PLM in globally networked manufacturing companies

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Tiikerinloikka tehokkuuden nostamiseen 3.10.2013
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  – Concepts
  – Questions
  – The complexity of business
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  – Case companies
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  – QCA (qualitative comparative analysis)
    • Frame aspects (PLM maturity, business characterization, PLM system architecture)
• Results / Questions
• Conclusions and Discussion
Some concepts

• PLM
  – a strategic business approach, which
    • applies business solutions,
    • collaborative creation, management and dissemination of product definition information
    • through-out the product lifecycle (PLC)
    • – CIMdata 2011

• PDM is the IT platform for PLM (PLM Interest Group 2012)

• PLM system architecture: CAD, CAE, EDM, PDM...
Research Questions

• What kind of business processes are the main customers of PLM (who benefits from PLM)?
• How mature are the PLM approaches of case companies?
• What kind of changes are taking place in PLM architectures of case companies?

• Maturity vs. business benefit – does maturity matter?
Research Context

International supply chains with worldwide, cross-functional collaboration

Production abroad largely independent of home location

Sales locations abroad, products exported from home location

Degree of globalization

Time

[1850] [1930] [1980] [2000]

[Jacob & Strube 2008]

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The complexity of products

- **Standard product** (CD-player, Washing machine)
- + variants defined by the company (Car, Laptop)
- + variants defined by the customer (Drilling machine)
- **One-of-a-kind product** (Plant)
The complexity of products

- Partly configurable delivery content
  - Standard
  - Partly configurable
    - Standard
    - Partly configurable
      - Standard
      - One of a kind
  - Configurable
  - One of a kind
  - Standard
The complexity of business

**Market strategy**
- Flexibility
- Systemic Customization
- Mass Production

**Sales-delivery**

**Product**
How businesses and products relate to each other?

- **Standard product – Mass production**
  - Composed of standard items and relations
  - Mass production: off the shelf / MTO
    - does not include engineering design
- **Configurable product – Mass / systemic customization**
  - Composed of variant and standard items and relations
  - Includes mass production (of parts) and configuration but no engineering design
- **1 of a kind – Project delivery**
  - Composed of variant and standard items and relations as well as ETO items and relations
  - Includes mass production, configuration and engineering
Benchmarked companies

- 6 companies / Businesses
  - Type: Standard & Configured products, Project deliveries (new & Life cycle business)
  - Turnover $\sim 5 \times 10^{8-9}$ € (30-60% service)
  - Global operations
    - Personnel $\sim 7,000-32,000$ (> 50% abroad – up to 90%)
    - Product management typically in Finland
Data collection

1st Interview (3-4 h)
- 2-4 interviewers
- 1-2 interviewee
- Overview: notes

Site Visit (3-4 h)
- Focused presentation / 2-4 persons
- Questions / 10-20 persons from other companies
- Focused: Recorded

Case Studies & Related material
- Focused Case Studies (e.g. M.Sc. theses) on PLM Processes
- Slides, www, experience...
Benchmark reports and collected data
Analysis [Ragin 1989]

- Development of Frame
  - Iteration on list of properties and values of cases
- Preparation of material
  - Transcriptions of BM-site visits
  - Analysis of transcriptions, notes & additional material (e.g. initial state reports, slides)
  - BM-reports (6 pcs. / 1 for each company)
- Framework
  - Filling + verification and validation of framework content → analysing ≈ comparison of cases
Synthesis of Frame

• Maturity (Stark 2004, Batenburg et al. 2006)
  – Application of PLM, Involvement and understanding, Organisational integration, Level of interoperability, General description

• Business / Product type (Schomburg 1980, Lampel et al. 1996, Pulkkinen 2007)
  – MTS, ETO, CTO – Fixed product, Family or no product
  – Tangible Product vs. Service

• Architecture (Crnkovic et al. 2003, Bergsjö et al. 2006)
  – Legacy, Single Source, Service oriented
# Maturity (initial levels)

<table>
<thead>
<tr>
<th></th>
<th>Level 0</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application of PLM</strong></td>
<td>Non-existent</td>
<td>Local initiatives exist, but there is no overall vision</td>
</tr>
<tr>
<td><strong>Involvement and</strong></td>
<td>From few to none people involved</td>
<td>Few people understand PLM</td>
</tr>
<tr>
<td><strong>understanding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organisational</strong></td>
<td>No integration</td>
<td>Simple departmental integrations between some PDM tools</td>
</tr>
<tr>
<td><strong>integration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level of</strong></td>
<td>Between individual tools only</td>
<td>On a departmental level</td>
</tr>
<tr>
<td><strong>interoperability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>General description</strong></td>
<td>There is no PLM investment and individual legacy systems are used.</td>
<td>PLM is realized as individual applications integrated on a departmental level. There is no overall PLM vision.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Maturity (advanced levels)

