A Methodology for Simulation Development on the Basis of Cause-and-Effect Modeling in E-Commerce

Axel Hummel[1], Heiko Kern[1], René Keßler[2] and Arndt Döhler[2]

[1] Business Information Systems, University of Leipzig

[2] Intershop Communications AG

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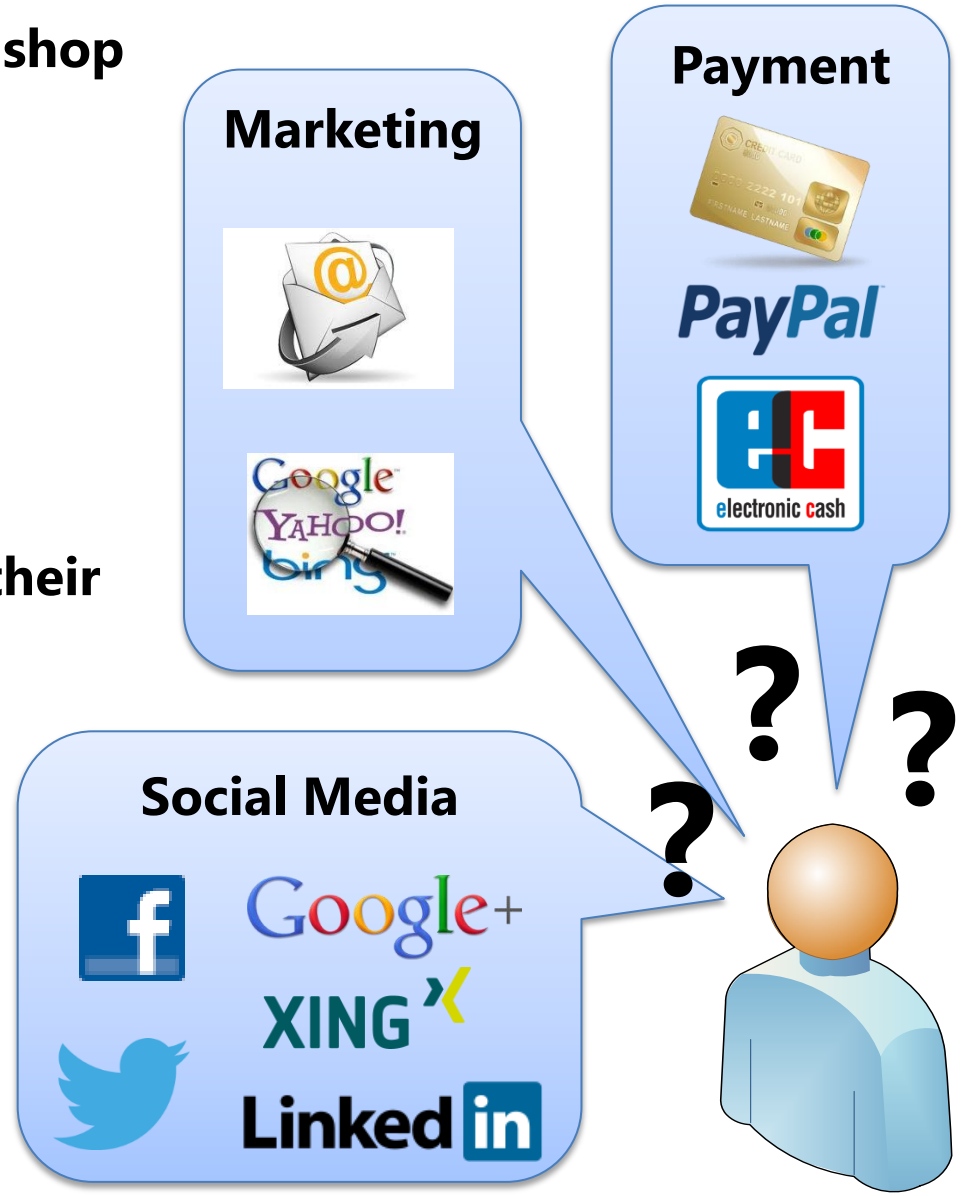
Outline

1) Introduction
2) Requirements
3) Existing methodologies
4) The SimProgno methodology
5) Conclusion

