1) Given unlabeled conversations, how can a system automatically induce and organize domain-specific concepts?

- **Ontology Induction** (Chen et al., 2013 & 2014)
  - Frame-semantic parsing on ASR results (Das et al., 2013)
  - Local: slot candidate
  - Lexical unit → slot filler

- **Structure Learning** (Chen et al., 2015a)
  - Type syntax dependencies on ASR

2) With the automatically acquired knowledge, how can a system understand utterances?

- **Semantic Decoding** (Chen et al., 2015b) → **Behavior Prediction**
  - **1st Issue**: How to induce domain-specific concepts?
    - **Relation Propagation Model**
    - **Feature Knowledge Graph**
    - **Concept Knowledge Graph**
    - Assumption: The domain-specific features/concepts have more dependency to each other.
    - **Objective**: \( \sum_{f' \in \mathcal{F}} \sum_{f \in \mathcal{G}} \ln \sigma(f) > 0 \)
    - **Matrix Factorization (MF)**
      - Model implicit feedback
      - Objective: \( p(f^+) > p(f^-) \)
  - **2nd Issue**: Hidden semantics cannot be observed but may benefit understanding performance.

- **Semantic Observation**
  - **Utterance 1**: "I would like a cheap restaurant"
  - **Utterance 2**: "Find a restaurant with Chinese food"

**Ontology Induction**

- **Feature Model**
- **Relation Model**
- **Concept Model**
- **Graph Structure**

**SLU Modeling by Matrix Factorization**

- **1st Issue**: How to induce domain-specific concepts?
  - **Relation Propagation Model**
  - **Feature Knowledge Graph**
  - **Concept Knowledge Graph**
  - Assumption: The domain-specific features/concepts have more dependency to each other.
  - **Objective**: \( \sum_{f' \in \mathcal{F}} \sum_{f \in \mathcal{G}} \ln \sigma(f) > 0 \)

**Semantic Decoding**

- **Utterance 1**: "I would like a cheap restaurant"
- **Utterance 2**: "Find a restaurant with Chinese food"

**Behavior Prediction**

- **SLU Component**
- **Domain-Specific Ontology**
- **Semantic Decoding**
- **Behavior Prediction**

**Framework**

- **Knowledge Acquisition**
  - **Ontology Induction**
  - **Frame Induction**
  - **Structure Learning**

- **SLU Modeling by Matrix Factorization**
  - **Feature Relation Model**
  - **Relation Propagation Model**
  - **Semantic Decoding**
  - **Behavior Prediction**

**Goal**

- **Can a dialogue system automatically learn open domain knowledge and then understand users?**
  - Domain: restaurant recommendation in an in-car setting (WER = 37%)
    - Dialogue slots: addr, area, food, phone, postcode, pricerange, task, type