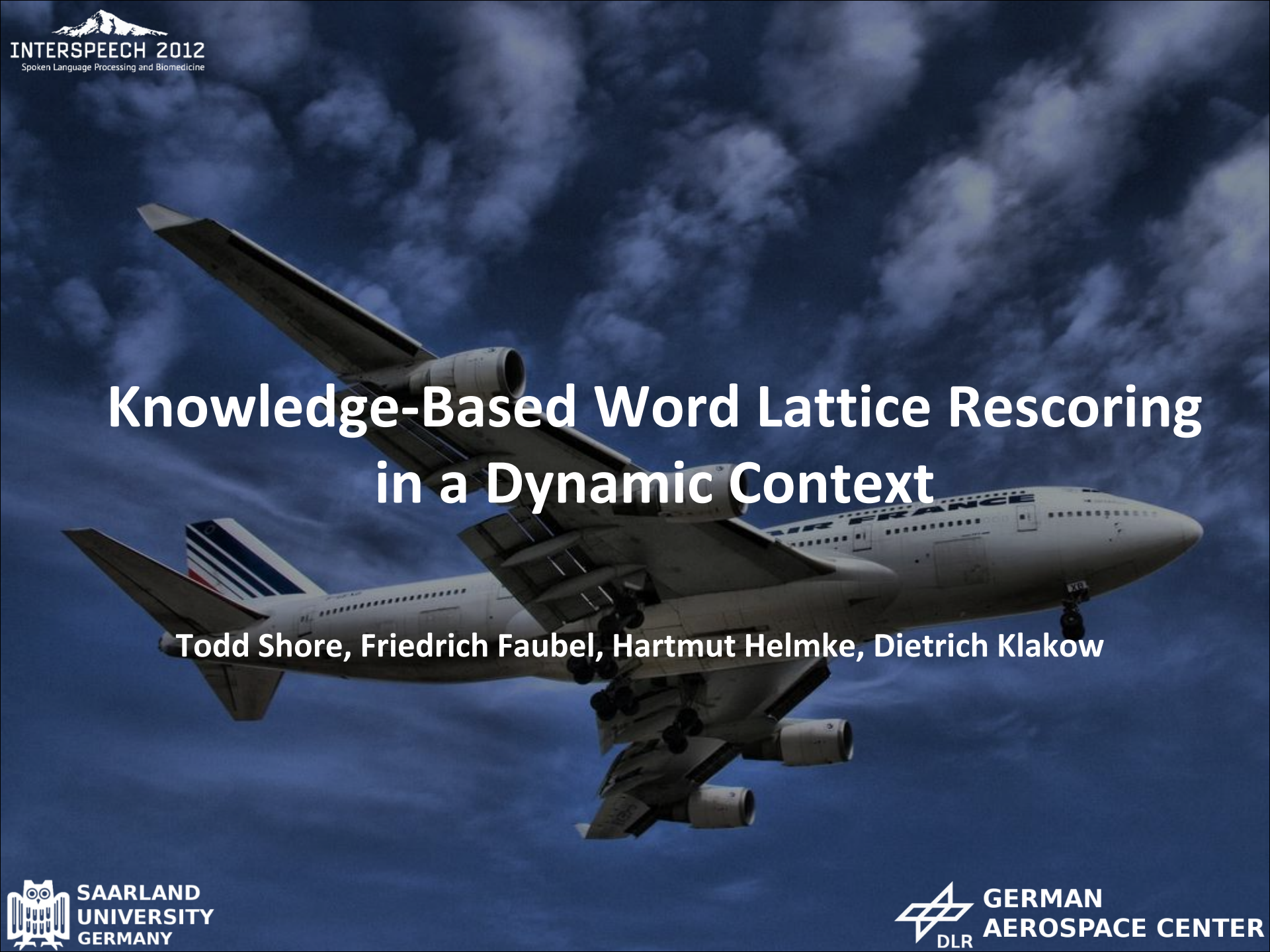

Knowledge-Based Word Lattice Rescoring in a Dynamic Context

Todd Shore, Friedrich Faubel, Hartmut Helmke, Dietrich Klakow

SAARLAND UNIVERSITY GERMANY

DLR GERMAN AEROSPACE CENTER

Section I

Motivation

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- **However:** there are domains in which the situational context of utterances is available, e.g. air traffic control (ATC) or command and control tasks

- **Approach taken in this work:** incorporate contextual knowledge into ASR by rescoring word lattice output of an ATC task

Section II

The Air Traffic Control Task

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- Air traffic controllers at their workstations

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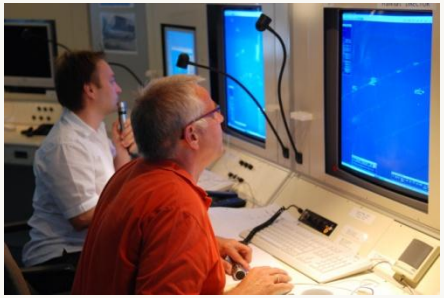
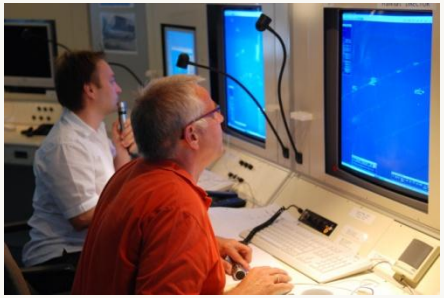


- **Primary objective:**
  - maintain aircraft separation
  - safely guide approaching aircraft to their runway threshold
  - integrate departing and passing aircraft

The Air Traffic Control Task

- Air traffic controllers at their workstations



- **Have access to:**
  - radar screens revealing aircraft positions and speeds
  - flight plans
  - weather reports, indicators for speed of wind, etc.

The Air Traffic Control Task

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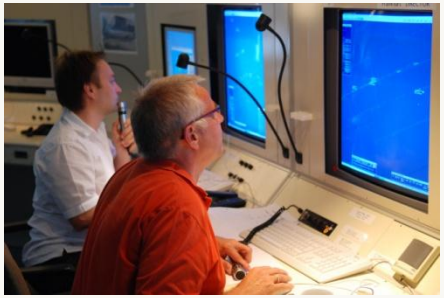

- **Implementation:**
  - issue verbal commands to aircraft pilots
  - use of a standardized subset of English which is formally specified by the International Civil Aviation Organization (ICAO)

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Type	Values	Example
DESCENT	ALT	*descend altitude* ALT *feet*
DESCENT	FL	*descend flight level* FL
REDUCE	SPD	*reduce speed* SPD *knots*
TURN	DIR, HDG	*turn* DIR *heading* HDG

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- **Example:** *„Delta four three niner turn right heading two two zero“*

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- **Example:** *„Delta four three niner turn right heading two two zero“*