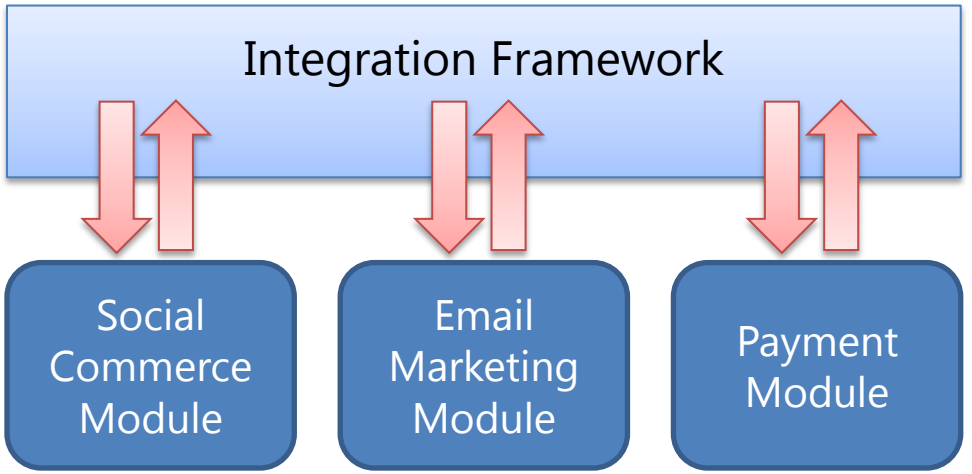
Introduction

- **Optimal configuration of an online shop is a challenging task**
  - High number of configuration parameters
  - Interdependencies between these parameters
- **Shop managers decide on basis of their expert knowledge**
  - Subjective and non-transparent decisions
  - Effects are difficult to predict



Introduction

- **Our objective**
  - Development of a simulation framework for shop managers
- **Solution**
  - Development of several simulation modules
  - Integration of simulation modules to define complex e-commerce scenarios



- **The structured development of the simulation modules requires a methodology**
  - High quality of the developed artifacts
  - Definition of responsibilities

Requirements for the SimProgno methodology

1) Involvement of domain experts

- Have domain knowledge

2) Abstraction of certain simulation techniques

- Independent of a special simulation technique

3) Usage of established methods and tools

4) Integration of simulations

- Interdependencies between the simulation modules

Existing methodologies

General methodologies

- Simulation technique-independent but too general for our purpose

System Dynamics methodologies

- Mostly specific for System Dynamics modeling
- Causal loop diagrams as abstraction of System Dynamics modeling

