# Dynamic Representation of Conversation in a Dialogue System

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www.kcl.ac.uk/research/groups/ds

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## Dialogue is Incremental

**A real dialogue system problem**

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| A: | I want to go to . . . |
| B: | Uh-huh |
| A: | Paris. |
| B: | OK. Let’s see . . . |
| A: | By train. Tomorrow. |

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  - Pauses, role changes, backchannels, continuations . . .
- Computational linguistic processing models have some way to catch up!. . .

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  - *Dynamic Syntax* [Kempson et al., 2001]
- A data structure to interface linguistic processing with domain semantics
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- An incremental dialogue framework
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**Split Turn Taking Puzzle**

| | |
|---|---|
| A: | Did you . . . |
| B: | Burn myself? |

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*like*

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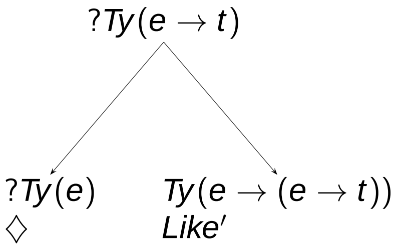
IF      $?Ty(e \rightarrow t)$
THEN    make($\langle\downarrow_1\rangle$);go($\langle\downarrow\rangle$);
        put($Fo(Like')$,
        $Ty(e \rightarrow (e \rightarrow t))$)
        go($\langle\uparrow_1\rangle$); make($\langle\downarrow_0\rangle$);
        go($\langle\downarrow_0\rangle$); put($?Ty(e)$)
ELSE    ABORT
```



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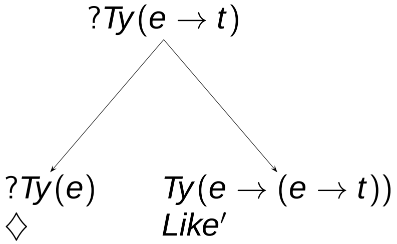

- *Computational actions* are general rules that can be fired independently of lexical actions. They give DS *predictivity*

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Processing *John likes Mary*

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\color{red}{\Diamond}, ?Ty(e) & & ?Ty(e \rightarrow t)
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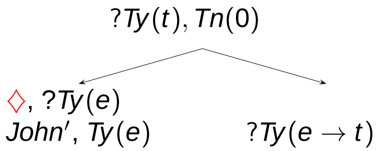

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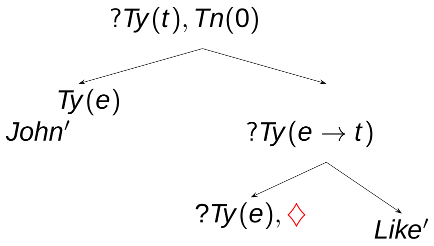

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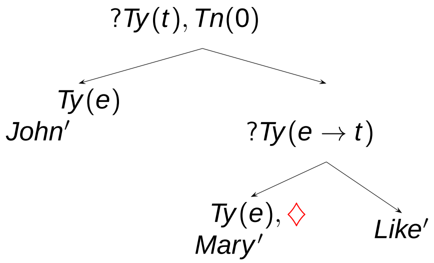

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$$\begin{tikzcd}
& ?Ty(t), Tn(0) \arrow[dl] \arrow[dr] & & \\
\begin{array}{c} Ty(e) \\ John' \end{array} & & \begin{array}{c} Like'(Mary') \\ ?Ty(e \rightarrow t), \diamondsuit \end{array} \arrow[dl] \arrow[dr] & \\
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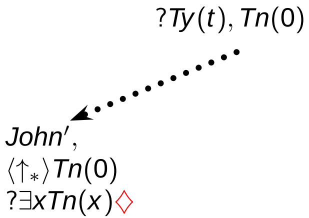