- **Relevant Information:**
  - DL 439
  - TURN, DIR=right, HDG=220

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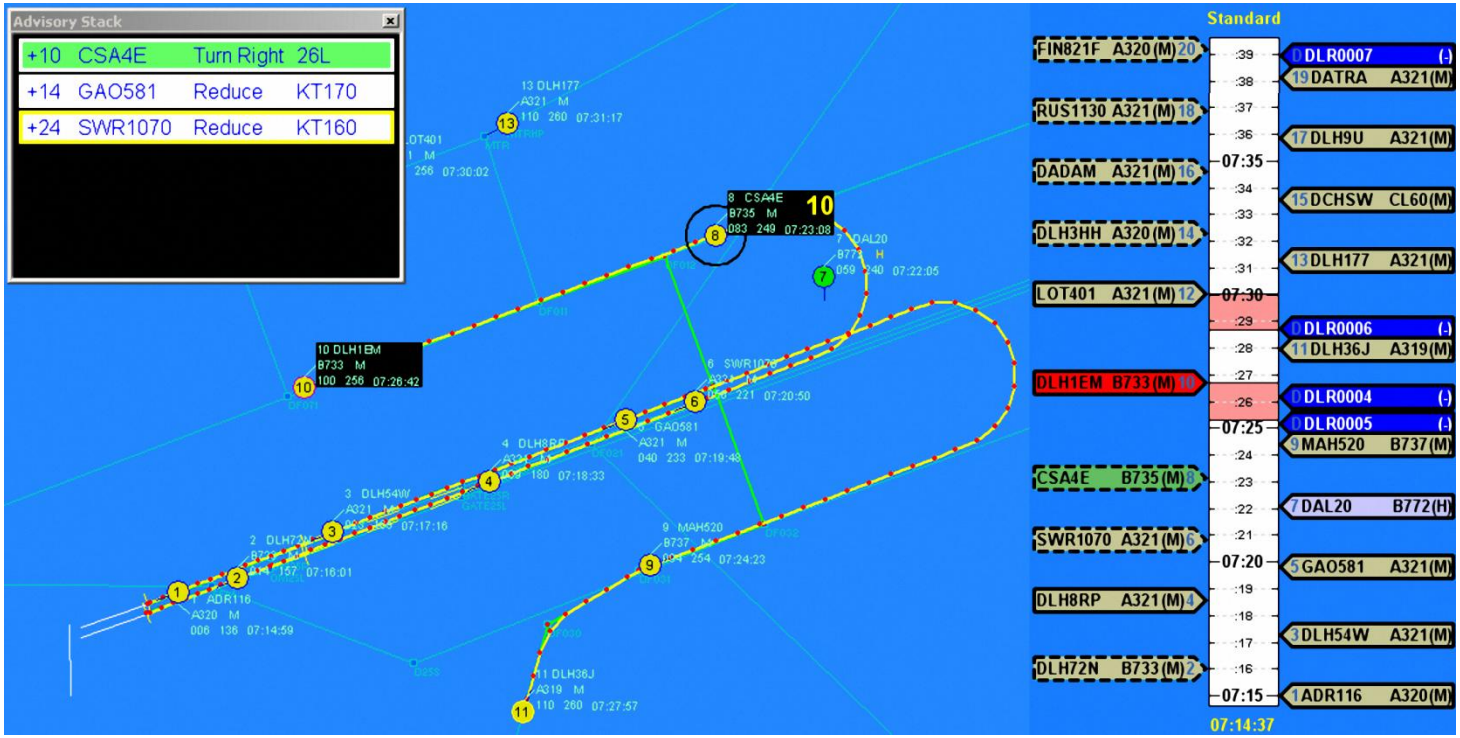
- But where does this information come from?

The Air Traffic Control Task

- Modernized ATC workspace as envisioned by the German Aerospace Center (DLR)

The Air Traffic Control Task

- … including the arrival manager **4D-CARMA**, which assists controllers in managing aircraft arrivals



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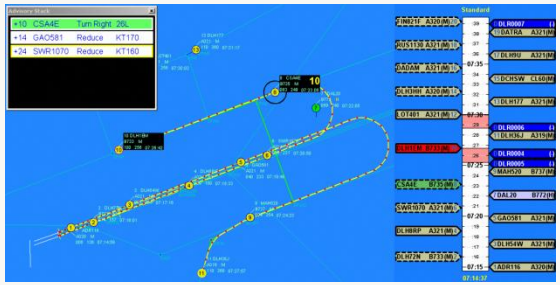

- **This system allows us to extract:**
  - the callsigns of aircraft in the airspace
  - the aircraft positions relative to the radar
  - Their speeds, altitudes, climb/descend rates, reduce rates, etc.

Section III

Knowledge-Based Lattice Rescoring

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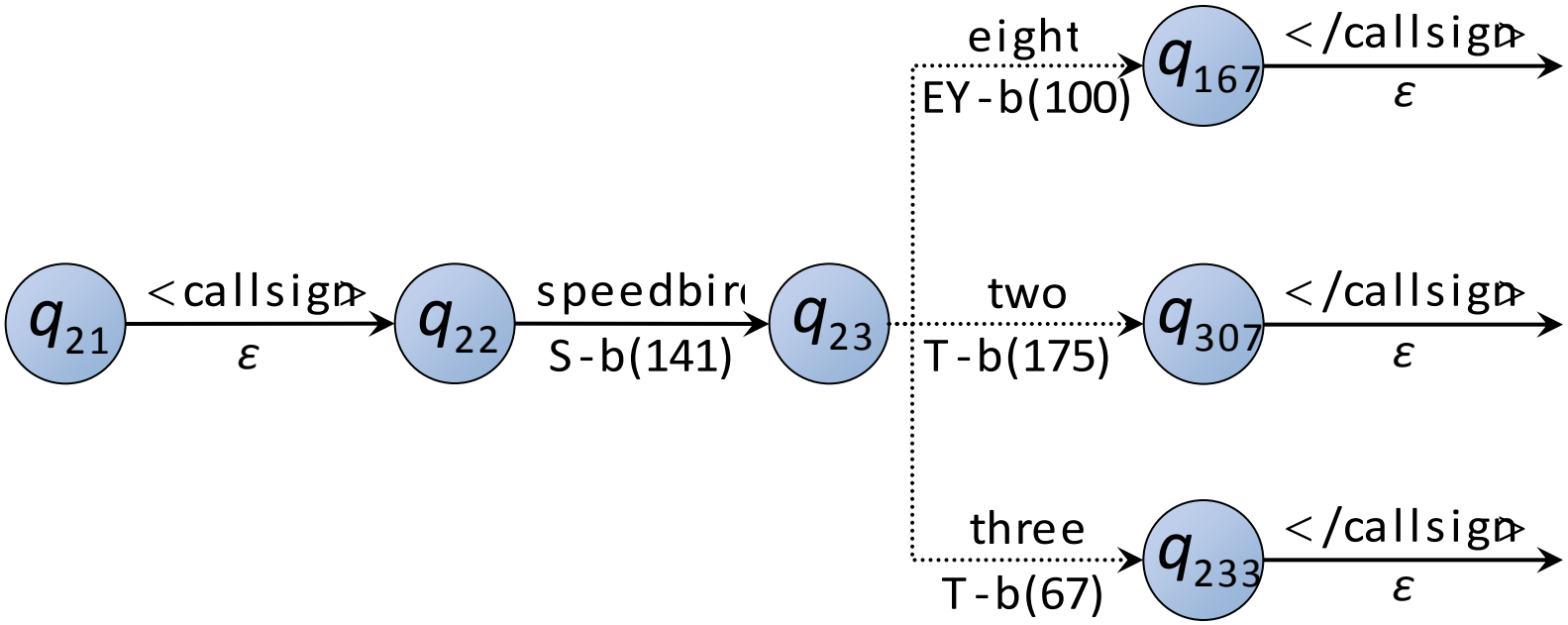