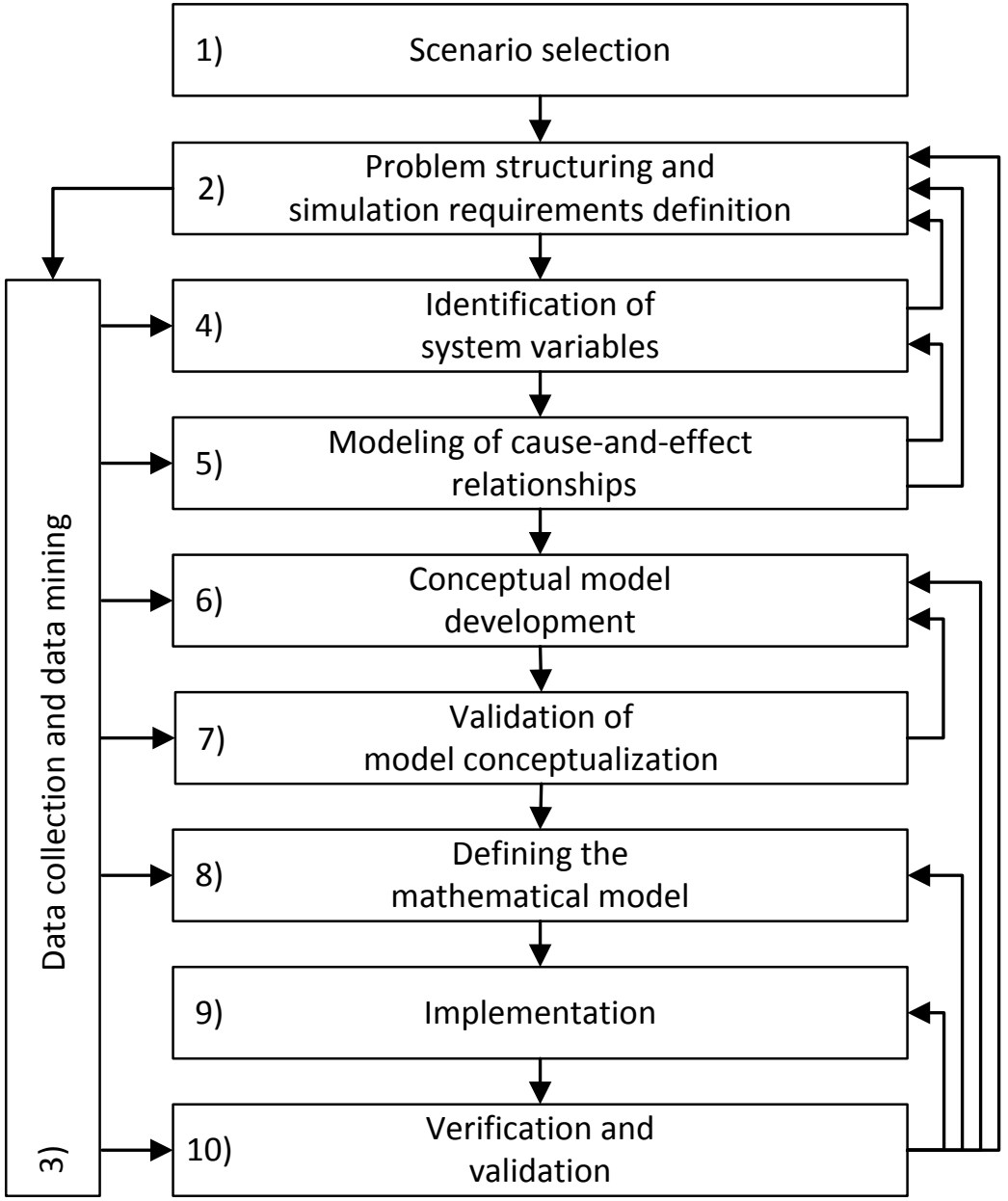
Agent-oriented methodologies

- Specific for agent-oriented modeling
- Not designed for the simulation context

General weaknesses

- No guidelines for the explicit involvement of domain experts
- No guidelines for the integration of simulation models

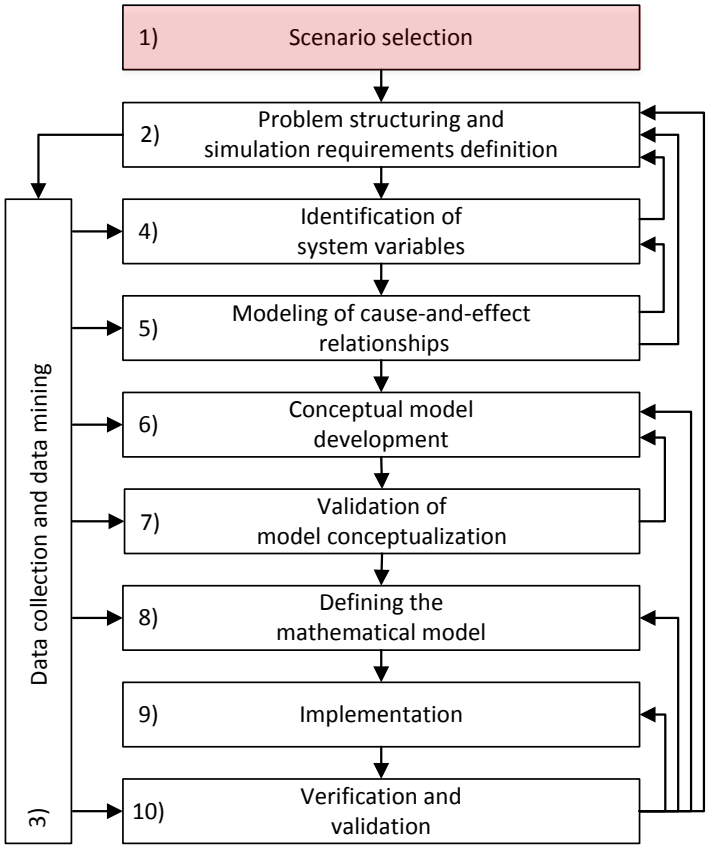
The SimProgno methodology – process steps



- **10 process steps**
- **Mostly sequential order**

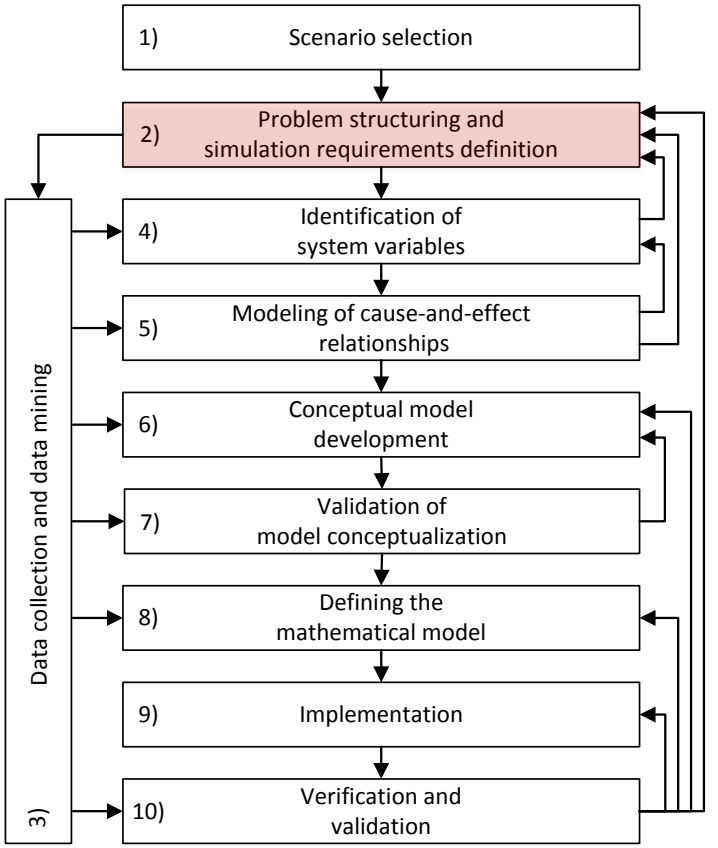
The SimProgno methodology – process steps

