Errors, Intentions, and Explanations –

Feedback Generation for Language Tutoring Systems

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Overview

- A Vision

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- Where we are?

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- Error Diagnosis and Ambiguity

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- Intentions for Hypothesis Selection
- Conclusions

A Vision

- having a system which . . .
  - . . . facilitates goal-oriented interaction
  - . . . encourages the student to *actively* produce language
  - . . . puts few constraining limitations on language use
  - . . . provides helpful feedback for the student to improve

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  BRIAN FARRINGTON (Eurocall 2000)

Where we are?

- We can provide helpful error explanations . . .
  - . . . under strong domain restrictions
  - . . . for language with limited lexical and grammar coverage
  - . . . using approximative linguistic knowledge
  - . . . making simplifying assumptions on error types and maximum error complexity

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  - . . . using approximative linguistic knowledge
  - . . . making simplifying assumptions on error types and maximum error complexity
- We know that . . .
  - . . . existing system solutions are too restricted
  - . . . explanation quality is sometimes poor

Where we are?

- We tend to neglect that . . .
  - . . . every explanation is targeted at a particular correction proposal
  - . . . the *only* criterion available to determine the optimum proposal is the ”similarity” of the corrected to the original student solution
  - . . . ”similarity” is relative to the knowledge captured by a particular model
  - . . . the quality of error descriptions depends on knowledge being available at the *right point in time*

Where we are?

- We believe that explanation quality could be improved by using . . .
  - . . . more precise linguistic descriptions
  - . . . strong support from extra-linguistic knowledge
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Where we are?

- We believe that explanation quality could be improved by using . . .
  - . . . more precise linguistic descriptions
  - . . . strong support from extra-linguistic knowledge
  - . . . reference to the non-linguistic context
- We should become aware of the fact that . . .
  - . . . the ideal point of reference is the intention of the learner.

Where we are?

- Why intentions?

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    - e.g. asking *”What did you want to say?”*
    - can be communicated by linguistic and non-linguistic means
  - could provide a strong support for guiding the diagnosis

Error Diagnosis and Ambiguity

- ambiguity

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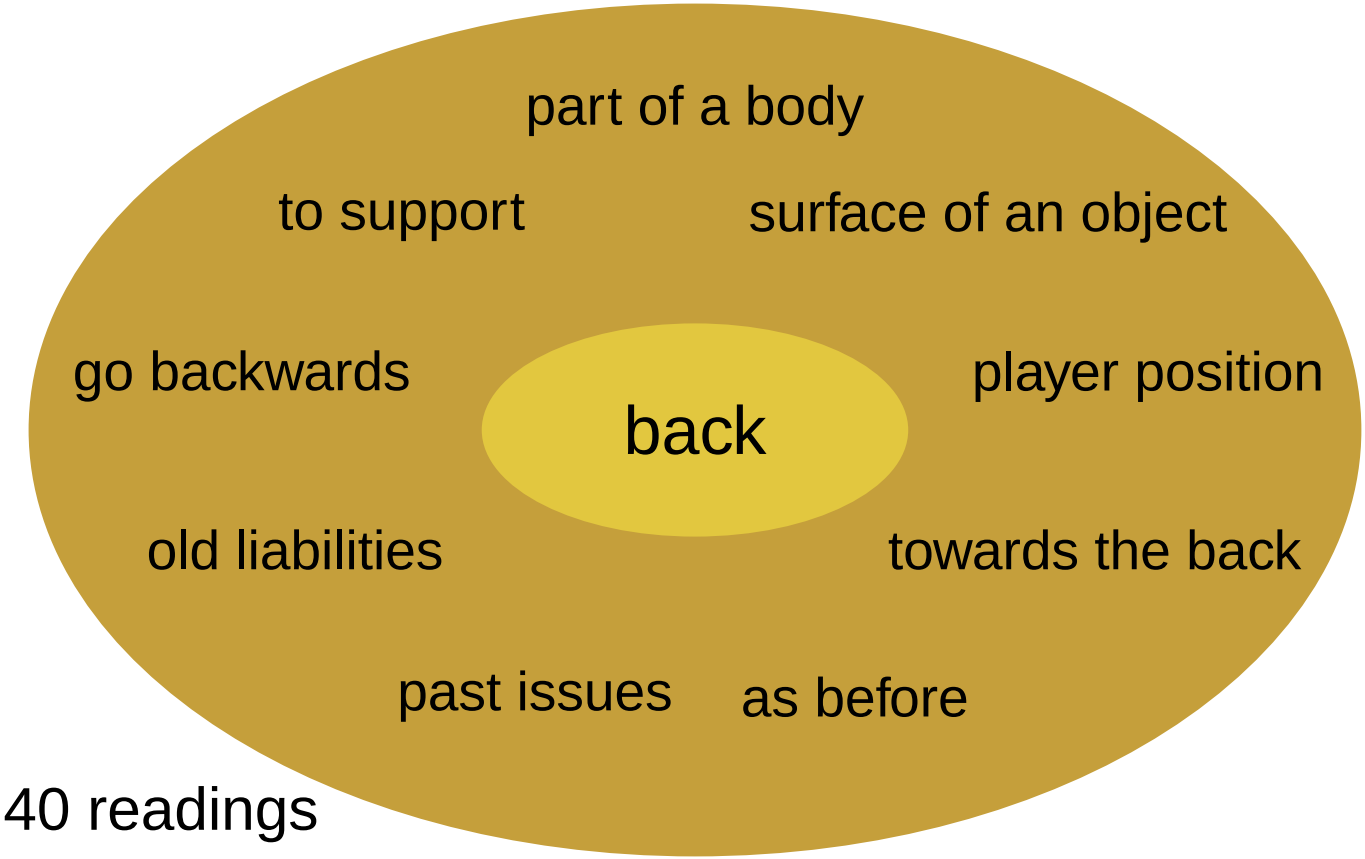

LDOCE: 40 readings

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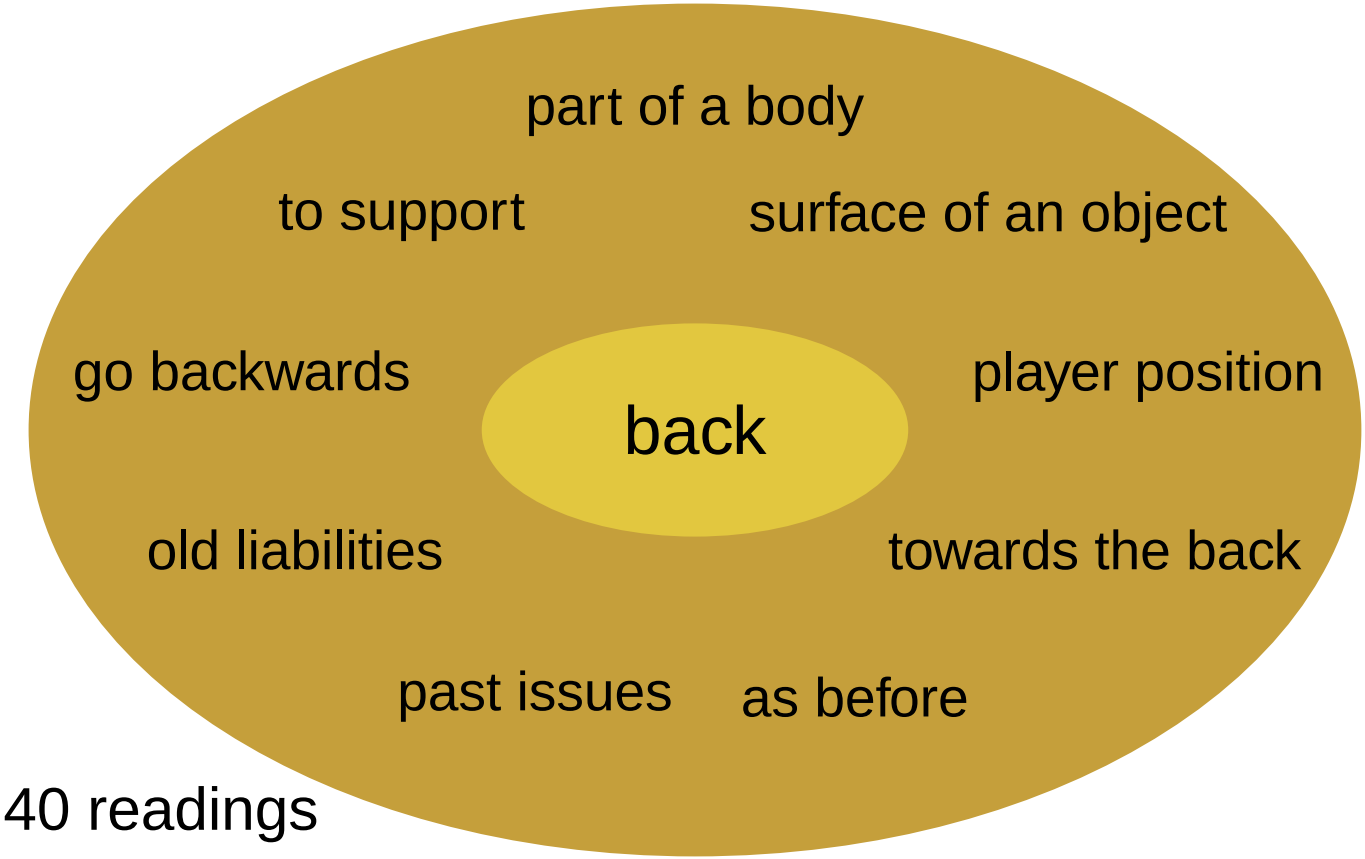

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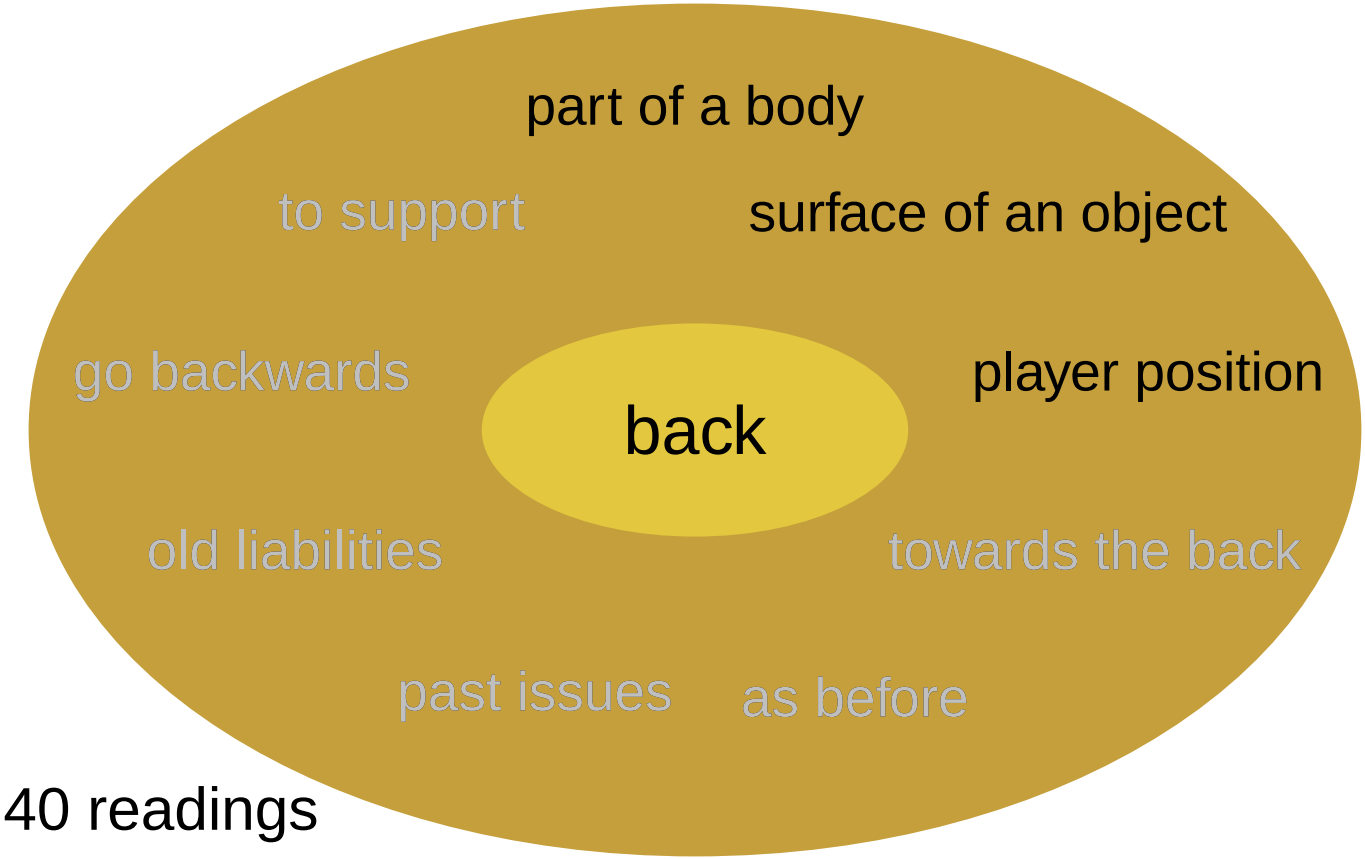

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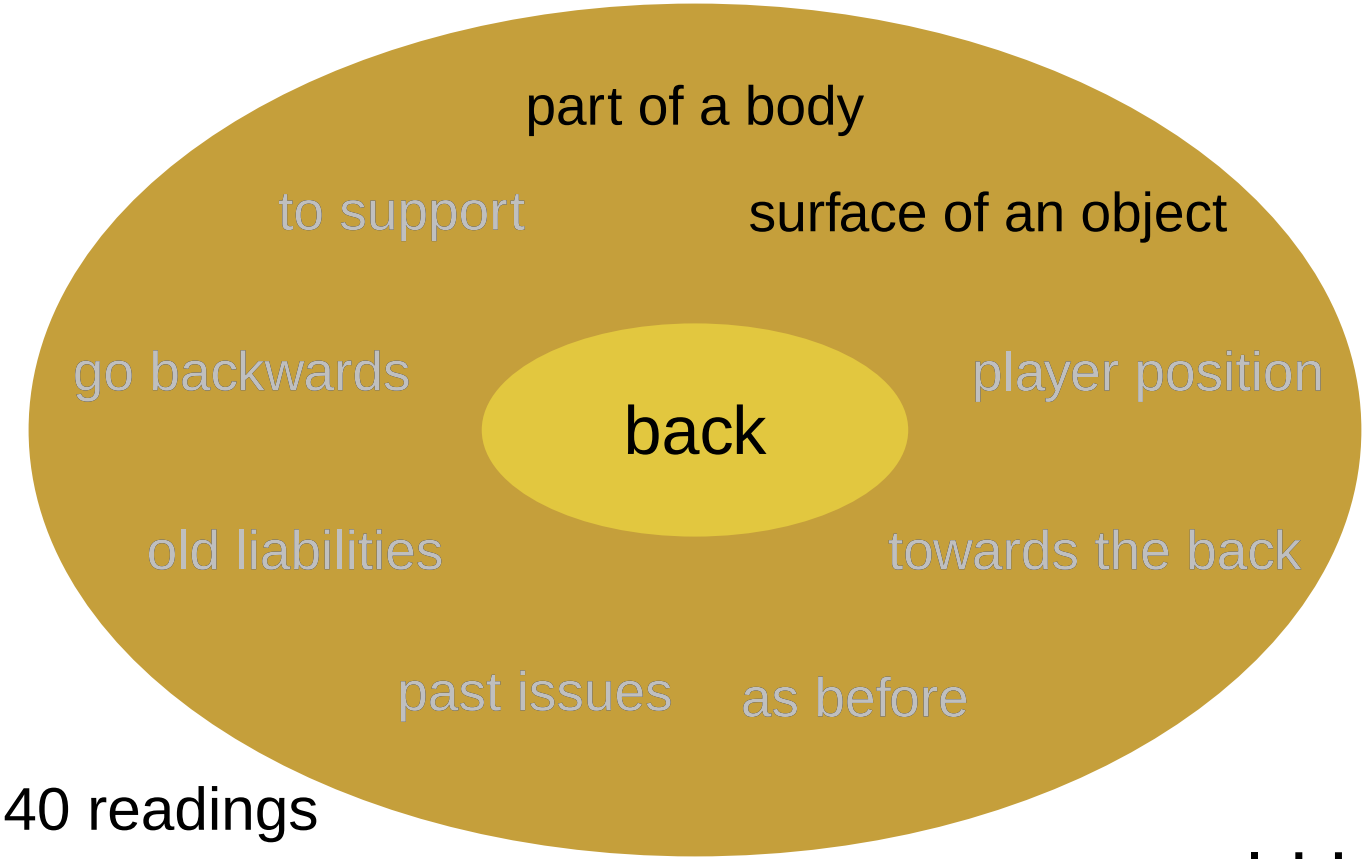

