An Agent-Based Simulation of Payment Behavior in E-Commerce

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Outline

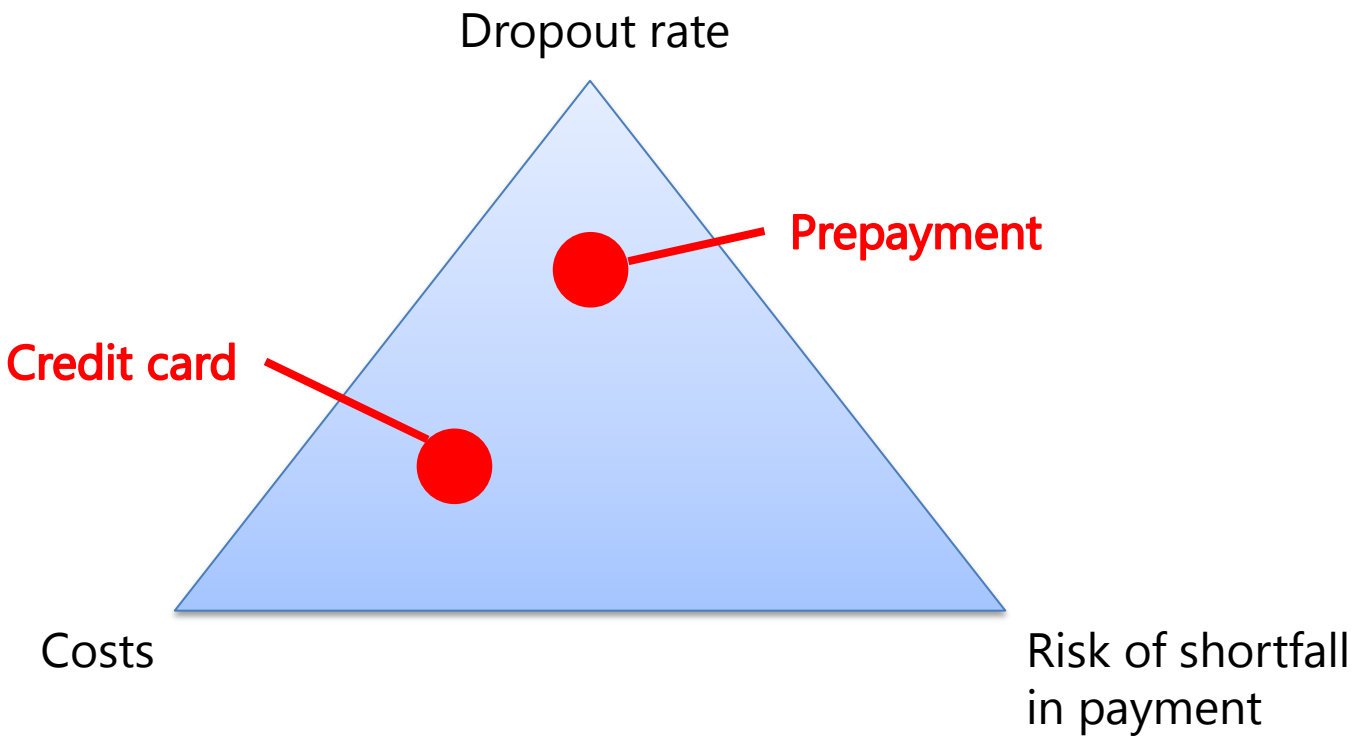
1) Introduction and problem motivation
2) Simulation model
3) Evaluation of the simulation results
4) Validation of the simulation
5) Conclusion

