An Approach to Reveal Starting Points for PSS Design Support with Dynamic Models

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Introduction and Motivation

Definiton of a PSS

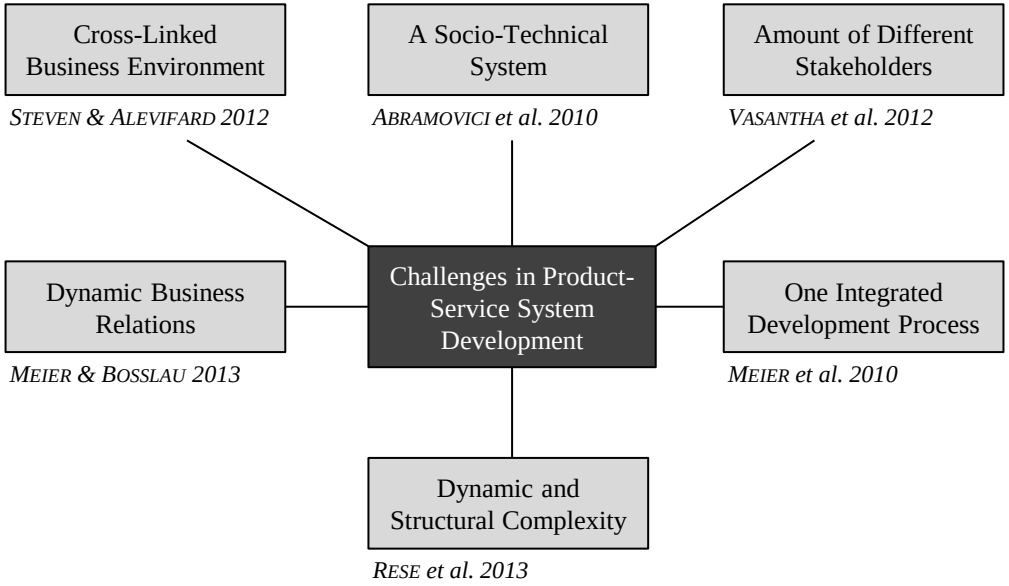
A Product-Service System is a marketable set consisting of tangible and intangible assets (product view) and is characterized by an integrated development process (process view).

Adopted from: Goedkoop et al. 1999; Mont 2002; Manzini & Vezzoli 2003; Tukker & Tischner 2006; Tan et al. 2007; Botta 2007; Baines et al. 2007; Vasantha et al. 2012; Finken et al. 2013; Marques et al. 2013

Challenges in PSS development

→Use of structural and dynamic models seems promising

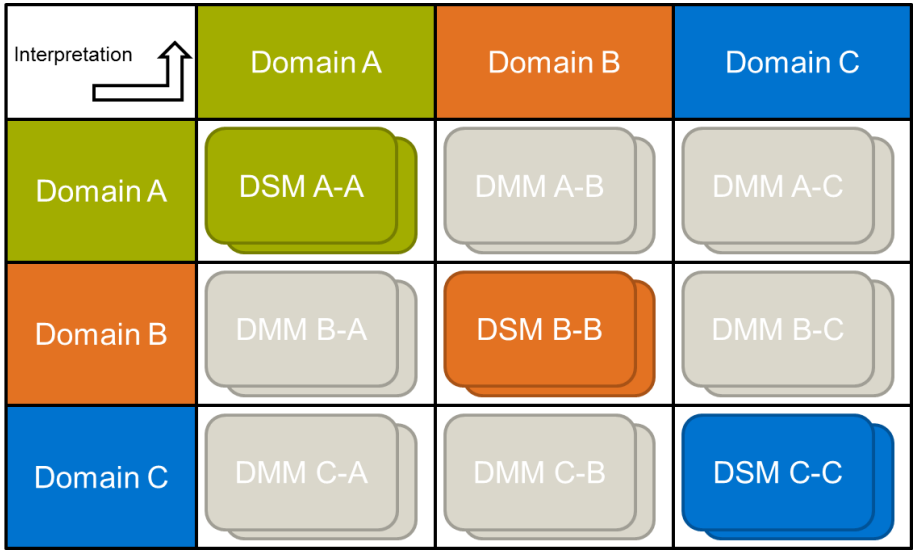
→Application on an exemplarily use case of an e-bike sharing system



→**Objective: Reveal starting points for PSS design support with structural and dynamic models**

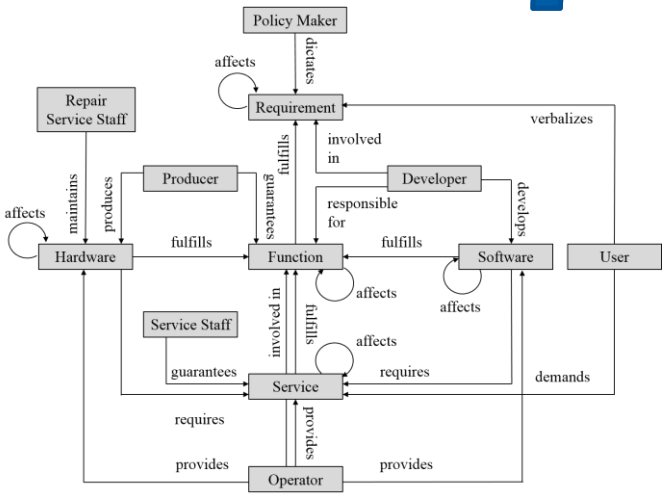
Structural system modeling

- Increases system understanding and allows system analysis
- Elements are assigned to domains
- System representation in matrixes and graphs
- Three matrix types:
  Multiple Domain Matrix (MDM),
  Design Structure Matrix (DSM)
  & Domain Mapping Matrix (DMM)
- Various analysis criteria for system analysis



Use Case PSSycle (I)

