

Modelling and Managing Dialogue Approaches and Challenges

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Introduction

A dialogue model / system:

- RUDI, implementation of theory of dialogue semantics / pragmatics (SDRT) [joint work with Alex Lascarides (Edinburgh), Ann Copestake (Stanford / Cambridge)]

Introduction

- RUDI:
 - not practical system, "testbed" for theory of dialogue semantics and pragmatics
 - deep processing: "real" grammar, "real" LFs, "real" inference
 - not a (full) dial sys!
 - overhearer* that tracks conversation and
 - computes certain context sensitive aspects of its meaning,
 - and asks for clarification, if it has problems understanding what it tracks.

Overview of talk

- RUDI
 - RUDI-01: Bridging Relations (Schlangen et al. 2001, 2004)
 - Phenomenon
 - SDRT
 - Implementation
 - RUDI-02: Fragments (Schlangen and Lascarides 2002)
 - Phenomenon
 - Implementation
 - RUDI-04: Clarification Requests (Schlangen 2004)
 - Phenomenon
 - Implementation
- Information-State Update Framework
- Summary

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} context sensitivity of interpretation
} interaction management

RUDI-01: Bridging Relations

A: How do I open this car?

B: Push the left front door (of [this car]).
R_{of}(left front door, [this car])

- definite descriptions refer to entities that are *given* in a discourse.
- this "givenness" can be implicit, via an implicit "bridging relation" to an entity in the context. (Clark 1977)

What does RUDI do?

A: We should meet next week. } *Q-Elab*

B: How about Friday? } *(= Friday next week)*

- computes Bridging Inferences...
- ...via computing Discourse Structure

(RUDI = Resolving Underspecification using Discourse Information)

What does RUDI do?

A: We should meet next week. } *Q-Elab*

B: How about Friday? } *(= Friday next week)*

- computes Bridging Inferences...
- ...via computing Discourse Structure
- is a proof-of-concept implementation of SDRT

Intro to SDRT

- SDRT (Asher 1993, Asher & Lascarides 2003)
 - dynamic semantics + (AI-style) pragmatics
 - DRT + rhetorical relations (Hobbs 1985, Mann & Thompson 1987)

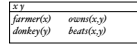
Intro to SDRT

- SDRT (Asher 1993, Asher & Lascarides 2003)
 - models "pragmatic competence": more than what grammar outputs, less than full belief revision
- (1) John arrived in Edinburgh.
Peter met him at the platform.

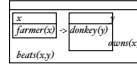
SDRT = DRT + ...

- DRT (Kamp & Reyle 1993): semantics of discourses.

(2) A farmer owns a donkey.
He beats it.



(3) Every farmer owns a donkey.
??He beats it.



- Accessibility constraint

SDRT = DRT + rhetorical relations

(5) Max fell. John helped him up.

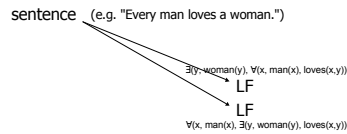
(6) Max fell. John pushed him.

- Temporal order is determined by rhetorical structure.

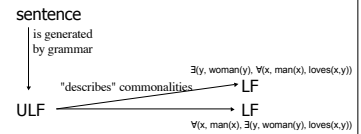
SDRT in a nutshell

- SDRTs: Extend DRT with rhetorical relations, which encapsulate additional content.
- Central notion: coherence. Utterances must be connected to context via rhetorical relations.
- Separate logic of content from logic in which discourse structure (i.e., which rhetorical relations hold) is computed, keeping the latter simpler.
- When computing DS, always use "cheapest" information source that is sufficient: syntax, lex. semantics, sem., DK, WK, cognitive states...
- Technical ingredients:
 - underspecified logical forms
 - default logics

Ingredient: Underspecification



Ingredient: Underspecification



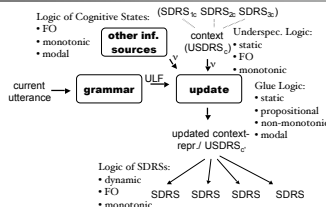
Ingredient: Underspecification

ULFs: partial descriptions of LFs, representing what's common between them, leaving out what differs.

Description logic can be simpler than described logic, since it only needs to express info about *form* of described LF.

$\forall(x, man(x), \exists(y, woman(y), loves(x,y)))$

Logics of Conversation



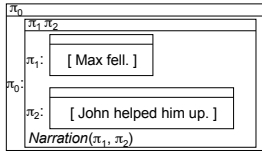
SDRT: Logic of Content

(5) Max fell.
John helped him up.