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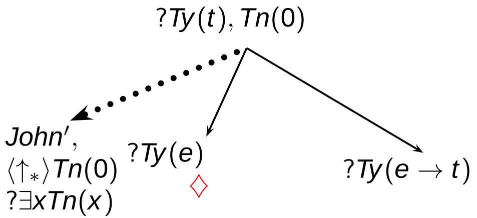

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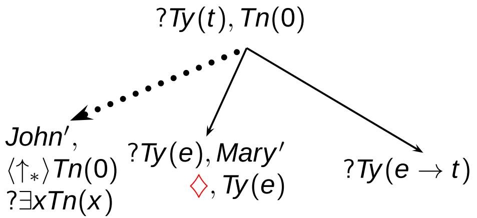
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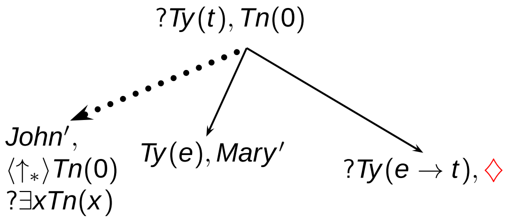
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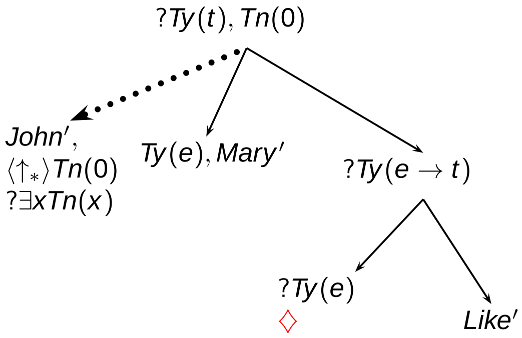

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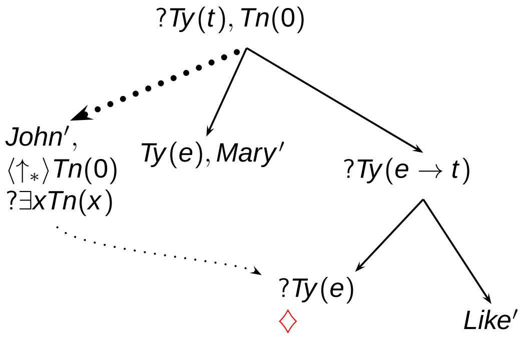

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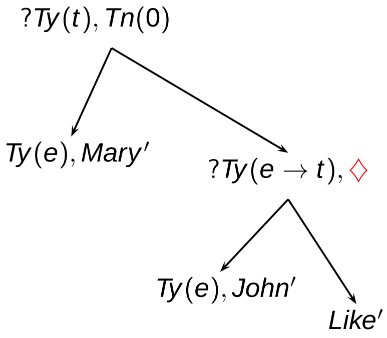

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- DS parsing can also be seen as a *tree* lattice [Sato, 2010]
  - Nodes = trees
  - Edges = lexical/computational actions

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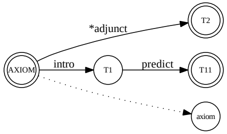
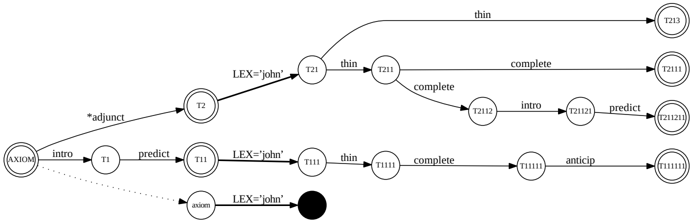


## DS DAG

“John”


thin
T213
LEX=’john’
T21
thin
T211
complete
T2111
complete
T2112
intro
T21121
predict
T211211
*adjunct
T2
AXIOM
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T1
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T111111
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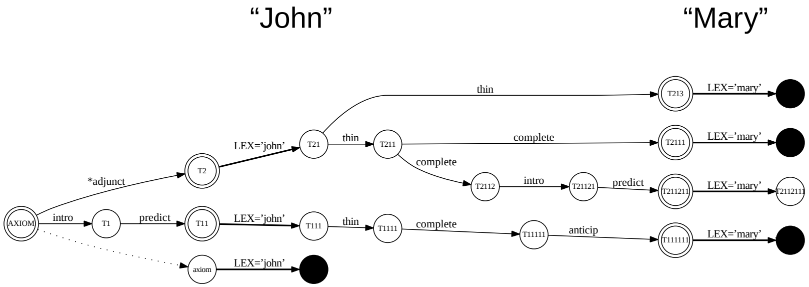

“John”
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- Underspecified semantic placeholders can be integrated through backtracking triggers like do-auxilliaries and pronouns

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$$\begin{tikzcd}
 & \begin{bmatrix} x : \mathit{john} \\ p : \mathit{leave}(x) \end{bmatrix} \arrow[dl] \arrow[dr] & \\
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- Recently, a Davidsonian [Davidson, 1980] event-based semantics for tense has been incorporated [Cann, 2010]

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...

$$\begin{bmatrix} e = \textit{now} & : & e_s \\ e1 = \textit{future} & : & e_s \\ x1 = \textit{Paris} & : & e \\ p2 = \textit{to}(e1, x1) & : & t \\ x = \textit{speaker} & : & e \\ p1 = \textit{go}(e1, x) & : & t \\ p = \textit{want}(e, x, p1) & : & t \end{bmatrix}$$

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I want to go to Paris from London . . .

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$\mathit{Trip}$ :
$\mathit{to} = \mathit{paris}$
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- Provides a nice interface between Dynamic Syntax $\leftrightarrow$ domain semantic frames

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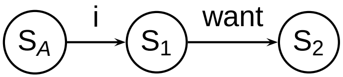

$$\begin{tikzcd} S_A \arrow[r, "i"] & S_1 \arrow[r, "want"] & S_2 \end{tikzcd}$$