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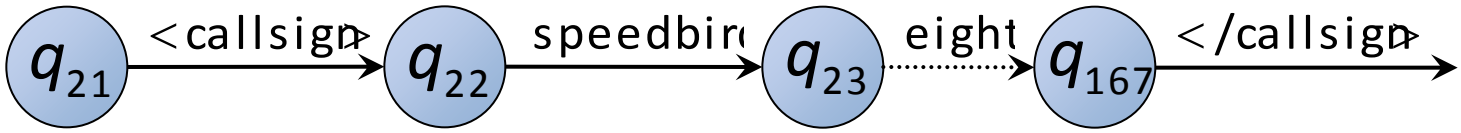

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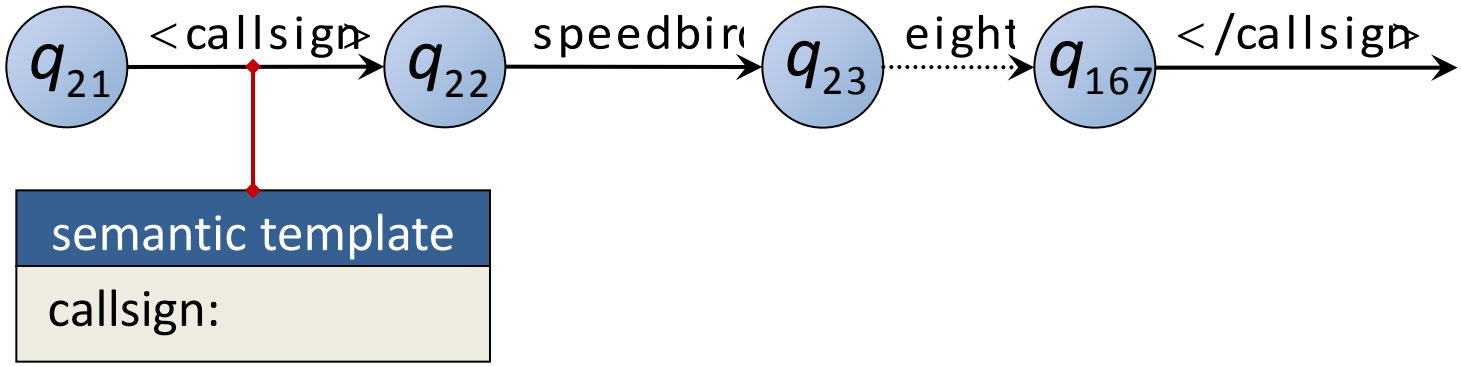

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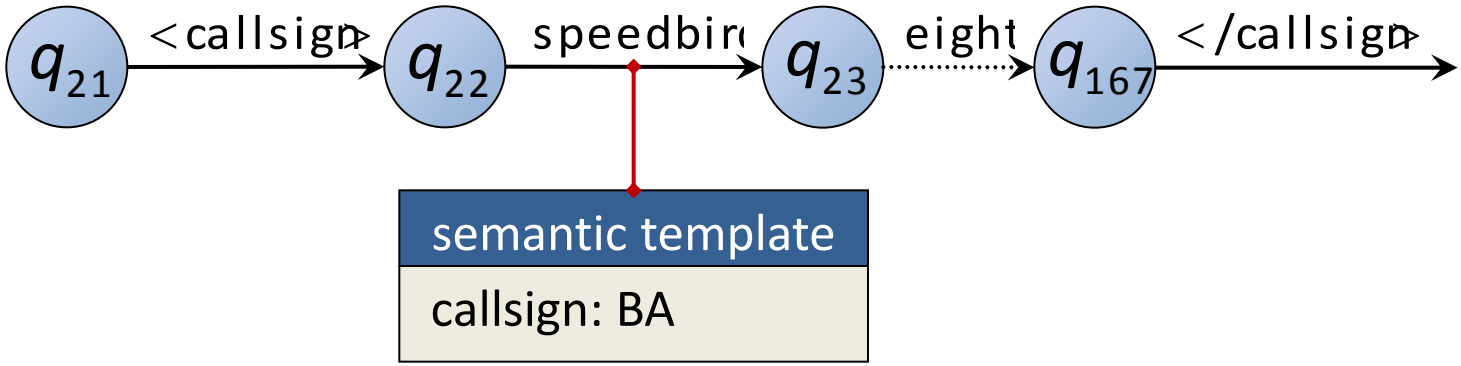

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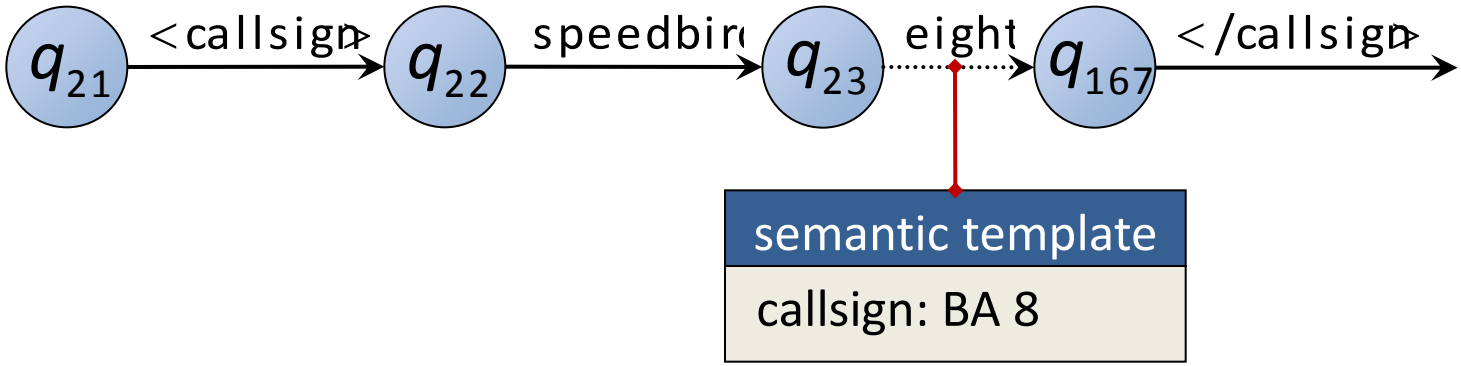