- **Scenario selection**
  - Identification of a relevant e-commerce scenario
  - Used approaches
    - **Online survey**
    - **Studies published by market research companies**
    - **Interviews of domain experts**



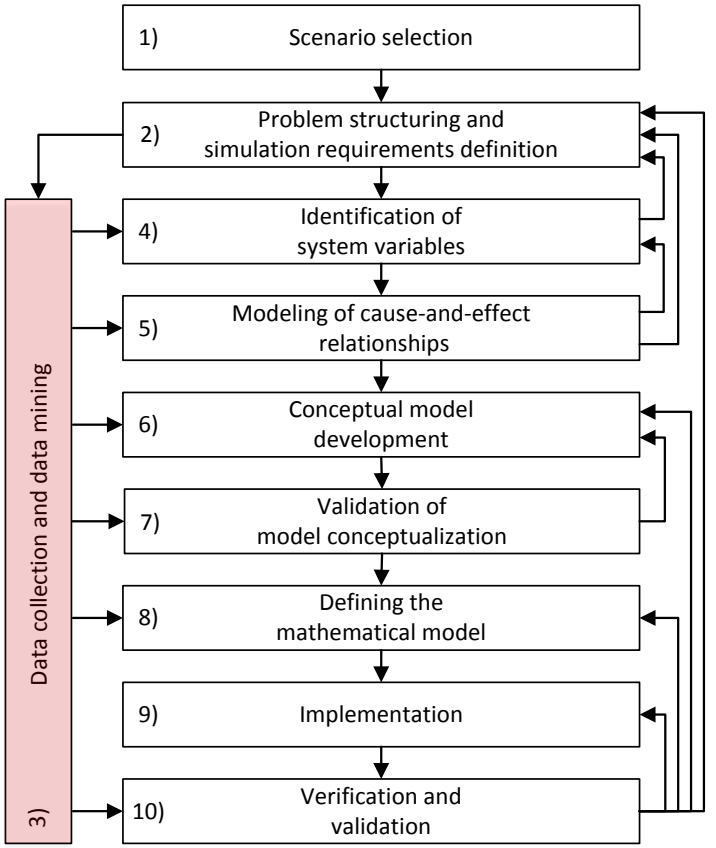
The SimProgno methodology – process steps

- **Problem structuring and simulation requirements definition**
  - Precise problem formulation
    - **Is simulation a suitable tool?**
    - **Which questions should be answered by the simulation?**
  - Workshop with domain expert



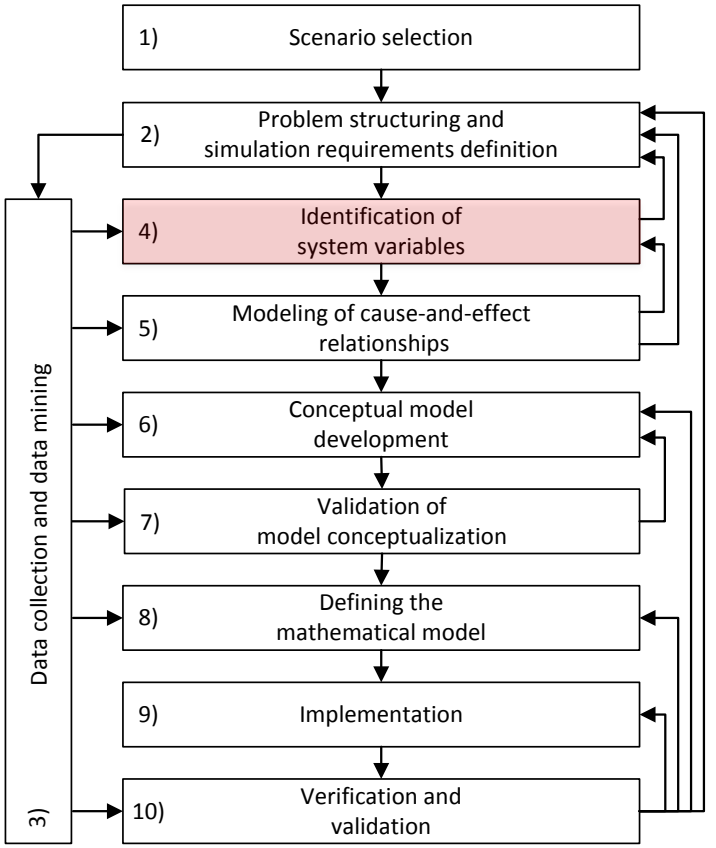
The SimProgno methodology – process steps