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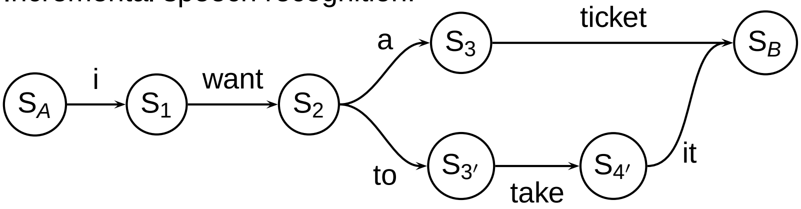

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S_A \arrow[r, "\text{i}"] & S_1 \arrow[r, "\text{want}"] & S_2 \arrow[ur, bend left, "\text{a}"] \arrow[dr, bend right, "\text{to}"'] & & & \\
 & & & S_{3'} \arrow[r, "\text{take}"'] & S_{4'} \arrow[uur, bend right, "\text{it}"'] &
\end{tikzcd}$$

- A DS DAG could interface with this?...

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    - A standard dialogue systems approach of one move per utterance, fragment resolution mechanisms
    - Not much in the way of *semantics*
- A *domain-general* incremental semantics is needed for various dialogue phenomena

## Putting voice recognition and DS parsing together

- DS $\leftrightarrow$ ASR in Jindigo
  - Incremental *word* lattice subsumes finer grained incremental *parse* lattice
  - “Big” word hypothesis edges from the ASR subsume the “thin” lexical/computational action edges from parsing

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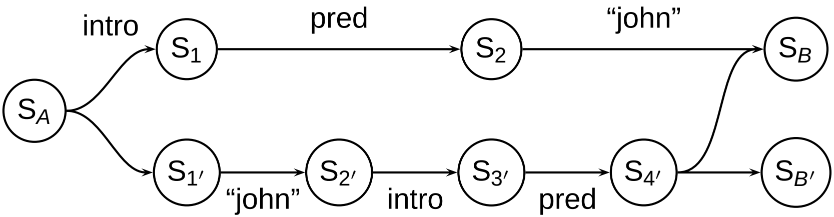

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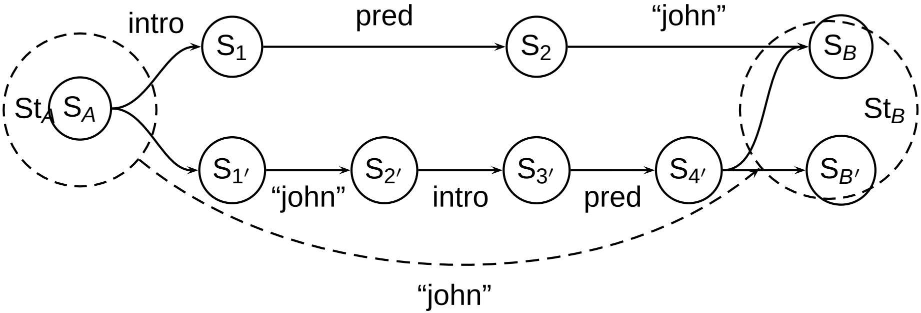

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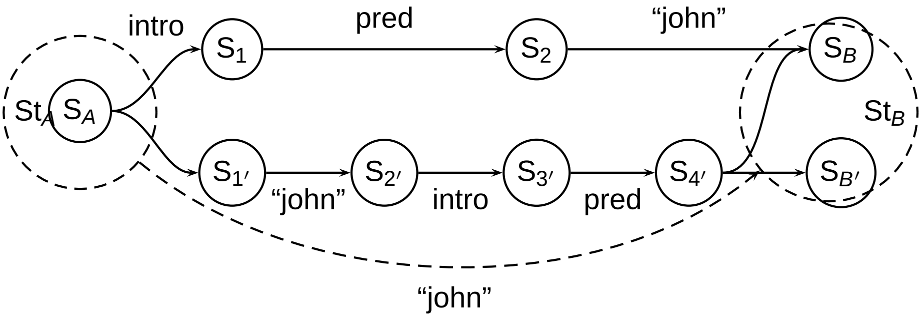

- The best parse hypothesis will be *committed* when it is *grounded in* a committed ASR hypothesis

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- The parse state is maintained, so new trees and new record types can be introduced and replace a revoked domain frame concept

## Generation

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- This is work in progress!

## Module interaction: sharing tree lattices

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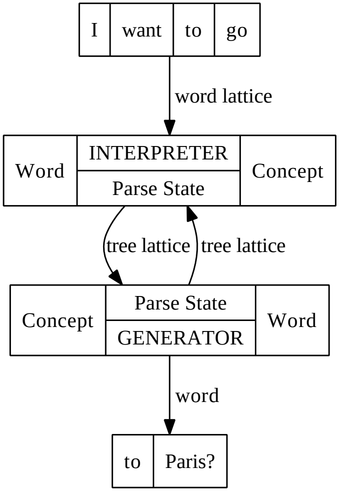

## Jindigo demo

[Jindigo demo]

## Future work: repair simulation

- Simulating error phenomena such as self-repair and hesitation should be possible

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  - the incremental goal tree subsumption checking of the DS generation process [Purver and Kempson, 2004]
  - repair strategy: if a new goal tree from a dialogue manager does not subsume the current one, *backtrack* through the context DAG until a tree is found where subsumption does occur and then start generating again from there
  - error causes: possible information flow deadlocks between jindigo modules

## Thanks for listening!

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Ruth Kempson, Pat Healey, Christine Howes,

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