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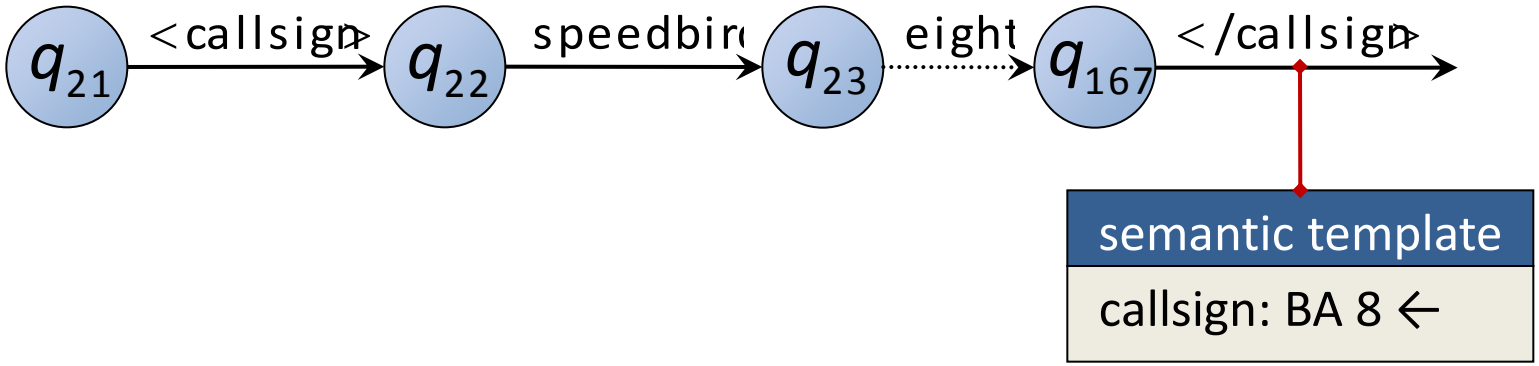

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- **Principal Idea:** penalize invalid callsigns and unlikely command values based on discourse representation system

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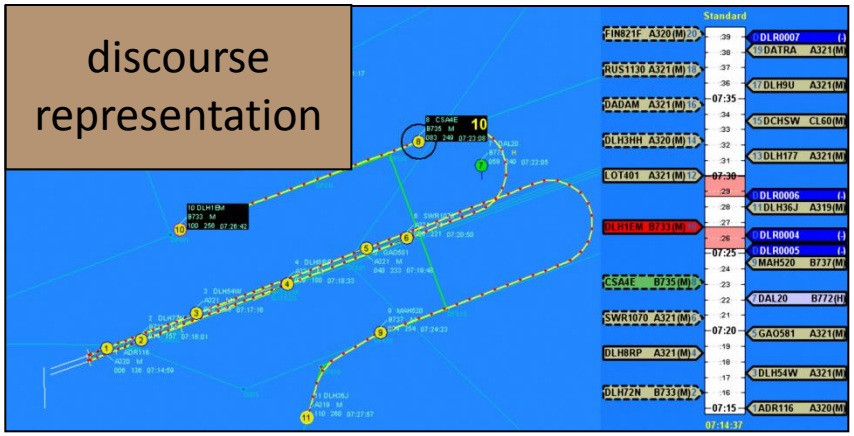

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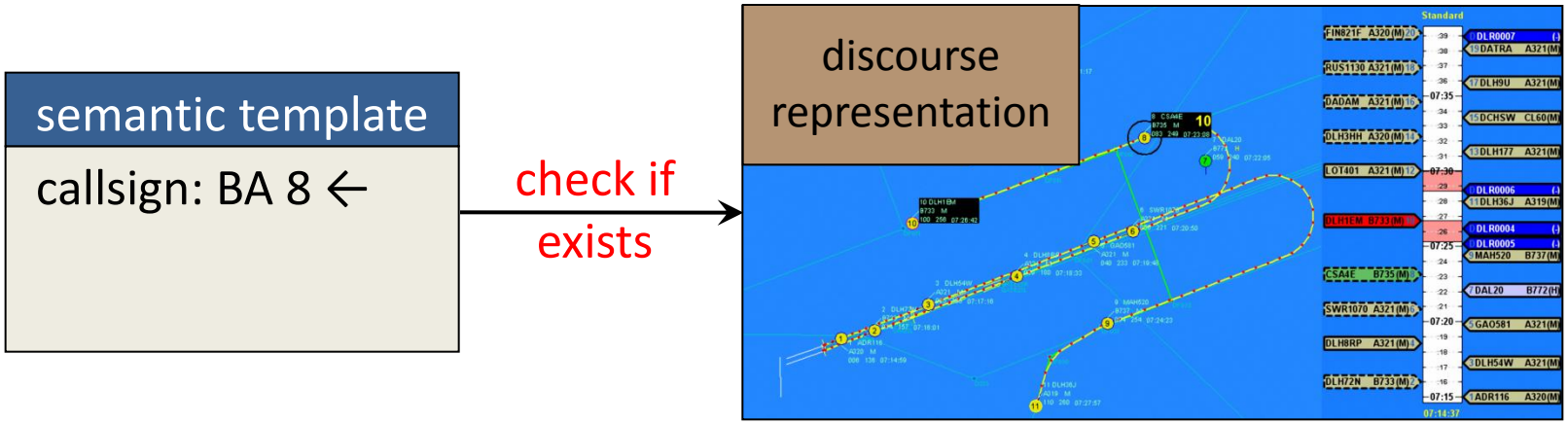

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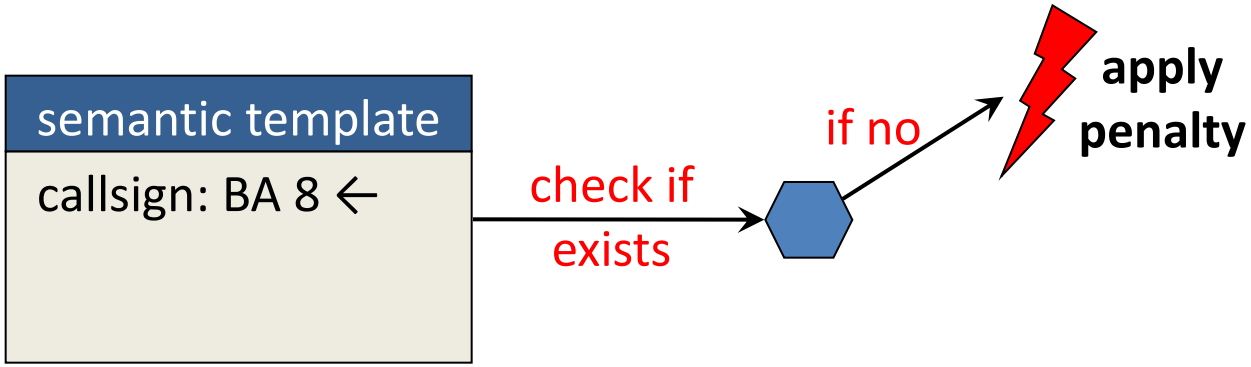