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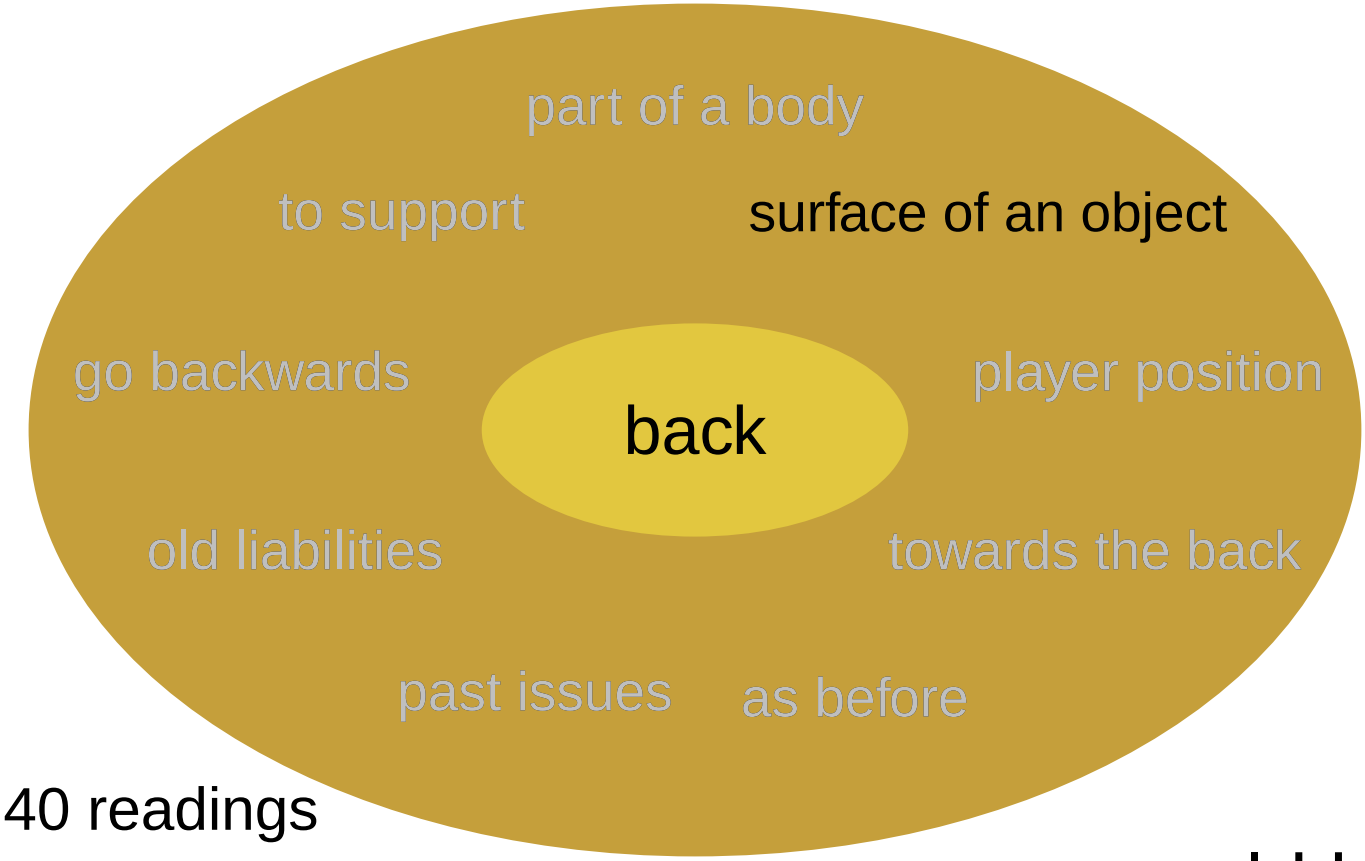

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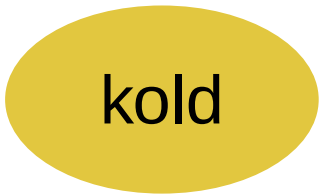

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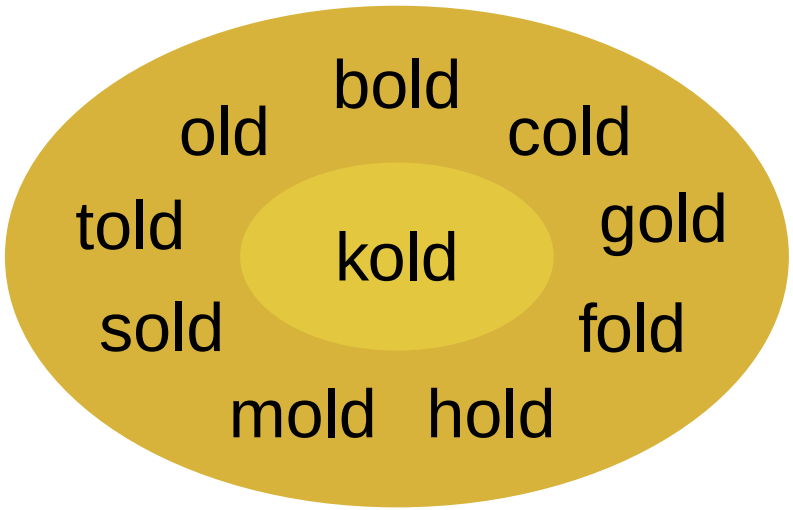

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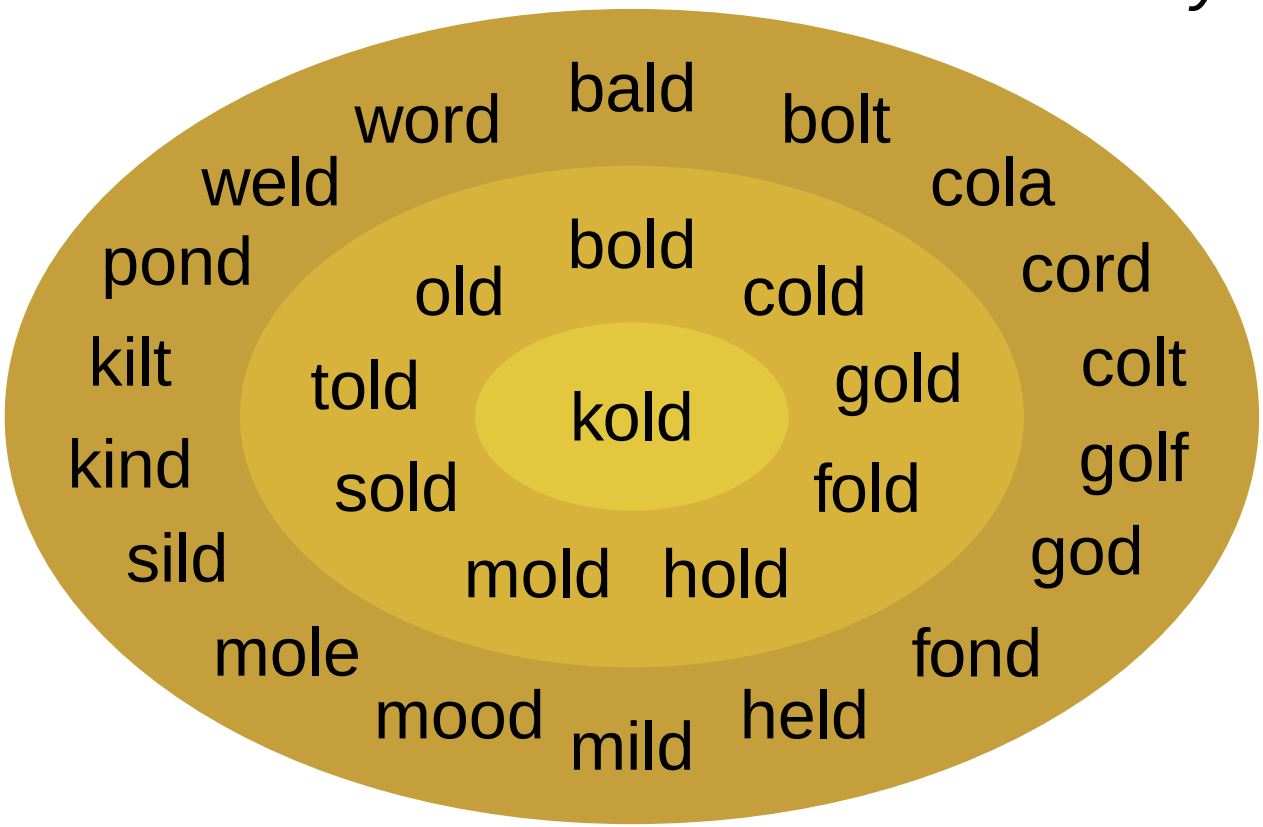

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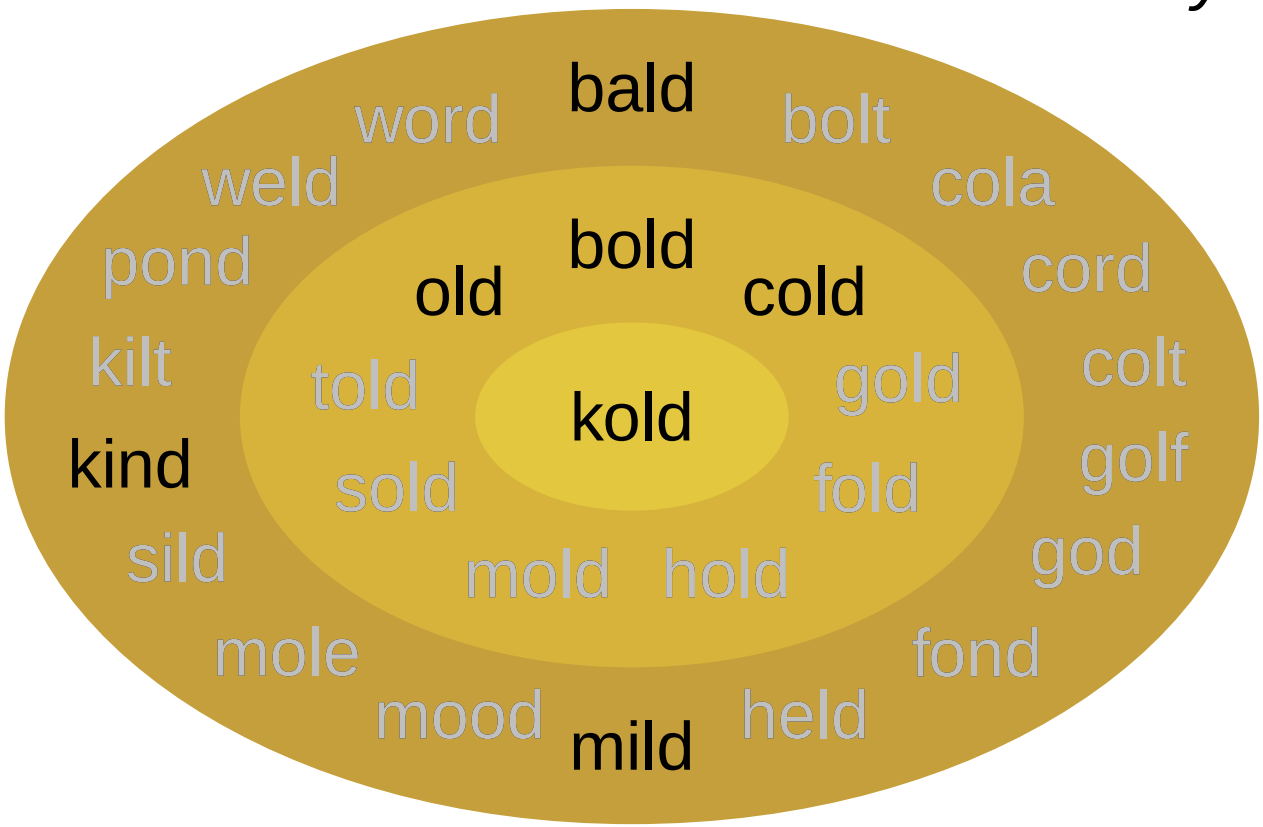

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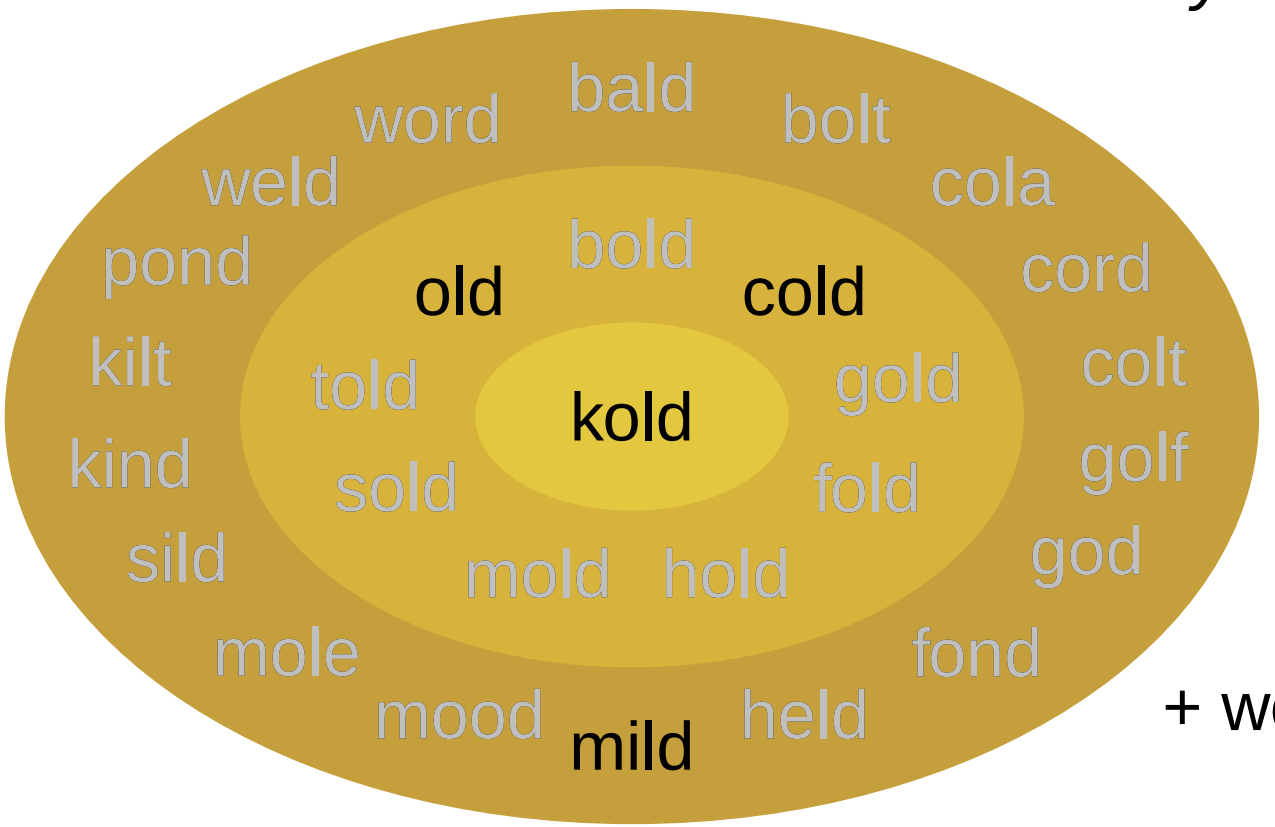

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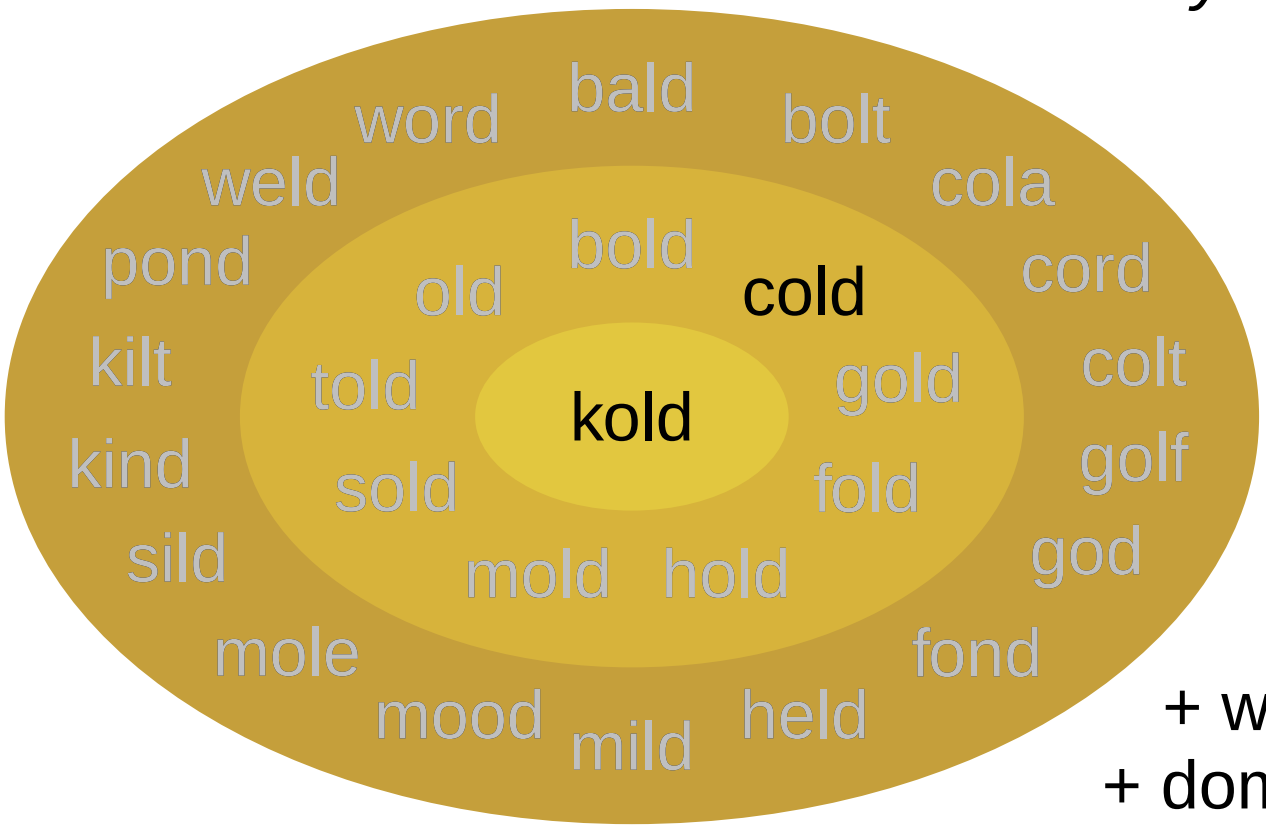