- **Data collection and data mining**
  - Parallel to the remaining process steps
  - Necessary for model development, model calibration and model validation
  - Data sources
    - **Related projects of the domain experts**
    - **Real transaction data of online-shops**
    - **Surveys**



The SimProgno methodology – process steps

- **Identification of system variables**
  - Expert workshops consisting of three phases
    1. **Collection**
    2. **Consolidation**
    3. **Clustering**
  - Classification of the system variables
    - **Input parameters**
      - Local and global
    - **Output parameters**
      - Local and global
    - **Auxiliary parameters**



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Number of fans

Perception probability

newsfeed impressions

Rate of active users

Clickthrough rate

Shop visits

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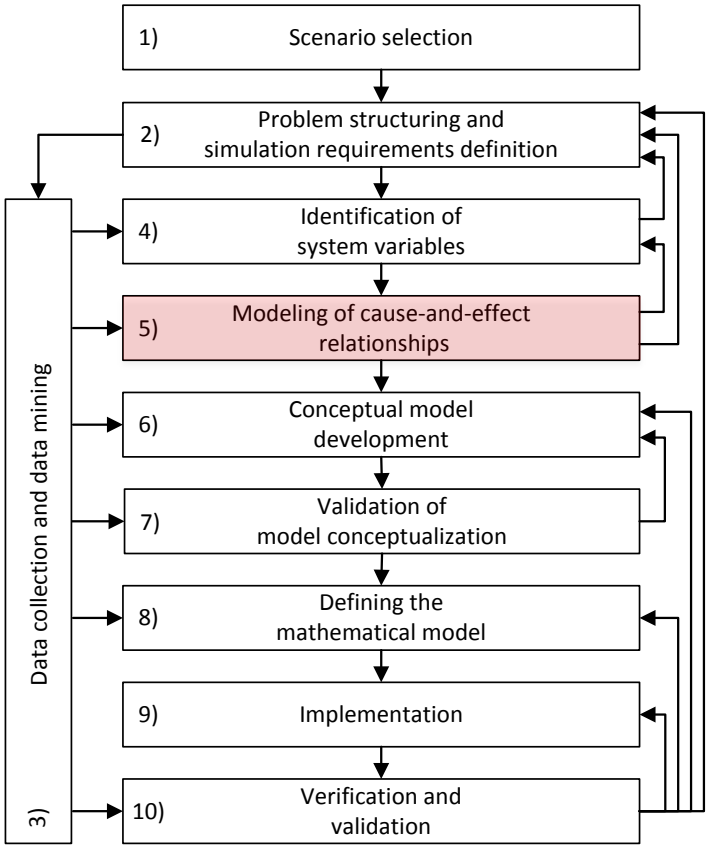
The SimProgno methodology – process steps

- **Modeling of cause-and-effect relationships**
  - Specification of a causal loop diagram
  - Third expert workshop
    - **Identification of dependencies between the system variables**
    - **Cause-and-effect specification**
    - **Detailed specification of the cause-and-effect relationships**
      - Polarity
      - temporal effect
  - Refinement of the initial causal loop diagram



