

Mixed Intention Sets in Dialogue Planning

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Abstract: Non-collaborative dialogues are characterized by congruent and incongruent, partly conflicting intentions, that means mixed intention sets of the participants. Such dialogues are challenging for a number of reasons when supported by dialogue systems. We introduce a model of *Situated Dialogue Action (SAM)* that represents system-supported dialogues between multiple participants with mixed intention sets triggered by non-collaborative dialogue situations. Selected parts of SAM are instantiated by means of a Question-Answering (QA) system. We discuss our findings due to the instantiation in a QA setting and gave implications for future work.

1 Introduction

Do you remember your last dialogue? Perhaps, this dialogue was of collaborative nature, i.e., all dialogue partners had a shared intention for participating in the dialogue, e.g., when cooking a meal together. More likely, it was a non-collaborative dialogue characterized by congruent and incongruent, partly conflicting intentions, that means mixed intention sets of the participants. Such non-collaborative dialogues represent the main part of everyday dialogues and dominate the daily communication between people, e.g., in meetings as well as healthcare, sport or sales situations. Dialogue systems face diverse challenges when supporting such non-collaborative dialogues in real world environments. First, mixed intention sets of the participants lay stress on the explicit handling and processing of intentions within dialogue planning. In this context, environmental effects on the diversification of intentions during dialogue need to be considered. Second, when technically supporting non-collaborative interaction, dialogue systems take the role of representatives for indirect, absent human participants, e.g., dialogue systems can be used in online shopping situations as substitutes for sales personnel. Although, dialogue systems adopt intentions of absent participants and create strategies for satisfying these adopted intentions. Third, human participants in non-collaborative dialogues are able to balance individual and anticipated intentions of other participants during dialogue. Therefore, mixed intention sets should be satisfied [MS58] within dialogue planning for gaining non-collaborative dialogues perceived as fair in the sense of utility by all dialogue participants. These challenges will be addressed by applying an explicit representation of mixed intention sets embedded in a model of *Situated Dialogue Action (SAM)*. The model enables the explicit handling

and processing of intentions as well as related dialogue actions in dialogue planning. Furthermore, non-collaborative dialogues with mixed intentions sets are considered from a game-theoretic perspective, i.e., non-collaborative dialogues are considered successful if all dialogue partners perceive the final result as sufficiently fair.

Our overall objective is the investigation of dialogue systems that support non-collaborative dialogues covering mixed intention sets and that achieve fair outcomes for all participants (cf. appendix A). In this work, we will focus on challenges in planning of non-collaborative dialogues. Therefore, the contribution of this paper is an approach for situated dialogue action considering mixed intention sets in non-collaborative dialogues.

The paper is organized as follows. We will discuss related work in Sec. 2. Afterwards, the *Situated Dialogue Action Model (SAM)* is introduced (Sec. 3). Next, the exemplary instantiation of parts of the model is described by means of a Question-Answering system in the retail domain (Sec. 4). Finally, we discuss our findings and provide an outlook on future work in Sec. 5 before summarizing the results of this contribution in Sec. 6.

2 Related Work

We consider congruent and incongruent intentions in dialogues; but what does intention mean in general? Intention is intending to do something in the future. Therefore it is a mean for coordination of agents plans [AI190, CL90]. Cohen & Levesque (1990) consider intention as a composite concept consisting of choice and commitment that is valid as long as the conditions remain constant [CL90]. Regarding related work on psycholinguistics, multi-agent systems, computer linguistics, AI as well as philosophy and cognitive science, two main research issues can be identified that are relevant for this contribution. First, sophisticated approaches for representing actor intentions and their relationships to environmental components, i.e. situational circumstances as well as mechanisms for processing these relationships are missing [KP93, PBL05, CL90, SA91, AI190]. Second, the intention-based handling of communicative situations is insufficient. Georgeff et al. (1998) [GPP⁺98] declare missing mechanisms for explicit handling of intention models in interactions between multiple agents. Furthermore, the absence of learning processes for enabling an adaptation to new situations based on intention models is mentioned [GPP⁺98]. Furthermore, non-collaborative dialogues were rarely considered in the context of dialogue planning [MP93, GS86, McK85, MT86, Hob78] and the processing of mixed intention sets in dialogues and interaction in general [Man02, Loc98, GK93, Sea90, CCC00, Sea69]. [ARM⁺00] presents embodied conversational agents in simulated non-collaborative sales conversations but focuses on personality factors without directly addressing the user. In the field of multi-agent systems, approaches for non-collaborative interaction are considered without giving insights into their application in dialogue scenarios or the processing of incongruent as well as congruent intentions of participants [GKW10].