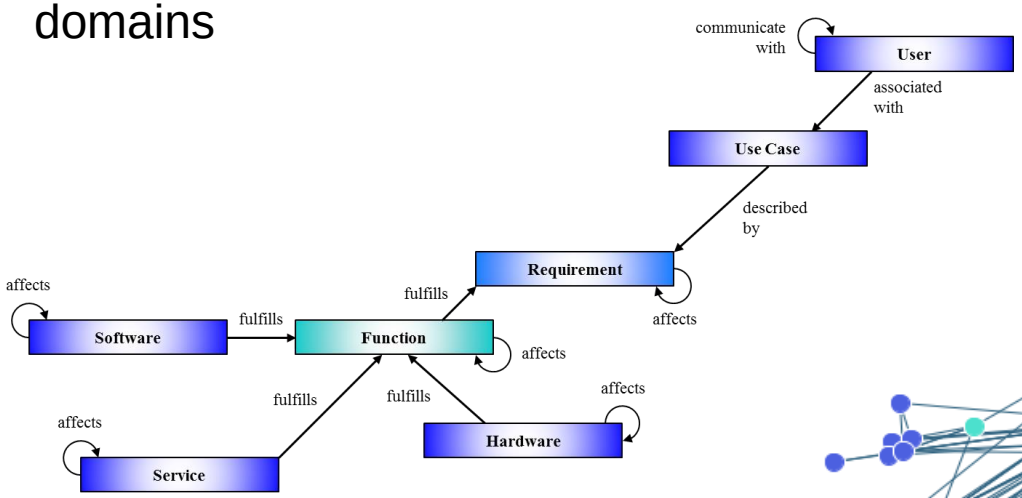
- PSSycle: e-bike sharing system
- Developed as a demonstrator in the collaborative research center SFB 768
- Consists of four product domains, one service domain and several stakeholder domains

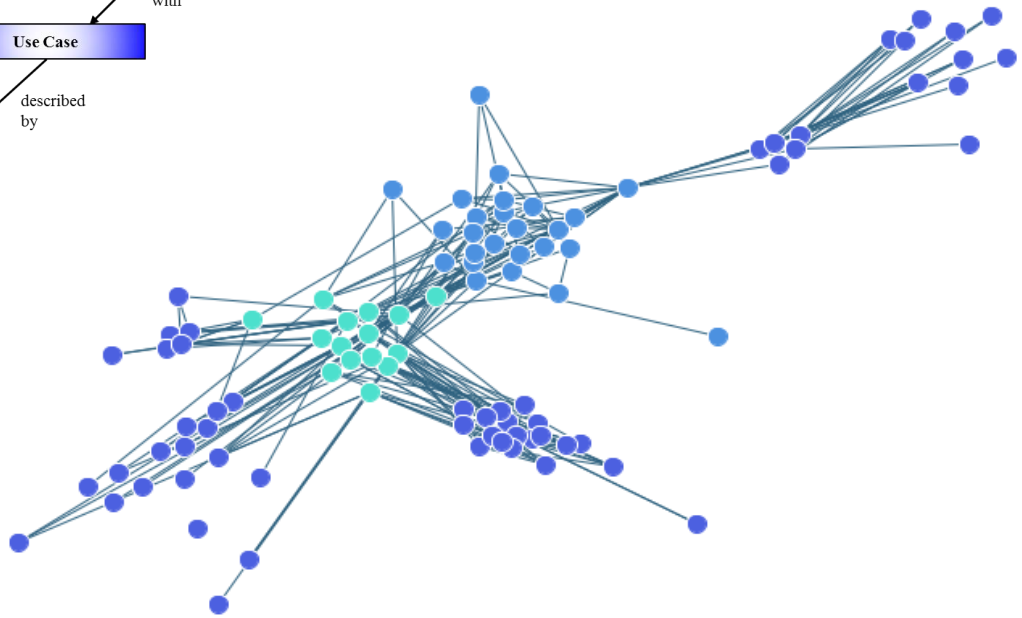


		Requirement	Function	Hardware	Software	Service	Use Case	User
		1	2	3	4	5	6	7
Requirement	1	affects						
Function	2	fulfills	affects					
Hardware	3		fulfills	affects				
Software	4		fulfills		affects			
Service	5		fulfills			affects		
Use Case	6	described by						
User	7						associated with	communicate with

Use Case PSSycle (II)

- PSSycle: e-bike sharing system
- Developed as a demonstrator in the collaborative research center SFB 768
- Consists of four product domains, one service domain and several stakeholder domains





- Structural analysis is also applicable in PSS context

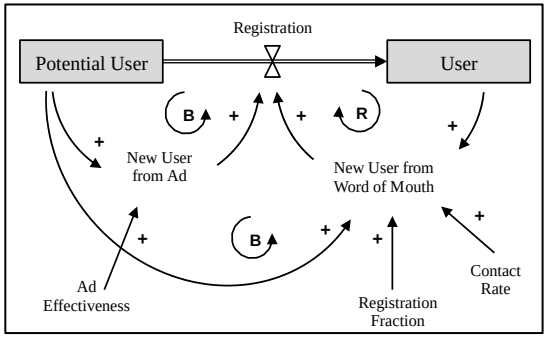
Dynamic Models (I)

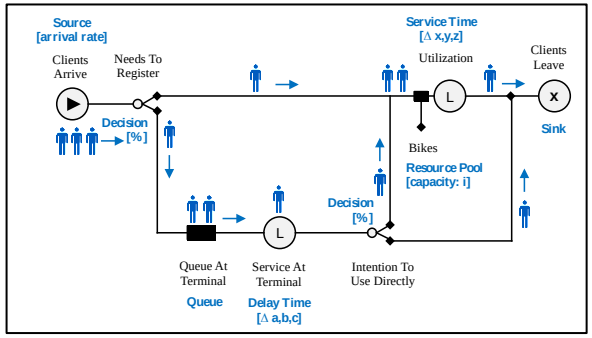
System Dynamics (SD)

- Commonly used
- Behavior results from system structure, represented by stocks and flows
- SD used in PSS context for business model analysis and development [Meier & Boßlau 2013]
- SD to analyze the impact of changes within the innovation process of PSS [Kasperek et al. 2014]
- SD to analyze service performance of an PSS [Legnani et al. 2010]