Introduction

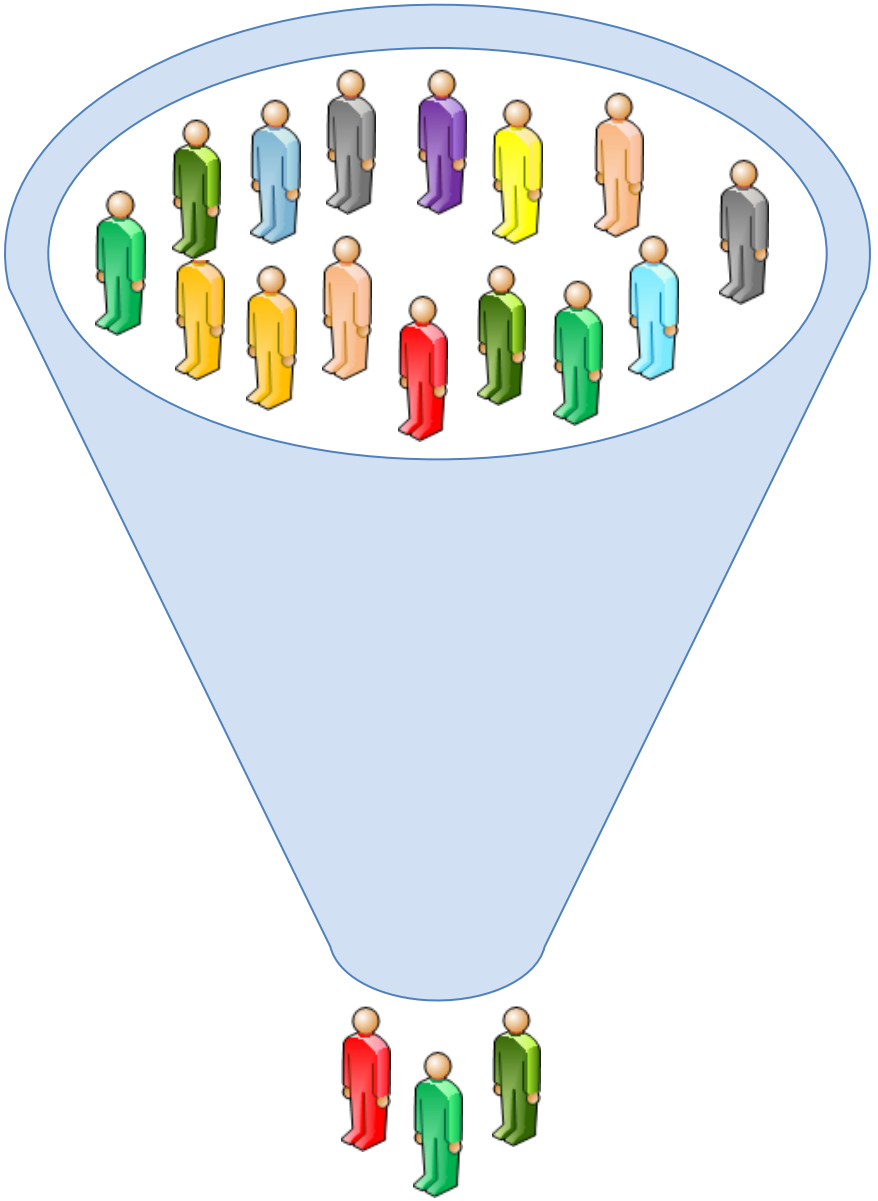
- **Current situation**
  - E-commerce is an important channel of distribution in order to sell products or provide services
  - Business and consumers (B2C): online store
  - Success depends on an optimal configuration of different aspects (shop layout, marketing activities, available payment methods, …)
- **Problem**
  - Optimal configuration requires knowledge about
    - **Interdependency between configuration parameters**
    - **Impact of the parameters within the e-commerce ecosystem**
  - Store managers decide on basis of their expert knowledge

Configuration of payment methods

- **Unsolved question**
  - How many payment methods should be offered in an online store?
  - Which are the best payment methods?
- **Aspects of payment methods**