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- error assumptions are even necessary for correct word forms if the utterance is syntactically inacceptable

  **It is very told in here.*

Error Diagnosis and Ambiguity

- character-based correction proposals are rather poor explanations no indication
  - what might have caused the error
  - how to avoid a similar error in the future

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  - what might have caused the error
  - how to avoid a similar error in the future
- possible causes:
  - substitution or insertion of neighboring keys
  - phonetic similarity
  - interference from another language

Error Diagnosis and Ambiguity

- different *error perspectives*
  - the same error can be explained in different ways
  - introduces yet another type of diagnostic ambiguity
  - provides also additional criteria for hypothesis selection

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- *kold* $\rightarrow$ *cold*:
  phonetic confusion is most plausible

Error Diagnosis and Ambiguity

- different perspectives might lead to differently complex error descriptions

  **It was there fault.*

  - no error assumption on a purely phonetic level
  - character-based explanation with two substitutions

    → minimal error heuristics fails if phonetic similarity is ignored

Error Diagnosis and Ambiguity

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  - no error assumption on a purely phonetic level
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    → minimal error heuristics fails if phonetic similarity is ignored
    - cheaper character-based corrections available:

      there → *here*
    - do not remove the syntactic inconsistency

Dealing with Diagnostic Ambiguity

1. The necessity to consider erroneous input increases (local) ambiguity.
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2. Errors can be explained from different perspectives.
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   - usually plausibility is a gradual notion
3. Least effort corrections do not always yield satisfying error explanations.

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5. Considering an error might even be necessary if the input seems (locally) acceptable.

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  1. late selection:
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     - a subsequent selection step selects the most plausible ones
  2. early integration:
     - the domain knowledge is directly integrated into the diagnosis procedure
     - guides it towards the most plausible explanation

Constraint-Based Diagnosis

- example: morpho-syntactic regulartities
  - constraints model the compatibility of feature assignments
  - feature assignments need not be unique

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  - constraints model the compatibility of feature assignments
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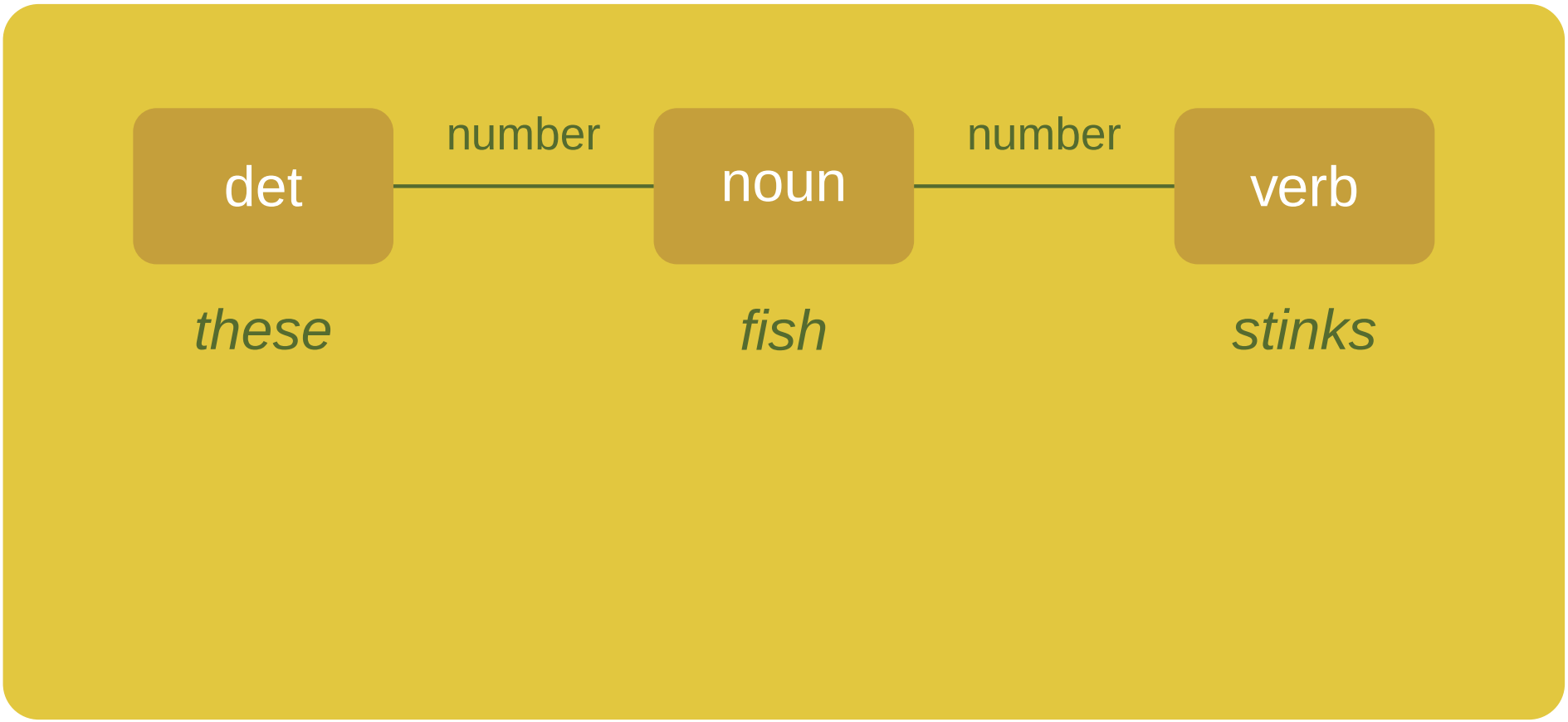
- for *all* variable assignments find the constraints that are violated
- if an assignment with no constraint violations is found, signal ”ok”
- else find the assignment with a minimum number of constraint violations
- output the explanation(s) connected to the violated constraint(s)

Constraint-Based Diagnosis

- an ambiguous diagnosis problem



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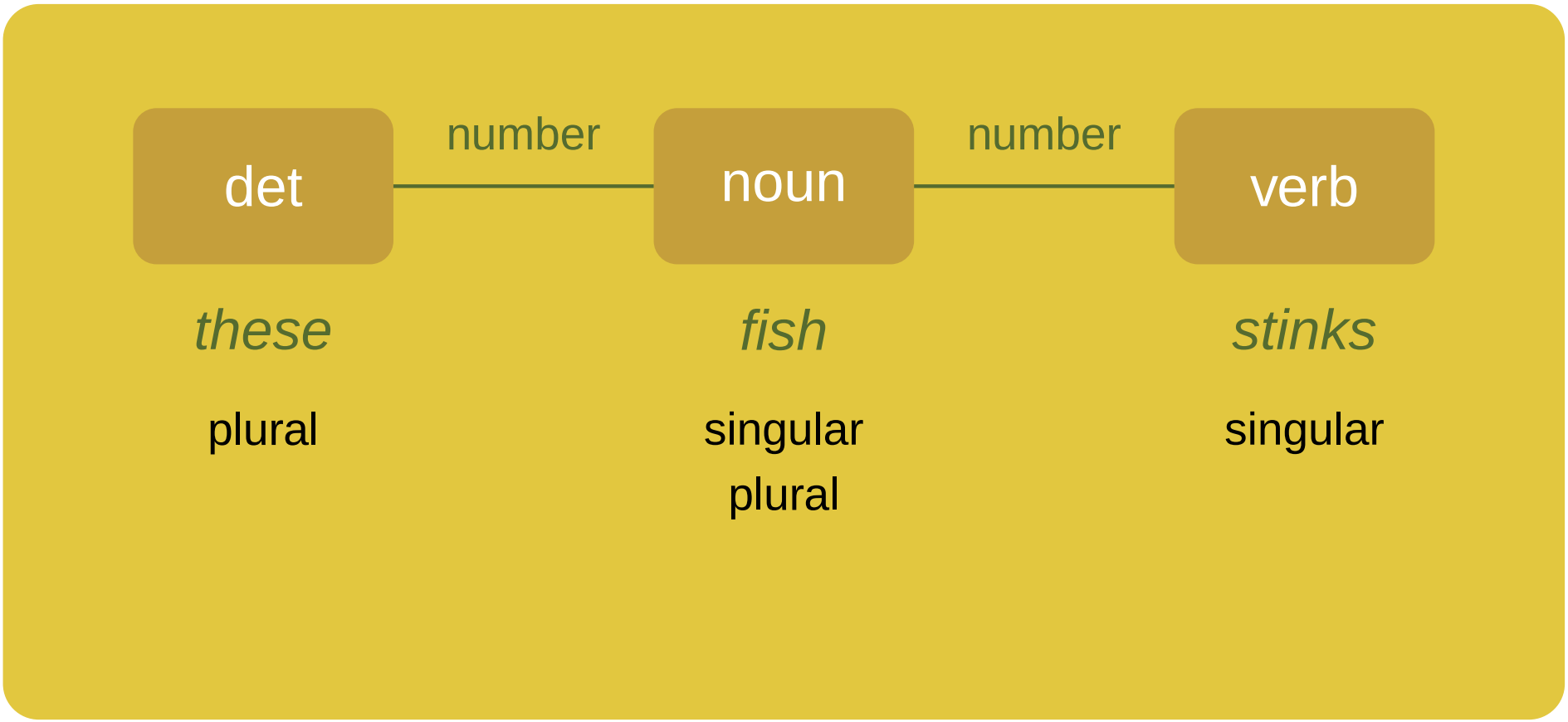

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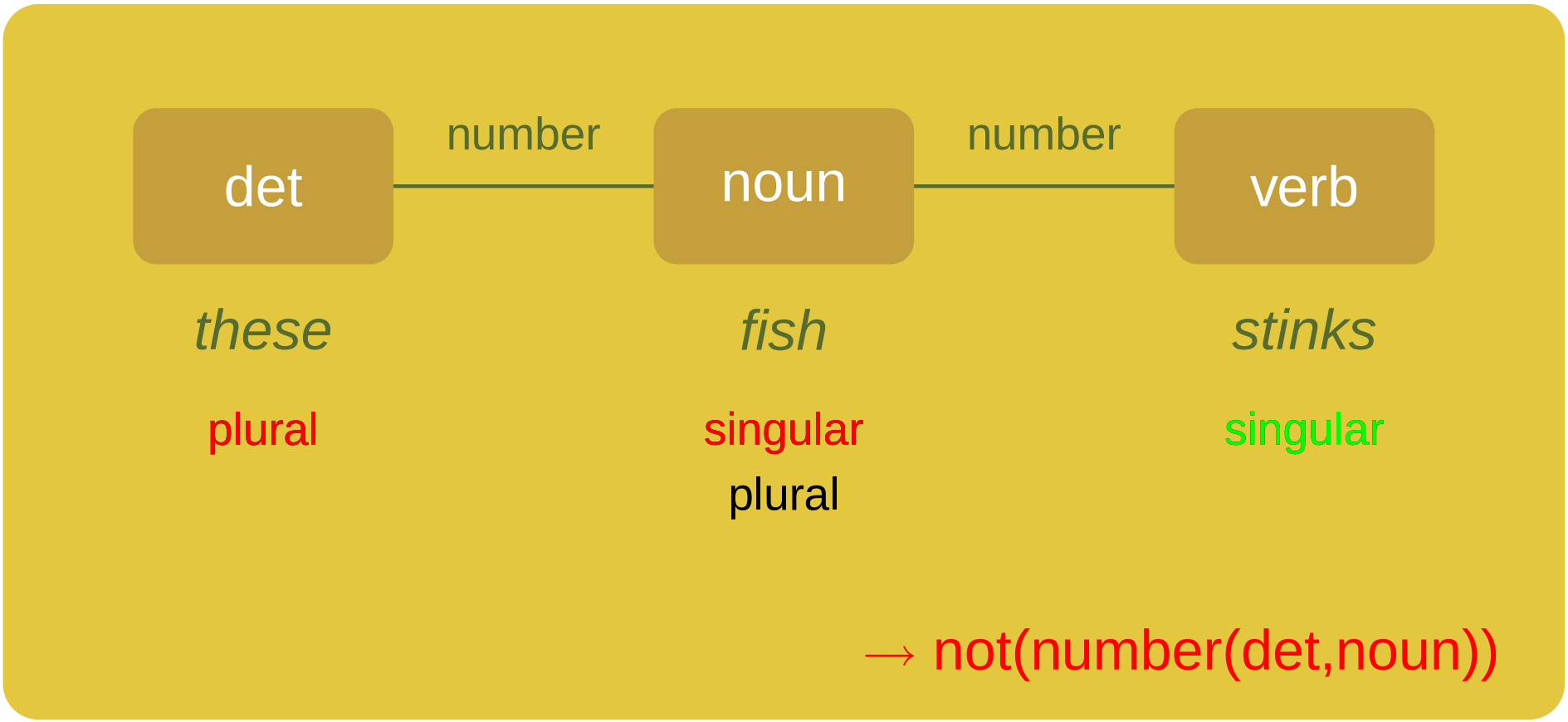

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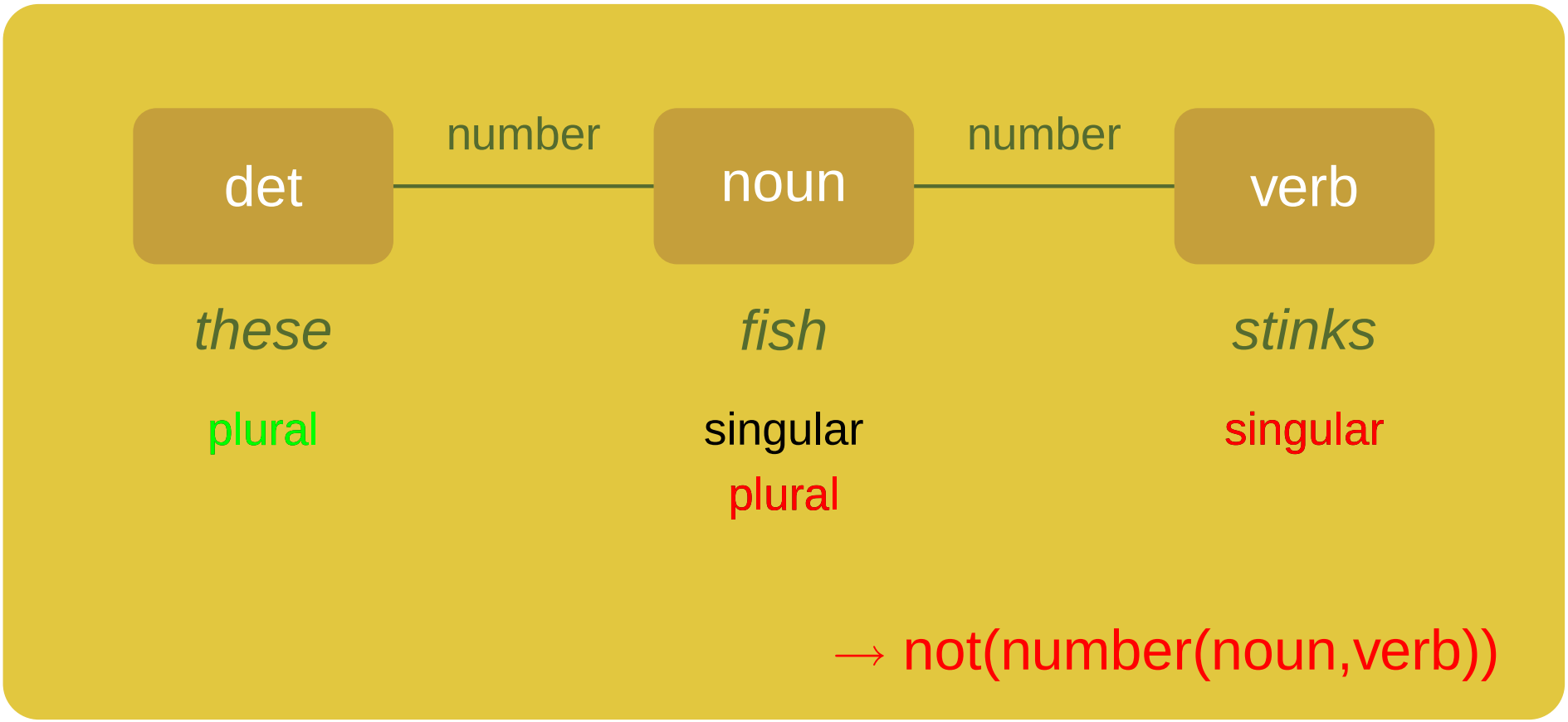