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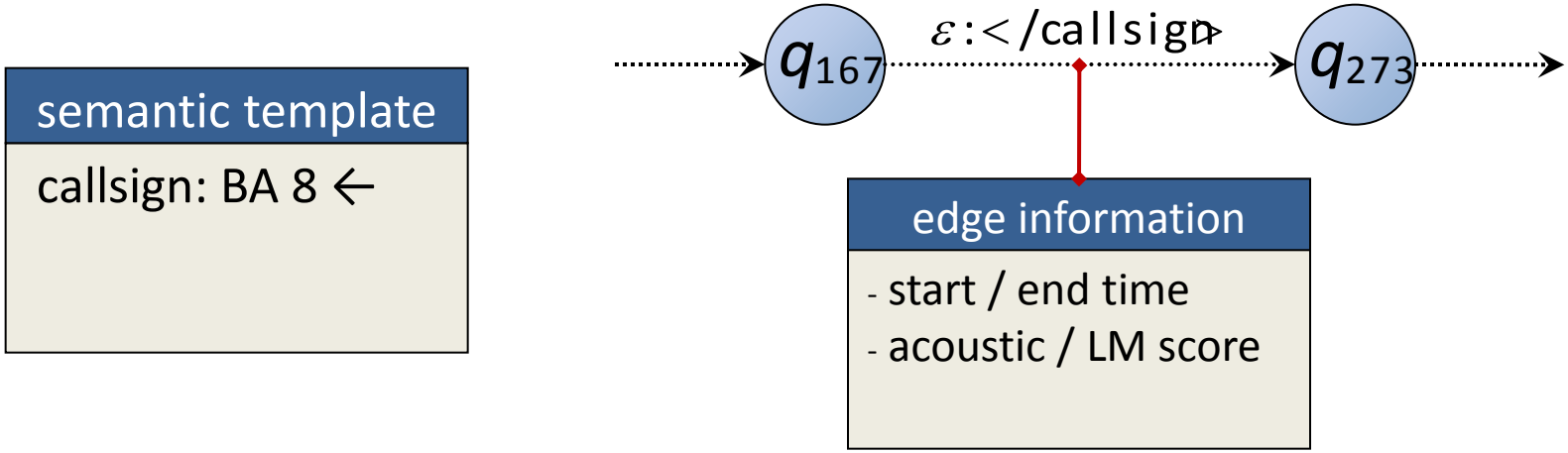

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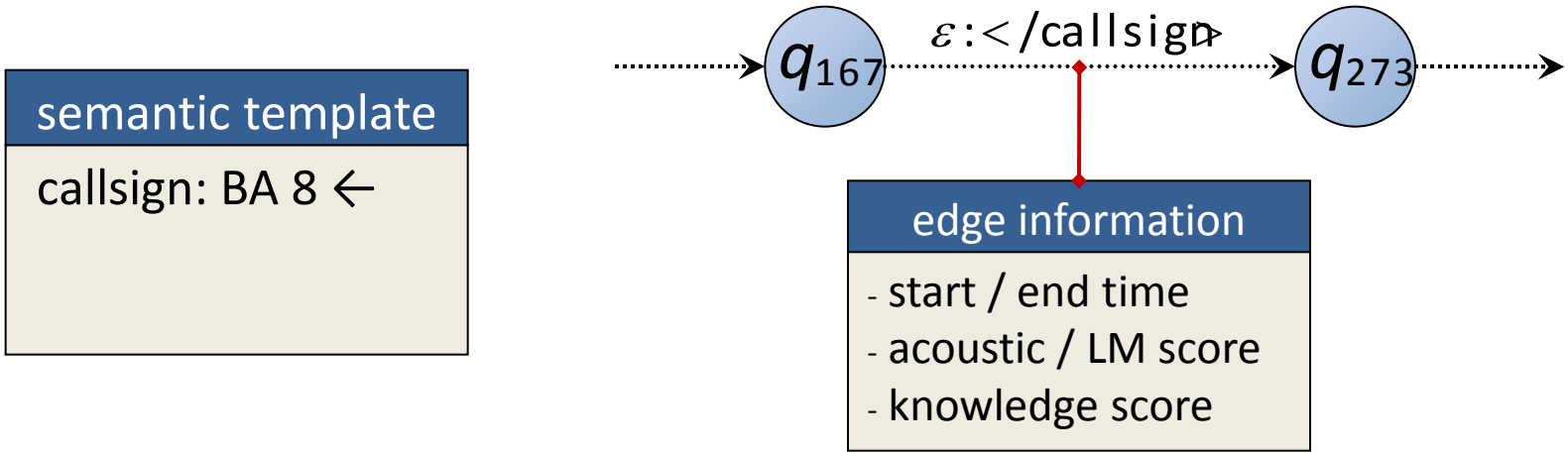

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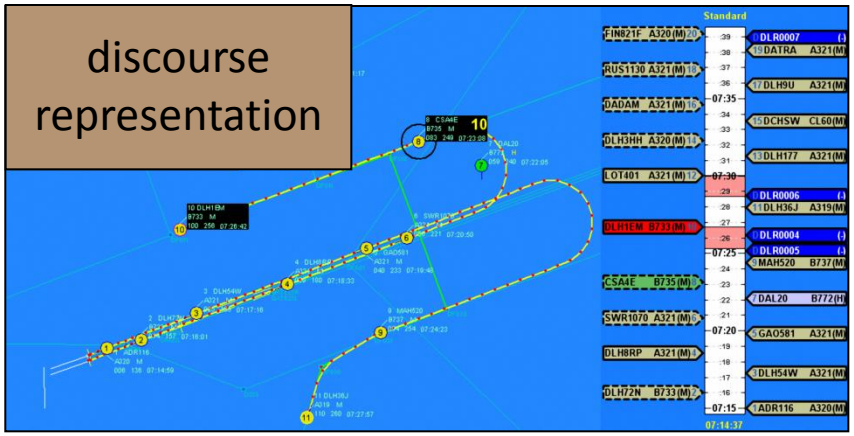

