A Simple Language Model for Task-Oriented Dialogue

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Dialogue

There are broadly two categories of dialogue:

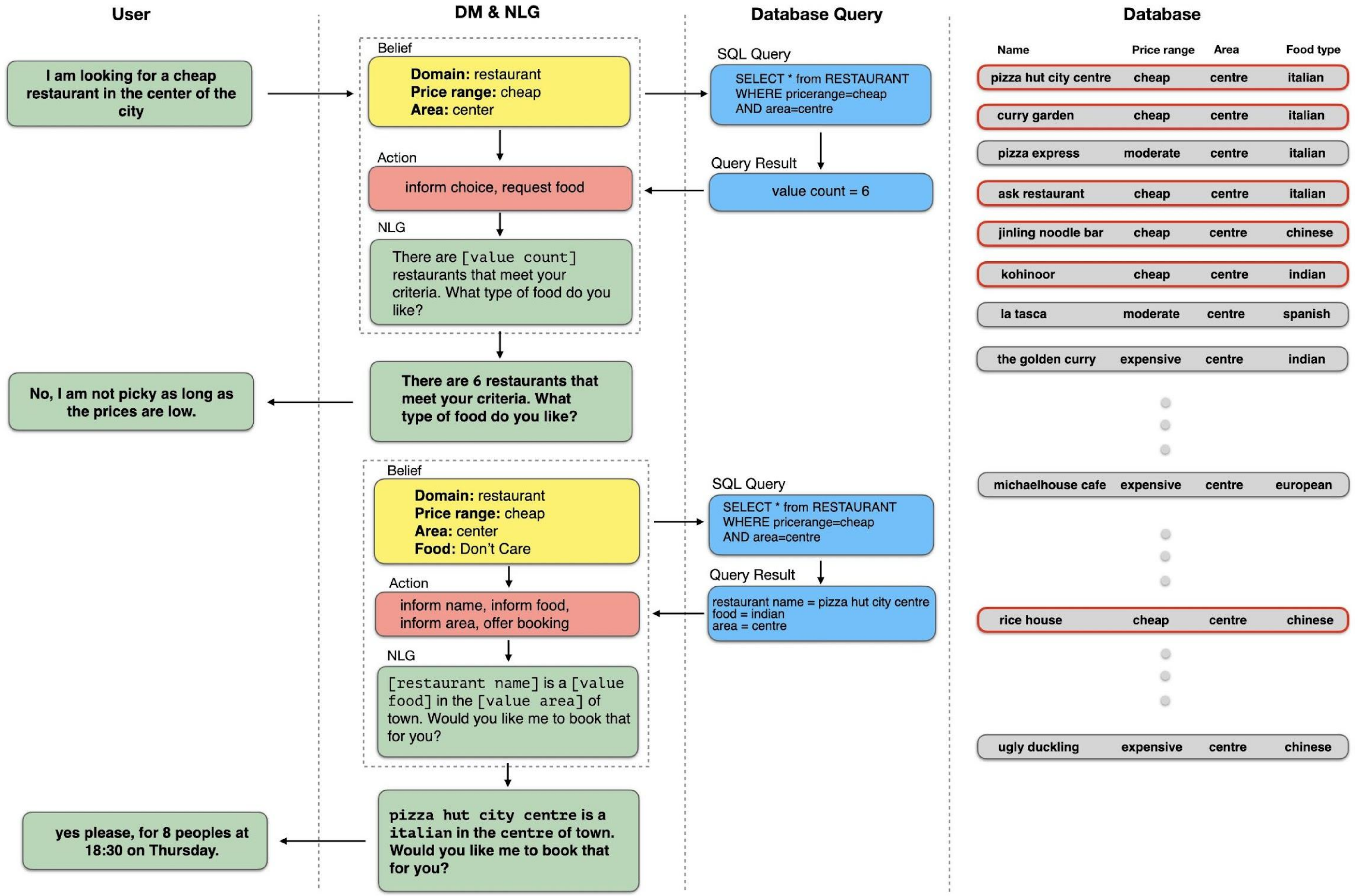
- **Open-domain dialogue:** focus on making chit-chat, open-ended conversations with humans more natural and engaging. They are usually trained end-to-end using large-scale data from social media