[Max fell.]
[John helped him up.]

SDRT: Logic of Content

- (5) Max fell.
John helped him up.



Some Meaning Postulates

content-level relations:

■ Axiom on Narration:

- $\phi_{Narration(\alpha, \beta)} \Rightarrow$ (a) $e_\alpha < e_\beta$ and
(b) things don't move location between the end of e_α and start of e_β

■ Axiom on Explanation:

- $\phi_{Explanation(\alpha, \beta)} \Rightarrow \neg e_\alpha < e_\beta$
 $\phi_{Explanation(\alpha, \beta)} \Rightarrow (\text{event}(e_\alpha) \Rightarrow e_\beta < e_\alpha)$

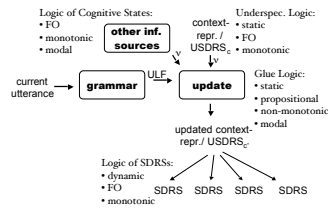
Another Meaning Postulate

cognitive-level relations:

■ Semantics of IQAP (indirect question-answer pair)

- (a) $IQAP(\alpha, \beta) \Rightarrow K_\beta$
(b) K_β contains sufficient content such that when it is added to $S(\alpha)$'s beliefs, he can nonmonotonically compute a direct answer to his question.

Logics of Conversation



SDRT: Construction

■ which info is needed to infer rhet. rel.?

- sometimes it's explicitly signalled:
 - (11) Max fell.
And then Peter kicked him.
- most of the times it isn't, and we need WK, knowledge about cognitive states, goals etc.:
 - (12) Max fell.
Peter pushed him.
 - (13) Smoke a pack of cigarettes a day
and you'll die before you reach 30.

SDRT: Construction

■ note: these are *default* guesses.

- (16) Max took an aspirin.
He was sick.
- (17) Max took an aspirin overdose.
He was sick.

Logic must be able to handle conflicting information.

SDRT: Construction

■ another desideratum: logic must be decidable.

\Rightarrow use *Common-sense Entailment* (Asher 1997; Morreau 1994), a non-monotonic propositional logic.

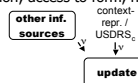
Glue logic: how is info accessed?

■ Axiom schema for inferring rhet. rels:

$$(?(\alpha, \beta) \wedge [\text{some info.}]) > R(\alpha, \beta)$$

- Logic of content is a FOPL, glue logic is propositional. How does info get from content to glue logic?

\Rightarrow transfer function; access to form, not (all) entailments.



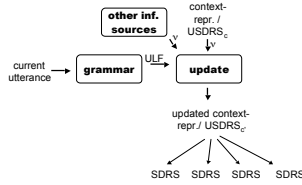
Glue Logic: Some Axioms

- IQAP $?(\alpha, \beta) \wedge \alpha : ? > IQAP(\alpha, \beta)$
- Q-Elab $?(\alpha, \beta) \wedge \beta : ? > Q\text{-Elab}(\alpha, \beta)$
- QAP $?(\alpha, \beta) \wedge \alpha : ? \wedge \text{qap-sat}(\alpha, \beta) > QAP(\alpha, \beta)$
- Elab $?(\alpha, \beta) \wedge \text{subtype}_D(\beta, \alpha) > \text{Elab}(\alpha, \beta)$
- Expl $?(\alpha, \beta) \wedge \text{cause}_D(\beta, \alpha) > \text{Expl}(\alpha, \beta)$

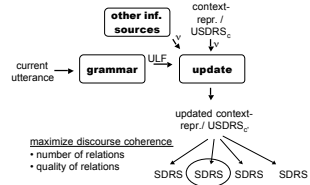
Glue Logic: Some Axioms

- IQAP $\exists(\alpha, \beta) \wedge \alpha: ? \rightarrow \text{IQAP}(\alpha, \beta)$
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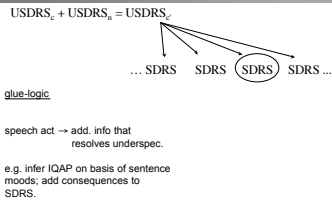
Logics of Conversation



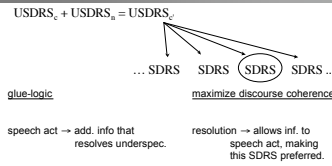
Maximize discourse coherence



Resolving Underspec., Inf. Flow



Resolving Underspec., Inf. Flow



SDRT, summary

- rhetorical relations* are essential to capture semantics of discourse;
- computing DS can be done in different (simpler) logic than needed to represent content;
- this *glue logic* must be a default logic;
- two ways to resolve underspec:
 - either added semantic consequences of rhetorical relation resolve underspec, or
 - certain resolution is preferred, because it maximises discourse coherence.

