Software Production: fundamental research for the software society

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Utrecht University

Software Engineering Netherlands
3 December 2014
Outline

- Software products
  - Software types
  - Economic context
  - Research framework
- Software production
  - Software product management,
  - Software ecosystems
  - Incremental method evolution
- Challenges for the research community
- Invitation and discussion
Societal context

ICT innovations create new products, services, companies, jobs, economic value, social value

International:
Google
SAP
Oracle
Microsoft
Sage
FaceBook
SalesForce
...

Netherlands:
TomTom
Planon
GX
Exact
Unit4
Afas
Mendix
...


What is a Software Product?

A **Software Product** is defined as

*a packaged configuration of software components, or a software-based service with auxiliary materials, which is released for and traded in a specific market* (Xu & Brinkkemper, EJIS 2007)

Examples:
- ERP software
- Bookkeeping service
- Operating systems
- Desk-top publishing
- Computer-aided design
- Software development environments
- Customer-relationship mgmt
  ...

Essentially *all* software you are using in daily life and work ...
What is a software product?

What is being sold?

Device

Software

Number of copies

One

Multiple

Microprogram

Tailor-made software

Embedded software

Software product

Cloud software

Packaged software
Key differences

1. Market introduction requires precise *synchronization* of dependable software engineering activities

2. The same product requires *installation and usage* in different organizations, with different *hardware and software platforms*

3. The vendor company stays *owner* of the software and auxiliary materials, while the usage is *licensed* to the customers

   Note: Cloud and mobile have huge impact on 2
Four main software types

1. System infrastructure software
2. Development tooling
3. Enterprise applications
4. Games and consumer apps
Software types

1. System infrastructure software
   - Foundation of software stack
   - Security, systems management
   - Not industry or function specific
   - Many in open source
   Segments
   - Operating systems
   - Network, storage, security
   - Utilities, anti-virus, archiving

2. Tools
   - Development, execution
   - Allow for composition, reuse, optimization
   Segments
   - Portal and collaboration: user interface infrastructure
   - Information management: data layer
   - Modeling and development: for application logic
   - Execution and Integration platforms: execution of appl. logic
3. **Enterprise Applications**
   - Used by information workers and end-users
   - Bring some level of automation in business processes
   - Most are industry or function specific
   - Few in open source

   **Segments**
   - Office automation
   - Horizontal business apps: finance&accounting, ERP, CRM
   - Vertical business apps for industry specific solutions: billing, banking, travel reservations
   - Technical applications: design and creation of physical products

4. **Games and Consumer apps**
   - Consumer and professional games
   - Strongest shift from packaged to cloud and mobile

   **Segments**
   - Offline: Home consoles, handheld consoles, computers
   - Online: Cloud and mobile apps
   - Consumer apps: editing of video and photo, hobbies
Economic context

OECD (2008): “The product software sector is among the most rapidly growing sectors in OECD countries, with strong increases in value added, employment and R&D investment.”

EU
- 2.7 M employees
- Few good statistics

NL
- Dialogic research 2014
- 12,300 companies with 10,5 B euro revenue
- Export: 3.5 Beuro
- NL: 74,000 employees in NL-owned companies
- Total software: 2.8% GDP

http://www.nederlandict.nl/Files/TER/De%20Nederlandse%20softwareindustrie%202014.pdf
European Software Market

Overall market: 229 B€ in 2008
3,7% growth/year
Software business model

SSBS - EU27

- Online subscription
- Advertisement
- Associated services
- License and maintenance

M€

2007 2008 2009 2010 2011 2012
## Top 100 in EU software industry

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<th>Country</th>
<th>SW revenues 2010 (€M)</th>
<th>SW revenues 2011 (€M)</th>
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Source: Truffle 100, see www.truffle100.com
R&D jobs per country

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<th>Countries</th>
<th>Number R&amp;D employees</th>
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<th>R&amp;D investment (€M)</th>
<th>% of total</th>
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<td><strong>100%</strong></td>
<td><strong>6,841.1</strong></td>
<td><strong>100%</strong></td>
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</table>

Source: Truffle 100
see www.truffle100.com
Netherlands Export

*But, where is software?*

Source: The Observatory
SoftwareVOC

- Network of software industry in NL
  - About ~300 companies
  - Admin and meetings: Nederland ICT
  - Board: AFAS, Unit4, Exact, VitalHealth, Hydrologic, AgroVision, Levi9, UUtrecht
  - Annual conference SINC: run by CKC-seminars

- Industry invests heavily in Research and Development
  - ~25% of annual revenue (NL 2.5 Beuro ?)
  - Constant need for functional and technical innovation
  - Opportunity: Perform empirical and experimental research at industry premises
  - Industry is willing to pay for PhD research and match with cash