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- e.g. Russian
  - subject-verb: person, number, gender
  - noun phrase: number, gender, case, animatedness

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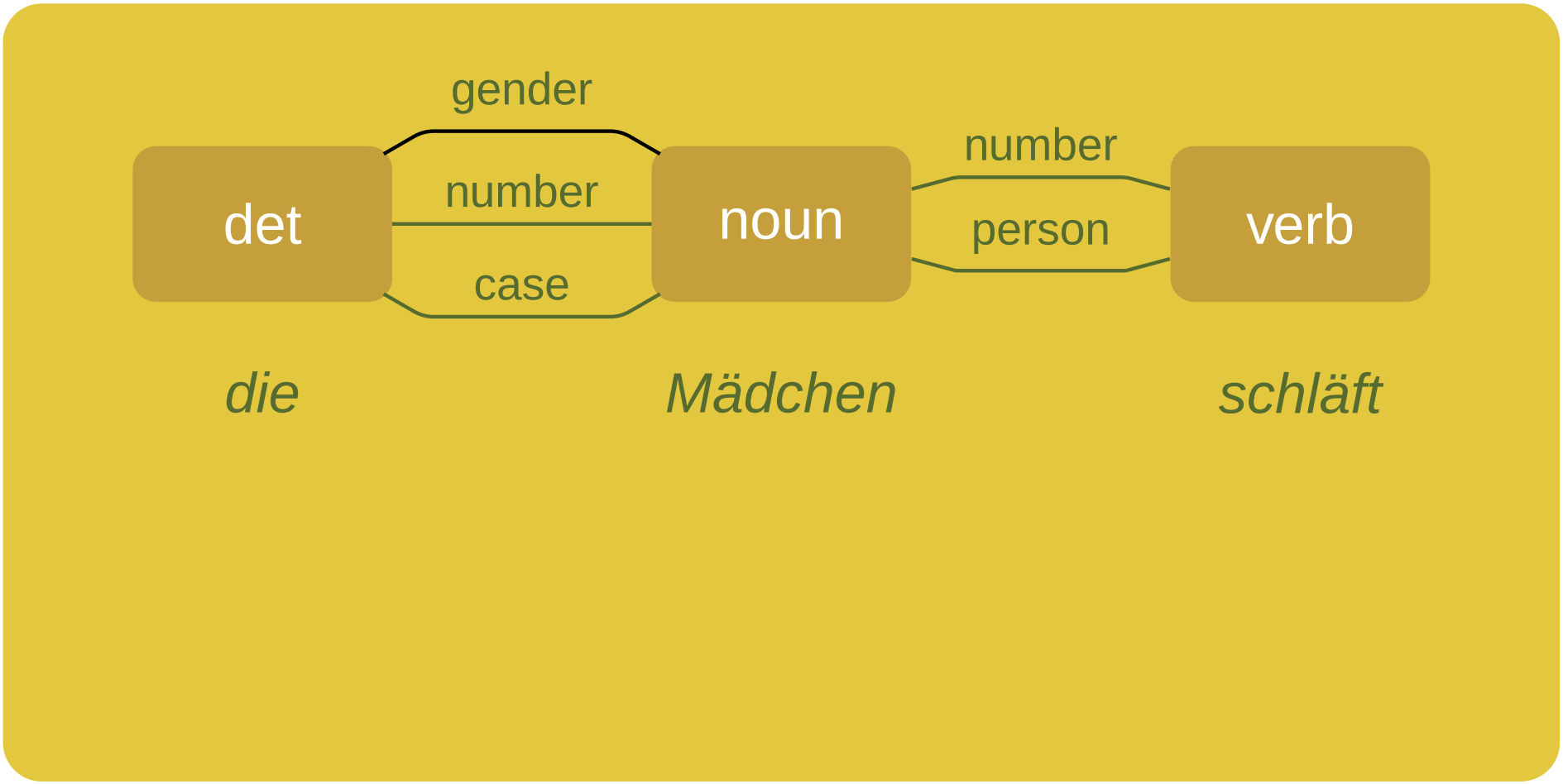

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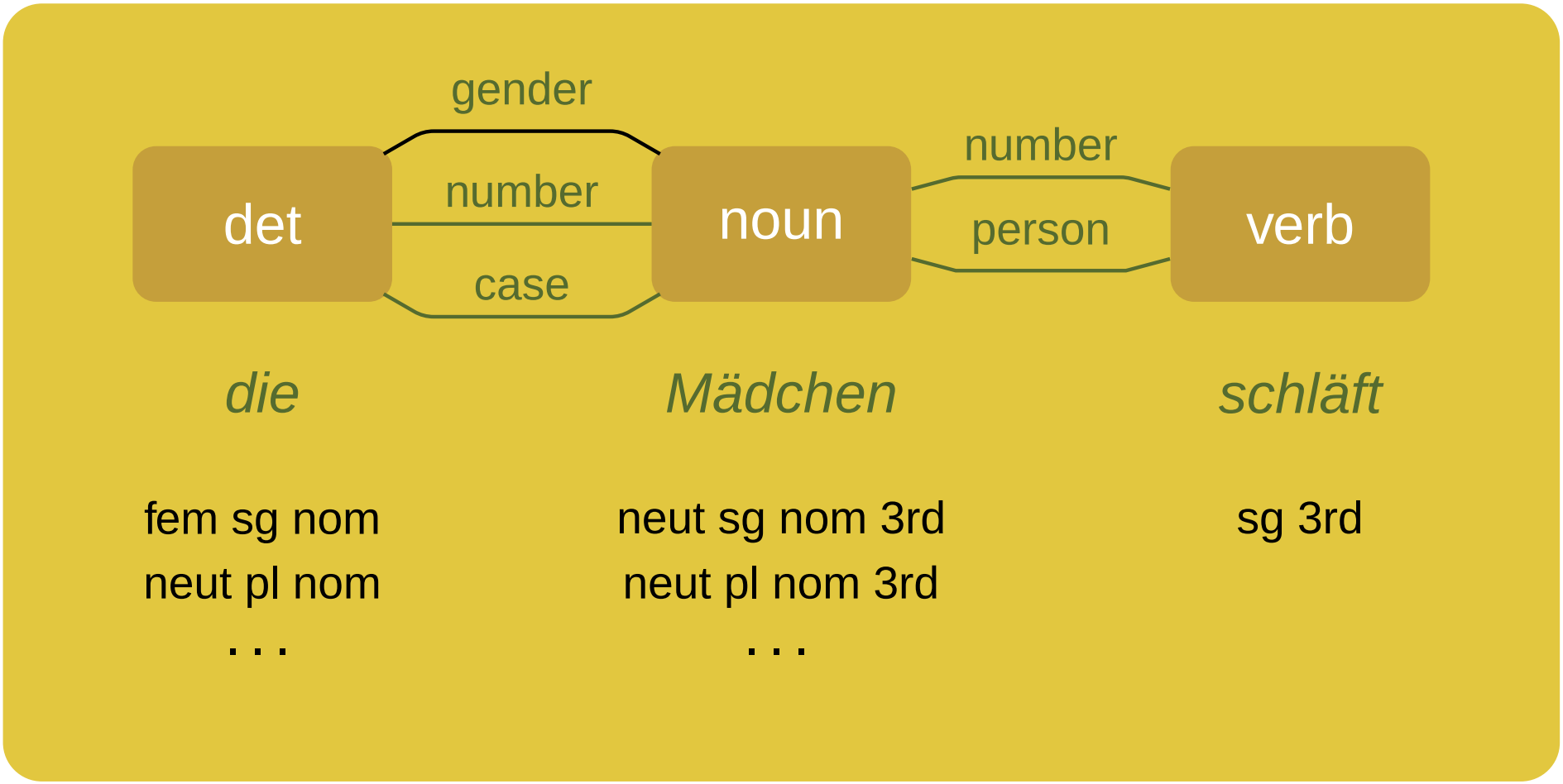

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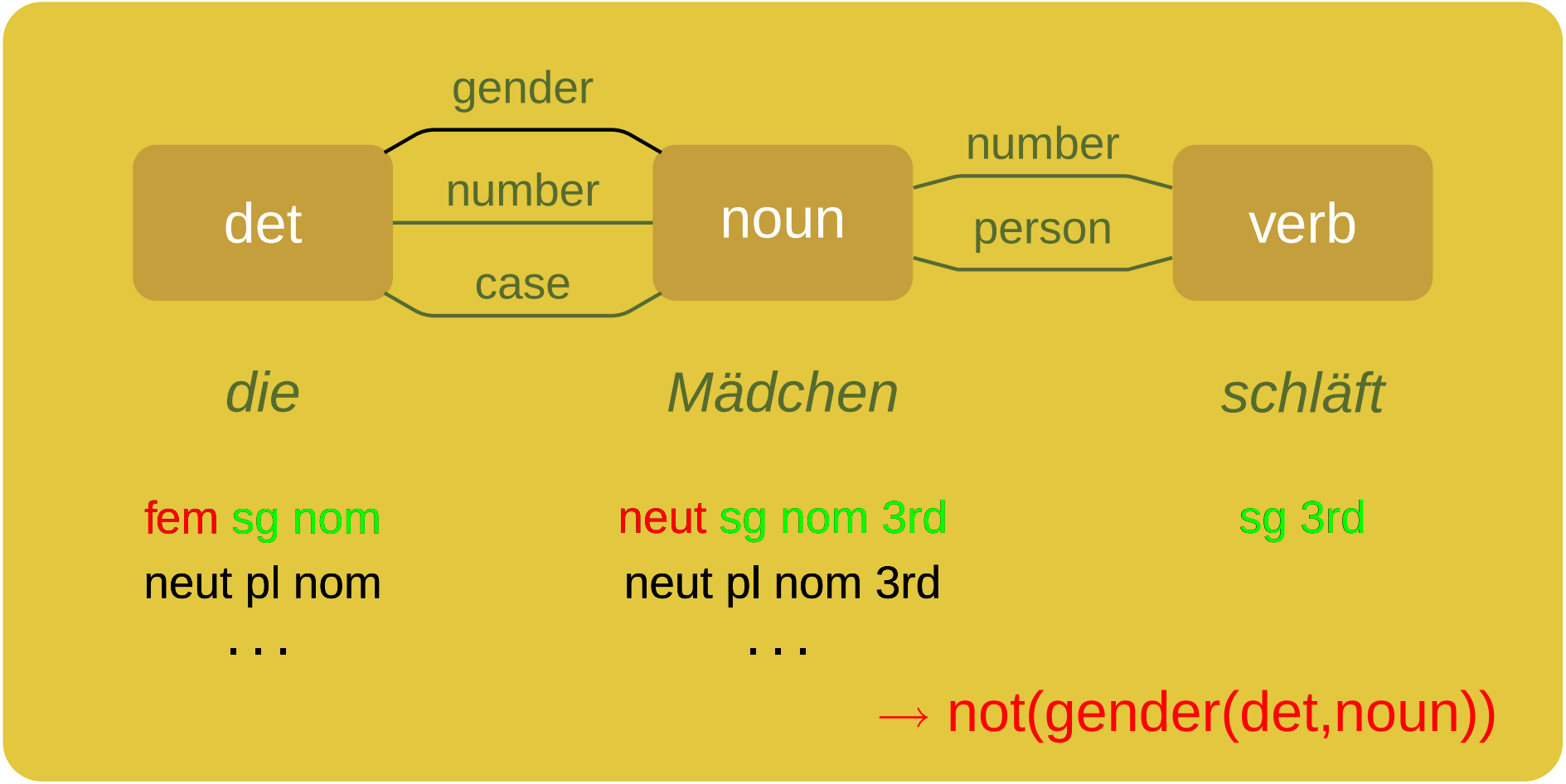

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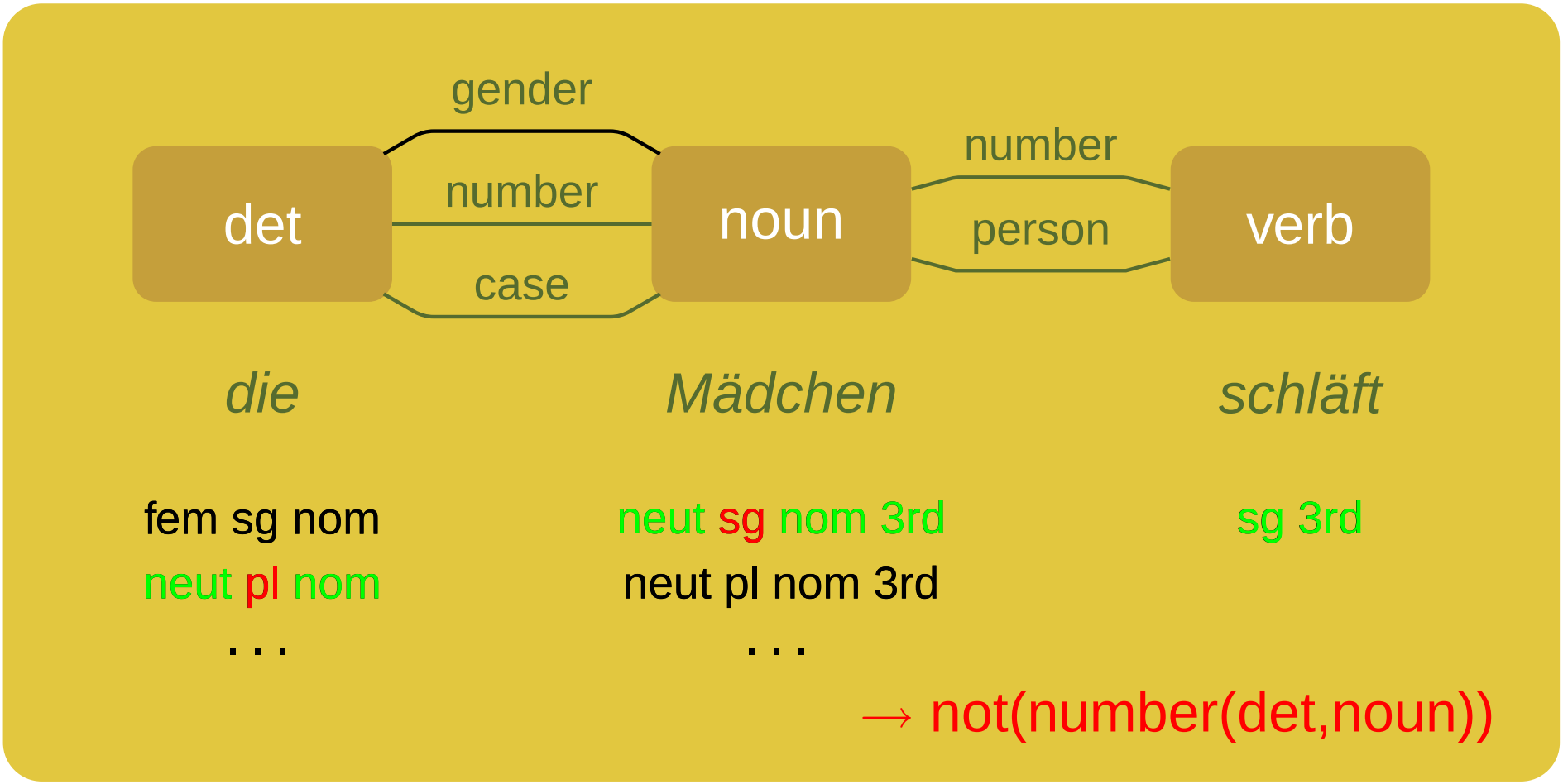

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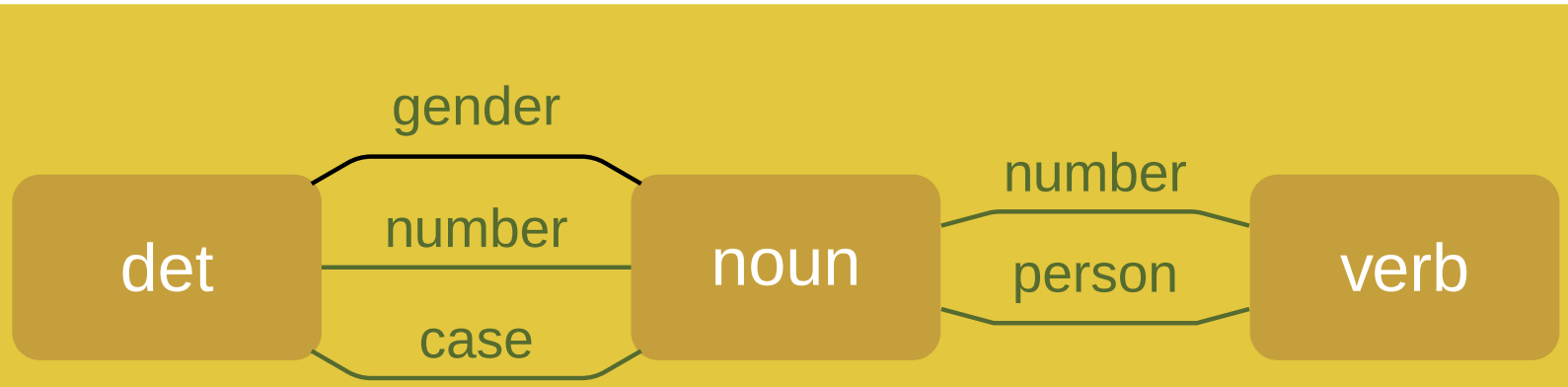

fem sg nom
neut pl nom
. . .