- **Task-oriented dialogue (TOD):** accomplish a goal described by a user in natural language. They often use a pipeline approach. The pipeline requires:
    - natural language understanding (NLU) for predicting domain and user intent
    - dialogue management (DM) predicting belief states and deciding which actions to take based on those beliefs
    - natural language generation (NLG) for generating responses

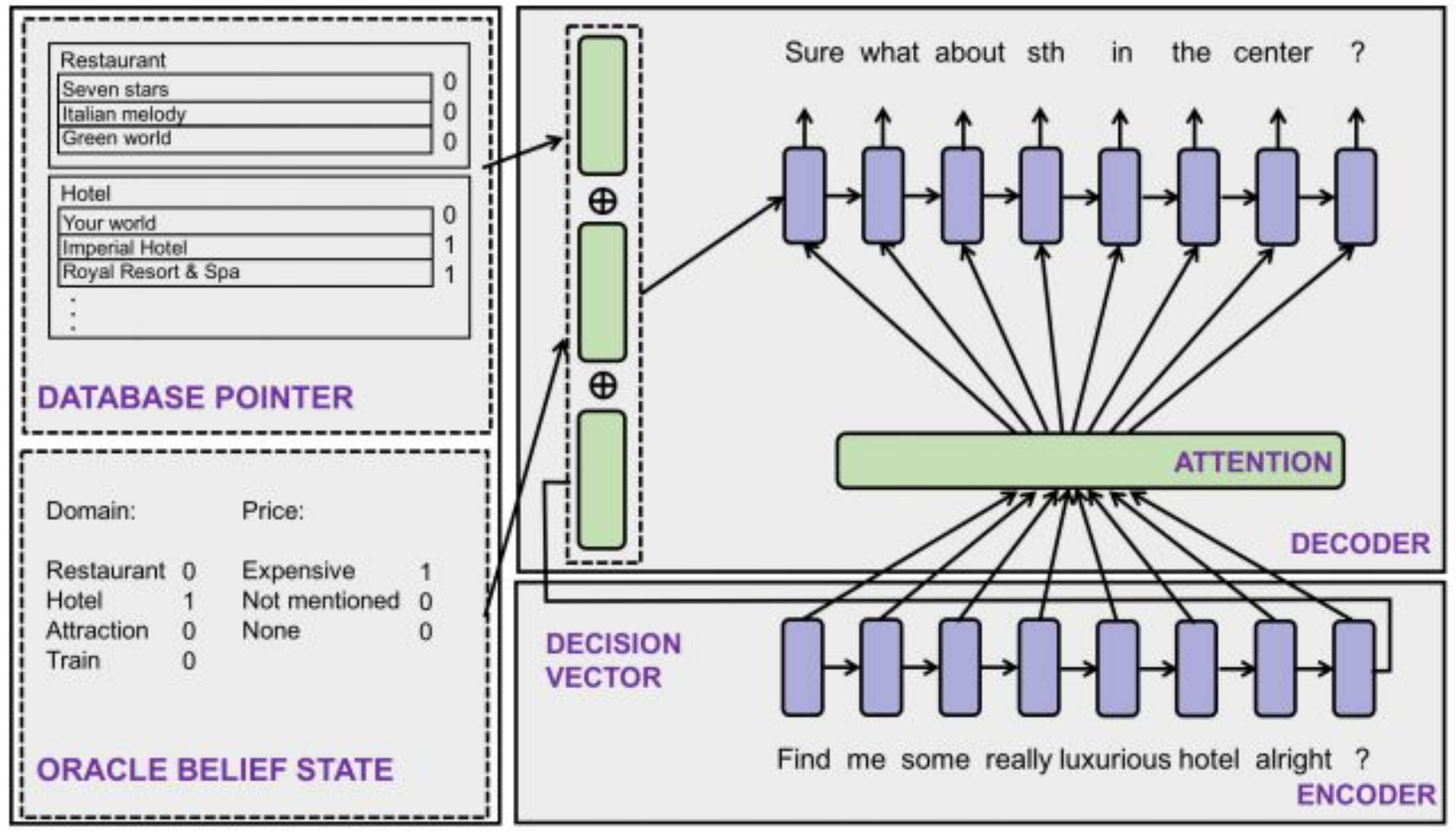
Task-Oriented Dialogue (TOD)