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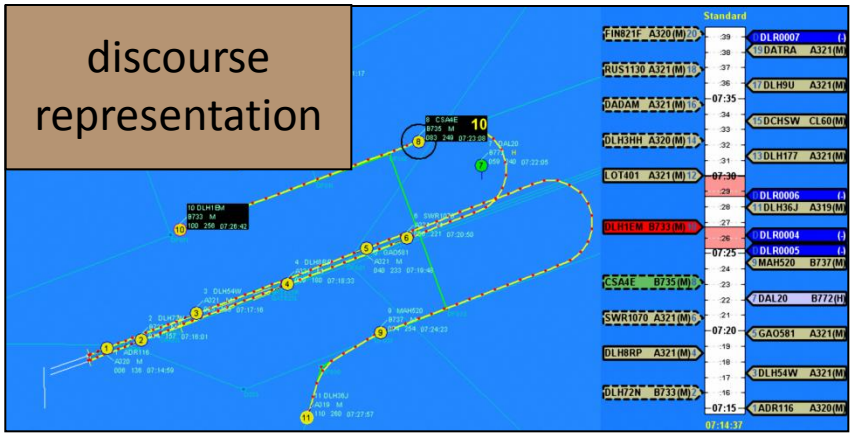

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check
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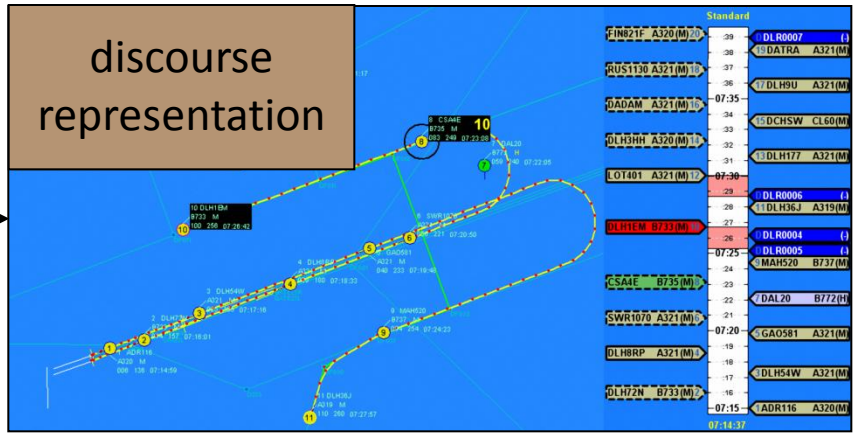

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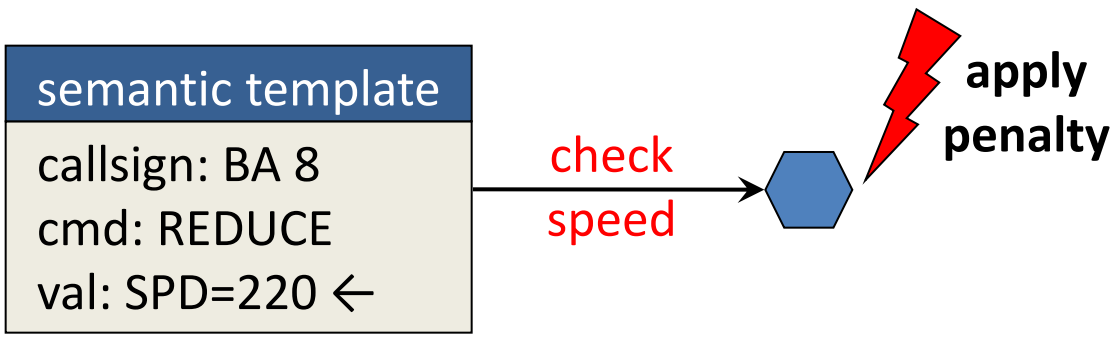

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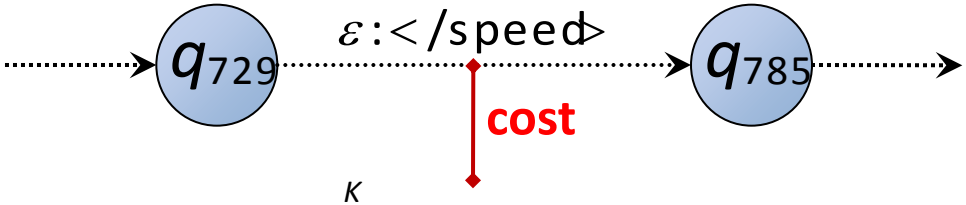

$$\partial_{kn}(q_i, q_j) = \sum_{k=1}^{K} \rho_k \, c_k \, (\text{callsign}, \text{cmd}, \text{val})$$

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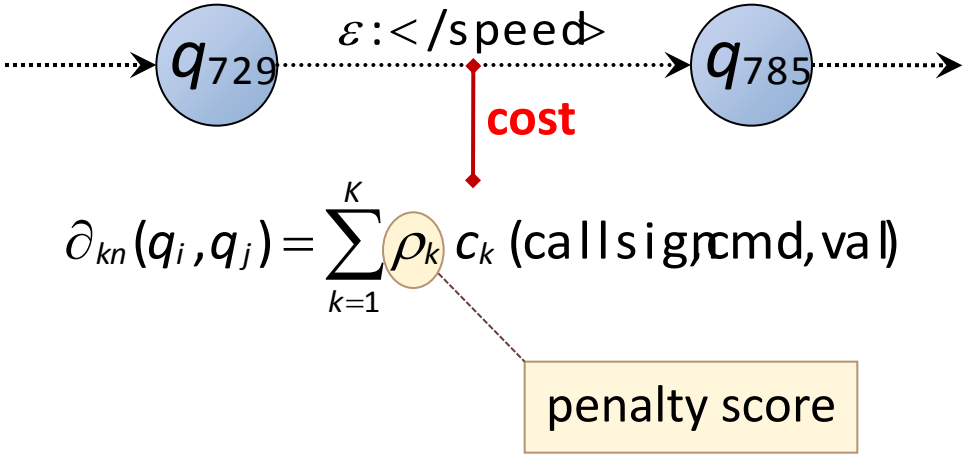

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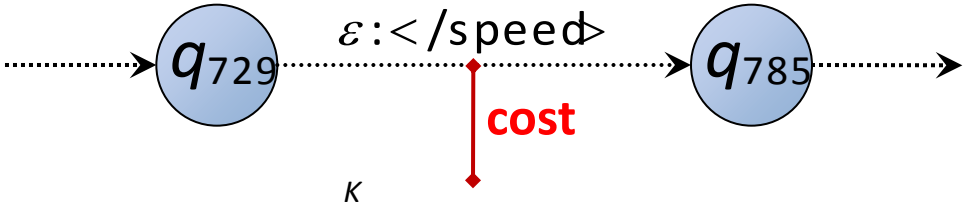

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constraint penalty function $c_k(\cdot) \rightarrow [0,1]$