neut sg nom 3rd
neut pl nom 3rd
. . .

sg 3rd

→ not(gender(det,noun))
not(number(det,noun)), not(number(noun,verb))

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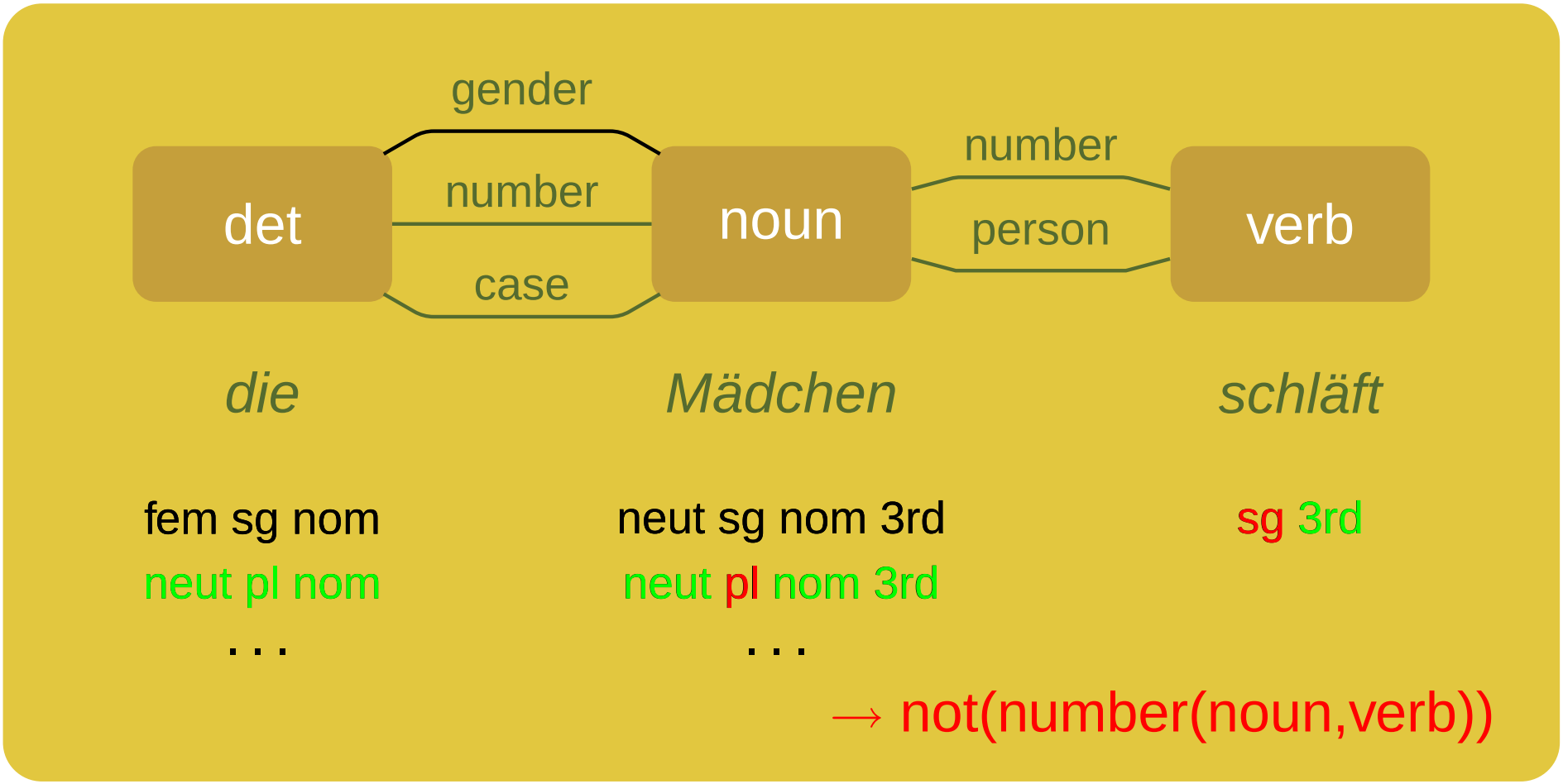

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Der Götter zürnen

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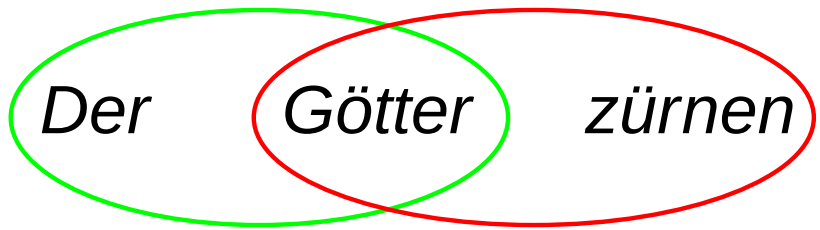

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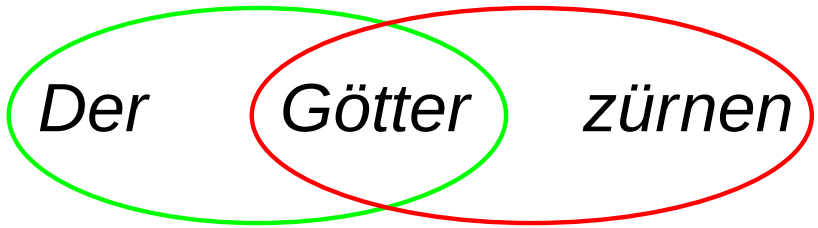

correct genitive case NP subject NP without nominative case

  - special treatment proposed

Constraint-Based Diagnosis

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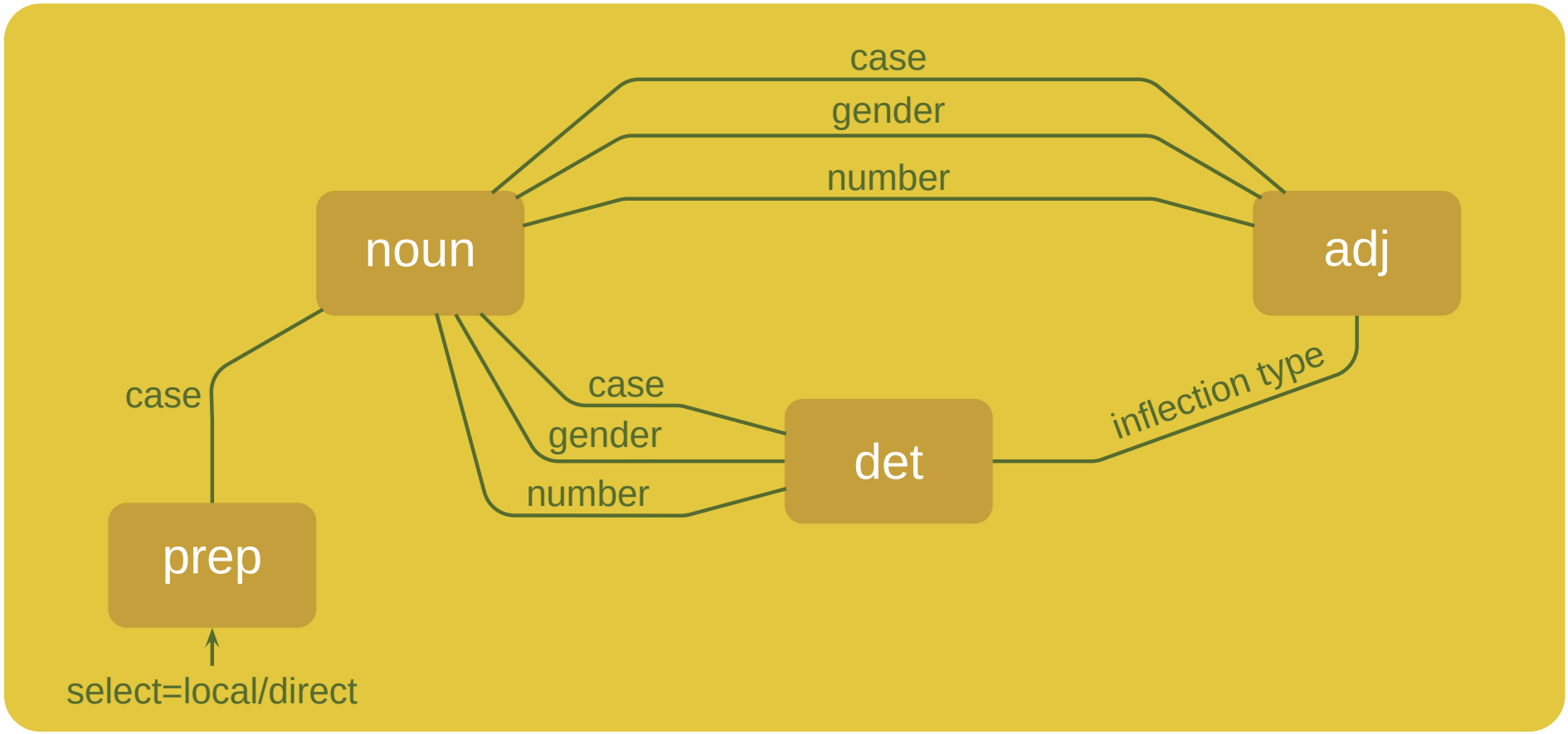
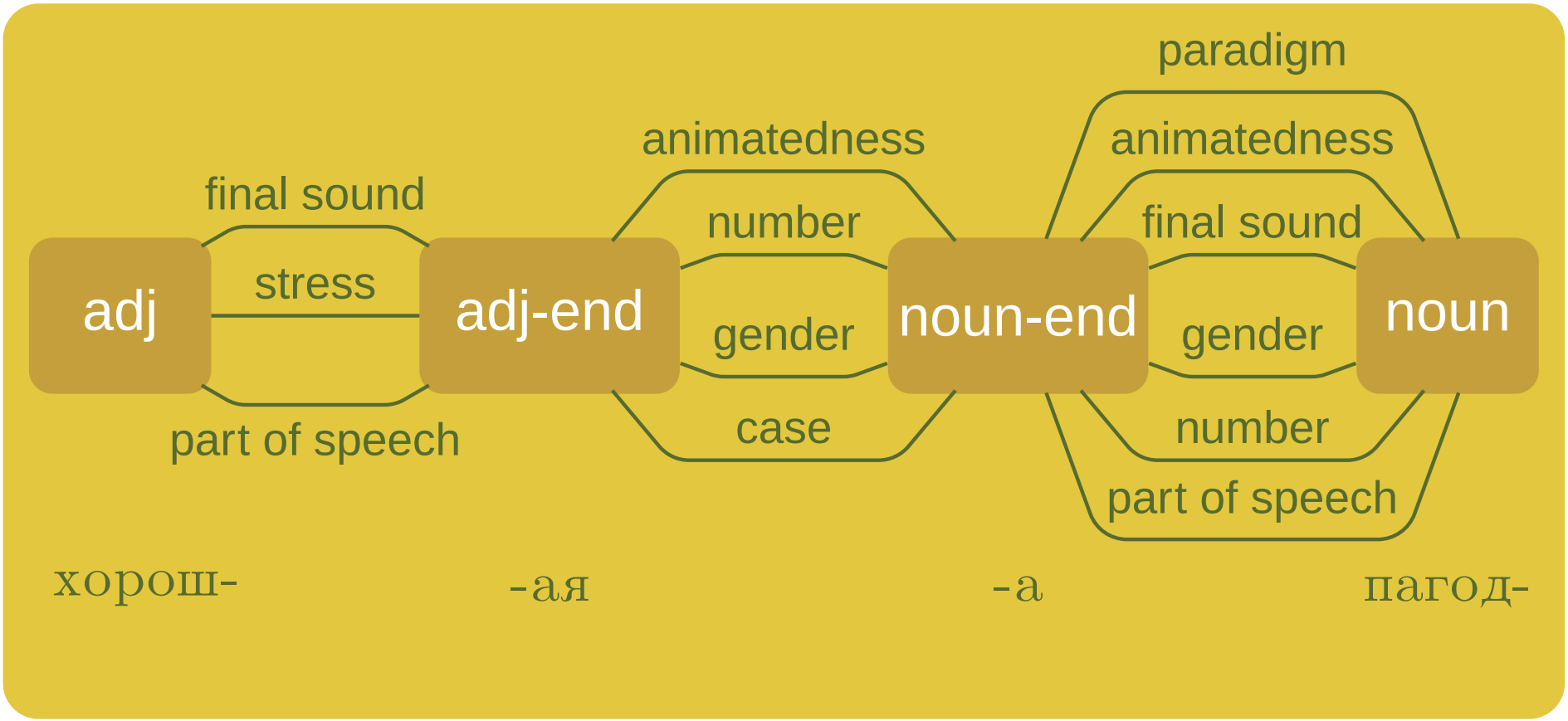
NP must have dative case

Agreement in a German PP



Inflection in a Russian NP



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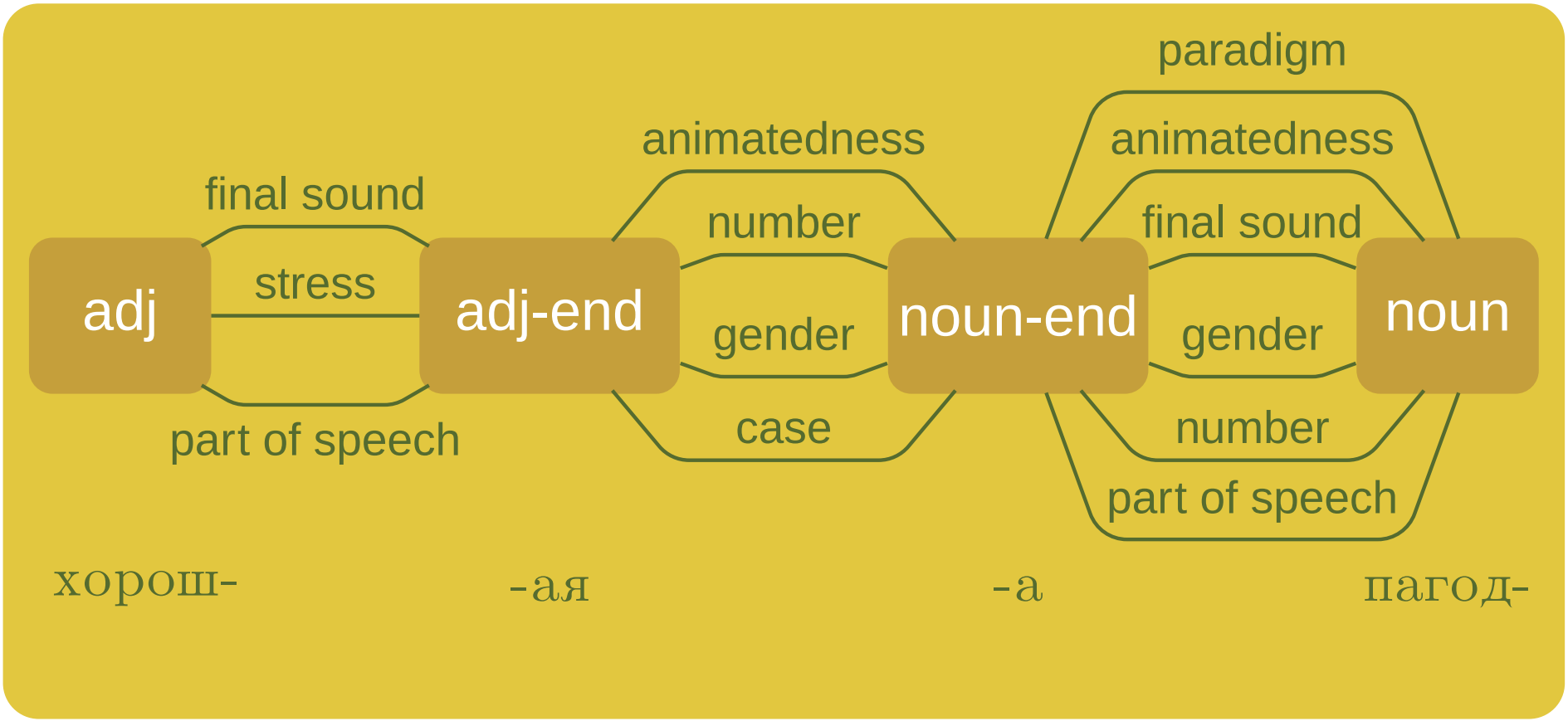

