Lessons Learned from an Experiment with Database Professionals

G. Banjac, D. Brdjanin, D. Banjac, S. Maric

University of Banja Luka, Bosnia & Herzegovina

Introduction

- Last several years of research in **M-lab** were devoted to **business process model-driven database design**
- During that period:
  - **Semantic capacity** of the business process models (BPMs) has been identified
  - Formal **transformation rules** have been specified
  - **Set of tools** for the automatic synthesis of the conceptual database model (CDM) has been implemented
- The **evaluation** of the approach and tools:
  - Case-study based
  - Experiment with undergraduate students
  - Experiment with professional database designers

Motivation

- Initial **case-study based evaluation** implied that the approach enables generation of the target CDM with **high percentage of completeness (>90%) and precision (>85%)**
- Results of an earlier controlled **experiment conducted with undergraduate students confirmed the initial results**
- Based on the experiences gained through the experiment with students, and in order to evaluate the approach more extensively and objectively, **an experiment with the professional DB designers was conducted**
- The **results** of the experiment with professional DB designers, as well as the **challenges and lessons learned** from the preparation and realization of the experiments, are presented here

Experiment with students

- Experiment design:
  - Experiment context:
    - **24 students** of undergraduate study program Computing and informatics at University of Banja Luka participated in the experiments
    - Students had **four assignments** (done individually) during the semester
  - Response variables:
    - **Recall** – percentage of the target CDM that is automatically generated
    - **Precision** – percentage of correctly generated concepts in an automatically generated model

Experiment with students

- Subjects, settings and assignments

	Goal	Assignment
SE-1	Compare an automatically generated CDM with a manually designed CDM for the same business system	Manually create CDM based on the collaborative BPM representing *Order processing*
SE-2	Compare an automatically generated CDM with a manually designed CDM for the same business system	Manually create CDM based on the collaborative BPM representing *E-mail voting* (BPMN spec.)
SE-3	Compare the results of the initial evaluation and the results of the students' evaluation	Evaluate the CDM that is automatically generated based on collaborative BPM representing *E-mail voting*
SE-4	Compare automatically generated CDMs with a manually designed CDMs for different business systems	Create collaborative BPM illustrating real business process and then manually create CDM based on that collaborative BPM

Results (experiment with students)

- **The average values of recall and precision for classes are very high (>95%) and slightly lower for associations (>85%)**
- **Results do not significantly differ from the initial** case-study based evaluation

Experiments	Classes		Associations	
	Recall [%]	Precision [%]	Recall [%]	Precision [%]
SE-1	96.43	100.00	88.35	92.78
SE-2	95.56	100.00	83.54	77.76
SE-3	94.45	100.00	87.47	89.98
SE-4	98.09	100.00	91.86	85.79
Mean	96.13	100.00	87.81	86.58

Experiment with DB professionals

- Experiment design:
  - Experiment context:
    - **135 candidates** have been invited to participate **voluntarily** in the experiments
    - Participants were graduate engineers with **years of practical experience** in database design and development of database intensive software systems
    - Experiment started at the end of 2016 and lasted four months
    - During the experiment the participants finished **two assignments** each
    - Each assignment was done **individually**

Category	Number
Total number of candidates invited to participate in the experiment	135
Total number of candidates who expressed consent to participate	67
Total number of candidates who expressed conditional consent to participate	28
Total number of candidates who did not agree to participate	14
Total number of candidates who did not respond to the invitation for participation	26