Discrete Event Simulation (DE)

- Process flow chart shows sequences of operations of entities
- DE model to analyze different system parameters in a car sharing system [Kuntzky et al. 2013]
- Applicability of DE for different PSS types [Weidmann et al. 2015]





Dynamic Models (II)

Agent-Based Modeling (ABM)

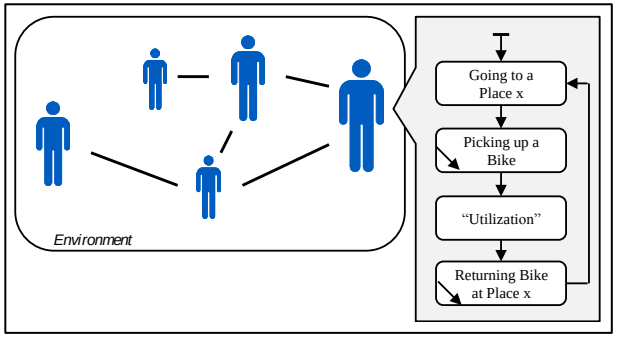
- Collection of autonomous decision-making entities (agents)
- Evaluation of user satisfaction in a use-oriented PSS [Maisenbacher et al. 2014]

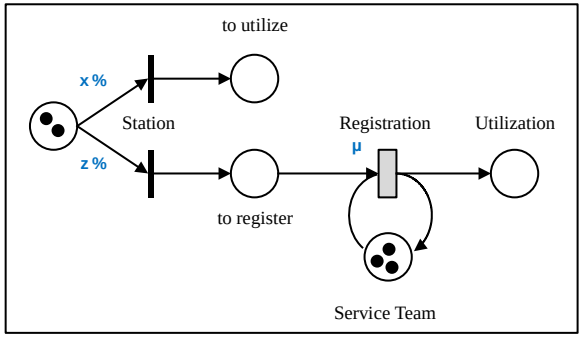
Petri Net (PN)

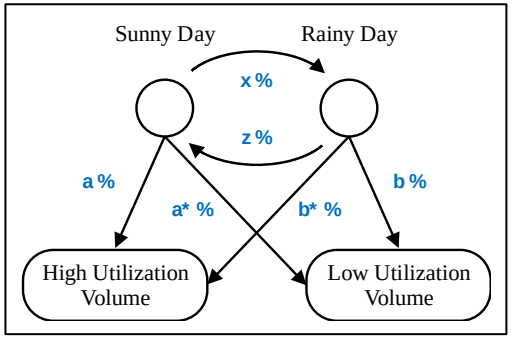
- PN analysis to model and simulate discrete events of states and state transitions in a system

Further dynamic models

- Bayesian Networks (BN)
- Modeling of Dynamic Systems (MoDyS) and Simulation of Dynamic Systems (SiDyS)