What does RUDI do?

- A: We should meet next week. \uparrow *Q-Elab*
- B: How about Friday? \uparrow (= Friday next week)
- computes Bridging Inferences / Disc. Struct. ...
 - ...for domain of scheduling dialogues.

Why scheduling dialogues?

- corpus available: VerbMobil
- grammar available: ERG
- nicely restricted domain:
 - simple goal: agree on a time
 - simple plan: zoom in on time
 - utterances are either about good or about bad times.
 - finite number of bridging relations, conventionalised.

2 ways of resolving underspec.

- A: We should meet next week.
- B: How about Friday?
- $\text{day_of_week}(x, \text{Fri}) \wedge B(x, y) \wedge y: ? \wedge B: ?$
- inferring Q-Elab $\exists(\alpha, \beta) \wedge \beta: ? \rightarrow \text{Q-Elab}(\alpha, \beta)$
- semantics of Q-Elab β is a question s.t. all answers elaborate on plan to reach goal of α
 $\Rightarrow \text{temp_incl}(t_\alpha, t_\beta)$
- Inferring DS \Rightarrow Resolving US

2 ways of resolving underspec.

- A: We should meet next week.
 B: I'm busy from the 24th until the 3rd.
- rejection or elaboration?

October 2003						
S	M	Tu	W	Th	F	S
			1	2	3	4
5	6	7	8	9	10	11
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Resolving US \Rightarrow Inferring DS

Speech acts / Rhet. Rels in RUDI

- $Q_Elab(\alpha, \beta)$
 - β is a question; any possible answer elaborates a plan for achieving a SARG of α
- $IQAP(\alpha, \beta)$
 - α is a question; questioner can infer direct answer from β
- $Plan-Correction(\alpha, \beta)$
 - β is proposition; speaker of β rejects a SARG of α
- $Plan-Elaboration(\alpha, \beta)$
 - β is proposition; elaborates plan to achieve SARG of α

Speech acts / Rhet. Rels in RUDI

- $Q_Elab(\alpha, \beta)$
 - $\neg(\alpha, \beta) \wedge \beta \rightarrow Q_Elab(\alpha, \beta)$
 - all answers elaborate plan for achieving SARG of α :
 $Q_Elab(\alpha, \beta) \rightarrow temp_include(SARG_{\alpha, \beta})$
- $IQAP(\alpha, \beta)$
 - $\neg(\alpha, \beta) \wedge \alpha \rightarrow IQAP(\alpha, \beta)$
 - questioner can infer direct answer to α from β :
 $IQAP(\alpha, \beta) \rightarrow temp_overlap(SARG_{\alpha, \beta})$

Speech acts / Rhet. Rels in RUDI

- $Plan-Correction(\alpha, \beta)$
 - β is proposition; speaker of β rejects a SARG of α
 - $\neg(\alpha, \beta) \wedge \beta \wedge temp_include(t_p, SARG_{\alpha, \beta}) \rightarrow P-Corr(\alpha, \beta)$

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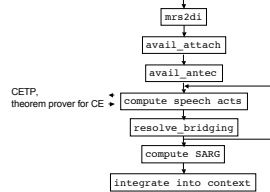
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 - $\neg(\alpha, \beta) \wedge \beta \wedge temp_include(t_p, SARG_{\alpha, \beta}) \rightarrow P-Corr(\alpha, \beta)$
- $Plan-Elaboration(\alpha, \beta)$
 - β elaborates plan to achieve SARG of α
 - $\neg(\alpha, \beta) \wedge \beta \wedge temp_overlap(SARG_{\alpha, \beta}) \rightarrow P-Elab(\alpha, \beta)$

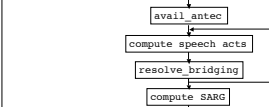
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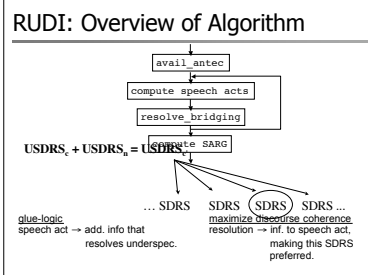
A: We should meet next week.
 B: I'm busy from the 24th until the 3rd.