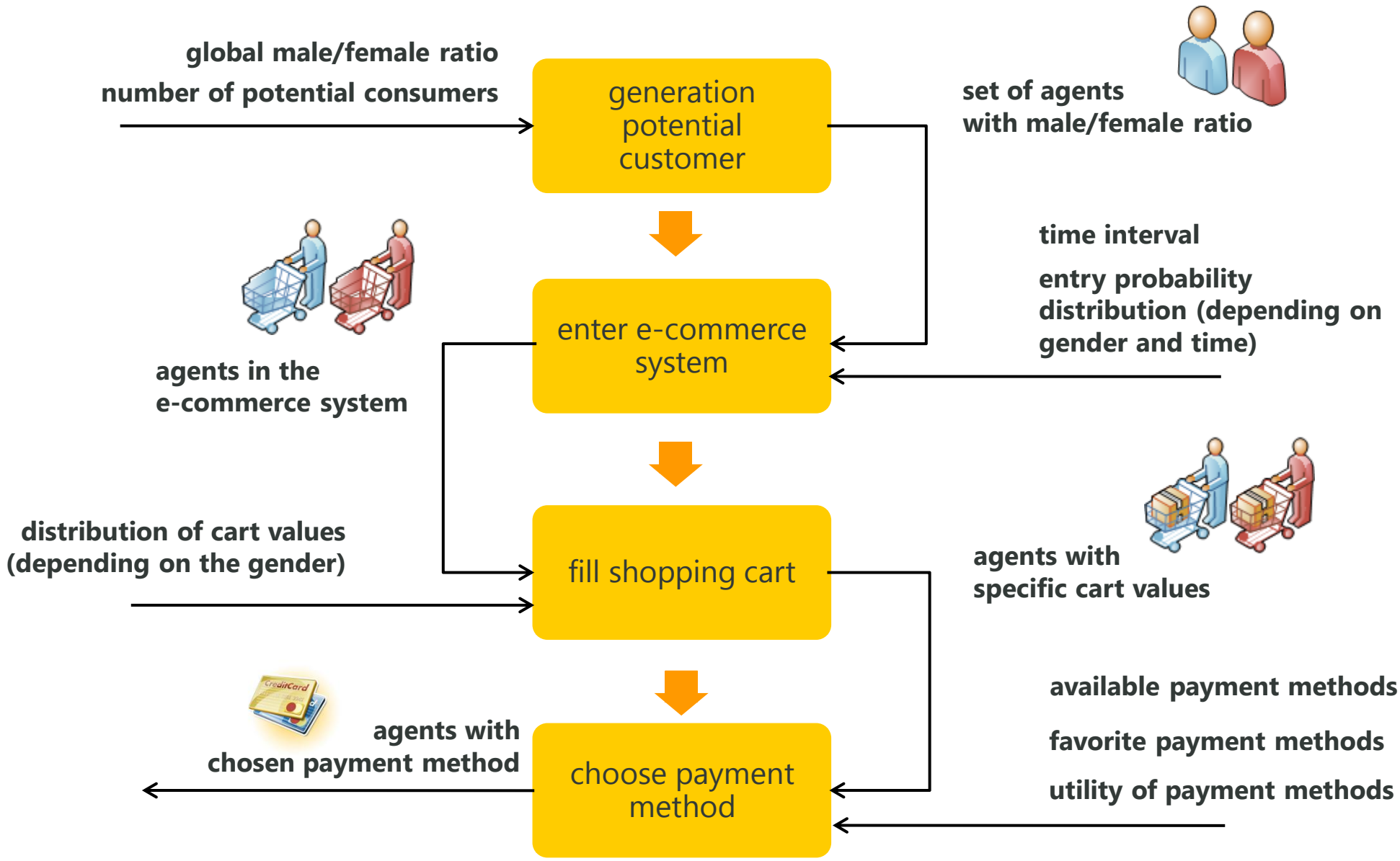


General workflow in online stores



- Enter online store
- Search and find
- Fill shopping cart
- Buy

Overview of the shopping simulation



Simulation of the payment behavoir

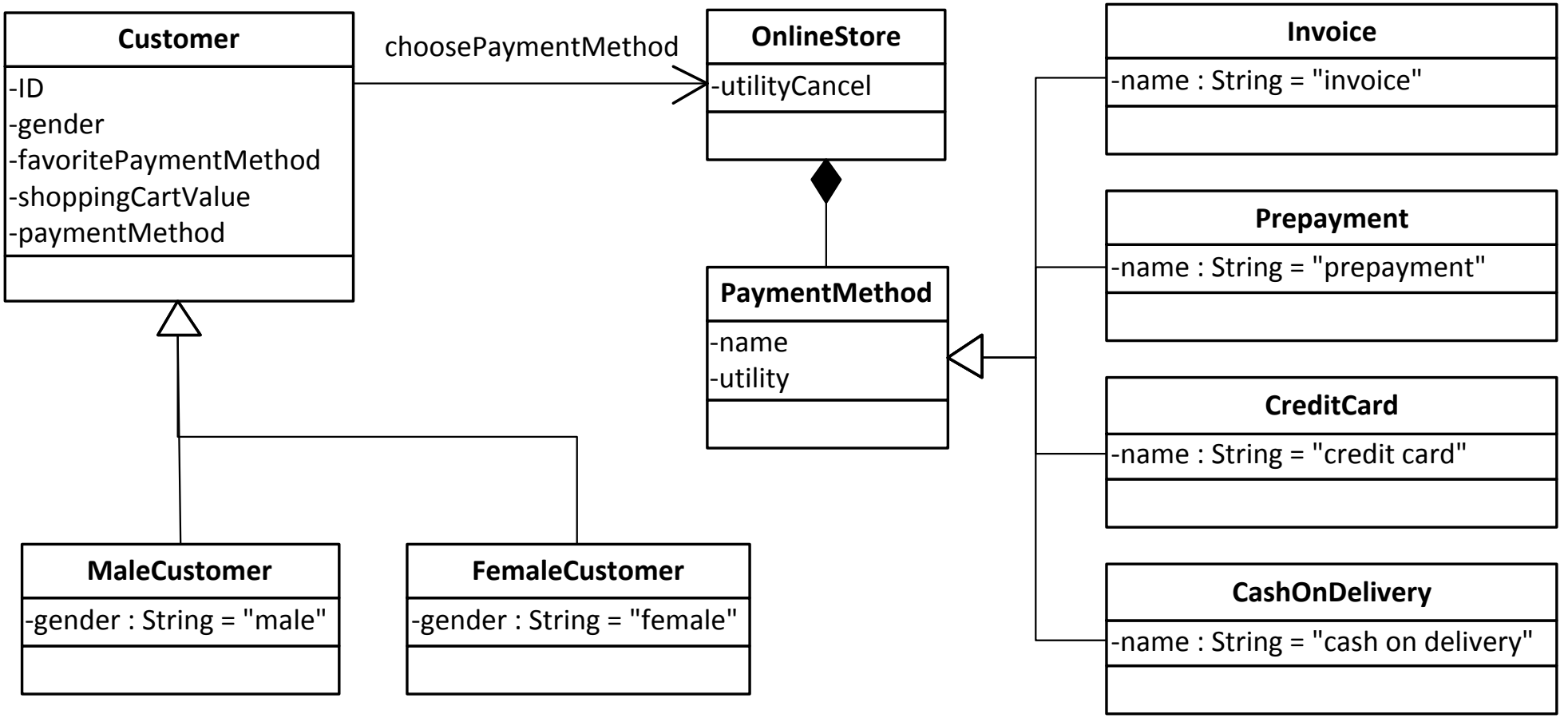
- **Simulation objective**
  - Reproduce the payment behavior of customers
- **Two possible scenarios**
  1) Disable an existing payment method
  2) Add a new payment method
- **We will focus on the first case!**
- **Practical relevance of scenario one**
  - Complete deactivation of the payment method (high costs, fraud cases, …)
  - Customer dependent availability of payment methods (scoring, value of the shopping cart)