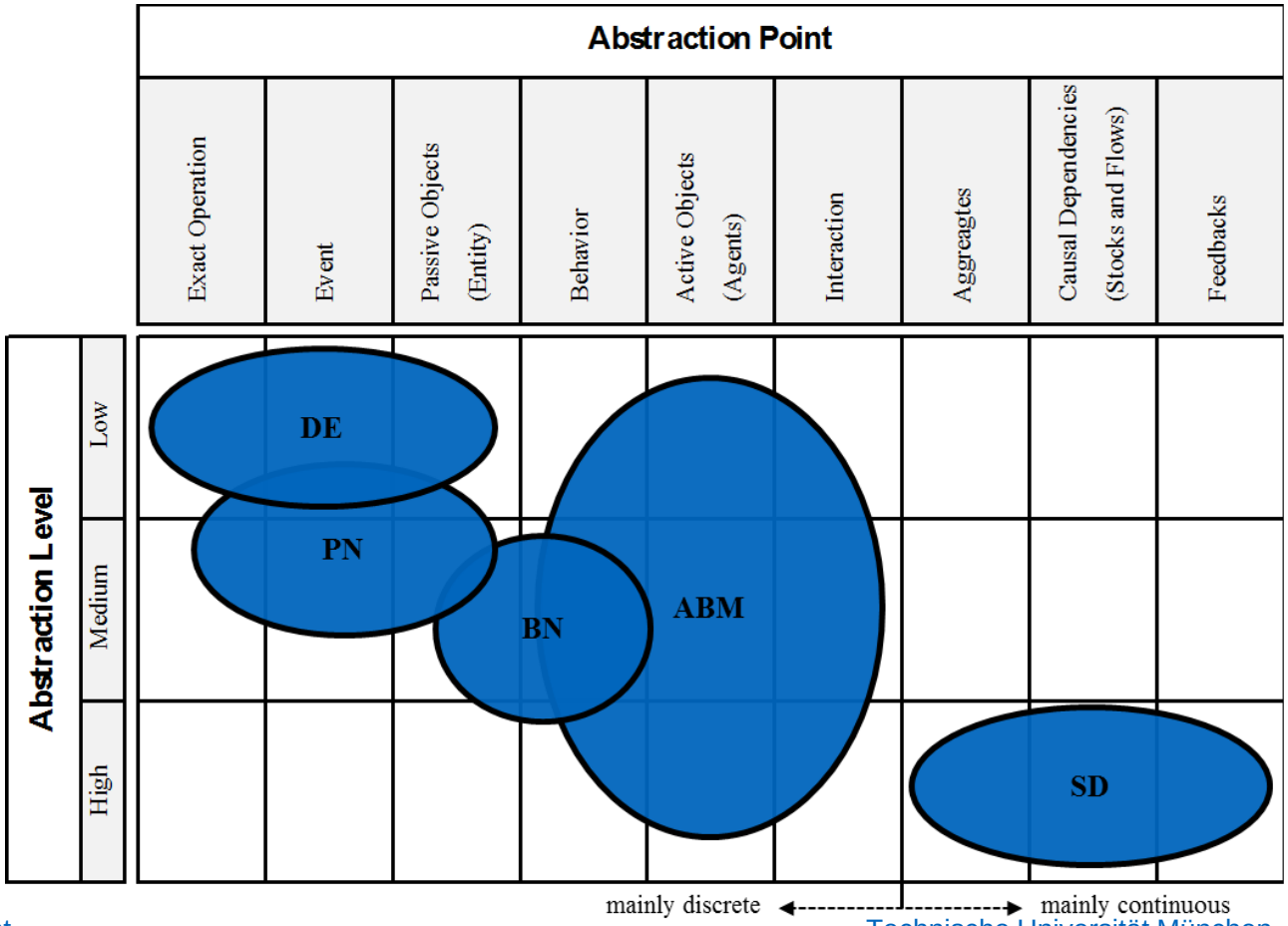






Classification of dynamic models

- Each dynamic method serves a particular abstraction level or level of detail
  [Borshchev & Filippov 2004; Borshchev 2013]
- Additionally the abstraction point is defined by the objective of the analysis

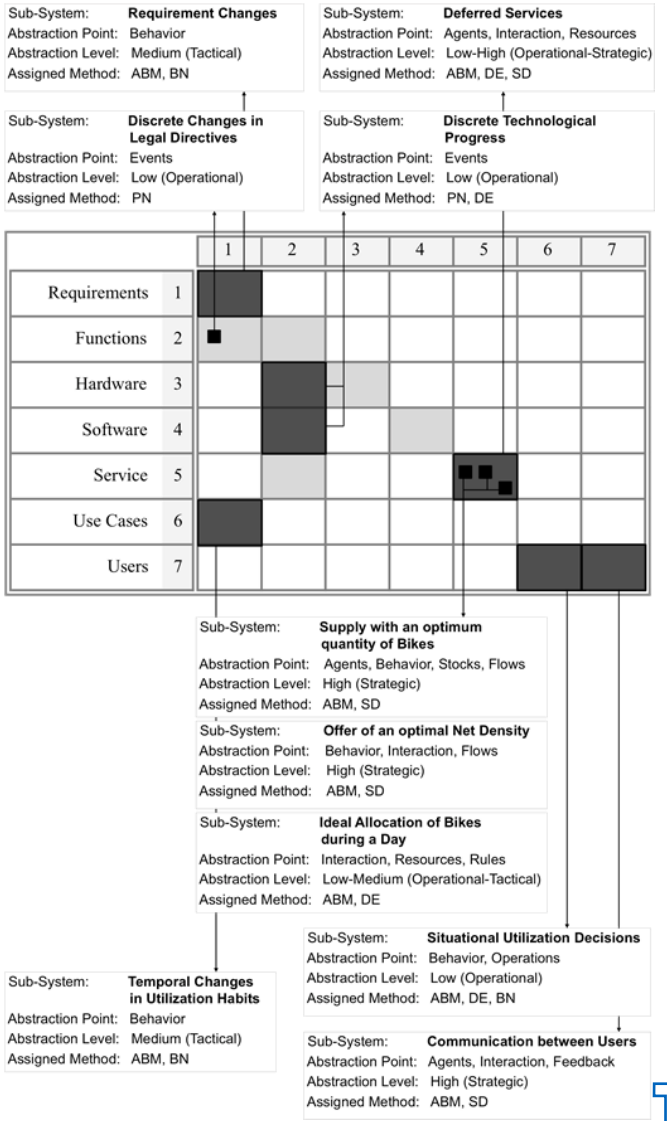


Allocation of dynamic models to exemplarily PSS structure

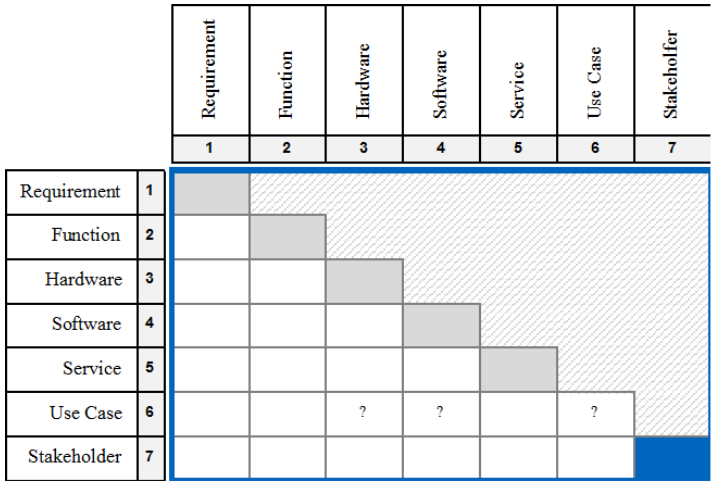
- Identification of domains/sub-sets with a distinctive dynamic behavior
- Definition of the abstraction point and abstraction level
- Selection of a dynamic modeling method

Performed application evaluations

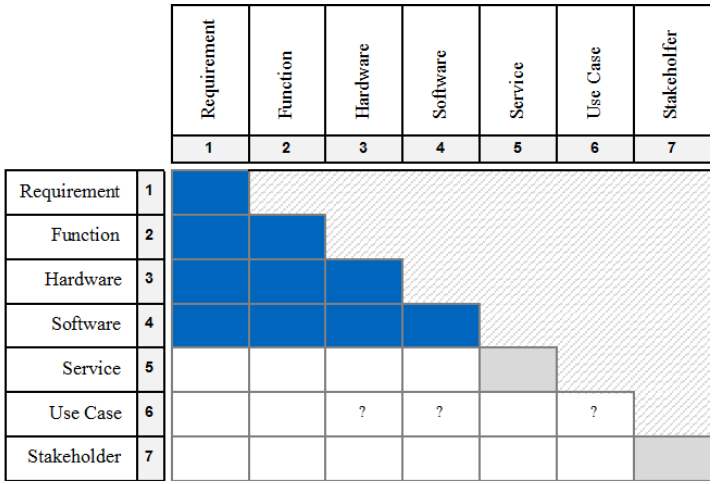
- SD of PSS development process
  [Kasperek et. al. 2015]
- SD of aquisition of new PSS users
- DE for optimization of service tasks
  [Weidmann et al. 2015]
- Optimal product supply with ABM
  [Maisenbacher et al. 2014]
- Implementation of a new hardware component or new legal derectives with PN