- Let’s not waste taxpayers’ money
Research at Utrecht University

- Software Production
- Software Product Management
- Software Ecosystems and Delivery
- Software Architecting
- Game Production
- Knowledge networks

See www.cs.uu.nl
Take home message

Scientific research in the field of software production is fundamental for creating innovative products and services, for new companies, jobs, economic and social value, but cooperation with the software industry is key to get well founded theories.
Outline

- Software products
  - Software types
  - Economic context
  - Research framework
- Software production
  - Software product management,
  - Software ecosystems
  - Incremental method evolution
- Challenges for the research community
- Invitation and discussion
Binary Priority Listing in large scale RM

Bebensee et al., REFSQ 2010
Customer Involvement Factory

- Reports of questions, complaints or bugs
- Approximately 60,000 reports per year
- Handled by helpdesk and consultancy
- 85% can be solved by referring to the manual
- 15% is a bug or shortcoming

Kabbedijk et al., RE 2009
The **Product Backlog** contains a prioritized list of all items relevant to a specific product.

The **Product Management Software Backlog** consists of tasks that can be finished by the SPM team within the sprint.
Release planning with ILP

- Mathematical formalization using Integer Linear Programming
- Given are:
  - Lists of requirements
  - Revenue estimates
  - Resource cost estimates
  - Development teams and capacities
- Managerial steering mechanisms
  - Team transfers
  - Deadline extension
  - External resources
  - Mandatory requirements

Akker et al., REFSQ 2005; Li et al., REJ 2010
There are $n$ requirements $R_j$.
$v_j =$ estimated revenue of $R_j$
$a_j =$ estimated resources need for $R_j$
$Q =$ number of developers in pool.
$T =$ development period
$d(T) =$ number of working days in planning period

$$x_j = \begin{cases} 
1 & \text{if requirement } R_j \text{ is selected;} \\
0 & \text{otherwise.}
\end{cases}$$

$$\max \sum_{j=1}^{n} v_j x_j \quad \text{subject to}$$

$$\sum_{j=1}^{n} a_j x_j \leq d(T)Q,$$

$$x_j \in \{0, 1\},$$

for $j = 1, \ldots, n.$
Team development and transfers

\[ a_{ij} = \text{estimated resource need for } R_j \text{ from team } i. \]

There are \( m \) teams.

\[ Q_i = \text{number of developers in team } i. \]

\[ U_{\text{cap}} = \text{atomic transfer capacity unit} \]

\[ y_{ik} = \text{number of transfer capacity units from team } i \text{ deployed in team } k. \]

\[ \alpha_{ki} = \text{transfer effectiveness factor (from team } k \text{ to team } i). \]

\[
\sum_{j=1}^{n} a_{ij}x_j \leq d(T)Q_i, \quad \text{for } i = 1, \ldots, m.
\]

\[
\max \sum_{j=1}^{n} v_jx_j \text{ subject to }
\]

\[
\sum_{j=1}^{n} a_{ij}x_j \leq U_{\text{cap}}[y_{ii} + \sum_{k:k \neq i}^{m} \alpha_{ki}y_{ki}] \quad \text{for } , i = 1, \ldots, m,
\]

\[
\sum_{k=1}^{m} y_{ik} = m_i, \quad \text{for } i = 1, \ldots, m,
\]

\[ x_j \in \{0, 1\}, \quad \text{for } j = 1, \ldots, n, \]

\[ y_{ik} \text{ nonnegative and integral,} \quad \text{for } j = 1, \ldots, n. \]
SPM Competence Model

Van de Weerd et al., RE 2006
## Maturity profile in Product Management

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<th>Focus area</th>
<th>Maturity levels</th>
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<td>Requirements identification</td>
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Van de Weerd et al., ICSOB 2010
**Maturity analysis of 68 software producers**

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</table>

Many organizations have low maturity

Percentage of organizations achieving the level

Intriguing data

Many organizations have low maturity

Intriguing data

Bekkers et al., RE 2012
Key decisions in Software Start-ups

Released: 17 Jan 2013

See Amazon
Outline

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CCU - Customer Configuration Updating

Vendor

Vendor Repository

Product

Receive Info

Receive Update

Deploy/Install Update

Configure

Vendor Feedback

Activate Update

Deactivate

Reconfigure

Rollback/Deinstall

Remove

Uninformed Customer

Customer Possesses Update

Installed Customer

Activated Customer

Jansen et al, ICSE 2006
The Catalogue of Customization Realization Techniques

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</table>

(a) Infrastructure centered architecture, (b) Run-time variant component specialization, (c) Variant component implementations, (d) Condition on variable, (e) Code fragment super-imposition

Jansen et al., ICWE 2010
Microsoft Internet Explorer has encountered a problem and needs to close. We are sorry for the inconvenience.