RUDI: Overview of Algorithm



RUDI: Overview of Algorithm





Discussion

- But will this scale up?
 - mechanism for resolving underspec. should transfer to other domains, but
 - interface to reasoning about plans must be more complicated for almost all other domains.

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context sensitivity of interpretation

interaction management

Phenomena - Fragments

- Spontaneous spoken language
 - syntax of utterances
 - disfluencies
- Context sensitive interpretation
 - anaphora;
 - fragments;
 - dialogue acts;
 - gestures;
- Interaction Management
 - turn taking;
 - initiative;
 - grounding

Fragments: utt. that are intentionally non-sentential, but convey messages.

A: Who came to the party?
B: Peter (*came to the party*).

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Fragments:

- frequent: around 10% in typical dialogue (Fernández & Ginzburg 2002, Schlangen 2003)
- not just answers, occur in all sorts of contexts

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Fragments, two kinds:

- **resolution via identity:**
A: On what day, shall we meet?
B: On Monday (shall we meet).
- **resolution via inference:**
A: Peter has left already.
B: Exams.
(= Peter has left because he has to take / supervise / mark / etc. exams)

Phenomena - Fragments

- Spontaneous spoken language
 - syntax of utterances
 - disfluencies
- Context sensitive interpretation
 - anaphora;
 - fragments;
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Fragments, two kinds:

- **resolution via identity:**
A: Wem hat er geschmeichelt?
B: Dem Jungen. / *Den Jungen.
- **resolution via inference:**
A: Wen hat er gelobt?
B: Den Jungen. / *Dem Jungen.
-> syntactic parallelism!

RUDI, fragments

- extended grammar with rules for fragments:
 - phrases -> sentence w/ underspec. predicate ("Monday" -> *unknown(Monday)*)
- transfer some syntactic information to information state (so that syn.par. can be enforced)

RUDI, fragments

- resolution via identity:**
A: On what day shall we meet?
B: On Monday.

$$IQAP \quad ?(\alpha, \beta) \wedge \alpha? \rightarrow IQAP(\alpha, \beta)$$

$$Frag \quad IQAP \rightarrow QAP \quad IQAP(\alpha, \beta) \wedge frag(\beta) \rightarrow QAP(\alpha, \beta)$$

$$Frag-QAP-C \rightarrow Irvi \quad QAP(\alpha, \beta) \wedge aq(c) \rightarrow res-v-id(\alpha, \beta)$$

res-v-id does lambda-abstraction & application of question to answer, also checks syn-par.

RUDI, fragments

- resolution via inference:
A: Let's meet next week.
B: OK. Friday? (= How about Friday next week?)
- No changes needed! Temporal expression can be accessed in ULF ("unknown(Friday)").
- All relevant semantic consequences follow from computing \mathcal{Q}_i -Lab in this domain.

RUDI, fragments: summary

- resolve *res-via-id*. fragments via additional constraints on the rules for SAs;
- resolve *res-via-inf*. in domain specific way.

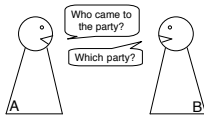
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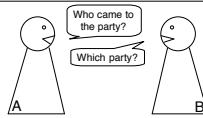
interaction management

RUDI - Clarification Requests

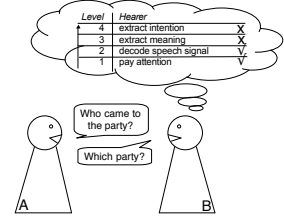


RUDI - Clarification Requests

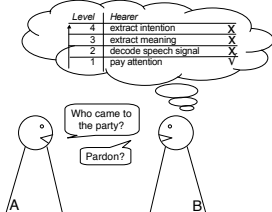
- indicate *understanding problem*.
- RUDI distinguishes two dimensions:
 - source of the problem
 - severity of the problem.



