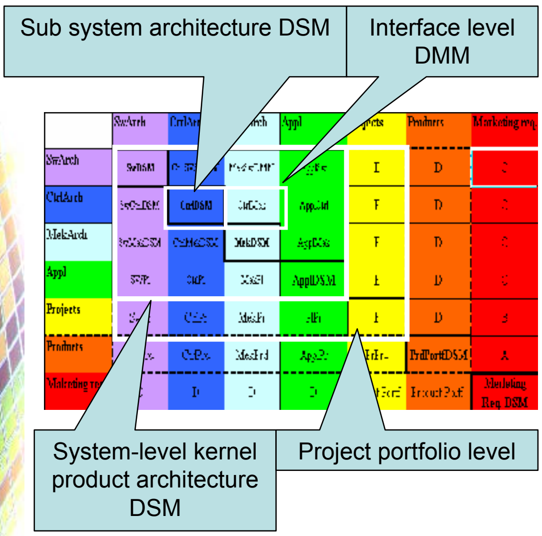
Research approach – Information driven management approach

- We explore the structure of the problem to make assumptions explicit, rather then implicit
- The structure of the problem is seen as a spreadsheet showing for each item the information needed to solve the problem and what other items it directly depends on
- Matrices are used to map a set of items toward itself (NxN) or to map a set of items toward another set of items (NxP)
  - NxN approach is named Design (or Dependence) Structure Matrix (DSM) (Steward 1967, 1981, Eppinger et. al.)
  - NxP approach is named Domain Mapping Matrix (DMM) (Danilovic, 2001, 2005, Maurer 2005, Danilovic & Browning, 2007)

Participative research approach

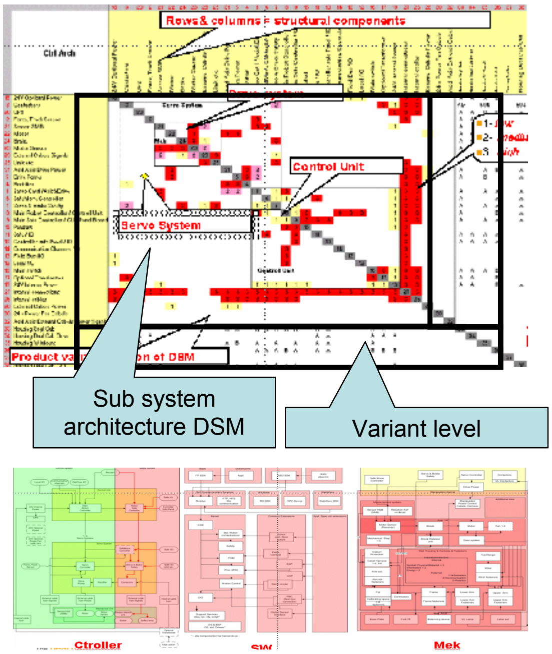
- Research method
  - Interviews with people in one small company
  - Direct observation of their daily work in product development
  - Workshops using dialogue in identifying relations between competences and products
- Feedback of data and the analysis to respondents in order to check that chosen approach is reasonable well reflecting their working experiences
- Feedback to management in order to support their strategically analysis of data in order to define strategic actions to achieve core competence development in the company

Data set structure



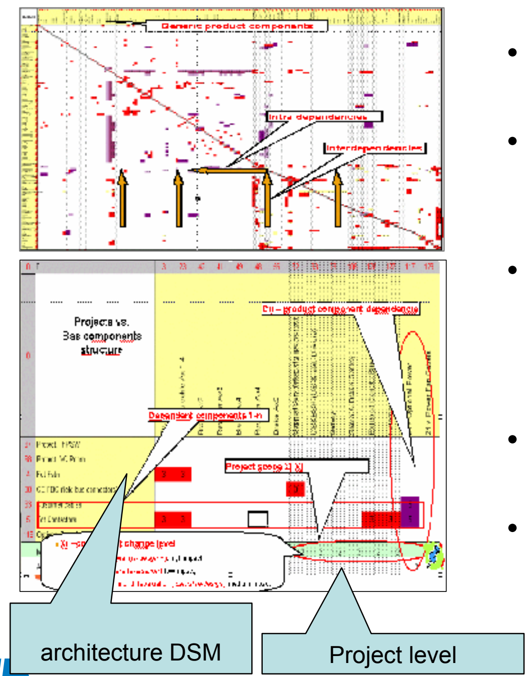
- Data set is DSM/DMM based
- System-level consists of four component structure /architecture DSMs for sub system /application group and 12 inter-component DMMs, representing the dependencies between those groups
- Project portfolio level links projects with system-level components representation
- Product / Market level link market requirements with system - level product structure and project portfolio