If you were in the middle of something, the information you were working on might be lost.

☑ Restart Microsoft Internet Explorer

Please tell Microsoft about this problem.
We have created an error report that you can send to help us improve Microsoft Internet Explorer. We will treat this report as confidential and anonymous.

To see what data this error report contains, click here.

Send Error Report  Don't Send
Feedback in Software Supply Chains
Software Operation Knowledge

**Definition:**

**Software Operation Knowledge** is knowledge of in-the-field performance, quality and usage of software, and knowledge of in-the-field end-user software experience feedback.

*Vd Schuur et al., CSMR 2011*
Intention mining in user behaviour

Epure et al., CAiSE 2014
Software Ecosystems modeling

Product Stack: dependency on third party software

Lucassen et al., ICSOB 2012
Software Supply Chain
Managing SECO dependencies
Book on Software Ecosystems

Published March 2013
See Amazon
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- Invitation and discussion
The software startup

Start with a simple process
Incremental Process Capability

Gradual more extensive processes are added dependent on:
- product
- development culture
- internal maturity
- external stakeholders
On-line Method Engine

Product software company

Process need

Feedback

Need & situation analysis

Selection of process alternatives

Assembly of process advice

Method Base
- situational factors
- method fragments
- assembly rules
- method fragments

Product Software Knowledge Infrastructure

Existing methods (books, articles, online resources)

Experiences (case studies)

Advice

Van de Weerd et al., CAiSE 2007
Incremental Method Evolution

Universiteit Utrecht

Van de Weerd et al., IST 2010
Formalization of Method Incrementation

Definition 3.1
The mapping \( \text{method}: T \rightarrow M \), where \( m = \text{method}(t) \) means that the method \( m \in M \) is the valid method at time \( t \).

Definition 3.6
A method increment is a method fragment \( f \in F \) such that \( \exists i \text{ contains}(f, \text{method}(t_i)) \land \neg \text{contains}(f, \text{method}(t_{i-1})) \)

Definition 3.7
The mapping insert \( F \times M \rightarrow M: \text{insert}(f, m_1) = m_2 \)
means that the method fragment \( f \)
has been inserted in the method \( m_1 \)
resulting into method \( m_2 \)

Rule 3.1 Insertion of concepts
\( \text{insert}(c, m_i) = m_{i+1} \Rightarrow \neg \text{concept}(c, m_i) \land \text{concept}(c, m_{i+1}) \)

Example
\( \text{insert}(\text{RELEASE TABLE}, \text{BaanIncr2}) = \text{BaanIncr3} \Rightarrow \neg \text{concept}(\text{RELEASE TABLE}, \text{BaanIncr2}) \land \text{concept}(\text{RELEASE TABLE}, \text{BaanIncr3}) \)
The release table was not a concept in BaanIncr2 and therefore inserted to get BaanIncr3
Collaboration patterns

Kristjansson et al., JKE 2011
Product Knowledge Center

Nonaka spiral
Outline

- Software products
  - Software types
  - Economic context
  - Research framework
- Software production
  - Software product management,
  - Software ecosystems
  - Incremental method evolution
- Challenges for the research community
- Invitation and discussion
# Research differences

## Software Engineering

1. One customer  
2. Any domain  
3. Different projects  
4. Pool of workers  
5. Changing collaboration patterns  
6. Main players: project mgr, systems architect, requirements engineer  
7. ...  

## Software Production

1. One market  
2. Same domain: domain experts  
3. Release projects  
4. Fixed organization  
5. Fixed collaboration  
6. Main players: CTO, software architect, product manager  
7. ...
Research differences

**Software Engineering**

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**Software Production**

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7. . . .

Great opportunities for experimental SE research !!
Research Challenges

- What are the fundamental theories of Software Production?
- How can optimal multi-tenant customizations be deployed in a secure manner?
- How can high volume requirements selection be performed in techno-economic alignment?
- How can maturity growth in software production be supported by incremental method evolution?
- Can we build fault tolerant components in the software supply chain, both from a technical as well as from an organizational perspective?
- What are the essential development tools for product development and deployment?
Invitation and Discussion

SINC
Software Industry Conference, 12 March 2015
See http://www.softwareindustryconference.com/

Call: 4 slots with academic presentations

Questions?

- Papers see: www.dblp.org
- Email: S.Brinkkemper@uu.nl
- Contact me in case you are interested in joining a national or European project in Software Production

- Upcoming: Vacancies for assistant professors