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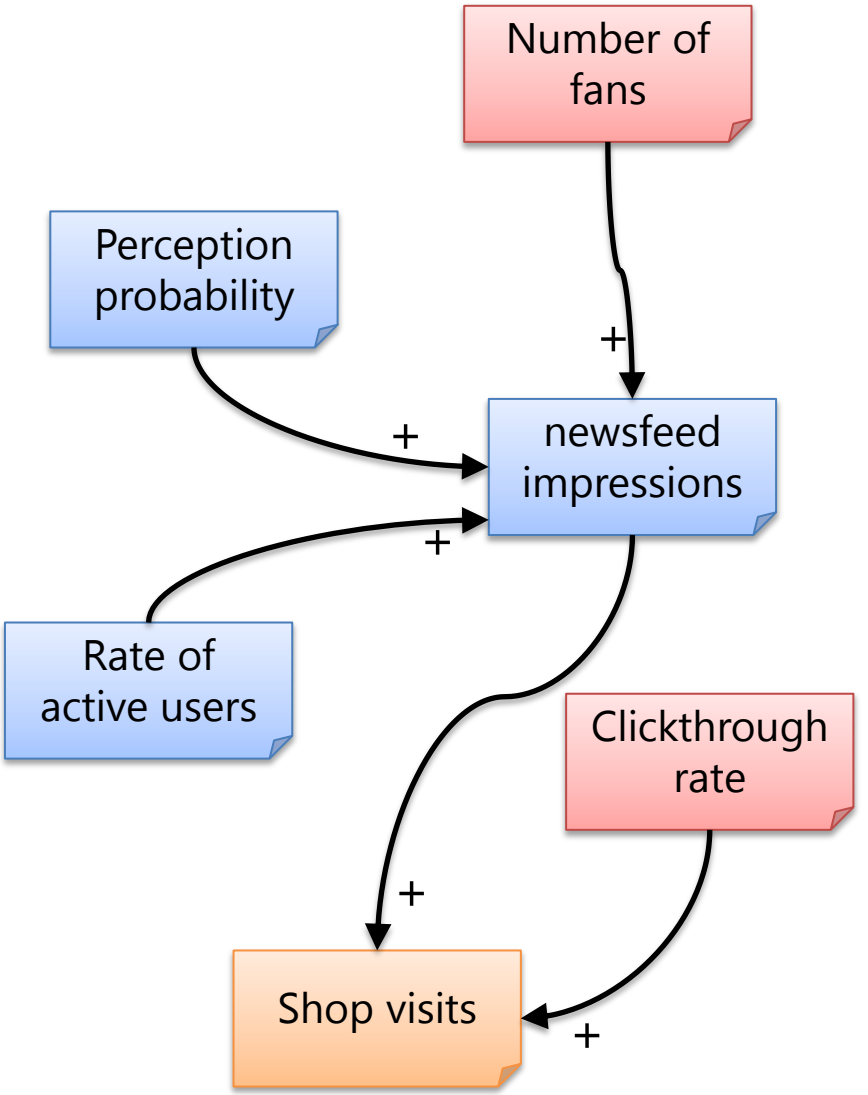
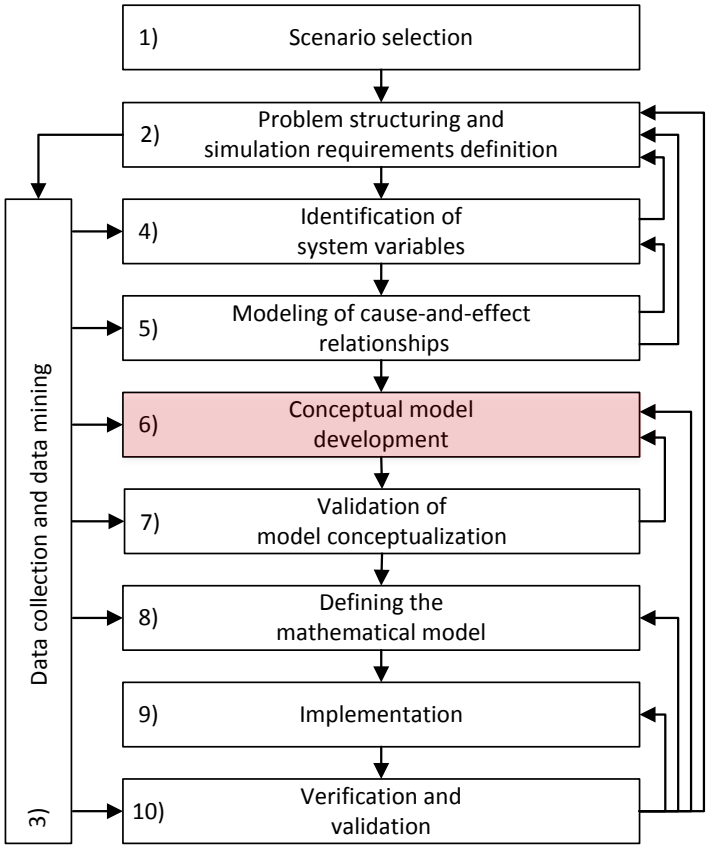