- additional diagnostic capabilities:
  detection of erroneous inflection patterns

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  - the student might have thought that ”child” is not a singular form:

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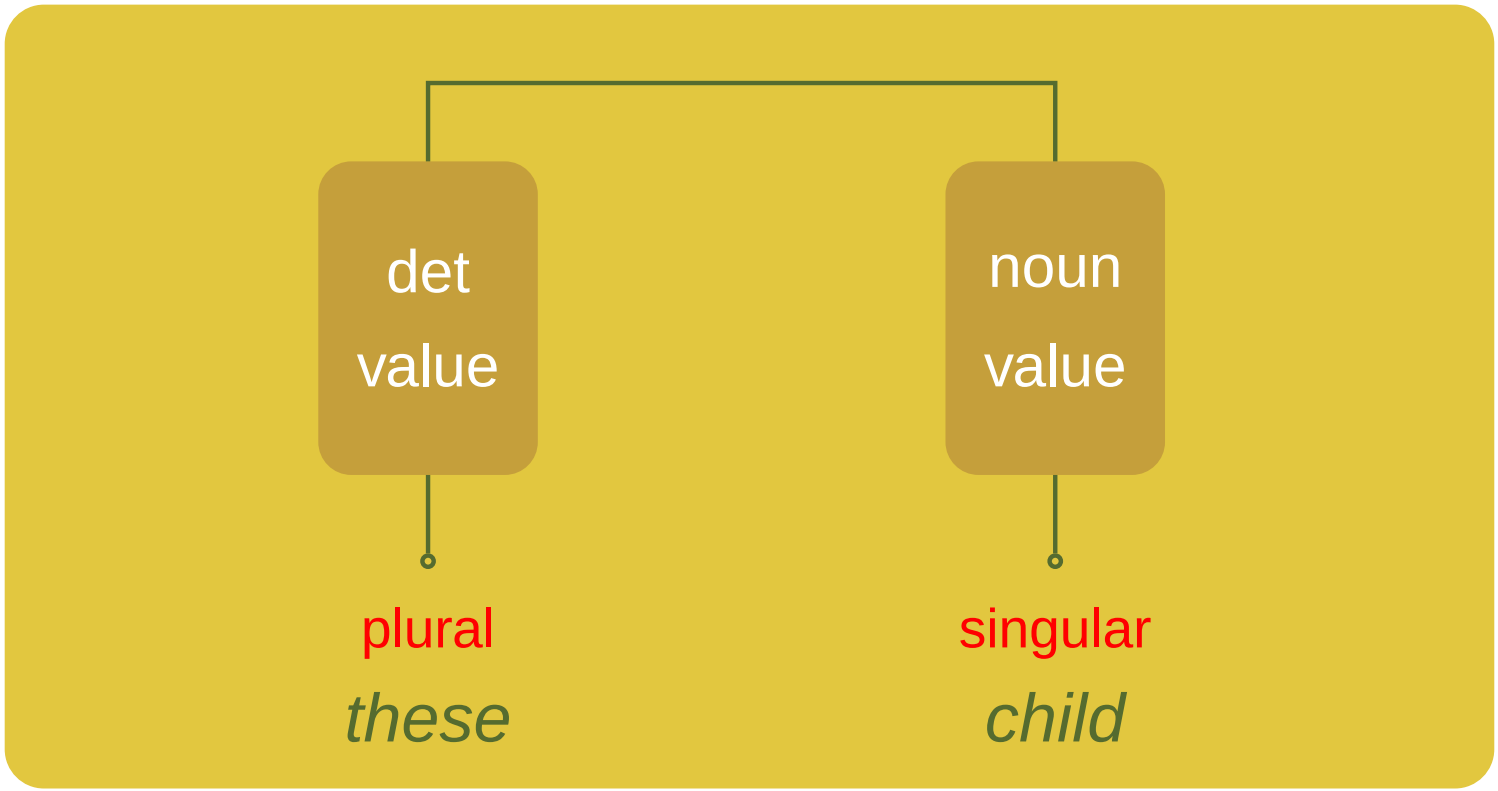
  - sometimes yields more concise explanations
- performing a separate error simulation with lexical value assignment components

Constraint-Based Diagnosis

- without an disambiguating context fact diagnoses are always ambiguous



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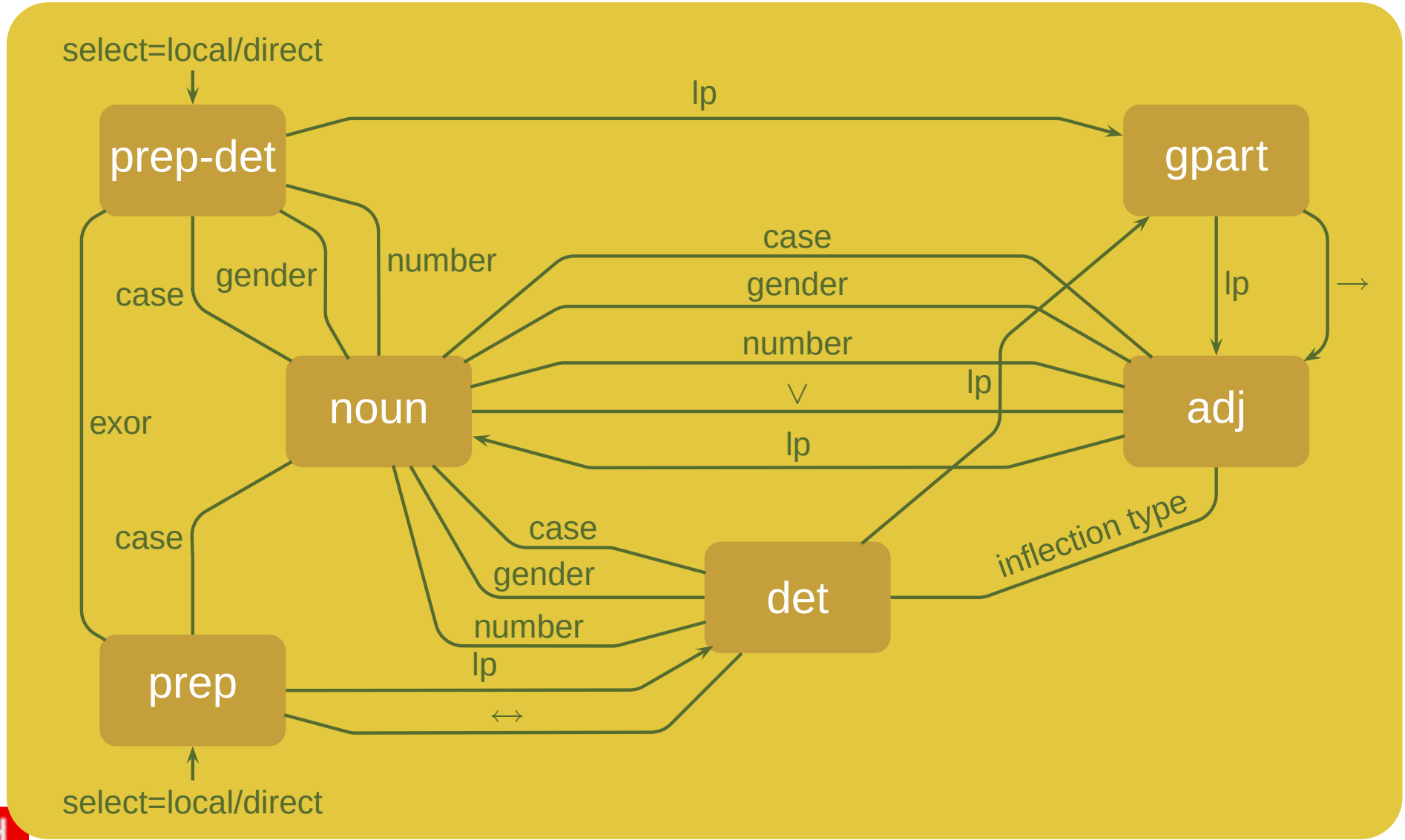
- the two error perspectives are complementary
- provide alternative information about an error
  - grammar rules vs. correction proposals
- descriptions can be differently complex
- both are required
- SCHWIND (1994): rule errors only
- HEIFT (1999): fact errors only

Constraint-Based Diagnosis

- approach can be extended to
  - linear precedence regularities
  - co-occurrence constraints

  within the limits of a fixed structural pattern

Constraints for a German PP



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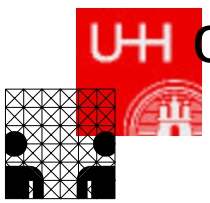
- no diagnostic bias
- multitude of diagnostic information
  - hypothesis selection required
  - selection can be sensitive to a didactic goal and / or the desires of the student



Late Hypothesis Selection

- system architecture

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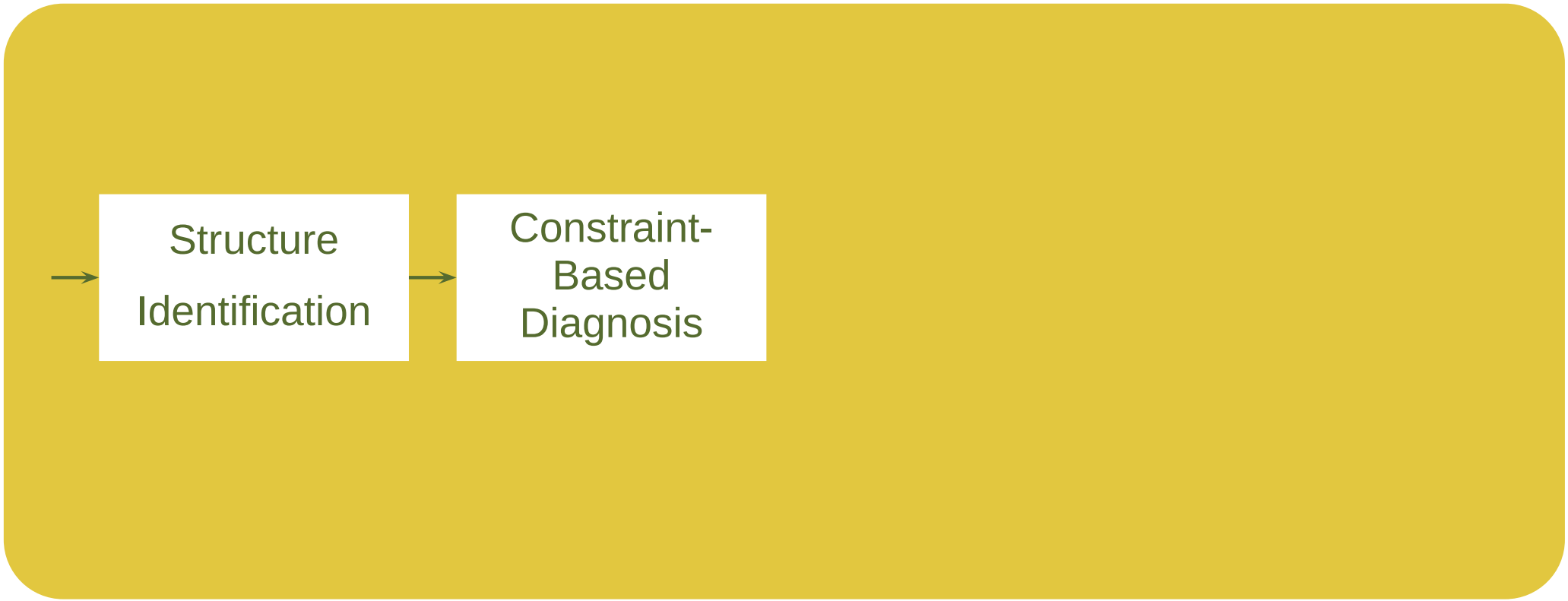

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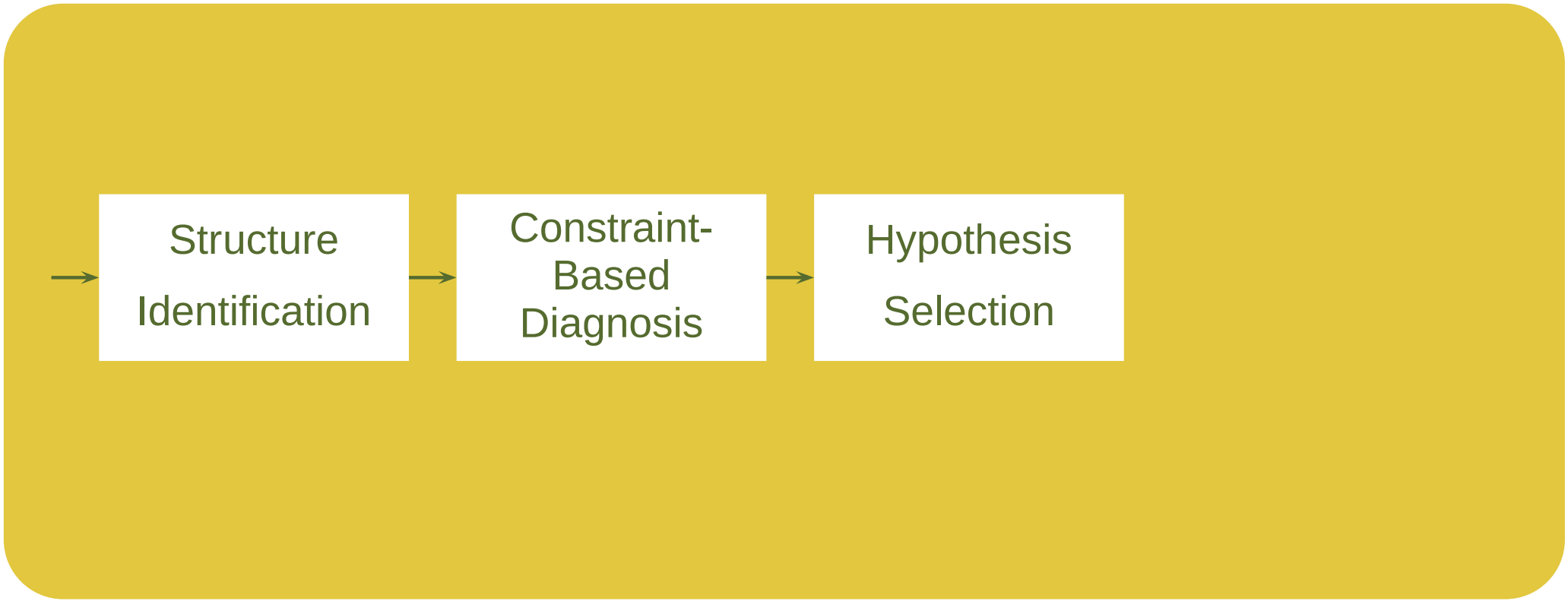

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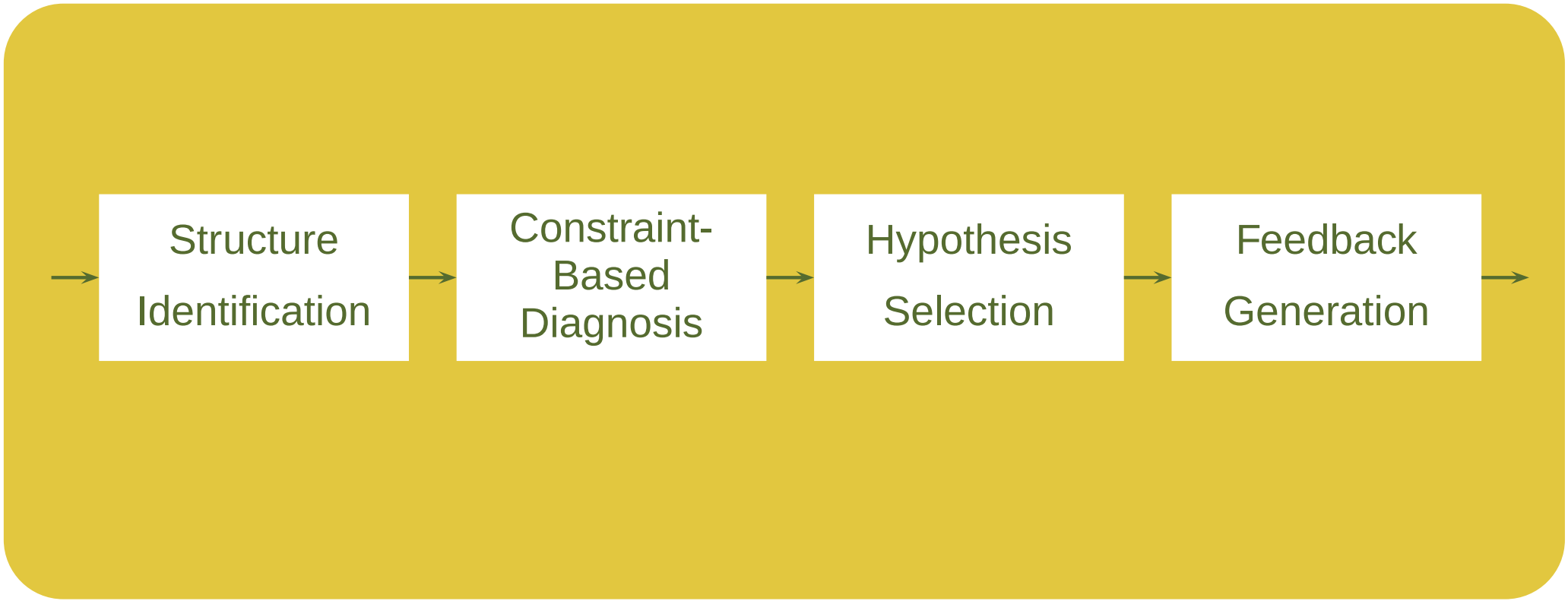