3 Situated Dialogue Action Model (SAM)

The *Situated Dialogue Action Model (SAM)* (cf. Fig. 1) represents system-supported dialogues between multiple participants with mixed intention sets triggered by non-collaborative dialogue situations. As a sophisticated approach for representing actor intentions and their relations to the framing situation, SAM focuses on four main concepts that are linked by a bidirectional reasoning cycle: *Situation*, *Dialogue Action*, *Behavioral Intention* and *Goals*. According to [Suc87], SAM adopts the concept of situated action, i.e., environmental effects directly trigger actions instead of planning actions contingent on situational circumstances that cannot be anticipated in advance. Therefore, SAM focuses on goals that are triggered by situations. Dialogue systems that instantiate SAM are able to act in a reactive as well as proactive manner when processing mixed intention sets in non-collaborative dialogues. This is realized by the bidirectional reasoning cycle that covers eight reasoning mechanisms *1.A – 2.D* each connecting two concepts of SAM [KP93, PBL05, CL90, SA91, All90, GPP⁺98].

First, the *Situation* concept describes the situational circumstances of non-collaborative dialogues between multiple actors [GPP⁺98, RG95b, RG95a]). Concerning the composi-

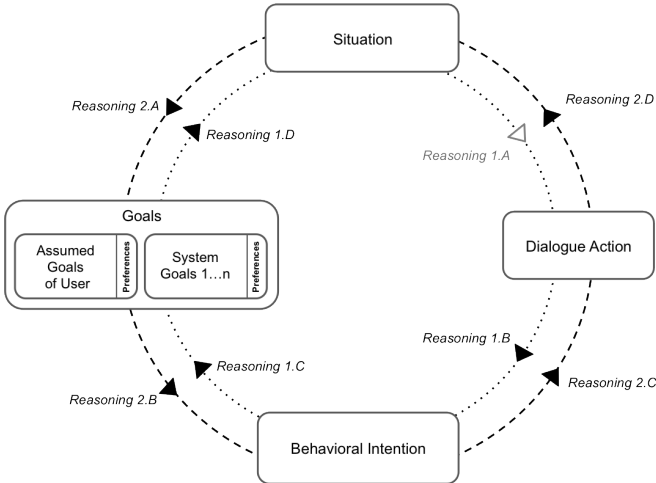


Figure 1: Situated Dialogue Action Model (SAM)

tion of the *Situation* concept, the direction of thought given by the Abstract Information System Model (AISM) [MV12] was picked up. *Situation* covers (1) roles of actors, i.e., policies, obligations and cultural norms, (2) actions that means interactions between actors and events within the environment, (3) information exchanged within interaction, (4) physical surroundings of the interaction, and (5) plain features of the situation, e.g., time, day of week.

The second concept *Goals* describes goals of actors as sets of desires, negative desires and neutral desires measured by preference values. Literature review showed that goal and intention models exclusively focus on desires as motivational states apart from [SA77] that

defined undesired states and [CL90] that mentioned a deduction of intentions from negations of desires in weak realism BDI scenarios. We assume that also neutral or negative attitudes, so called negative desires can result in intentions. SAM distinguishes between system goals and assumed goals of users. Though, system goals are predefined and represent goals of 1 to n absent human participants. Assumed goals of the user are approximated to the real, but unknown goals of human participants during situated dialogue action.

Behavioral Intentions are deduced from goals and describe an adopted goal on single actor level [GK96]. Due to the fact, that SAM considers non-collaborative dialogues between multiple actors, behavioral intentions represent specific combinations of incongruent and congruent actor goals [Bra87], i.e., mixed intention sets. Last, *Dialogue Action* represents the resulting situated dialogue action, e.g., presenting a generated natural language phrase.

3.1 Bidirectional Reasoning Cycle

SAM specifies two reasoning cycles each consisting of four reasoning mechanisms A – D: **Reasoning 1.A – Situation $\implies$ Dialogue Action.** This reasoning and the underlying mechanisms are unknown from the models perspective. This is due to the fact, that we are not able to read the users mind when she initiates some *Dialogue Action*, e.g. posing a question according to environmental effects.