Underlying assumptions of the payment behavior

– **The simulation model is based on the following assumptions:**

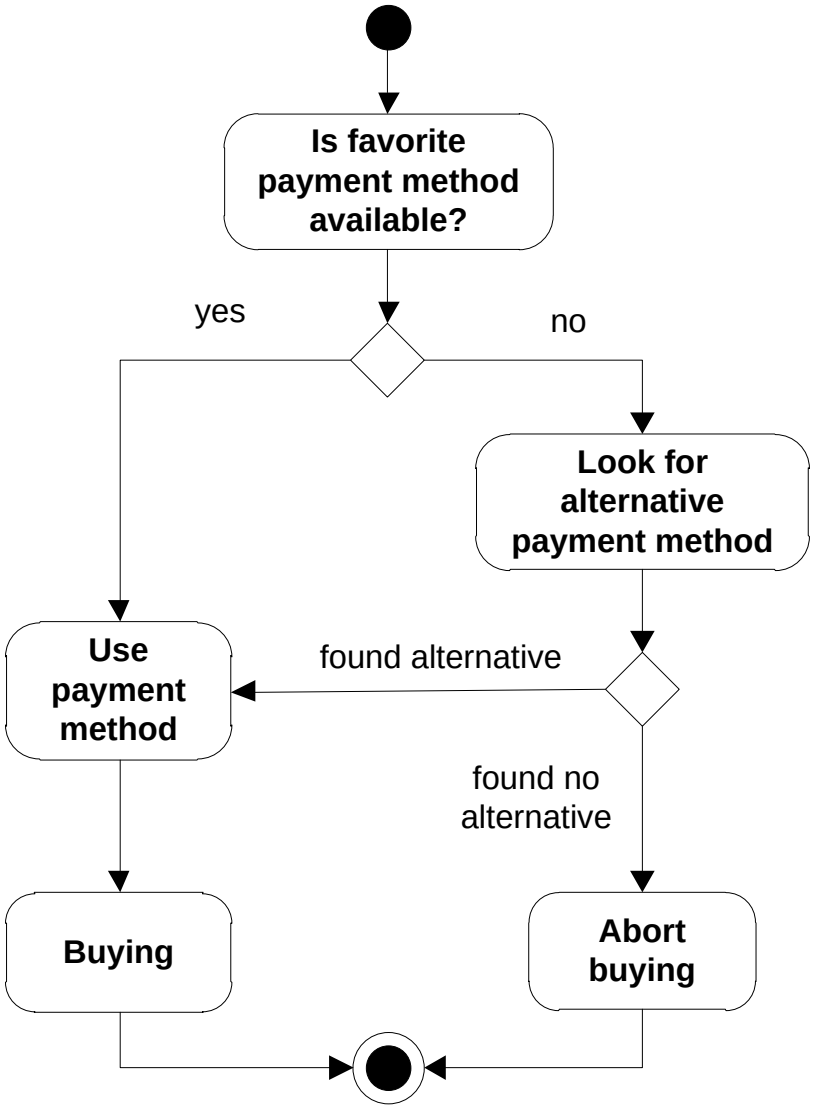
1. Every customer has a favored payment method.
2. If the favored payment method of a customer is available in the online store, then the customer will choose this payment method.
3. The favored payment method of a customer depends only on the customer's gender.
4. In a first step, we consider four payment methods, namely invoice, prepayment, credit card and cash on delivery.

The customer agent and its environment



Simulation of the payment decision

Behavior of the customer agent



If favorite payment method is available?

- **Yes:**
  - Payment method = favorite payment method
- **No:**
  - Calculate probability $\overline{\boldsymbol{P}}(P_i)$ for each alternative P_i(payment method or cancel):

$$\overline{\boldsymbol{P}}(P_i) = \frac{utility\ (P_i)}{\sum_{i=1}^{n} utility(P_i)}$$

$utility\ (P_i)$ = utility of alternative P_i

  - Decide on basis of the probabilities

Calibration of the simulation model

- **Gender ratio: 23% female and 77% male based on [Krabichler08]**
- **Ratio $r(P_i)$ of the several payment methods ($r(P_i) = fav_f(P_i)/fav_m(P_i)$)**

Invoice	Prepayment	Credit Card	Cash on Delivery	Cancel
1.20	0.66	0.52	0.53	1

- **Probability distribution of the favorite payment method [Krabichler08]**

Gender	Invoice	Prepayment	Credit Card	Cash on Delivery	Cancel
neuter	0.65	0.04	0.23	0.03	0.05
male	0.62	0.04	0.26	0.03	0.05
female	0.77	0.03	0.13	0.02	0.05