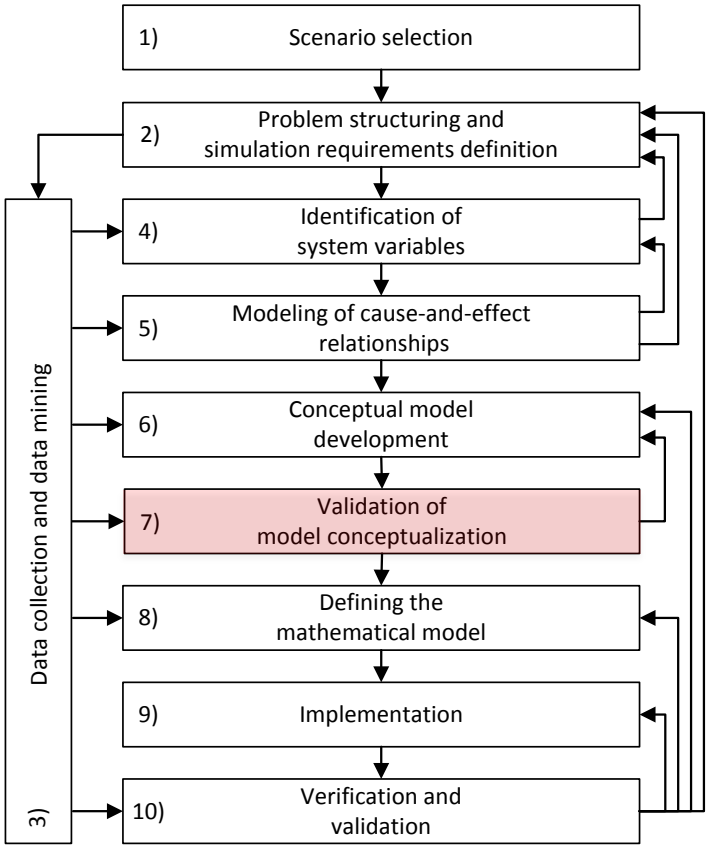
The SimProgno methodology – process steps

- **Conceptual model development**
  - Developing of a conceptual simulation model based on the cause-and-effect relationships
  - Which simulation technique is suitable?
    - **System Dynamics (SD)**
    - **Agent-based simulation (ABS)**
  - Interface specification
    - **Local input and output variables**
    - **Global input and output variables**



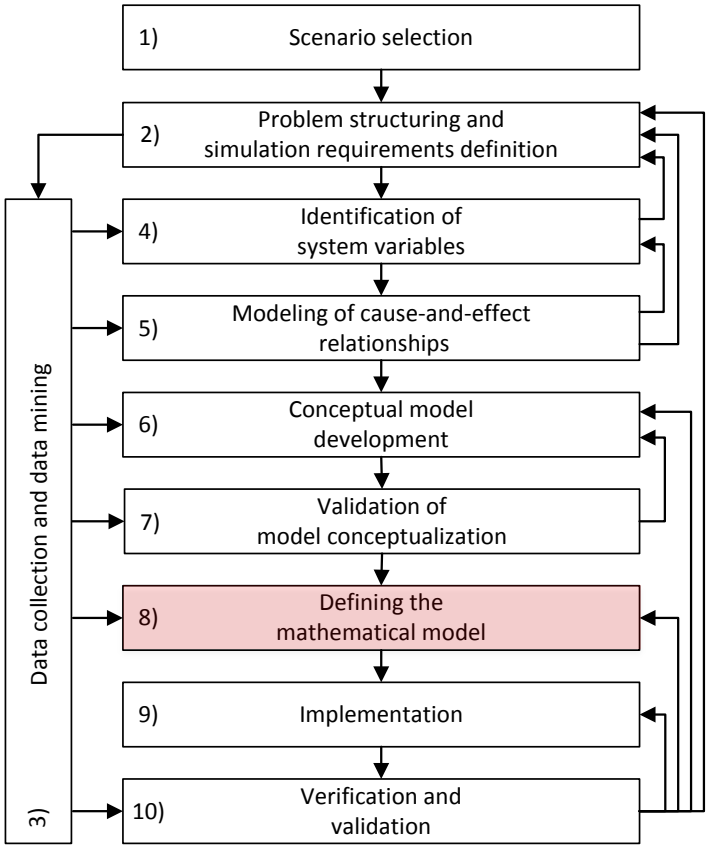
The SimProgno methodology – process steps

- **Validation of model conceptualization**
  - Workshop with the domain experts
  - Domain experts check
    - **Plausibility of the model**
    - **The specified requirements**
  - Graphical model representations
    - **Stock-and-flow diagrams (SD)**
    - **UML diagrams (ABS)**



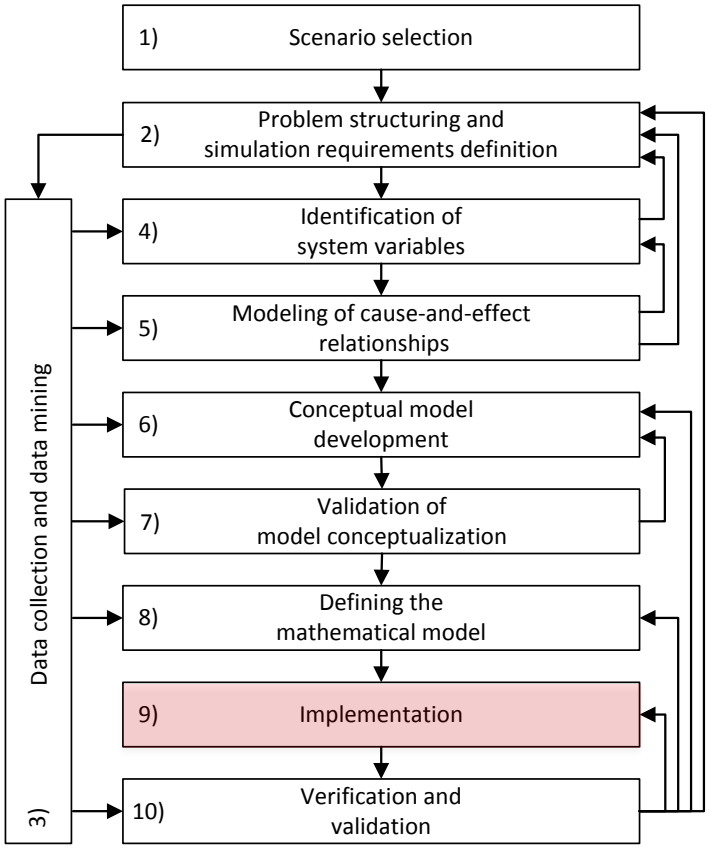
The SimProgno methodology – process steps