Reasoning 1.B – Dialogue Action $\implies$ Behavioral Intention. Reasoning 1.B enables the dialogue system to specify the *Behavioral Intention* of the user by analyzing the *Dialogue Action* that took place in a reactive manner.

Reasoning 1.C – Behavioral Intention $\implies$ Goals. Using the identified *Behavioral Intention*, Reasoning 1.C adjusts the model of assumed goals of the user in the sense of an approximation to the real but unknown goals of the user.

Reasoning 1.D – Goals $\implies$ Situation. Reasoning 1.D modifies the *Situation* concept according to the current *Dialogue Action* and updated *Goals*, e.g., the question that was posed is represented within a dialogue history.

Reasoning 2.A – Situation $\implies$ Goals. The second reasoning cycle starting with Reasoning 2.A allows the system to act in a proactive way according to situational changes, e.g., a *Dialogue Act* took place or an event occurred. System goals as well as assumed user goals are adjusted according to the situation.

Reasoning 2.B – Goals $\implies$ Behavioral Intention. Reasoning 2.B processes the pool of *Goals* consisting of system goals and assumed goals of the user with the objective to find satisficing combinations of *Goals* that represent the basis for generating dialogues perceived as fair by all participants. Based on game-theoretic approaches [Nas51, vNM44] as well as the deliberation of utility [NT11] such a combination of *Goals* is adopted as *Behavioral Intention*.

Reasoning 2.C – Behavioral Intention $\implies$ Dialogue Action. According to the adopted *Behavioral Intention*, Reasoning 2.C specifies the linguistic structure of the intended *Dialogue Action* and generates the related phrases.

Reasoning 2.D – Dialogue Action $\implies$ Situation. Last, Reasoning 2.D modifies the *Situation* concept similar to Reasoning 1.D based on the *Dialogue Action* that took place.

4 Instantiation of Reasoning 1.B and 2.B

Presenting work in progress, we will exemplify reasoning 1.B and 2.B of SAM by means of the Question-Answering (QA) system CoRA [JKMF10]. Based on the instantiation of these two reasoning mechanism, we will show the processing of mixed intentions set in non-collaborative QA settings. The web-based QA system processes applied sales conver-

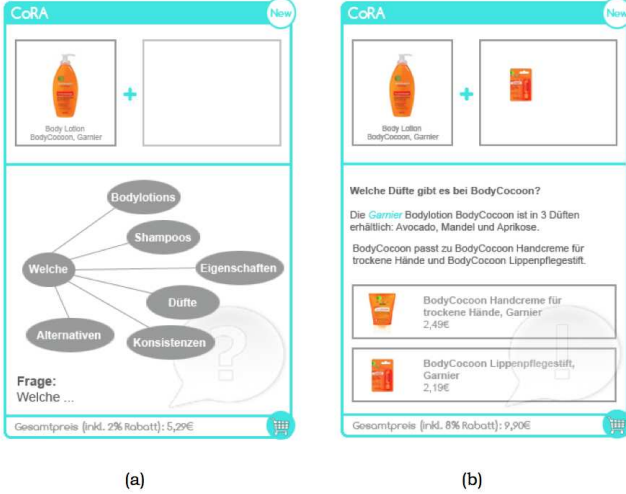


Figure 2: (a) Step-by-step composition of a question by means of CoRA user interface; (b) presentation of generated answer

sations at the point of sale settings. Based on a QA approach consisting of text schemata [McK85], text planning technologies [Man84] and rhetorical relations [Hob78, MT86], CoRA processes mixed intention sets of customers and retailers. Customers can use the CoRA prototype by means of their mobile device in stores. After scanning the barcode of a product, customers can pose a question based on the selection of single constituents step-by-step (cf. Fig. 2, a), e.g., “Which fragrance variants of body lotion BodyCocoon are available?” Thereupon, CoRA generates the appropriate answer (cf. Fig. 2, b), e.g., “The Garnier body lotion BodyCocoon is available in 3 fragrances: avocado, almond and apricot. BodyCocoon fits to BodyCocoon hand lotion for dry skin and BodyCocoon lipstick.” In the following, we will exemplify reasoning 1.B and 2.B by means of the question understanding and answer generation process in CoRA.