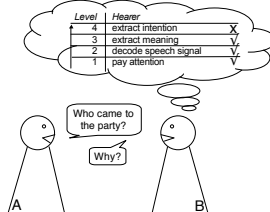
CR: problem source



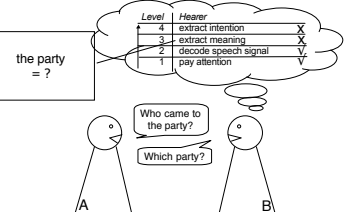
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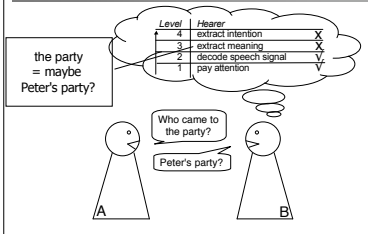
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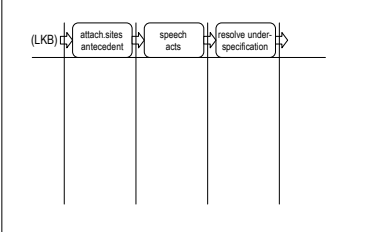
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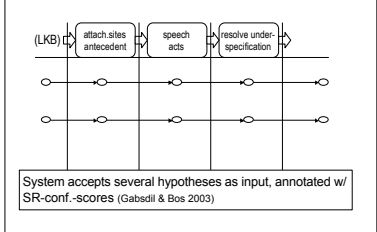
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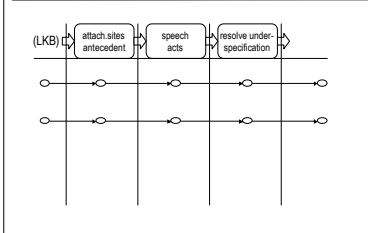
RUDI_{clar}



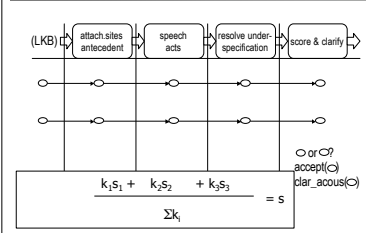
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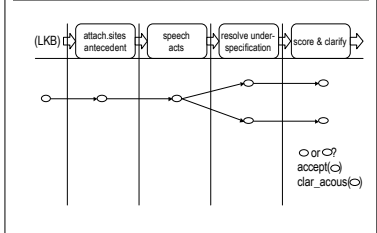
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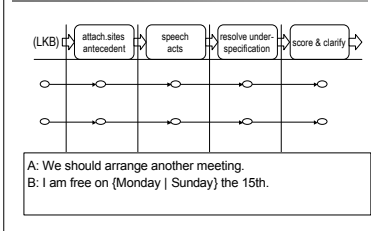
RUDI_{clar}



RUDI_{clar}

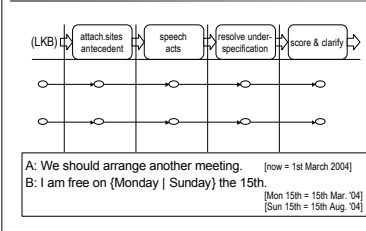


RUDI_{clar}



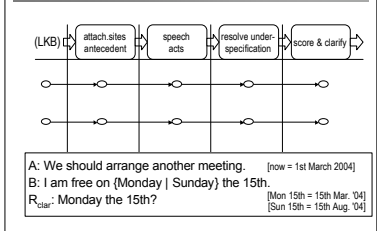
A: We should arrange another meeting.
B: I am free on {Monday | Sunday} the 15th.

RUDI_{clar}

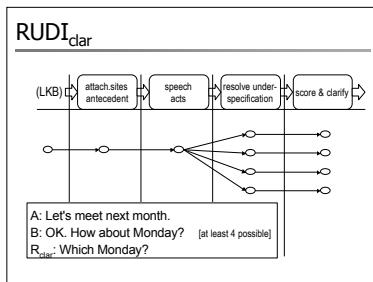
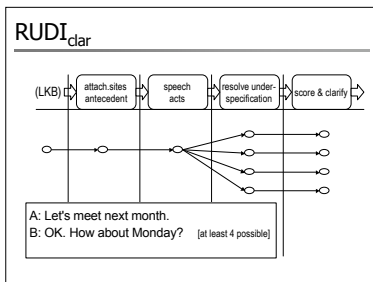
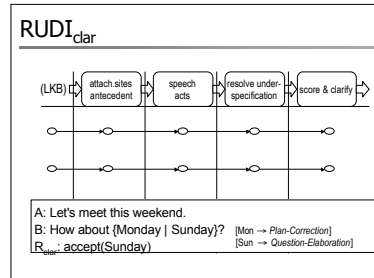
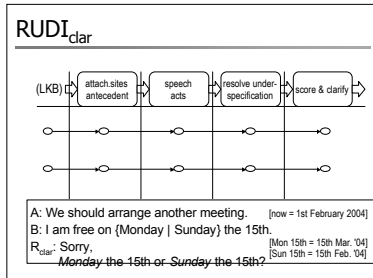
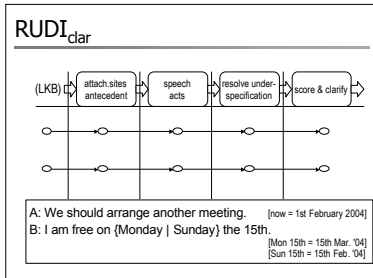