Modular-based model:

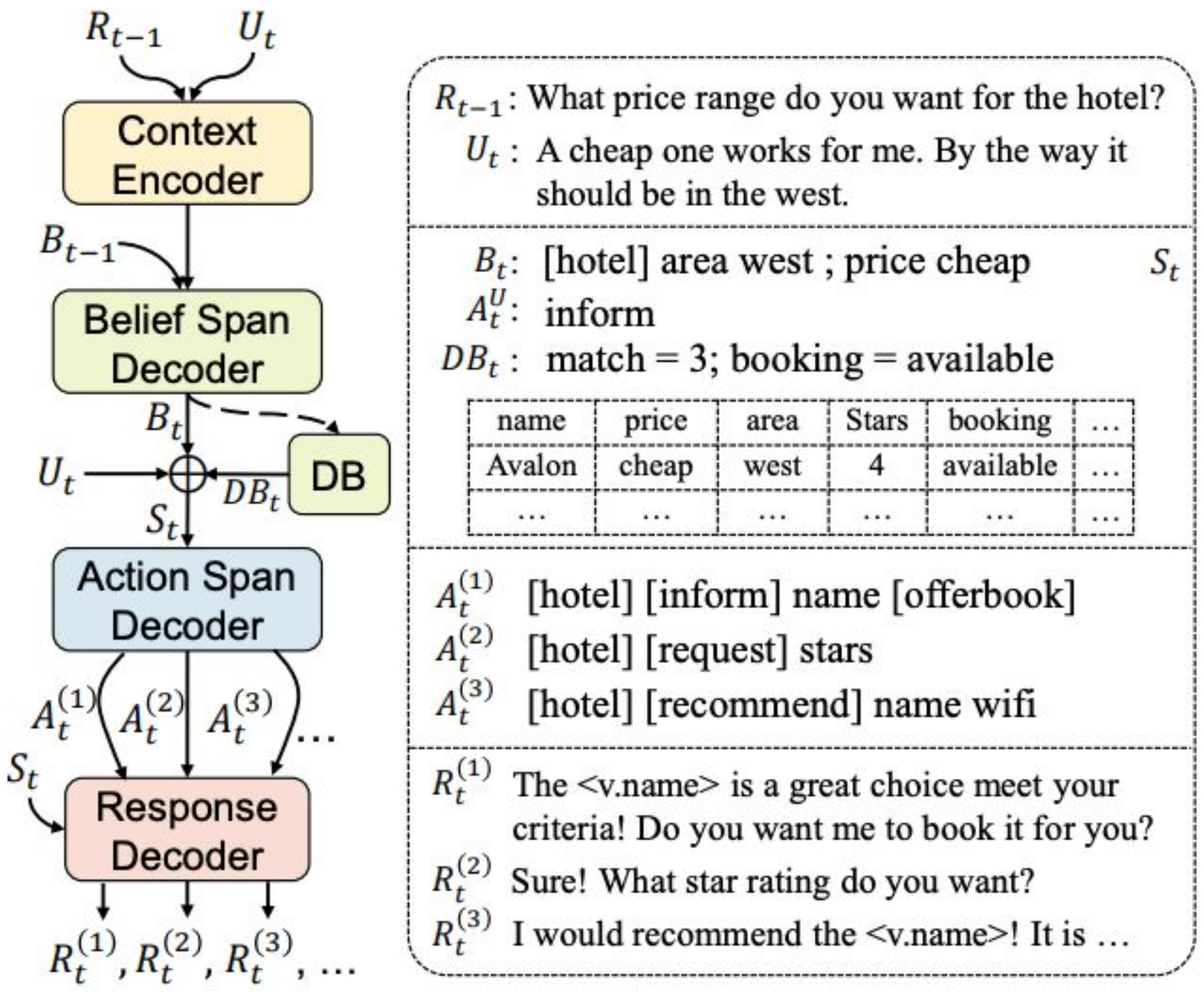
- The DM module employs dialogue belief and dialogue act labels as supervision
- The NLG module accesses templatized or natural responses
- The modular dependencies of these components can lead to error propagation when information is not fully provided to subsequent modules in the pipeline