4.1 Reasoning 1.B – From Question to Communicative Intention

CoRA instantiates reasoning mechanism 1.B by specifying the communicative user intention (cf. *Behavioral Intention*) based on processing the linguistic structure of the question posed by the user (cf. *Dialogue Action*). Question and answer structures in CoRA were

specified based on a speech corpus of sales conversations and consulting talks that was collected within the product domain of consumer electronics at a trade fair. After transcribing and analyzing the corpus, communicative intentions of customers in sales talks (cf. Fig. 3) and related question schemas were identified. Applying a schema-based approach

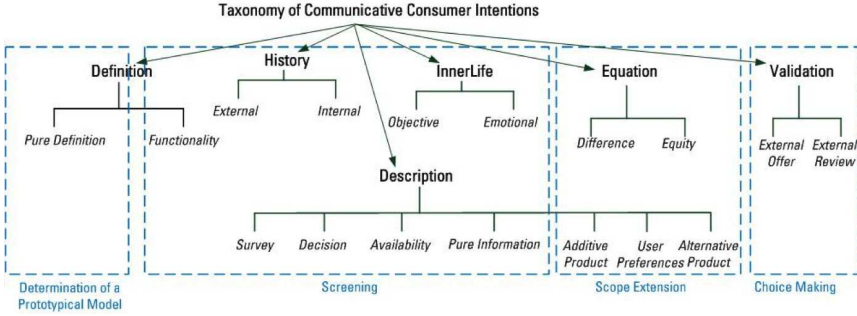


Figure 3: Taxonomy of communicative customer intentions in sales conversations assigned to phases of purchase decisions [MK08]

[McK85], 28 question schemas were specified that appeared frequently within sales dialogues, e.g., the question schema `DESCRIPTION_SURVEY_NUMBEROFPROPERTIES` (cf. Fig. 4) that represents question types as shown in Fig. 2 (b). Each question schema consists of a name, constraints, cue words, question segments in form of linked lists and a linguistic goal that represents the conversion of a communicative user intention into a machine processable representation. Question schemas are represented by means of

NAME:	Description_Survey_NumberOfProperties
USER-GOAL:	Survey_NumberOfProperties
LING-GOAL:	(NUMBEROF(PROPERTY) (?x in ?y))
CONSTRAINTS:	Established <i>PCategoryValue</i> (<i>y</i>) or Implementation of Option
CUE-WORDS:	[QT] Welche
SCHEMA:	[QT: Welche] [NP: <i>PProperty</i> : {x} ^p] [VP: geben (es) 3PS] {[DET: bei][NP: <i>PCategoryValue</i> : {y}]}*
Example:	Welche Farben gibt es? Welche Farben gibt es bei Navigationsgeräten?

Figure 4: Exemplary question schema `DESCRIPTION_SURVEY_NUMBEROFPROPERTIES`

a semantic knowledge base; the linguistic structures are filled with lemmas of the lexicon and non-linguistic product information. When the user selects a question segment, CoRA traverses the semantic network of question schemas and extracts the next potential segments. When CoRA is able to identify an unambiguous assignment of the already selected question segments (e.g., “Which fragrance variants ... ?”) to a question schema (e.g., `DESCRIPTION_SURVEY_NUMBEROFPROPERTIES`) (cf. Fig. 2 (a)), the communicative user intention (e.g., `SURVEY_NUMBEROFPROPERTIES`) is deduced

based on the linguistic goal (e.g., (NUMBEROF (PROPERTY) (?FRAGRANCES IN ?PRODUCT(BODYCOCOON_BODYLOTION))) (cf. Fig. 4).