A: We should arrange another meeting. [now = 1st March 2004]
B: I am free on {Monday | Sunday} the 15th.
[Mon 15th = 15th Mar '04]
[Sun 15th = 15th Aug '04]

RUDI_{clar}



A: We should arrange another meeting. [now = 1st March 2004]
B: I am free on {Monday | Sunday} the 15th.
R_{clar}: Monday the 15th?
[Mon 15th = 15th Mar '04]
[Sun 15th = 15th Aug '04]



- RUDI, clarification: summary**
- Confidence scores on all levels.
 - Distinguish:
 - domain-specific scoring rules ("prefer dates closer to now", "prefer times between 8am and 8pm", etc.)
 - discourse general sc. rules ("prefer direct SAs")
 - Combine these scores to one overall value that determines CR behaviour.

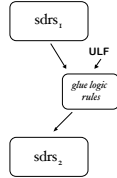
- Overview of talk**
- RUDI
 - RUDI-01: Bridging Relations
 - Phenomenon
 - SDRT
 - Implementation
 - RUDI-02: Fragments
 - Phenomenon
 - Implementation
 - RUDI-04: Clarification Requests
 - Phenomenon
 - Implementation
 - Information-State Update Framework
 - Summary
- context sensitivity of interpretation
- interaction management

- RUDI, summary**
- RUDI:
 - not practical system, "testbed" for theory of dialogue semantics and pragmatics
 - test theory / models
 - improve practical systems?
 - deep processing: "real" grammar, "real" LFs, "real" inference
 - future work: make more robust

- Overview of talk**
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Information State Update, intro

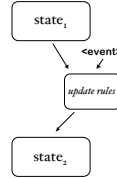
- Schematic view of update process in RUDI:



Information State Update, intro

- Schematic view of update process:

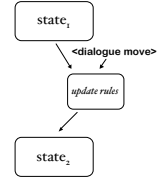
- Developed within the EU-project "Trindi" (Larsson 2002; Traum and Larsson 2006), integrating ideas from many previous projects.
- Not an approach per se: more an abstraction that allows different approaches to be compared, a framework.



Information State Update, intro

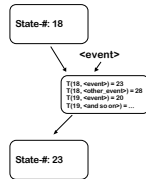
- More formally, an ISU-theory consists of:

- A formal representation of the **Information State**.
- A set of **Dialogue Moves** that trigger updates.
- A set of **Update Rules** that determine how observed moves change IS, or how changes in IS license moves to make.



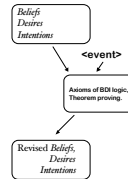
Information State Update, intro

- Is general enough to encode SD-style approaches:



Information State Update, intro

- ... or BDI approach:



Information State Update, intro

Why formulate your theory in this framework?

Best practice: allows

- models to be compared (common terminology);
- modules to be shared.

Information State Update, other

- systems that have been implemented in this framework:
 - GODIS (Larsson 2002). Uses QUD-stack to structure dialogue.
 - MIDAS (Bos 2000). Uses DRTs as part of IS. Theorem provers for updates.
 - EDIS (Mattheson, Poesio, Traum 2000). Focus on grounding and obligations.
 - RUDI (not actually in TRINDI-kit, but similar in spirit)

Summary

- SDRT
 - *Coherence*: information in discourse must be connected via rhetorical relations. Explains how discourse means more than indiv. utterances.
 - Computing DS can be done in simpler logic than needed for representing content.
- RUDI: implementation of SDRT for small domain.
- ISU: common terminology for Dialogue Models.

The end

Thank you!

<http://www.ling.uni-potsdam.de/~das>

Related Work - Hobbs et al.

- Hobbs et al. (1993)
 - "Interpretation as Abduction"
 - disc. interpr. as search for (cheapest) proof,
 - also coherence-driven,
 - but non-modular:
 - logic for interpreting content is same as that for composing LF of discourse
 - always uses common-sense reasoning, even for anaphora etc. (⇒ not informed by dyn. sem.)
 - weights are extra-logical machinery