Late Hypothesis Selection

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  - citation form preference:
    - explanations referring to the default case are more plausible
  - (L1 dependent) error type preference:
    - typical errors are more likely (e.g. gender in German)

Late Hypothesis Selection

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- late selection is only possible for limited exercises
- full enumeration of alternative hypotheses for more complex models is infeasible
  - direct integration of diagnosis and selection is necessary

Structural Constraints

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- instead of having rules to construct hierarchical representations use constraints to describe the space of possible structural descriptions
- Constraint Dependency Grammar (MARUYAMA 1990)
- initial space of hypotheses:
  - fully underspecified structural descriptions
  - every node modifies every other with all possible labels
  - containing all possible dependency trees for an utterance

Structural Constraints

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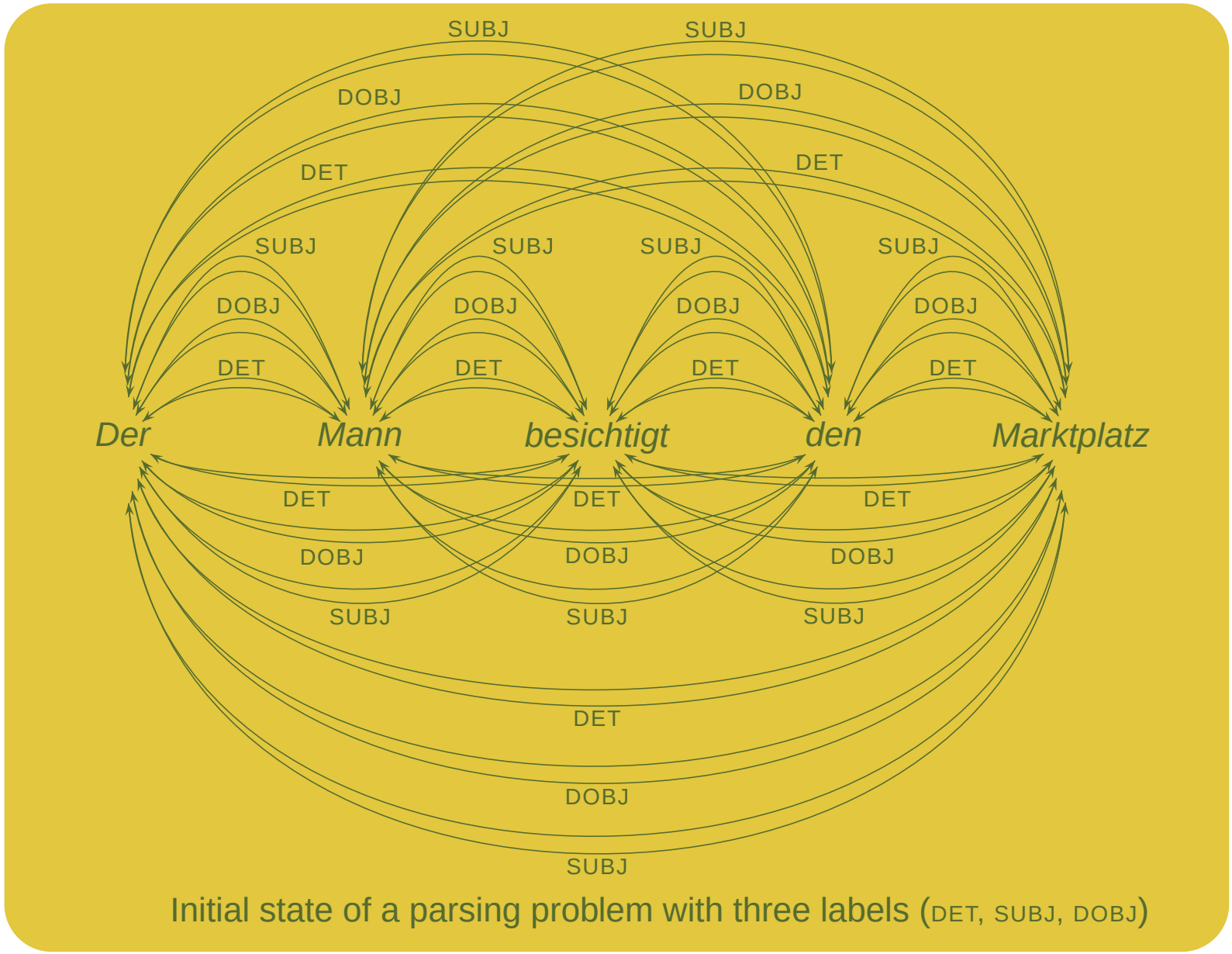
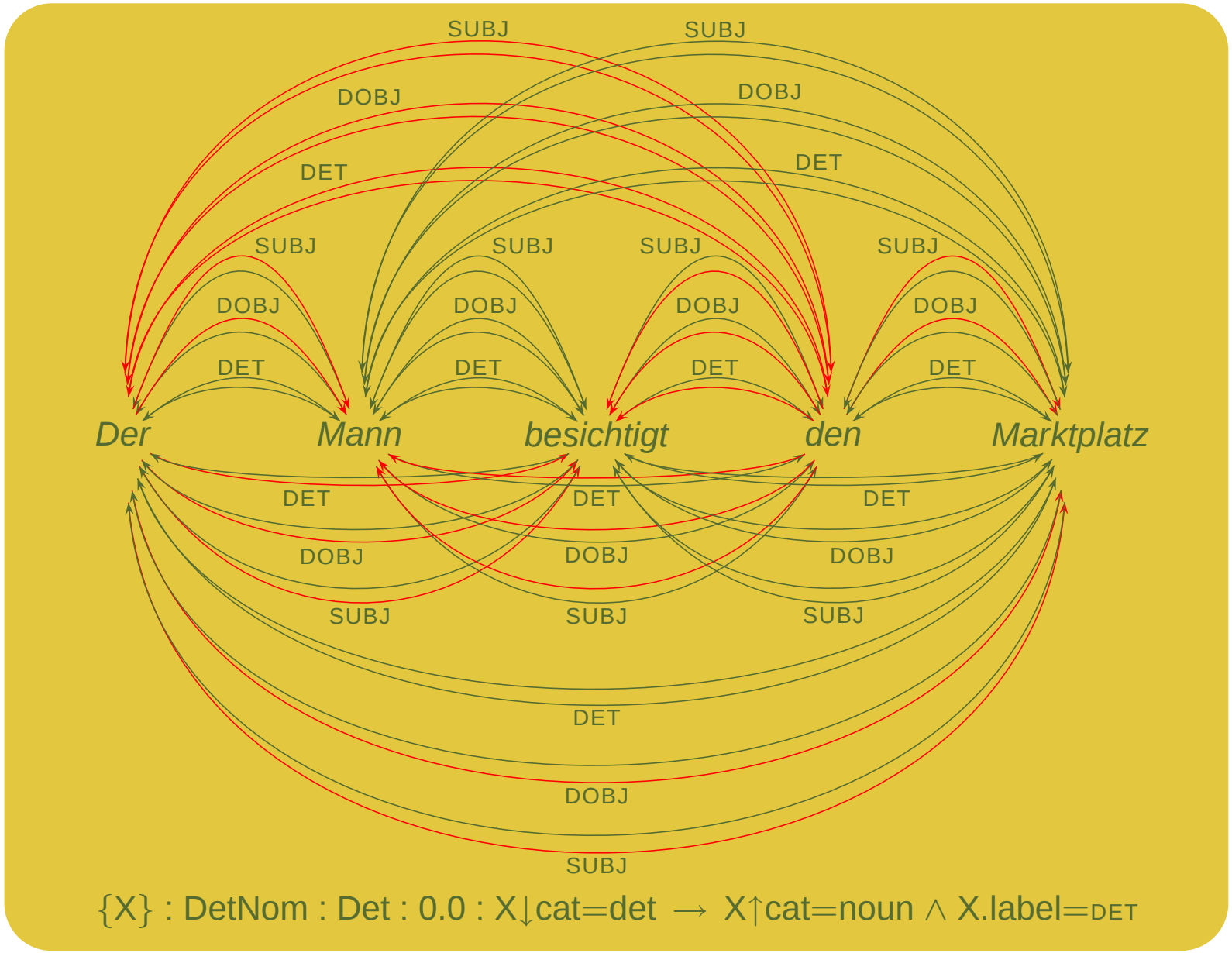
- constraints license certain dependency edges or combinations thereof
  - dependency edges which violate a constraint can be removed from the space of structural hypotheses
- constraints can be weighted
  - edges which violate a constraint are deprecated not removed
  - parsing becomes a *constraint optimization problem*
  - uncertain and preferntial knowledge can be included
    - e.g. the subject usually precedes the object

Structural Constraints



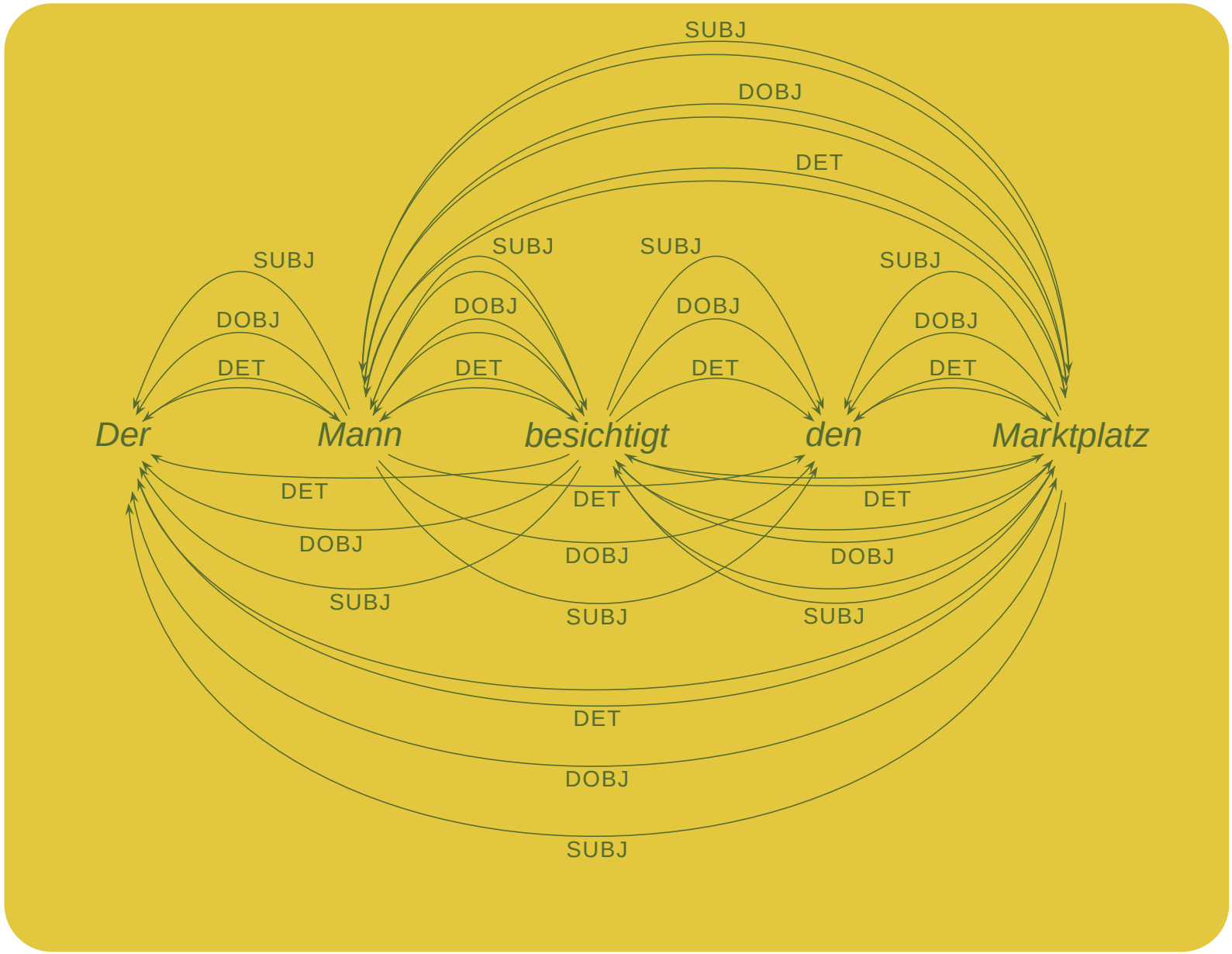
Initial state of a parsing problem with three labels (DET, SUBJ, DOBJ)

Structural Constraints



$\{X\}$: DetNom : Det : 0.0 : X↓cat=det → X↑cat=noun ∧ X.label=DET

Structural Constraints



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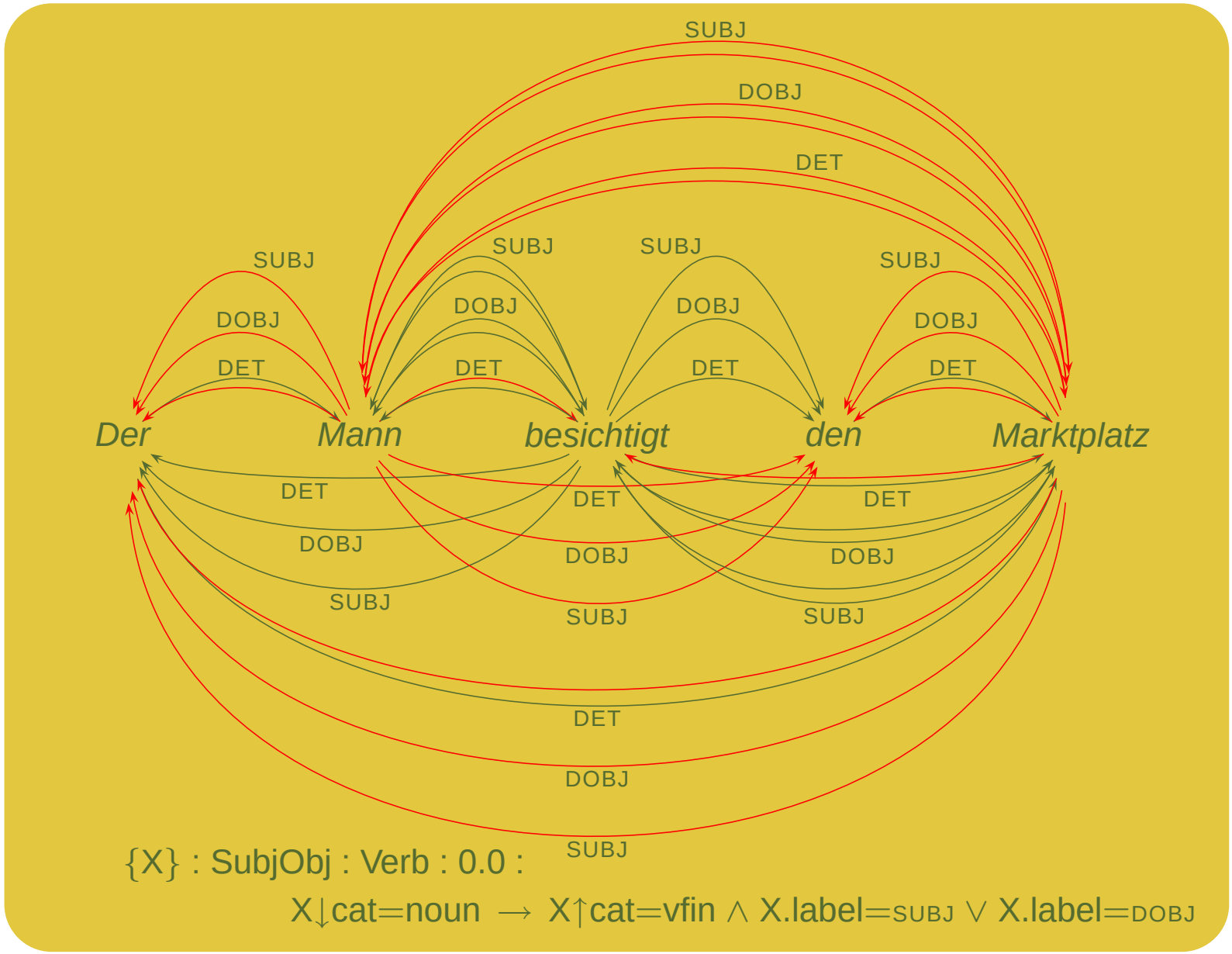