Traditional End-to-End TOD



Seq2Seq model with attention on oracle belief state and database pointer vector (MultiWOZ baseline) [1]



- DAMD [2]: Multi-decoder Seq2Seq
- Different decoder for belief, action, response

[1] Budzianowski, Paweł, et al. "Multiwoz-a large-scale multi-domain wizard-of-oz dataset for task-oriented dialogue modelling." *EMNLP,* 2018

[2] Zhang, Yichi, et al. "Task-Oriented Dialog Systems that Consider Multiple Appropriate Responses under the Same Context." *arXiv preprint arXiv:1911.10484* (2019).

SimpleTOD - Input representation

- We propose recasting task-oriented dialogue as a simple, causal (unidirectional) language modeling task
- We show that such an approach can solve all the sub-tasks in a unified way using multi-task maximum likelihood training
- Dialogue context comprises all previous user/system responses, Ct = [U0, S0, …, Ut]
- A single training sequence consists of the concatenation of context Ct, belief states Bt , database search results Dt, action decisions At, and system response St
- A schematic overview of each segment is shown below together with special tokens marking transition points.

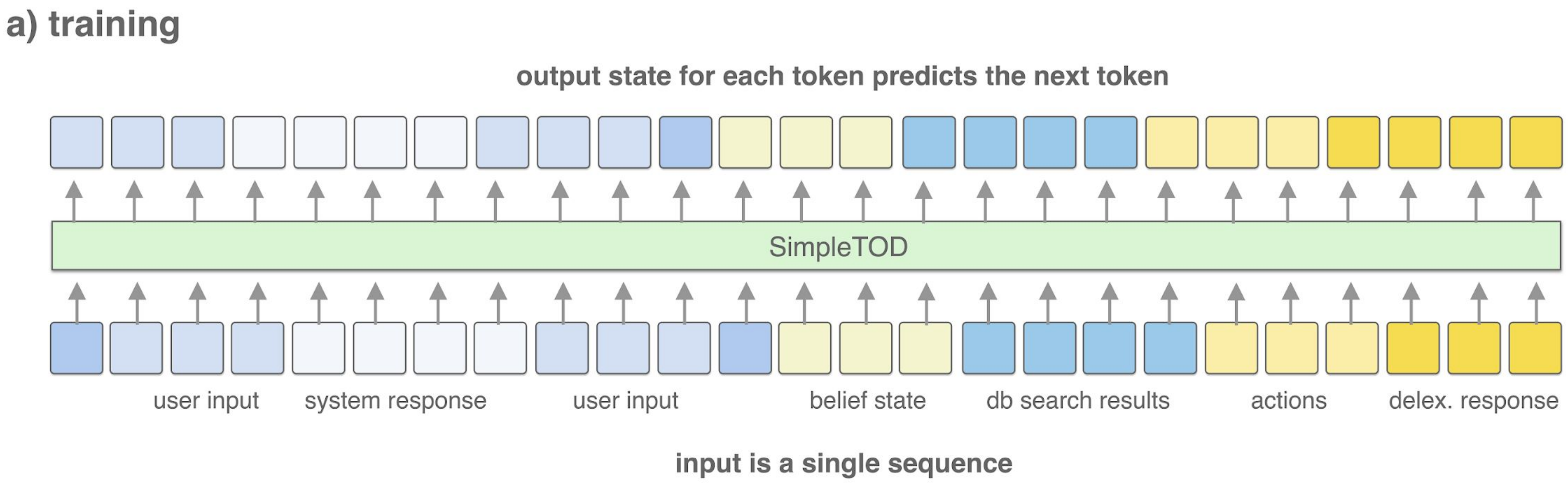
Context	[context] [user] *user input* [system] *system response* . . . [user] *user input* [endofcontext]
Belief State	[belief] *domain slot_name value, domain slot_name value,* . . . [endofbelief]
DB Search	[db] *#_matches, booking_status* [endofdb]
Action	[action] *domain action_type slot_name, domain action_type slot_name,* . . . [endofaction]
Response	[response] *system delexicalized response* [endofresponse]