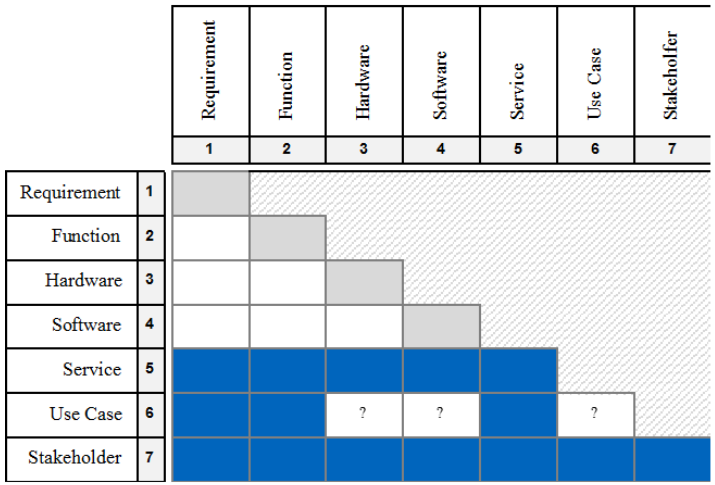
Suggestions for the applicability of dynamic models in PSS context



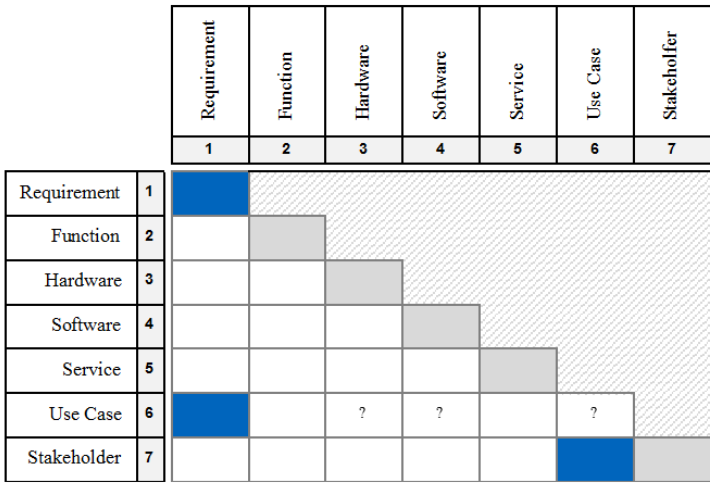
System dynamics



Discrete event simulation and Petri nets

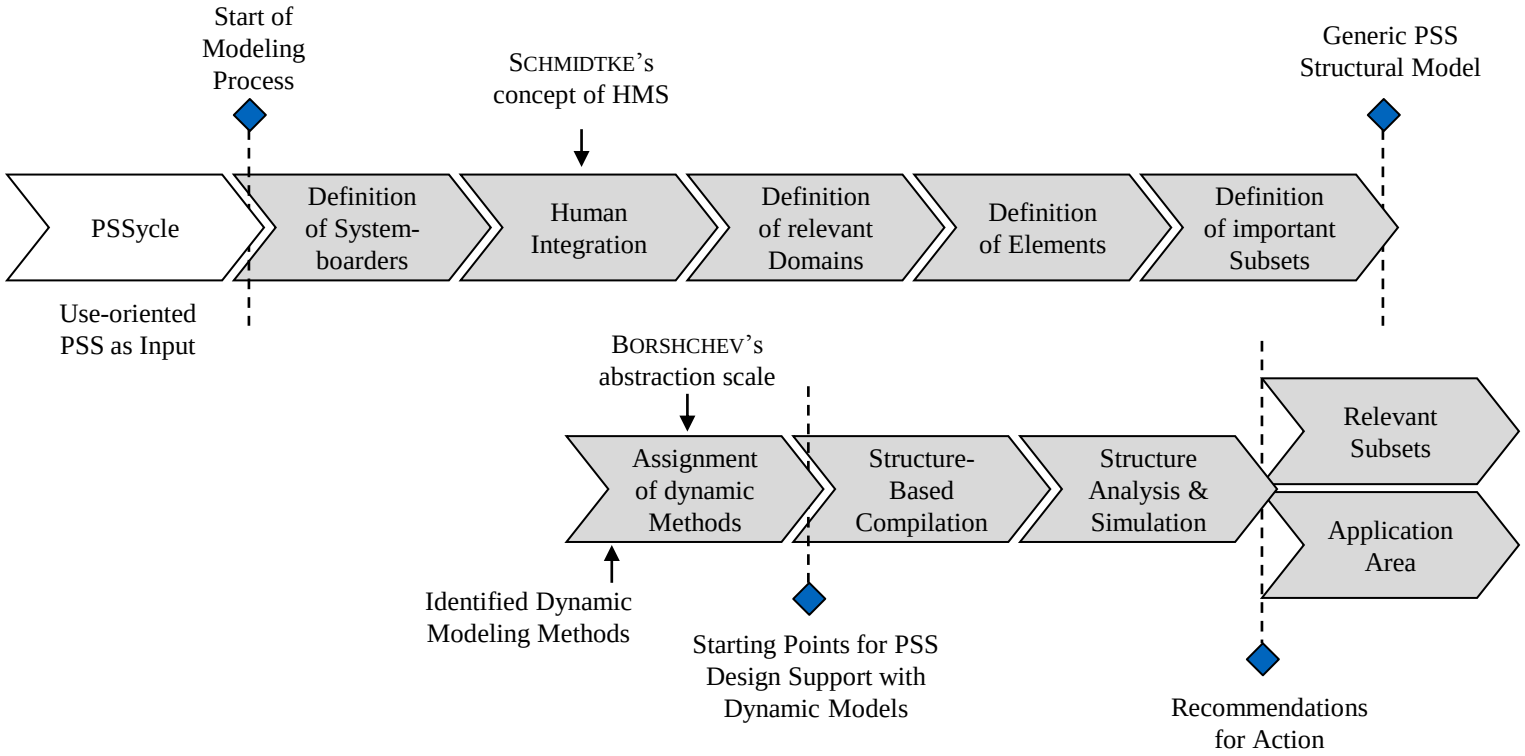


Agent-based modeling



Bayesian networks

Process to integrate structural and dynamic models in PSS development



Discussion

Discussion of the introduced MDM

- Seven displayed domains cannot perfectly display an entire PSS
- Dynamic models could be assigned to PSS structure
- Structural analysis only promising in classical domains
- Due to changes and refinement in the development process the abstraction level has to be periodically discussed

Discussion of the results of the presented models

- SD: + simple development of qualitative system model
  - quantitative feedback loops are difficult to discover
- DE: + simulation of uncertainty and impacts on future configurations
  - dynamic only emerges out of the system structure
- ABM: + individual acting agents and interactions
  - high modeling effort to model close to reality
- PN: 0 general applicability has been shown, but close to DE

Conclusion and Outlook

Conclusion

- Introduction of different dynamic approaches from literature
- Discussion of several dynamic modeling approaches for supporting PSS development