Experiment with DB professionals

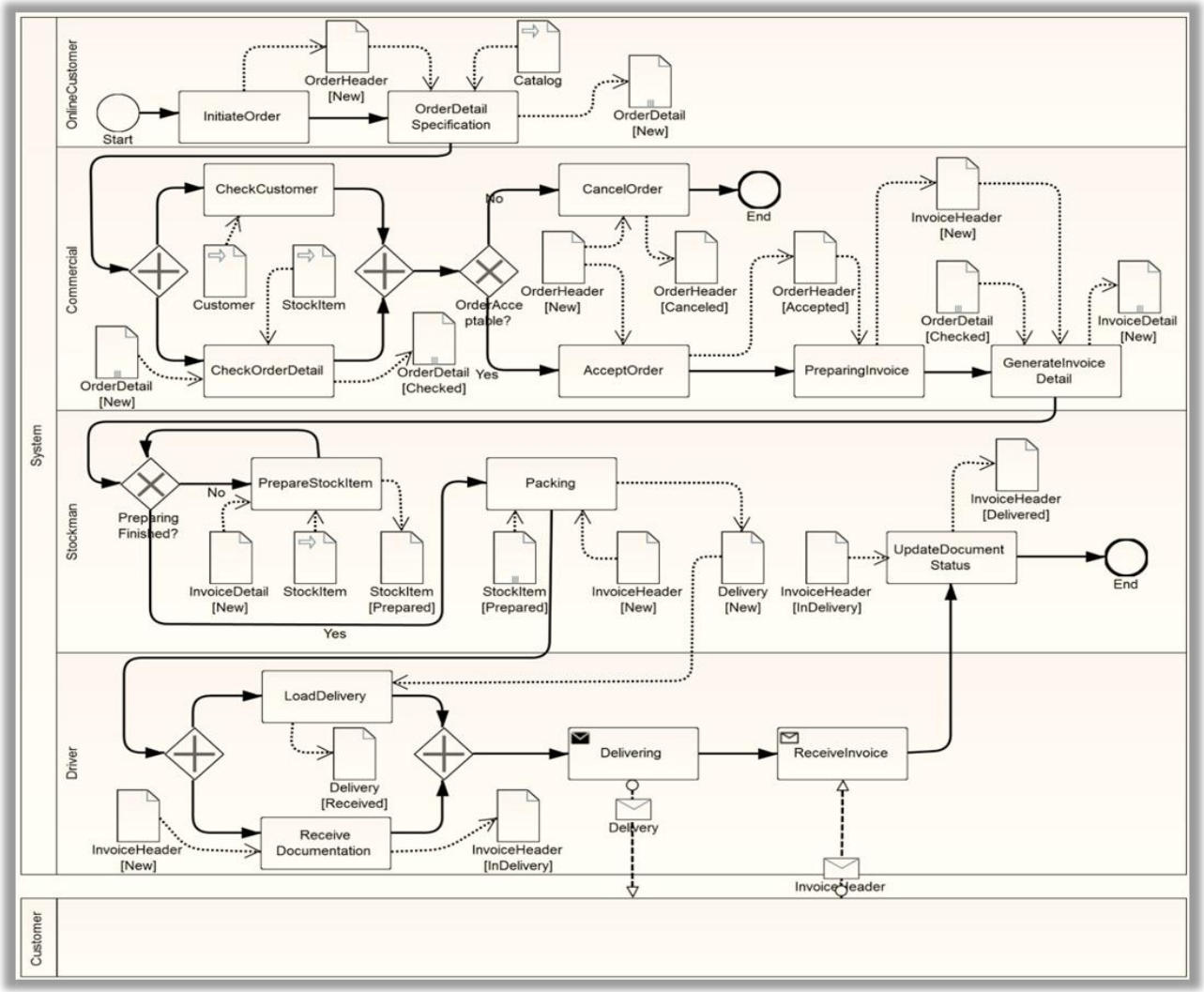
- Experiment #1 (PE-1):
  - The **first phase**:
    - Participants **manually designed CDMs based on the BPMN model**
    - All manually designed CDMs and evaluation forms were **reviewed by at least two teachers**
  - The **second phase**:
    - Participants were invited to **evaluate** their **manually designed CDMs against the automatically generated CDM**
- Experiment #2 (PE-2):
  - Participants **manually designed CDMs based on the same BPMN model**, but they used **automatically generated CDM as a starting point**
  - Participants were invited to **evaluate** their **manually designed CDMs against the automatically generated CDM**
  - The same experiment was also conducted with a **control group** (CG)