SimpleTOD (Training)

- A single training sequence consists of the concatenation Xt = [Ct, Bt, Dt, At, St]
- This allows us to model the joint probability p(x) over the sequence Xt
- SimpleTOD is optimized by minimizing the negative log likelihood over the joint sequence

$$p(x) = \prod_{i=1}^{n} p(x_i \mid x_{<i})$$

$$\mathscr{L}(D) = -\sum_{t=1}^{|D|} \sum_{i=1}^{n_t} \log p_\theta(x_i^t \mid x_{<i}^t)$$

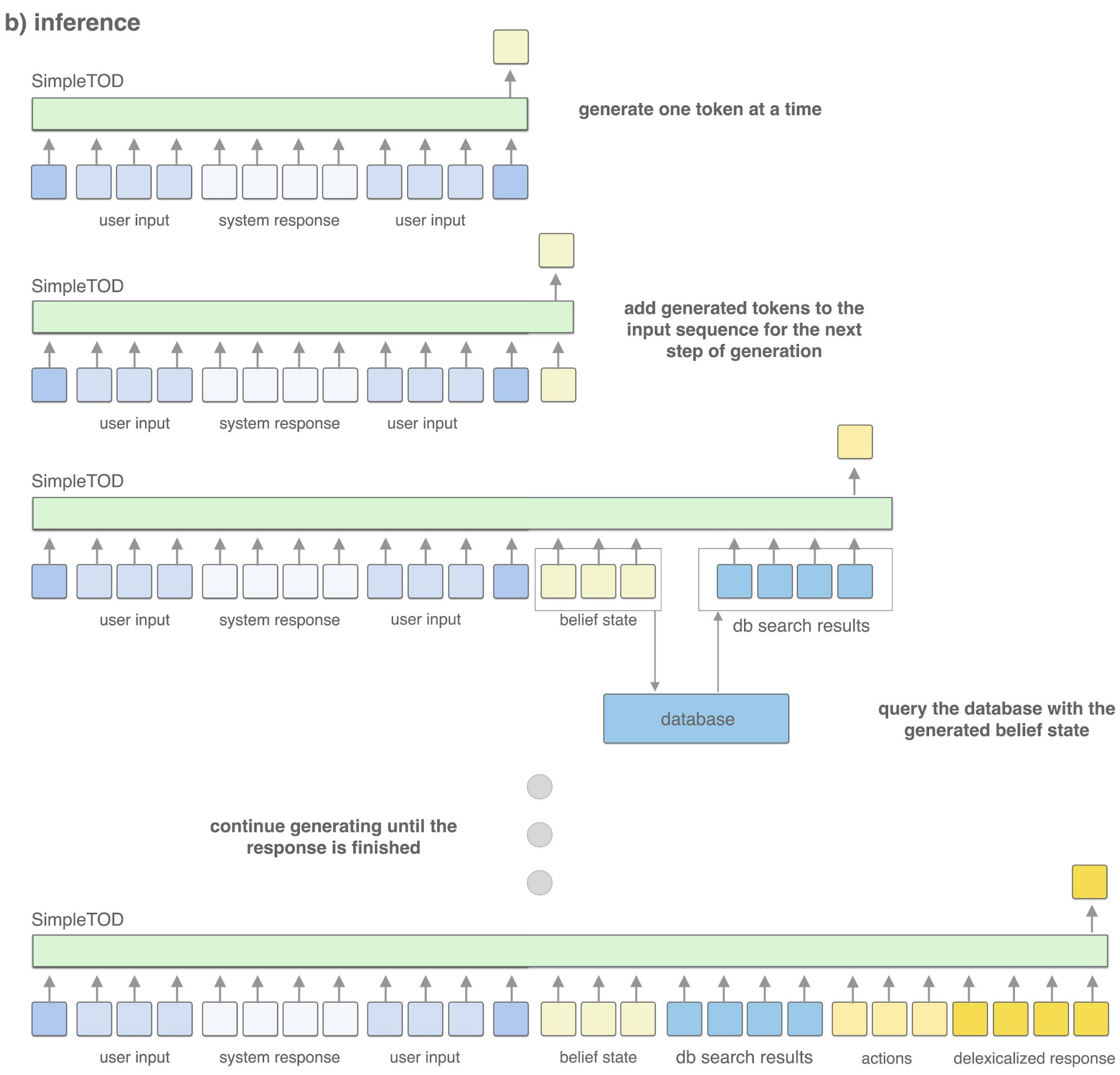


SimpleTOD (Inference)

$$B_t = SimpleTOD(C_t)$$

$$A_t = SimpleTOD([C_t, B_t, D_t])$$

$$S_t = SimpleTOD([C_t, B_t, D_t, A_t])$$



Noisy Annotations

To better understand the source of dialogue state tracking errors, we investigated MultiWOZ 2.1 annotations in depth.

We have defined four primary types of noisy-labels that could be considered mis-annotations

1. User provided multiple options, but context does not provide sufficient information to determine the true belief state
2. Belief state is not labeled, but context provides sufficient information
3. Belief state is labeled, but context lacks necessary information
4. Belief state value is misspelled according to the context information

A list of discovered noisy annotations in MultiWOZ 2.1 alongside a cleaned version of the test set are provided