- Classification of dynamic models
- Use of an MDM to asign dynamic models to PSS domains
- Evaluation with several exemplarily dynamic models

Outlook

- Application of the MDM model on further PSS examples
- Detailed comparison of petri nets and discrete event simulation
- Further discussion of relatively new models in PSS context (bayesian networks, multi-method simulation approaches, …)

Thank you for your attention!

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Requirement	1							
Function	2							
Hardware	3							
Software	4							
Service	5							
Use Case	6							
Stakeholder	7							

(a)

		Requirement	Function	Hardware	Software	Service	Use Case	Stakeholfer
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Requirement	1							
Function	2							
Hardware	3							
Software	4							
Service	5							
Use Case	6							
Stakeholder	7							

(b)

		Requirement	Function	Hardware	Software	Service	Use Case	Stakeholfer
		1	2	3	4	5	6	7
Requirement	1							
Function	2							
Hardware	3							
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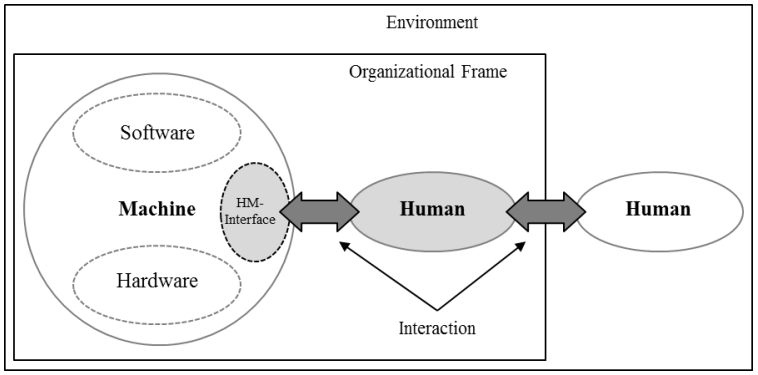
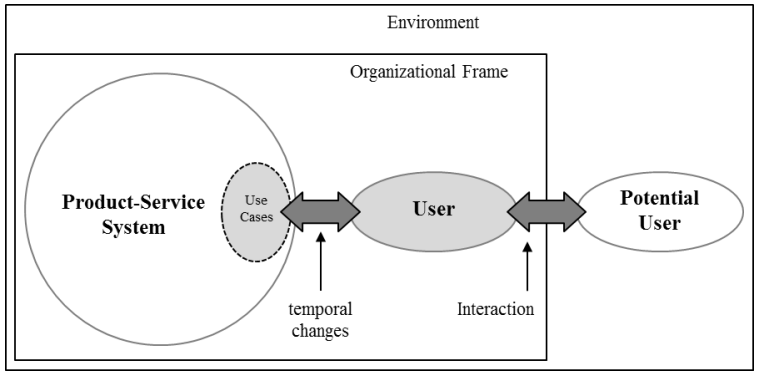
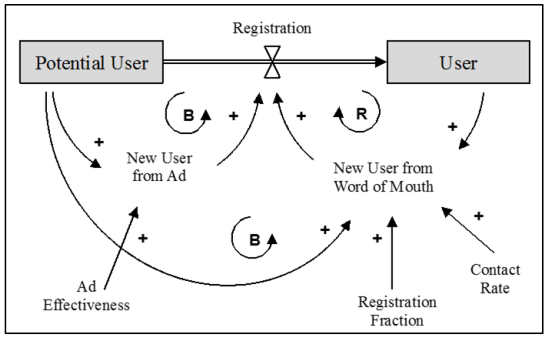
Use Case	6							
Stakeholder	7							

(c)

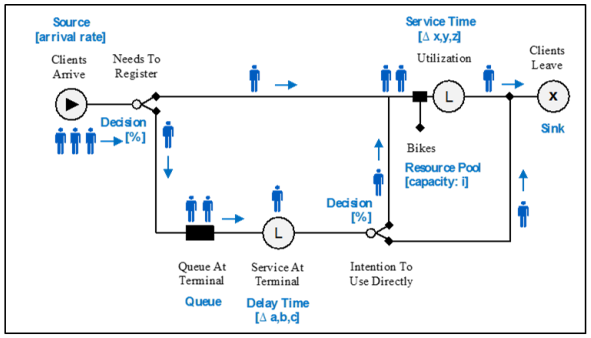




Dynamic Models (II)



System Dynamics (SD)