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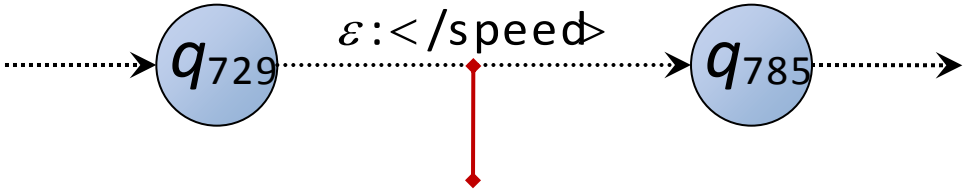

total cost:

$$\partial(\cdot) = \omega_{ac}\partial_{ac}(\cdot) + \omega_{lm}\partial_{lm}(\cdot) + \omega_{kn}\partial_{kn}(\cdot)$$

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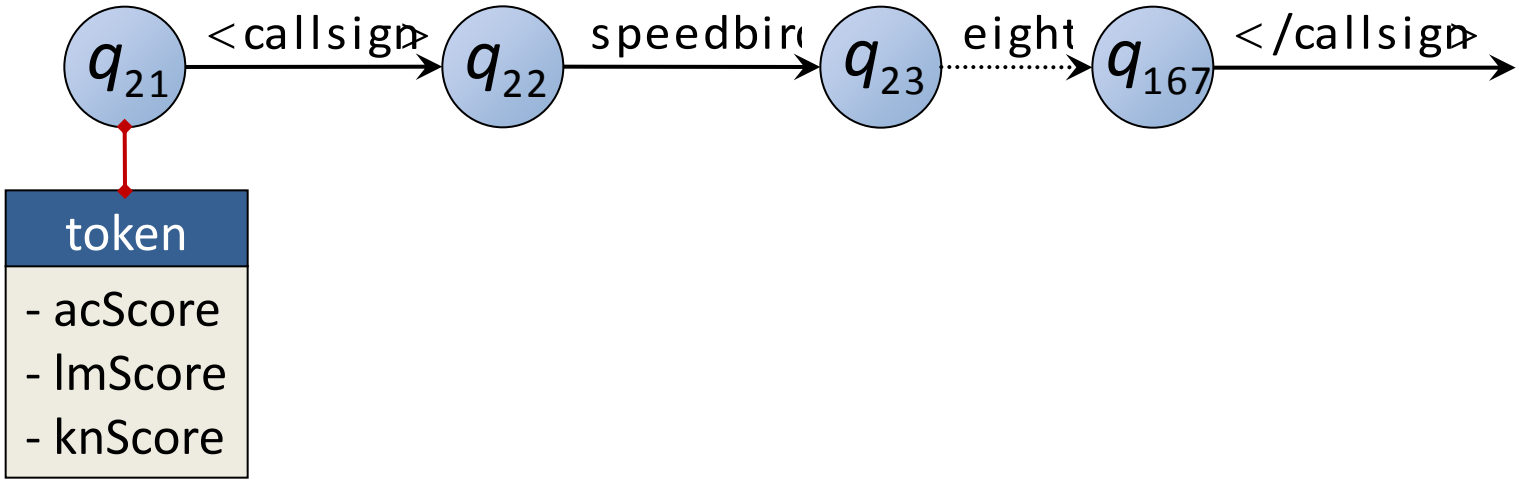

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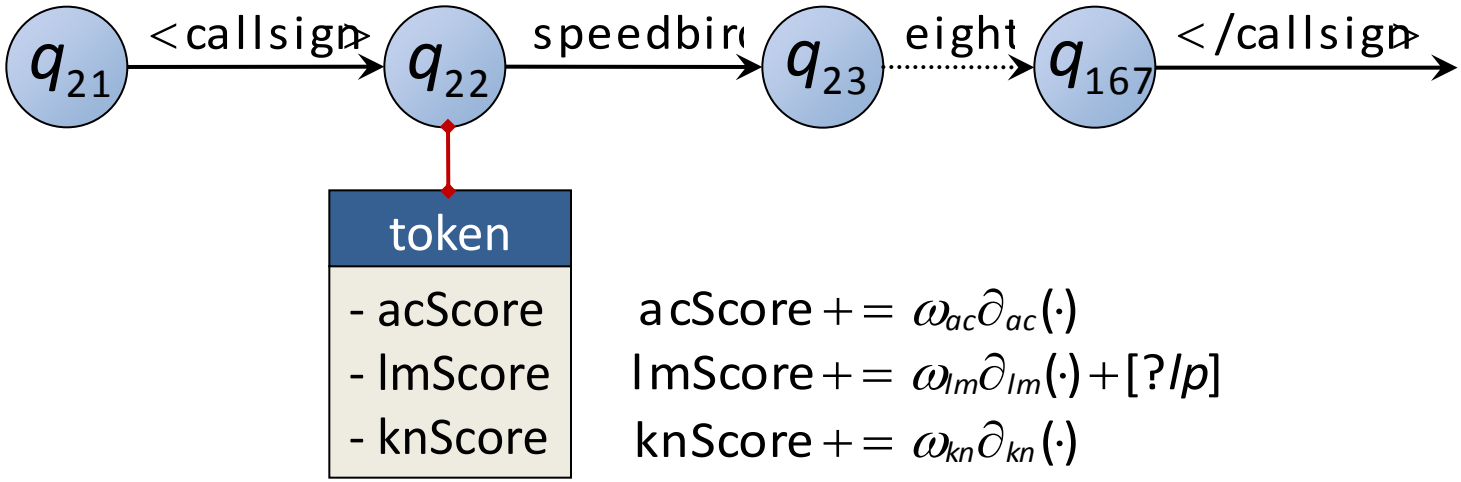