Dialogue State Tracking (DST)

Evaluation of Dialogue State Tracking (DST) on MultiWOZ 2.1 using joint goal accuracy metric

- ∗ **TRADE** proposes test label cleaning and recommended by MultiWOZ authors
- † **TripPy** uses label normalization and equivalent matching
- ∗∗ **DSTQA** uses the cleaning of TRADE model plus additional accounting for label variants

- SimpleTPDo no label-cleaning
- SimpleTOD* uses label-cleaning
- SimpleTOD+ performs cleaning c

Model	Decoder	Context Encoder	Extra Supervision	Joint Accuracy
TRADE*	Generative + Classifier	Bidirectional	-	45.6
DSTQA**	Classifier	Bidirectional	knowledge graph	51.17
DST-Picklist*	Classifier	Bidirectional	-	53.3
SST*	Generative	Bidirectional	schema graph	55.23
TripPy†	Classifier	Bidirectional	action decision	55.3
SimpleTOD^o	Generative	Unidirectional	-	55.72
SimpleTOD*	Generative	Unidirectional	-	**55.76**
SimpleTOD+	Generative	Unidirectional	-	57.47

Understanding long, multi-domain context

- This example also shows understanding dialogue states, where slots across domains are related.

- For example, taxi departure and taxi destination are inferred from attraction name and hotel name.