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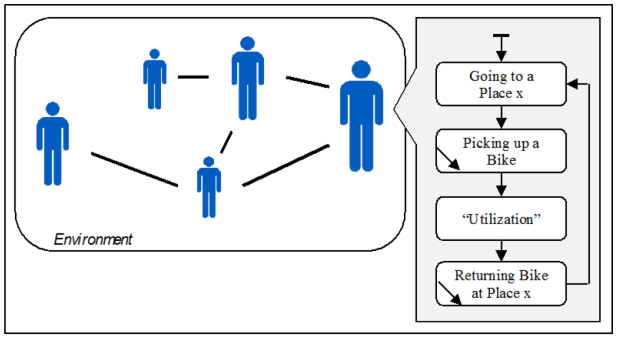

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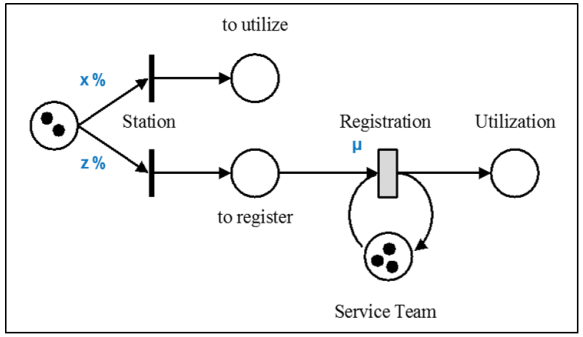
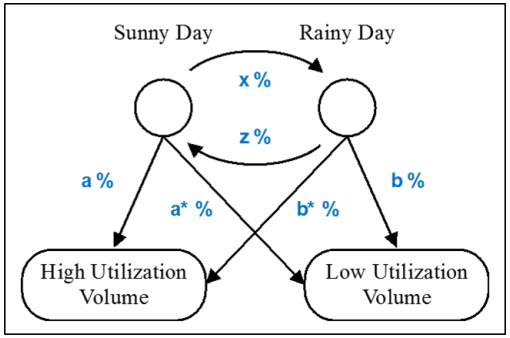
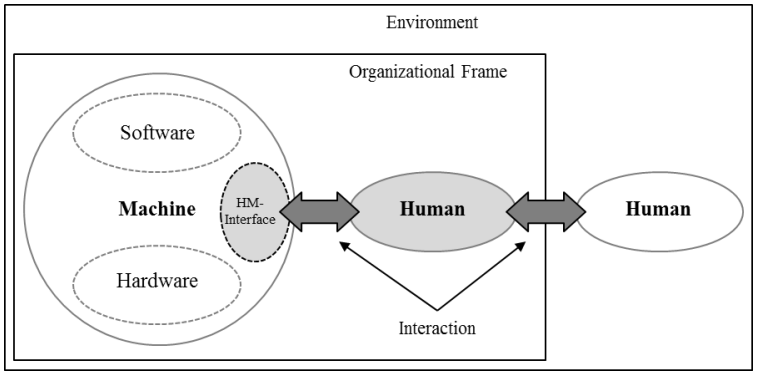


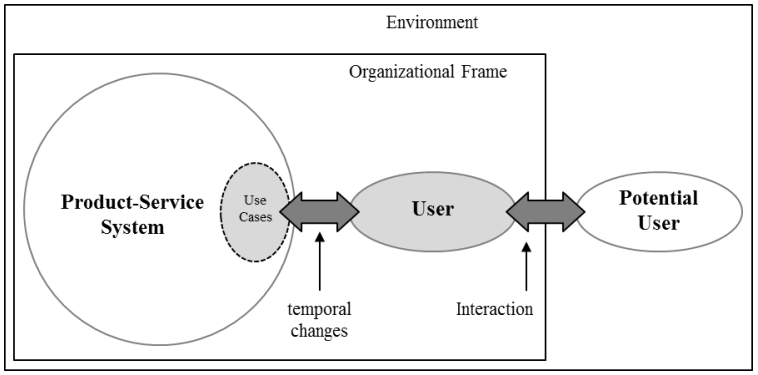
Petri Net Modeling (PN)



Bayesian Network Modeling (BN)

Important domains for modeling a PSS





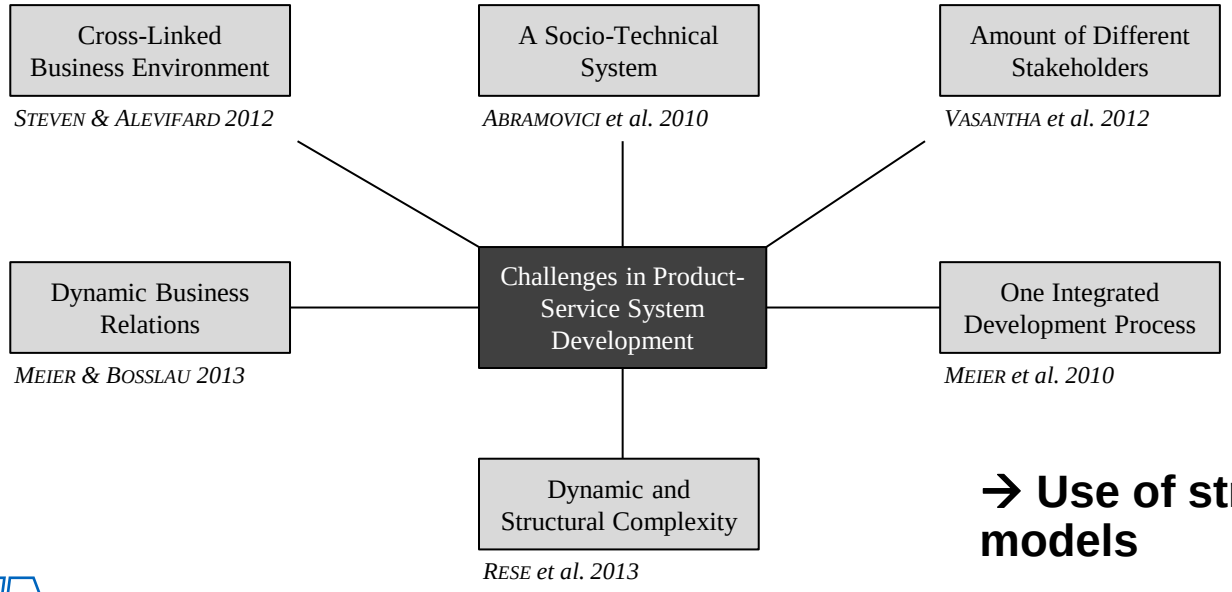
Introduction and Motivation

Definiton of a PSS

A Product-Service System is a marketable set consisting of tangible and intangible assets (product view) and is characterized by an integrated development process (process view).