- **Utility of payment methods based on [Rodenkirchen11]**

Invoice	Prepayment	Credit Card	Cash on Delivery	Cancel
0.96	0.09	0.29	0.12	0.3

Simulation results

Config.	P1	P2	P3	P4		P1	P2	P3	P4	Cancel
1	0	0	0	0		-	-	-	-	1.00
2	1	0	0	0		0.88	-	-	-	0.12
3	0	1	0	0		-	0.24	-	-	0.76
4	0	0	1	0		-	-	0.59	-	0.41
5	0	0	0	1		-	-	-	0.28	0.72
6	1	1	0	0		0.84	0.06	-	-	0.10
7	1	0	1	0		0.69	-	0.24	-	0.07
8	1	0	0	1		0.84	-	-	0.05	0.11
9	0	1	1	0		-	0.13	0.52	-	0.35
10	0	1	0	1		-	0.19	-	0.23	0.58
11	0	0	1	1		-	-	0.52	0.14	0.34
12	1	1	1	0		0.67	0.04	0.23	-	0.06
13	1	1	0	1		0.81	0.05	-	0.04	0.10
14	1	0	1	1		0.67	-	0.24	0.03	0.06
15	0	1	1	1		-	0.11	0.47	0.13	0.29
16	1	1	1	1		0.65	0.04	0.23	0.03	0.05

- **Number of customers:**
  - 100 000
- **Execution:**
  - 10 times

P1= invoice

P2= prepayment

P3= credit card

P4= cash on delivery

Evaluation of the simulation results

- **If |payment methods| ↑, then cancel ↓**
  - |payment methods| = 1, cancel = 50 %; |payment methods| = 2, cancel = 26 %

    |payment methods| = 3, cancel = 13 %; |payment methods| = 4, cancel = 5 %
- **Purchase on invoice has the highest rate of acceptance**
- **Cancel (invoice): 12 % <**

  Cancel (prepayment, credit card, cash on delivery): 29 %
- **Adding of a new payment method does not always reduce the dropout rate (Config. 6, Config. 13)**
- **One payment method can substitute another (Config. 12, Config. 14)**

Validation (reference values based on [Krabichler08])

Config.	P1	P2	P3	P4		Δ(P1)	Δ(P2)	Δ(P3)	Δ(P4)	Δ(Cancel)
1	0	0	0	0		-	-	-	-	0
3	0	1	0	0		-	0.03	-	-	0.03
6	1	1	0	0		0	0	-	-	0
9	0	1	1	0		-	0.02	0.01	-	0.01
10	0	1	0	1		-	0	-	0	0
13	1	1	0	1		0.01	0.01	-	0	0
16	1	1	1	1		0	0	0	0	0

absolute error Δ

Config.	P1	P2	P3	P4		δ(P1)	δ(P2)	δ(P3)	δ(P4)	δ(Cancel)
1	0	0	0	0		-	-	-	-	0 %
3	0	1	0	0		-	14 %	-	-	4 %
6	1	1	0	0		0 %	0 %	-	-	0 %
9	0	1	1	0		-	18 %	2 %	-	3 %
10	0	1	0	1		-	0 %	-	0 %	0 %
13	1	1	0	1		1 %	17 %	-	0 %	0 %
16	1	1	1	1		0 %	0 %	0 %	0 %	0 %

relative error δ

P1= invoice

P2= prepayment

P3= credit card

P4= cash on delivery

Conclusion

- **Agent-based simulation technique is applied to model the payment behavior of customers**
- **Benefits of the agent-based paradigm**
  - Natural way to model the behavior of customers (bottom-up)
  - Supports the iterative approach
- **Limitations**
  - Mapping from aggregated data to the agent properties is required
  - Problems with scalability
- **Simple simulation model with some weaknesses**
  - Limited number of payment methods and influencing factors
  - Adding of a new payment method can not be simulated

References

[Krabichler08] Krabichler, Thomas; Wittmann, Georg; Stahl, Ernst; Breitschaft, Markus: Erfolgsfaktor Payment—Der Einfluss der Zahlungsverfahren auf Ihren Umsatz (German): ibi research an der Universität Regensburg GmbH. (2008).

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Thank you for your attention!

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