PE-1	
Invited candidates:	**95**
Participants:	**31**

PE-2 (CG)	
Invited candidates:	**36 (59)**
Participants:	**23 (8)**

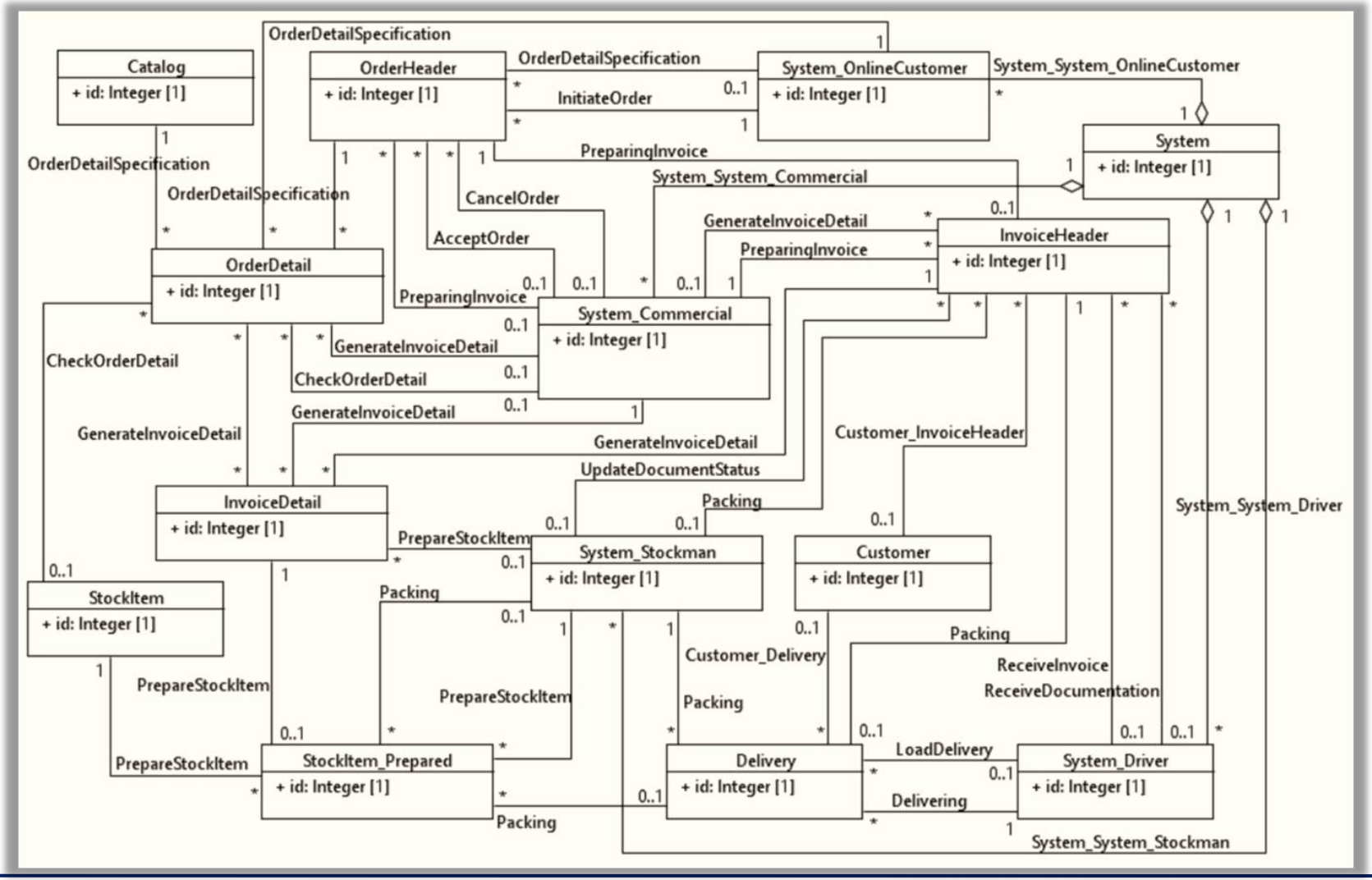
Experiment with DB professionals

- **Source model** (collaborative BPM represented by **BPMN**)