<table>
<tr><td>Context ('MUL1015', turn 10)</td><td><|context|> <|user|> i am looking for a pool somewhere in the south of cambridge . <|system|> i am sorry , but it does not look like we have a pool that matches your criteria . <|user|> how about some type of theater ? <|system|> the junction theatre is in the south area . would you like the address ? <|user|> yes , please provide the address and postcode as well . <|system|> the junction theatre is located on clifton way at postcode cb17gx . is there anything else i can assist you with ? <|user|> thanks . yes , i also need to find a guesthouse for my stay there . <|system|> are you needing the guesthouse in the south , also ? do you have a preference in price range ? <|user|> the area should be the centre . i need it to be cheap and have free parking . <|system|> i have 2 guesthouses that fit your criteria . 1 is the alexander bed and breakfast and the other is el shaddai . <|user|> what is the star rating -s for them ? <|system|> the alexander bed and breakfast has a 4 star rating while the el shaddai has 0 stars . would you like to book a room with either of these ? <|user|> ok great , thank you . i also need to book a taxi to get back and forth . <|system|> where did you wan to leave from and go to ? <|user|> i'll be leaving the theatre at 14:45 and going to the guesthouse . <|system|> let s back up a moment . which lodgings did you prefer , so we know where the taxi will be taking you ? <|user|> let s go with the alexander bed and breakfast . <|system|> your booking is complete , a grey volkswagen will be picking you up , contact number 07753429052 . can i help with anything else ? <|user|> cool beans ! sorry i was so much trouble . thanks so much for all of your help , you need a raise dealing with customers like me ! <|endofcontext|></td></tr>
<tr><td>Target</td><td><|belief|> attraction area south, attraction name the junction, attraction type theatre, hotel area centre, hotel name alexander bed and breakfast, hotel parking yes, hotel pricerange cheap, hotel type guesthouse, taxi departure the junction, taxi destination alexander bed and breakfast, taxi leaveat 14:45 <|belief|> <|action|> general bye none <|endofaction|> <|response|> it was no trouble at all ! i hope you have a fantastic trip and enjoy your stay ! <|endofresponse|></td></tr>
<tr><td>SimpleTOD</td><td><|belief|> attraction area south, attraction name the junction, attraction type theatre, hotel area centre, hotel name alexander bed and breakfast, hotel parking yes, hotel pricerange cheap, hotel type guesthouse, taxi departure the junction, taxi destination alexander bed and breakfast, taxi leaveat 14:45 <|endofbelief|> <|action|> general bye none <|endofaction|> <|response|> thank you for using our service <|endofresponse|></td></tr>
</table>

Table 9: Example of multi-domain dialogue state tracking for long context, where dialogue context spanning over 3 domains, i.e. attraction, hotel, and taxi. The belief states for taxi departure and destination (highlighted) should be inferred from hotel and attraction domains.

End-to-End Evaluation

Action and response generation uses three metrics.

inform and success rates: designed to capture how well the task was completed.

Inform rate: measures how often the entities provided by the system are correct.

Success rate: refers to how often the system is able to answer all the requested attributes by user.

BLUE score: is used to measure the fluency of the generated responses.

combined score: for action and response generation is computed as (BLEU + 0.5 ∗ (Inform + Success)).

Model	Belief State	DB Search	Action	Inform	Success	BLEU	Combined
DAMD+augmentation	generated	oracle	generated	76.3	60.4	16.6	85
SimpleTOD (ours)	generated	oracle	generated	78.1	63.4	16.91	87.66
SimpleTOD (ours)	generated	dynamic	generated	81.4	69.7	16.11	91.66
SimpleTOD (ours)	generated	-	generated	**84.4**	**70.1**	15.01	**92.26**

Table 2: Action and response generation on MultiWOZ 2.0 reveals that SimpleTOD, a single, causal language model, is sufficient to surpass prior work.

Model	Belief State	DB Search	Action	Inform	Success	BLEU	Combined
DAMD+augmentation	oracle	oracle	oracle	**95.4**	**87.2**	**27.3**	118.5
PARG	oracle	oracle	oracle	91.1	78.9	18.8	103.8
SimpleTOD (ours)	oracle	oracle	oracle	93.4	83.2	17.78	106.08
SimpleTOD (ours)	oracle	-	oracle	92.3	85.8	18.61	107.66
HDSA	oracle	oracle	generated	82.9	68.9	23.6	99.5
DAMD+augmentation	oracle	oracle	generated	**89.2**	77.9	18.6	102.5
ARDM	oracle	oracle	-	87.4	72.8	20.6	100.7
LaRL	oracle	oracle	generated	82.78	**79.2**	12.8	93.79
SimpleTOD (ours)	oracle	oracle	generated	84	72.8	16.1	94.5
SimpleTOD (ours)	oracle	-	generated	88.9	67.1	16.9	94.9