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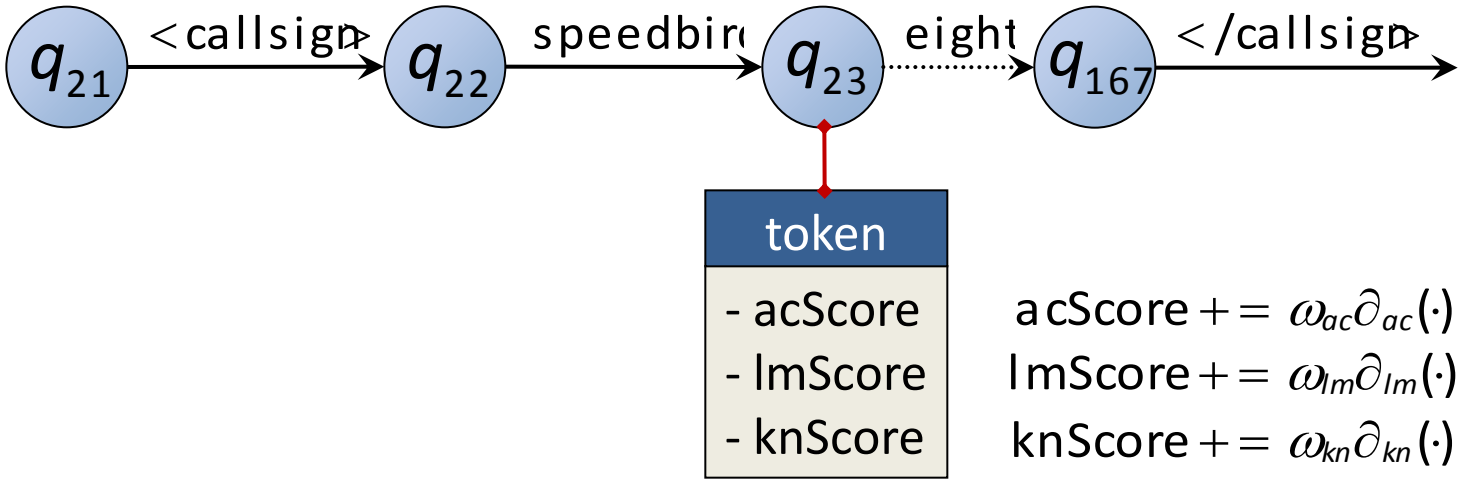

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1. Propagate scores along the nodes

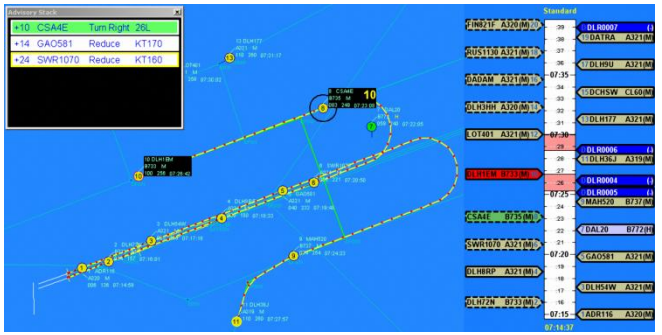
2. Trace back from best final state

Section IV

Rescoring Experiments

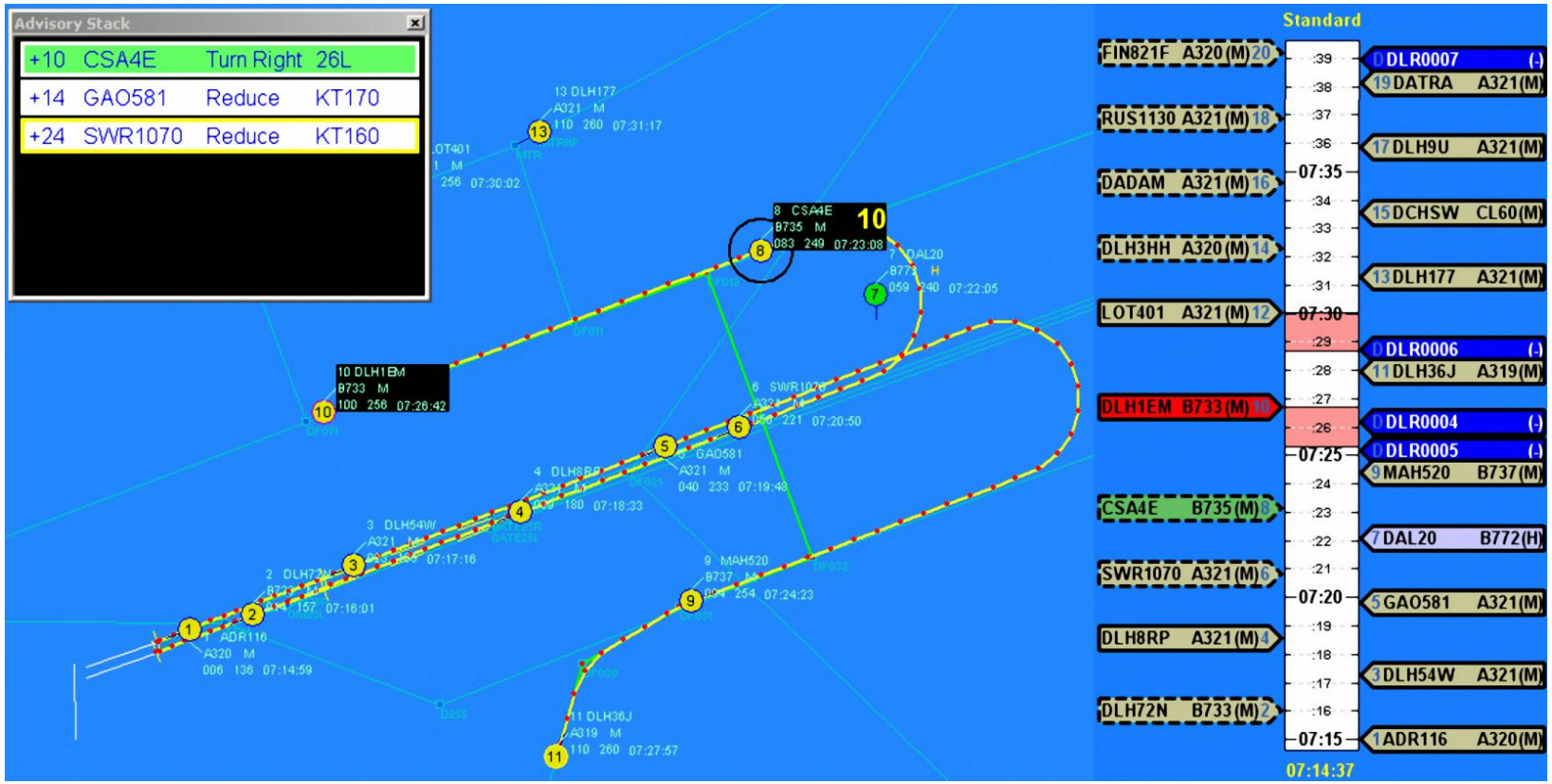
Rescoring Experiments

- **Corpus:**
  - recorded using the 4D-CARMA software from DLR
  - includes aircraft state vectors (5 second intervals)
  - total of 1,107 ATC commands
  - 9.5 words per sentence
  - approx. 100 minutes of speech



Rescoring Experiments

- **GUI used by the participants**



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Rescoring	WER	SER	MRR
None (baseline)	2.81	22.58	0.849
Callsign	0.55	4.61	0.966
Callsign, Spd, Alt	0.52	4.52	0.967
Oracle	0.31	2.07	0.979

Section V

Conclusions

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- We have shown how dynamic context knowledge can profitably be used for rescoring ASR hypotheses

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- This is of particular interest in scenarios where explicit context information is available, such as
  - ATC: radar-derived aircraft state vectors
  - video games
  - virtual reality


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Thank you very much
for your attention!
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GERMAN
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