Experiment with DB professionals

- Automatically generated **CDM** (represented by **UML class diagram**)



Results (experiment with DB professionals)

- The results of the evaluation of **automatically generated classes** in PE-1 and PE-2:

Average metrics and measures	PE-1	PE-2 (CG)
Number of classes in manually designed CDMs	12.80	12.00 (12.13)
Number of matching classes in manually designed CDMs and automatically generated CDM	8.80	10.52 (10.75)
Number of missing classes in automatically generated CDM	3.73	1.52 (1.38)
Number of excessive classes in automatically generated CDM	4.33	3.43 (3.25)
Recall [%]	76	89 (88)
Precision [%]	68	76 (77)

Results (experiment with DB professionals)

- The results of the evaluation of **automatically generated associations** in PE-1 and PE-2:

Average metrics and measures	PE-1	PE-2 (CG)
Number of associations in manually designed CDMs	17.30	22.05 (26.38)
Number of matching associations in manually designed CDMs and automatically generated CDM	11.33	18.05 (21.38)
Number of incorrect associations in automatically generated CDM	2.61	2.71 (1.75)
Number of missing associations in automatically generated CDM	5.43	2.95 (4.75)
Number of excessive associations in automatically generated CDM	18.83	16.10 (14.13)
Recall [%]	71	83 (83)
Precision [%]	85	89 (91)

Results (experiment with DB professionals)

- **Experiment PE-1:**
  - **Recall and precision** are lower in comparison with PE-2 and similar students' experiment SE-1
  - **These measures are still high (around or above 70%)**
  - Participants evaluated all excessive classes as incorrect in both experiments
- **Experiment PE-2:**
  - **Average recall is above 80% (for classes 90%)**
  - **Average precision for classes is above 75%**
  - **Average precision for associations is almost 90%**
  - **Very high results matching with the control group**

Results (experiment with DB professionals)

- The experiment confirms that the automatically generated CDM can also be **efficiently used as a starting point for manual design** of the target CDM, since it **significantly shortens the time** required for CDM design
- Participants **self-evaluation** in PE-1 and PE-2:

Average metrics	PE-1	PE-2	(CG)
Experience in database design [years]	7.19	5.96	(5.50)
Level of expertise in database design [1-5]	3.42	3.39	(2.83)
Level of expertise in BPMN modelling [1-5]	2.33	2.43	(1.67)
Estimated time required for manual CDM design [hours]	5.75	2.07	(2.00)
Time spent for manual CDM design [hours]	4.54	1.89	(2.50)

Challenges and lessons learned

- Much **more challenging and demanding** than the experiment conducted with students
- **Participants:**
  - No established community of professionals of the appropriate profile
  - Candidates were distributed in a large number of companies
- **Communication:**
  - Mostly done by email
    - Individual emails included additional assignment clarifications, reception of manually designed models and completed questionnaires
    - Group emails for delivering assessment, questionnaires and reminders

Challenges and lessons learned

- **Time slots and deadlines:**
  - Experiment took more time than estimated
  - Professional obligations and overload of the participants
  - Experiment was carried out in a period of four months around New Year
- **Participants' feedback** about the automatically generated CDM:
  - Many participants were fascinated with the completeness and correctness of the generated CDM
  - Although the significant percentage of generated associations were evaluated as excessive, many participants emphasized that the large majority of the redundant associations are correctly generated and are not unsuitable in the CDM

Conclusion and future work

- Results of the **experiments with professional DB designers confirm the results of the initial case-study based evaluation**, as well as the results obtained in the experiment conducted with students
- The experiment implies that the approach enables generation of the majority of concepts of the target conceptual model with a **very high percentage of completeness and precision**
- The experiment also confirms that the automatically generated CDM can also be **efficiently used as a starting point for manual design** of the target CDM
- The experiences gained through this experiment will be of great help in the **next experiment(s)** we plan to conduct **with DB professionals using** our new tool – **AMADEOS** (an online system for automated model-driven database design)

http://m-lab.etf.unibl.org:8080/amadeos

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Thank You!