Stage 1- Architecture DSM extenden



- Includes an structural part and variant part. The structural part is a result of clustering of systems components based on the level of dependencies between them. The version part visualizes how structural components differ between product families
- Flow diagrams as a start
- Difficulties visualizing the software – hardware state of the art dependency representation

Stage 2 – Merging and mapping projects with system architecture

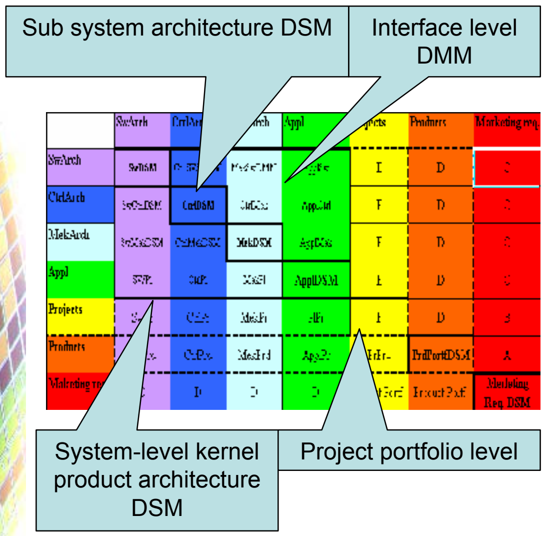


- Merge of sub system DSMs / interface DMMs into system DSM
- Architecture level : rows / columns represent sub systems conponents
- Project level: rows represent projects, column represents level of change to a system component within a project scope
- Points of interaction contains information on:
- Inter /intra project dependencies i.e. level of change to components in project scope

Stage 3 – Calculation project dependency index

- $\Sigma p\ Dp = \Sigma j\ Xj^* \Sigma i\ (Cij * Lij)$
  - p=1…m represent the number of projects to be analyzed in project portfolio (DMM, project vs. product structure)
  - i,j = 1…n represent n structural components in product structure DSM, i –rows, j-columns
  - Xj : estimated change level to component j within a project scope; 0 - not In scope; 1 - review; 2 - probable redesign; 3 - redesign
  - Cij : dependency level of product component i on component j , the value depends on the way of dependency representation.
  - Lij = 0; 1 where 0 represents the decision to keep the dependency unchanged and 1 to change it within a project scope
- If a component has different design for different product variant (families), resulting Dp value should be adjusted accordingly to represent additional design effort. Dp showed to be quite different for different types of products being developed. Examples: Max Dp would represent a complete redesign of a system, Dp=0 – independent component, high Dp level – shared systems. **More empirical data is required to see if it is possible to derive a correlation between an optimal Dp level for an individual development project, design transfer level and optimal project portfolio structure.**

System-level based project co-ordination process, 1(2)



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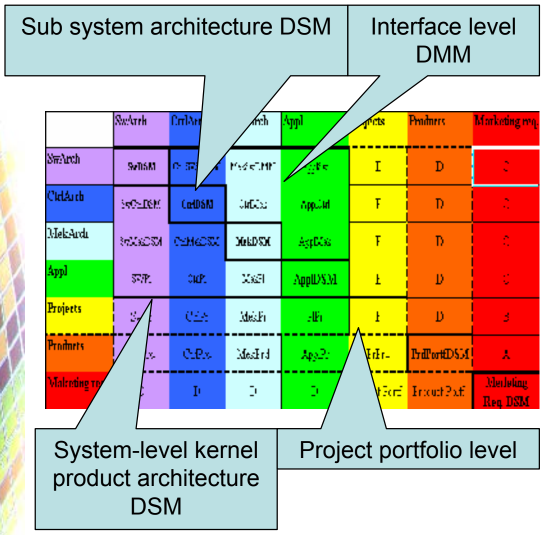
System-level based project co-ordination process, 2(2)



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Conclusions

- IDM (Information driven management approach)/DSM (Design or Dependency structure matrix) /DMM (Domain mapping matrix) Danilovic & Sandkull (2005), Danilovic & Browning (2007) based data set that is system-level founded and yet easy to use for different stakeholders in multi-project development environment was created.
- It should provide a holistic view linking both technical constraints driving integral system design and business drivers allowing for more effective project co-ordination in product development.
- The dependency level was calculated for several projects, demonstrating a dependency between project complexity level and system-level dependencies
- The potential application could be assessment of change-propagation effects of project technical decisions based on underlying (modular or integral) systems architecture on different product development and project management environment components and vice verse.
- If parameterized could be used to support set-based design approach

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