4.2 Reasoning 2.B – From Satellites to Answer Text Plan

Beside question schemas, frequently occurring answer structures were identified based on the analysis of the speech corpus. These answer structures were transformed into 13 plan operators [Man84] that define text plans for achieving an effect that satisfies a consumers communicative intention(s). Each plan operator consists of a single compulsive part that provides information requested by a user – called nucleus – and diverse optional parts – called satellites. A library of rhetorical relations interlinks these plan operator parts each representing specific components of an potential answer. CoRA implements the idea that the optional satellite parts of plan operators offer the possibility to satisfy system goals, i.e. goals of further indirect human participants in a non-collaborative dialogue. Imagine the retailer whose goals to increase profitability and revenue are represented by CoRA. In order to answer the exemplary question “Which fragrance variants of body lotion BodyCocoon are available?” (cf. Fig. 2), CoRA checks the pool of plan operators within the semantic knowledge base and selects the adequate plan operator NUMBER_PROPERTIES (cf. Fig. 5) for satisfying the communicative user intention SURVEY_NUMBEROFPROPERTIES that was identified before. The text plan of the answer is constructed based on processing

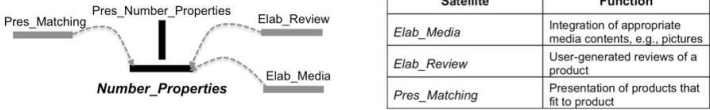


Figure 5: Exemplary plan operator NUMBER_PROPERTIES and description of function of satellites in answer text plan

the plan operator that offers a pool of optional satellites, e.g., PRES_MATCHING. Satellites are closely tied up to system and assumed user goals (cf. *Goals*). Depending on the satellites ability to satisfy a participants goal in the dialogue, it is rated with a high or low preference value. For instance, by integrating the satellite PRES_MATCHING into the final answer text plan as shown in Fig. 2, retailer goals (represented within system goals) concerning increase of revenue based on bundle sales are satisfied. Regarding the user as well as system goals, the pool of satellites is processed with the objective to find satisficing combinations of satellites for all dialogue participants (cf. *Behavioral Intention*). In CoRA, this is realized by an algorithm that observes the course of the dialogue. For avoiding repetitions and keeping a balance between integrated satellites, satellites that were part of the latest dialogue acts will not be considered within an ongoing answer generation. Finally, an answer consisting of nucleus and the satellite PRES_MATCHING is composed and displayed on the mobile interface: “The Garnier body lotion BodyCocoon is available in 3 fragrances: avocado, almond and apricot. BodyCocoon fits to BodyCocoon hand lotion

for dry skin and BodyCocoon lipstick.”

5 Discussion and Future Work

In the following, we will discuss our findings when instantiating the two reasoning mechanisms 1.B and 2.B of the introduced *Situated Dialogue Action Model (SAM)* by means of the QA system CoRA.

Dialogue settings. Within the instantiation by means of CoRA, the concept *Dialogue Action* was considered in QA settings. That means, in clockwise direction (reasoning cycle 1) *Dialogue Action* is restricted to questions whereas in counterclockwise rotation (reasoning cycle 2) the generation of answers is scheduled. In future work, the QA context will be opened up to real dialogue settings, i.e., the dialogue system is (1) independent of direct user questions and (2) has the ability to pose questions as well. This supports the idea of SAM that motivates reactive as well as proactive behavior of dialogue systems in non-collaborative dialogues.

Representation of goals and behavioral intentions. In CoRA, reasoning 2.B is instantiated within the processing of plan operators and related satellites. That means the processing of goals consisting of customer (i.e. user) and retailer (i.e. system) goals is mapped onto the algorithm of selecting and adjusting a situated answer text plan. In future work, the algorithm has to be supported by an explicit representations of goals and mixed intention sets that enable a detailed investigation of their relationships to environmental aspects and a more sophisticated processing of goals within non-collaborative dialogues.

Satisficing algorithm. Objective of SAM is the satisficing of mixed intention sets triggered by non-collaborative dialogue situations. In the instantiation of the model by means of CoRA, satisficing is realized by a simplified algorithm observing the course of the dialogue and avoiding the integration of satellites already applied in the latest dialogue acts for minimizing repetitions and keeping a balance. We intend to investigate a more sophisticated approach for adopting satellite combinations in the sense of satisficing mixed intention sets based on game-theoretic approaches [Nas51, vNM44] as well as the deliberation of utility [NT11] in future work.

Strategic framing. Furthermore, we assume that especially non-collaborative dialogues are framed by communication strategies that extend the perspective of single dialogue acts, for instance sales conversations that are characterized by underlying strategies of retailer as well of customers. In future work, the application of such framing strategies in non-collaborative dialogues will be investigated.