ADOPTED FROM: MEIER & BOSSLAU 2013

Challenges in PSS development



→ Use of structural and dynamic models

Tipps zu Grafiken und PowerPoint

Grafikprogramme

- **Vektorbasiert** beliebig skalierbar, nicht für Fotos/Scans geeignet, sondern für Strichgrafiken, schwer zu erlernen
  - PowerPoint (auf PE-Rechner)
  - InkScape (auf PE-Rechner)
  - Visio
  - Adobe Illustrator
  - Coral Draw
- **Pixelbasiert** nur bei hinreichender Auflösung skalierbar (Druck: 300dpi), für Fotos/Scans geeignet, leicht zu erlernen
  - Paint (auf PE-Rechner)
  - Paint Shop Pro
  - Gimp (auf PE-Rechner)
  - Corel Paint
  - Adobe PhotoShop (CS2 gratis)

Alternative Präsentationsprogramme

- PDF, z.B. aus Adobe InDesign
- Latex
- Analog (Papier, Folien)
- Prezi (http://prezi.com)

Shortcuts

- F5: Startet Präsentation (mit Shift-Taste auf aktueller Folie)
- B bzw. W: Bildschirm schwarz bzw. weiß
- Foliennummer + Enter: Springt auf Folie
- Windowstaste + P, dann „Erweitert“: ermöglicht Referentenansicht ohne zweiten Bildschirm
- Windowstaste + X: Servicemenü

Checkliste zu Lehre-Folien

Vorlesungen

- **Ziele**
  - Wissen vermitteln
  - Interesse wecken
  - Lerngrundlage bieten
- **Inhalte**
  - Weiterführende Literatur
  - selbsterklärende Folien
  - Agenda, Zwischenzusammenfassungen
  - Schaubilder (Inhalte & Zusammenhänge)
  - Notizen für Vertreter
  - Schwarze Folien
  - Hervorheben wichtiger Inhalte/Schlagworte
  - (reale) Beispiele für wichtige Inhalte

Übungen

- **Ziele**
  - Aufgaben vermitteln
  - Praxisbezug herstellen
  - Wissensanwendung
- **Inhalte**
  - Wiederholung der Vorlesung (2-3 Folien)
  - Anwendbare Beispiele (Zeit & Schwierigkeit)
  - Folie für Aufgabenstellung & Lösung separat
  - Lösungsvorlage

Checkliste zu Projekt-Folien

Konferenzen

- **Ziele**
  - Ergebnisse präsentieren
  - Feedback einholen
  - Überblick verschaffen
  - Selbstdarstellung
  - Außendarstellung PE
- **Inhalte**
  - Kernergebnisse
  - Vorgehensweise
  - Motivation
  - Beitrag zur Forschung
  - Ergebnisinterpretation

Projekt(abschluss)präsentationen

- **Ziele**
  - (Zwischen)ergebnisse vorstellen
  - Mehrwert verdeutlichen
  - Vorgehen vermitteln
  - Außendarstellung PE
- **Inhalte**
  - Kernergebnisse
  - Vorgehensweise (einfach!)
  - Ergebnisinterpretation

Studienarbeiten & Dokumentationen:

Nachvollziehbarkeit gewährleisten, Argumentationsgrundlage bilden, Überblick verschaffen, Kommunikationsmittel darstellen, Einblicke geben, Unterhalten, Außendarstellung PE

Gestaltungsrichtlinien

Text

- Schriftart: Arial
- Schriftgröße 18 pt
- Überschriften **fett & PE-blau**
- elementare Begriffe über **Fettdruck** kennzeichnen
- bei Schrift im Hintergrund Designfarbe grau (linke Spalte, ganz unten) verwenden

Abbildungen

- Bilder nicht zu **megabytelastig** (Download der Studenten!!)
- Text in Abbildungen: Lesbarkeit sicherstellen!!

Gestaltungsrichtlinien

Farben

- TUM-Blau verwenden (u.a. Überschriften)

TUM-Blau RGB 0/101/189

- TUM-Akzentfarben – sparsam verwenden

Grün RGB 162/173/0	**Orange** RGB 227/114/34	**Elfenbein** RGB 218/215/203

- In Vorlage definiert unter Designfarben

Weiß RGB 255/255/255 Hintergr. 1	**Schwarz** RGB 0/0/0 Text 1	**Weiß** RGB 255/255/255 Hintergr. 2	**TUM-Blau** RGB 0/101/189 Text 2	**Grün** RGB 162/173/0 Akzent 1	**Orange** RGB 227/114/34 Akzent 2	**Elfenbein** RGB 218/215/203 Akzent 3	**Dunkelblau** RGB 0/51/89 Akzent 4	**Blau** RGB 0/115/207 Akzent 5	**Hellblau** RGB 152/198/234 Akzent 6

Gestaltungsrichtlinien

Foliengestaltung

- Folienvorlagen nutzen: „**Start**“ -> „**Neue Folie**“ -> vorbereitete Layouts
- Folieninhalte nur innerhalb der definierten Zeichnungslinien

Effekte etc.

- Möglichst einfaches Foliendesign, d.h.:
  - Keine Farbverläufe / Transparenz / Schatten
  - Keine bewegten Animationen

    Ausnahme: „Erscheinen“ von Text

Folien auf Englisch

- Vorlage auf englisch nutzen bzw. im Folienmaster ändern: Product Development