- **Defining the mathematical model**
  - Specification of a complete quantitative simulation model
  - The equations are based on the results of phase three



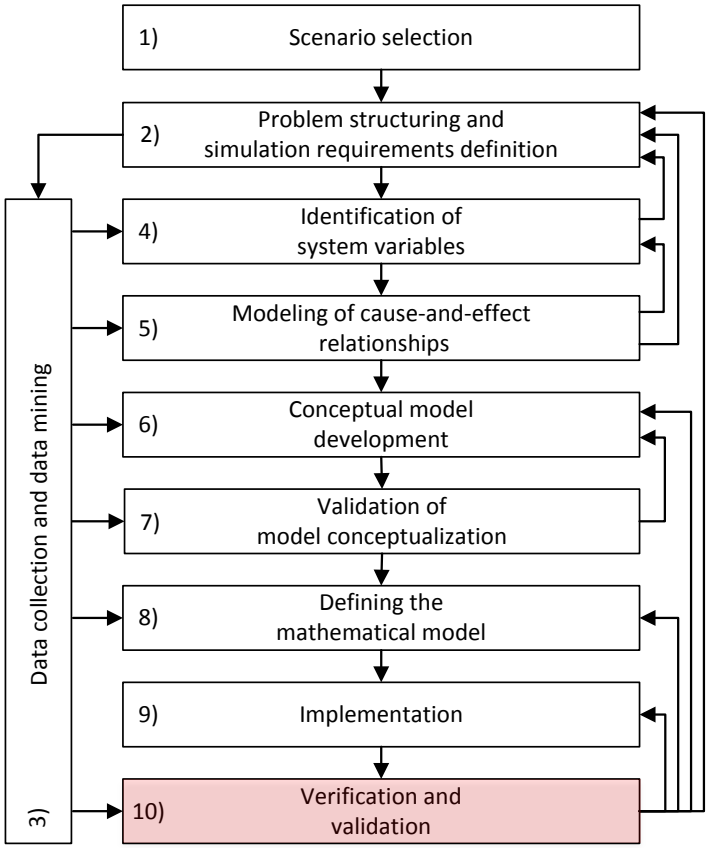
The SimProgno methodology – process steps

- **Defining the mathematical model**
  - Specification of a complete quantitative simulation model
  - The equations are based on the results of phase three
- **Implementation**
  - Model implementation using specialized tools
    - **Sphinx SD Tools (SD)**
    - **Repast Simphony (ABS)**



The SimProgno methodology – process steps

- **Verification and validation**
  - Verification
    - **Is the model implementation correct?**
  - Validation
    - **Is the simulation model correct?**
    - **Simulation experiments**
      - Input and internal parameters
      - Simulation period
      - Number of repetitions
      - Expected outputs
      - Lower and upper bounds
      - Sensitivity analysis



Conclusion

- **Fulfilment of requirements**
  - Continuous involvement of domain experts during the whole development process
  - Simulation technique-independent model description by causal loop diagrams
  - Usage of established methods and tools
    - **Creativity techniques**
    - **Causal loop diagrams**
    - **System Dynamics and agent-oriented methodologies and tools**
  - Integration of simulations
    - **Simulations are coupled together by its data flows**
    - **Classification of input and output parameters enables a stable interface specification**

Conclusion

- **General conclusion**
  - Methodology is used successfully to develop several simulations
  - Methodology and the results are accepted by the domain experts
- **Limitations**
  - Only two different simulation techniques are considered
  - Methodological framework for extending causal loop diagrams to agent-based models is missing

Thank you for your attention!

Contact information:

Axel Hummel

Business Information Systems

University of Leipzig

Johannisgasse 26

04103 Leipzig, Germany

phone: +49 341 9732360

hummel@informatik.uni-leipzig.de

http://bis.informatik.uni-leipzig.de/AxelHummel

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