6 Conclusion

Non-collaborative dialogues are characterized by congruent and incongruent, partly conflicting intentions, that means mixed intention sets of the participants. Such non-collaborative dialogues represent the main part of everyday dialogues and dominate the daily commu-

nication between people. Dialogue systems face diverse challenges when supporting non-collaborative dialogues: (1) explicit handling and processing of intentions within dialogue planning, (2) adoption of intentions of absent participants by dialogue systems and creation of strategies for satisfying these adopted intentions, and (3) satisficing of mixed intention sets within dialogue planning for gaining non-collaborative dialogues perceived as fair by all dialogue participants. We introduced a model of *Situated Dialogue Action (SAM)* that represents system-supported dialogues between multiple participants with mixed intention sets triggered by non-collaborative dialogue situations. Selected parts of SAM were instantiated by means of the Question-Answering system CoRA that processes applied sales conversations at the point of sale. We discussed our findings and gave implications for future work: (1) consideration of reactive and proactive behavior of dialogue systems in non-collaborative dialogues, (2) requirement of explicit representations of goals and mixed intention sets, (3) optimization of algorithm for satisficing mixed intention sets based on game-theoretic approaches as well as the deliberation of utility, and (4) application of overlaying communication strategies by dialogue systems in non-collaborative dialogues.

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A Abstract of PhD Thesis

Dialogues between humans are either collaborative or non-collaborative. In daily life, the main part of occurring dialogues is of non-collaborative nature; i.e. dialogue partners have individual intentions and do not pursue a shared intention in their conversation, for instance in sales talks. The support of such non-collaborative dialogues by dialogue systems is challenging for a number of reasons. First, non-collaborative dialogues are characterized by congruent and incongruent, partly conflicting intentions, that means mixed intention sets of the participants. Second, in non-collaborative dialogue situations, dialogue systems take the role of representatives for indirect, absent human participants. For instance, dialogue systems can be used in eCommerce situations as substitutes for sales personnel. That means dialogue systems adopt intentions of these absent participants and create strategies for satisfying these adopted intentions. Third, for realizing non-collaborative dialogues perceived as fair in the sense of utility by all dialogue participants, mixed intention sets are satisficed [MS58] within dialogue planning.

The integration of robust natural language processing technologies in information systems of everyday life is a long-standing vision to realize intuitive human-computer interaction [SBJSP08, SJ92, VJS⁺83]. Anyway, current implementations, e.g., Siri by Apple, focus on collaborative dialogues with congruent intentions. So far, non-collaborative dialogues were rarely considered in the context of dialogue planning [MP93, GS86, McK85, MT86,

Hob78] and the processing of mixed intention sets in dialogues and interaction in general [Man02, Loc98, GK93, Sea90, CCC00, Sea69]. In the field of multi-agent systems, approaches for non-collaborative interaction are considered without giving insights into their application in dialogue scenarios or the processing of incongruent as well as congruent intentions of participants [GKW10].

Within the PhD thesis “Satisficing Mixed Intention Sets in Non-Collaborative Dialogues”, these challenges will be addressed by applying an explicit representation of mixed intention sets embedded in a model of Situated Dialogue Action (SAM). The applicability of game-theoretical approaches and economic equilibrium theories in dialogue planning will be verified to realize a strategic behavior of the dialogue system. Following this direction of thought, non-collaborative dialogues are considered successful if all dialogue partners perceive the final result sufficiently fair. Objective of the PhD thesis is the investigation of dialogue systems that support non-collaborative dialogues covering mixed intention sets and that achieve fair outcomes for all participants. Although, real-life non-collaborative dialogues between two dialogue partners, e.g., sales conversations, will be considered in the thesis. The intentions of the dialogue partners for participating in these dialogues are congruent and incongruent, and are partially conflicting. Nevertheless, the participants are able to balance their individual as well the anticipated intentions of the counterparts during dialogue in a cooperative manner [Gri75]. The PhD thesis covers (1) the theoretical analysis of processing of mixed intention sets based on empirical studies in the domain of sales conversations, (2) the modeling of results, (3) the implementation of a prototypical dialogue system, and (4) the evaluation of the prototype. Instantiated in the retailing domain, the prototype will be realized as web-based retailing conversational agent that holds non-collaborative sales conversations with customers based on semantic web-based product information. By means of field experiments in stores the perceived fairness of the resulting dialogues shall be validated.

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