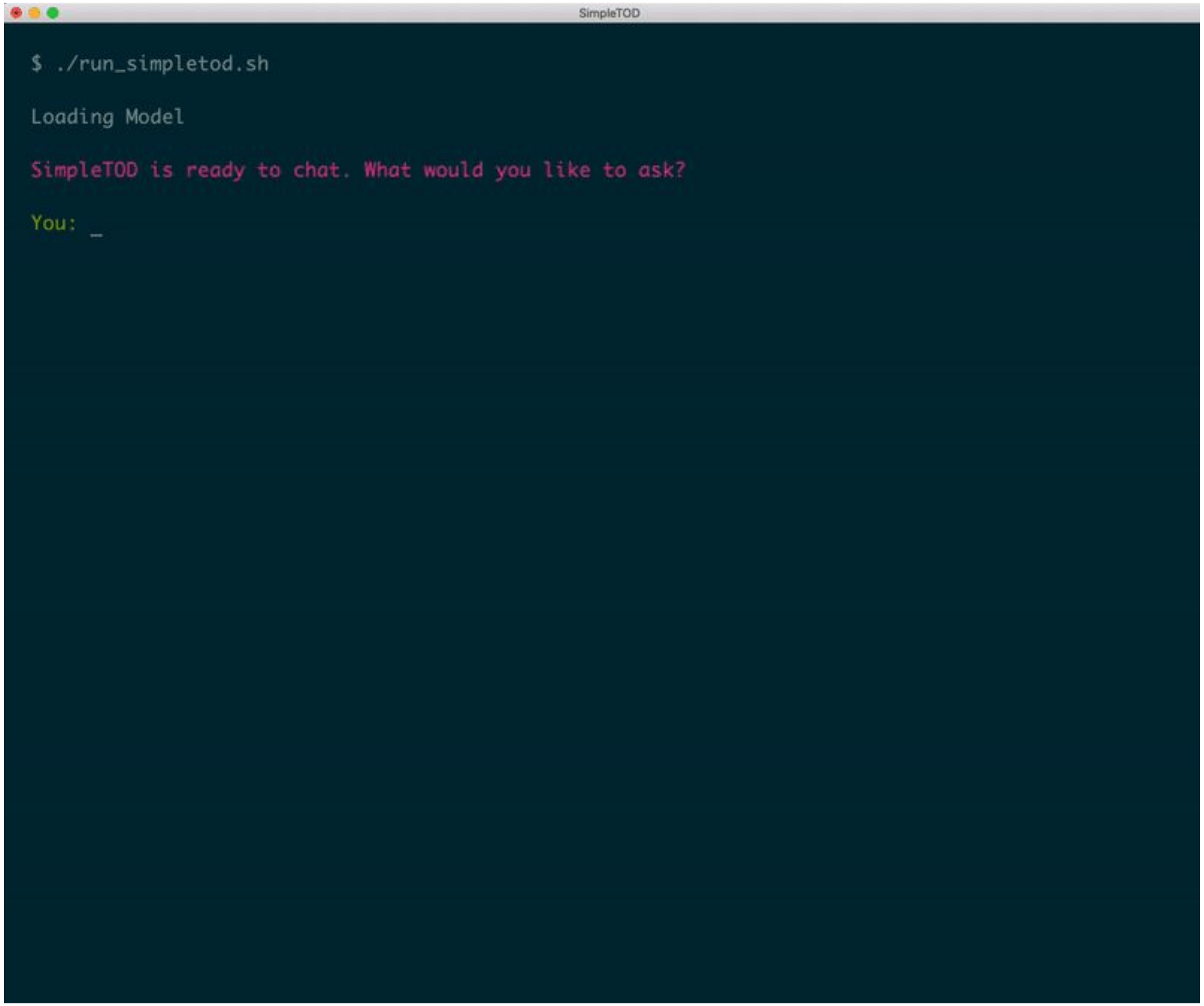
Table 7: SimpleTOD results on MultiWOZ 2.0 using oracle information.

Interaction with human

Description: A human is tasked to request SimpleTOD for reserving a hotel, and then for booking a train as well

It is shown that SimpleTOD is able to

- Understand human intent
- Able to request related information for hotel and train reservation
- Able to suggest useful information about available hotel and restaurant from database



Thank You!

Blog: https://blog.einstein.ai/simpletod

Code: https://github.com/salesforce/simpletod

Source code