<table>
<thead>
<tr>
<th>Application of PLM</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company-wide understanding of the importance of product data is taking shape</td>
<td>PLM is seen as a business problem spanning the whole product lifecycle</td>
<td></td>
</tr>
<tr>
<td>Involvement and understanding</td>
<td>It is clear for everyone where the company is and where it wants to be</td>
<td>Widespread understanding of PLM in the company and in its extended enterprise</td>
</tr>
<tr>
<td>Organisational integration</td>
<td>Integration between PDM tools and simple integrations with for example ERP</td>
<td>PDM tools are fully integrated and there is widespread integration with related systems such as ERP</td>
</tr>
<tr>
<td>Level of interoperability</td>
<td>On a cross-departmental level</td>
<td>Across the extended enterprise</td>
</tr>
<tr>
<td>General description</td>
<td>PLM is understood relatively well and integrated on a cross-departmental level</td>
<td>PLM is integrated across the supply chain. PLM is utilized in state-of-the-art ways, for example in a closed-loop fashion.</td>
</tr>
</tbody>
</table>
Frame (Business type)

<table>
<thead>
<tr>
<th>The business mode*</th>
<th>Offered product types &amp; their relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>integrated</td>
<td>All types, which… … are composed of each other</td>
</tr>
<tr>
<td>detached</td>
<td>… are treated as independent</td>
</tr>
<tr>
<td>projects</td>
<td>Projects contain hierarchically nested variants</td>
</tr>
</tbody>
</table>

* sales delivery process (MTS, CTO, ETO)
Frame (Product type)

The mode of business

- integrated
- detached
- projects

- Standard
- Configured
- Engineered
- Configured
- Standard

Standard Product Configured Engineered Project Configured Standard
## Frame (PLM system architecture)

<table>
<thead>
<tr>
<th></th>
<th>No integration</th>
<th>Full integration</th>
<th>Loose integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best in Class</td>
<td>LEGACY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All in one</td>
<td>SINGLE SOURCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer to peer</td>
<td></td>
<td>SERVICE ORIENTED</td>
<td></td>
</tr>
</tbody>
</table>
# Cases: maturity

<table>
<thead>
<tr>
<th>Maturity vs. Cases</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of PLM</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Involvement and understanding</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Organisational integration</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Level of interoperability</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>General description</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
Cases: business type

<table>
<thead>
<tr>
<th>Business vs. Cases</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales-Delivery type</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>- MTS</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>- ETO</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>- CTO</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Service business &gt; 50%</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
## Cases: PLM system architecture

<table>
<thead>
<tr>
<th></th>
<th>No integration</th>
<th>Full integration</th>
<th>Loose integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best in Class</td>
<td></td>
<td>F</td>
<td>B, C</td>
</tr>
<tr>
<td>All in one</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Peer to peer</td>
<td></td>
<td></td>
<td>A, D</td>
</tr>
</tbody>
</table>
Characteristics of implementation processes

• PLM implementation processes include projects on PDM, CAE, CM, … (company type)
  – From early 90’s (1 integrated, 1 project)
  – Late 90’s (2 integrated, 1 detached, 1 project)

• Integrated companies able to maintain
  – knowledge, items, data, new versions of systems…

• Pure project companies (consecutive implementations – no commonality & leverage by reuse)
PLM as is (or has been)

• Architecture
  – 5 legacy
  – 1 single source

• Cases
  – Mature (1-3): Wide support in integrated approach
  – Under construction (1-2): limited support for different business sectors
    • Detached approach (management of standard items for configuration)
    • Only for one business line in a company (also projects and standard products)
  – Awakening (1): projects are poorly supported
PLM in future (how ready?)

- Architecture
  - 4 single-source
  - 2 legacy

- Challenges with (engineering, supply, ...) networks
  - Processes, data flow and quality
  - Security, access and availability
  - MDM
Conclusions

• What kind of business processes are the main customers of PLM (who benefits from PLM)?
  – Standardized modules in PDM & Configuration knowledge (models of constraints, rules) in configuration →
  – Utilization of product configuration in project engineering

• How mature are the PLM approaches of case companies?
  – Easy to notice TOP 3: service orientation, integrated approach

• What kind of changes are taking place in PLM architectures of case companies?
  – Approach to tighter integration
  – From legacy to single source

• Maturity vs. business benefit – does maturity matter?
  – Yes, but PLM is “just” another strategic business initiative
Discussion

• State of the art solutions
  – What is the actual need of customization in Finnish (Globally operating) companies?

• Single source vs. diversified business
  – Does one-size-fits-all process model fit in the diversified modes of business?
  – Is integrated business approach a solution?
    • Implementation of common support for re-usable, standardized designs (modules, interfaces, …)
    • Design by re-use through utilization of MTS & CTS items in ETO

• Integration of dynamic networks (with a number of single source PLMs)
  – Is SOA an answer to integration in networks?
Questions?
Turnover of companies
The performance of case companies (scale 4-10)