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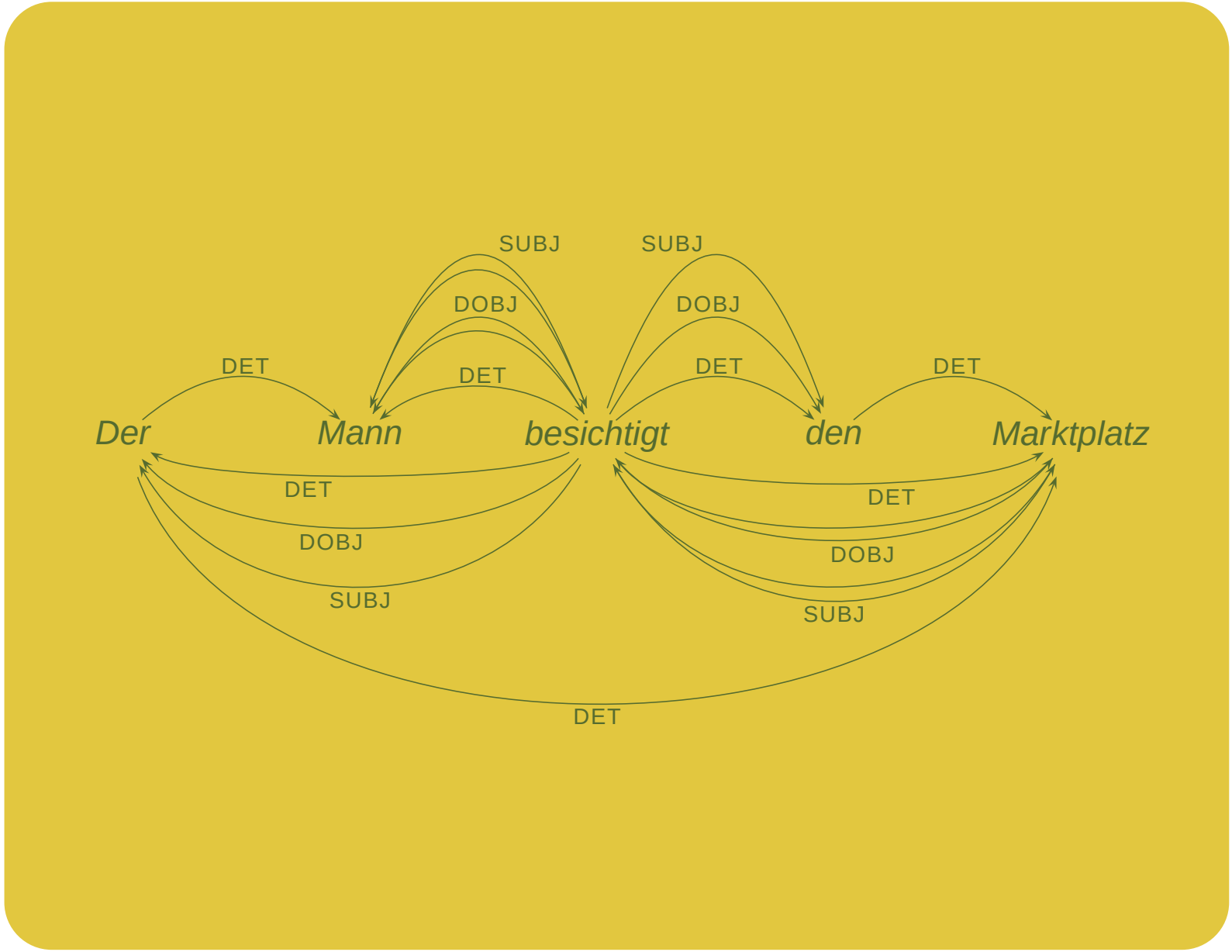

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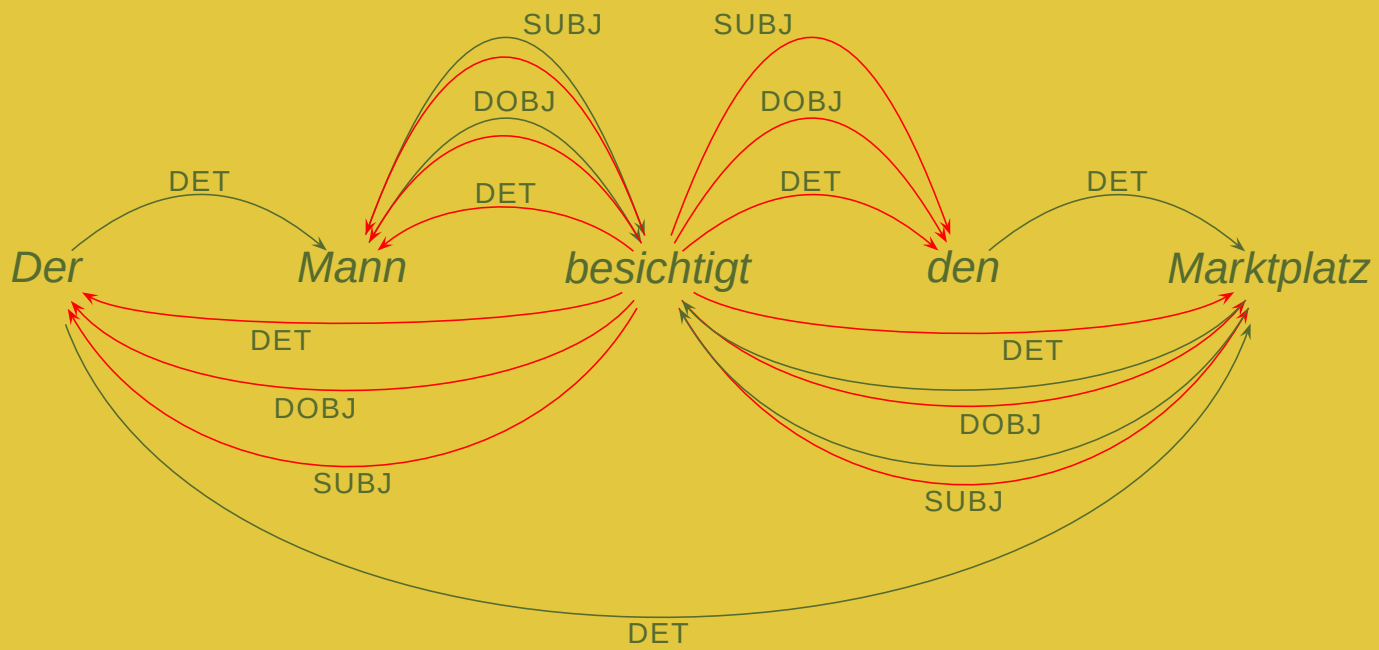
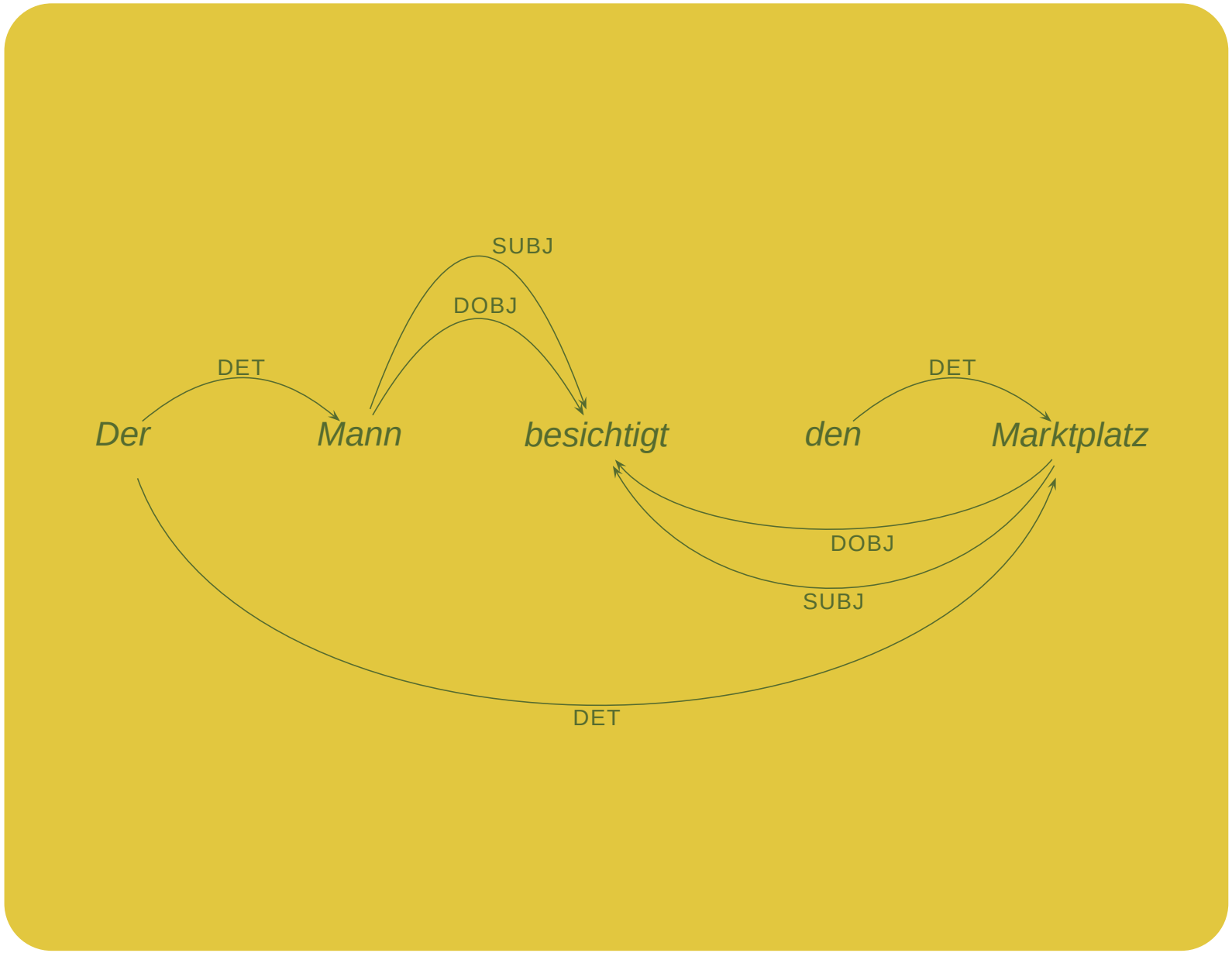


{X} : Root : Verb : 0.0 :
X↓cat=vfin → X↑cat=nil

Structural Constraints



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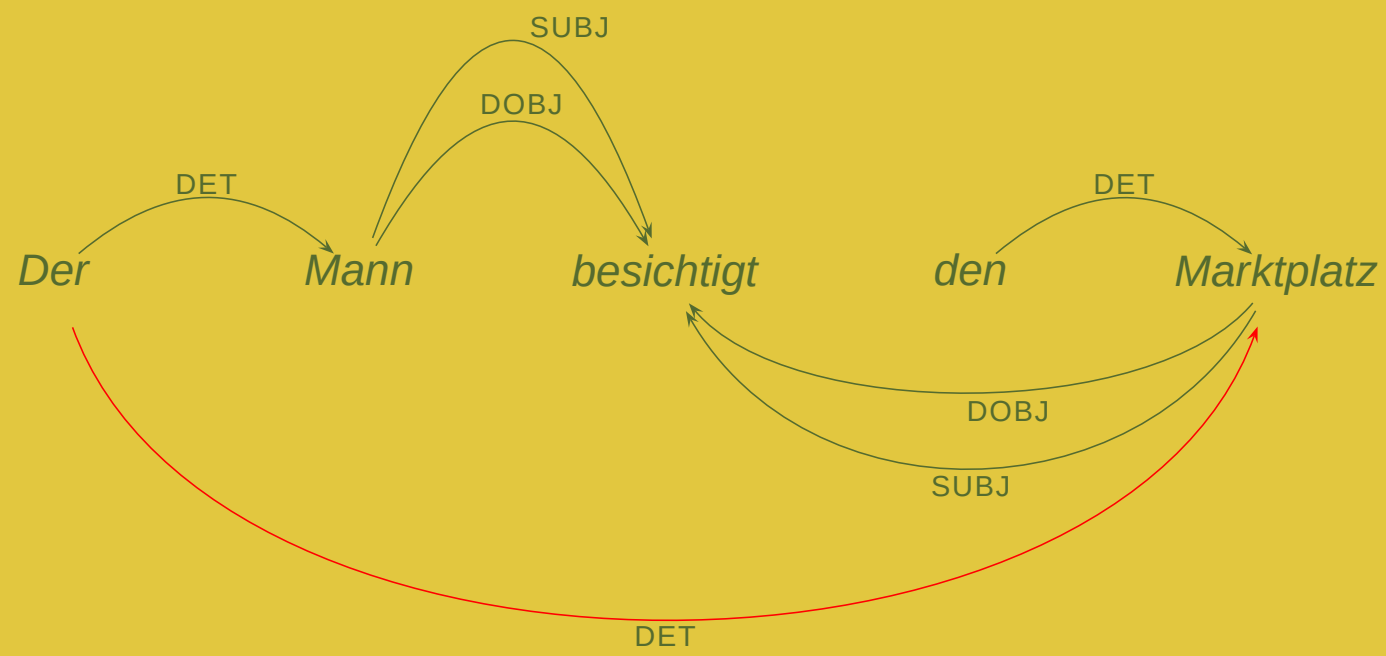
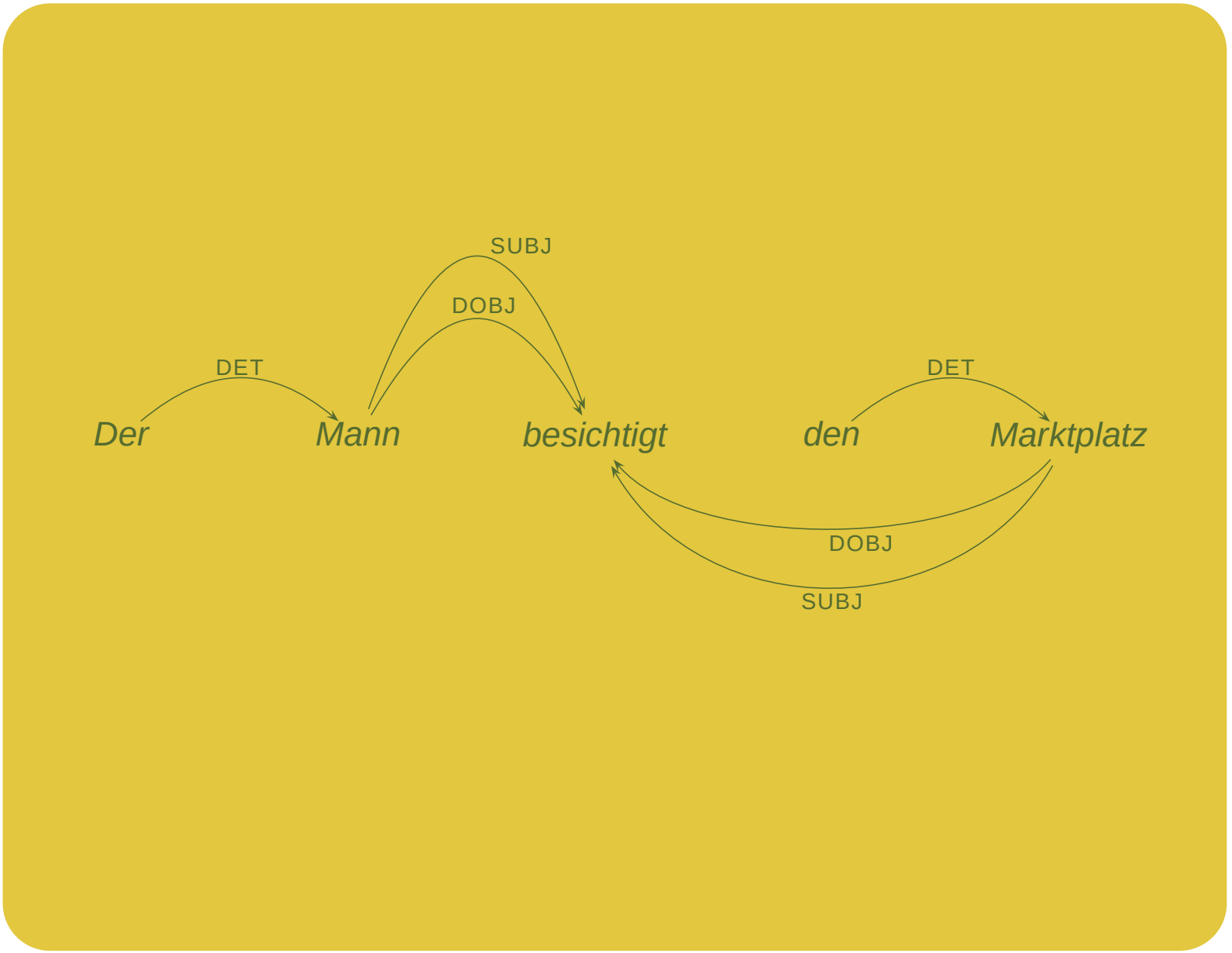


{X,Y} : Unique : General : 0.0 :
X↑id=Y↑id → X.label≠Y.label

Structural Constraints



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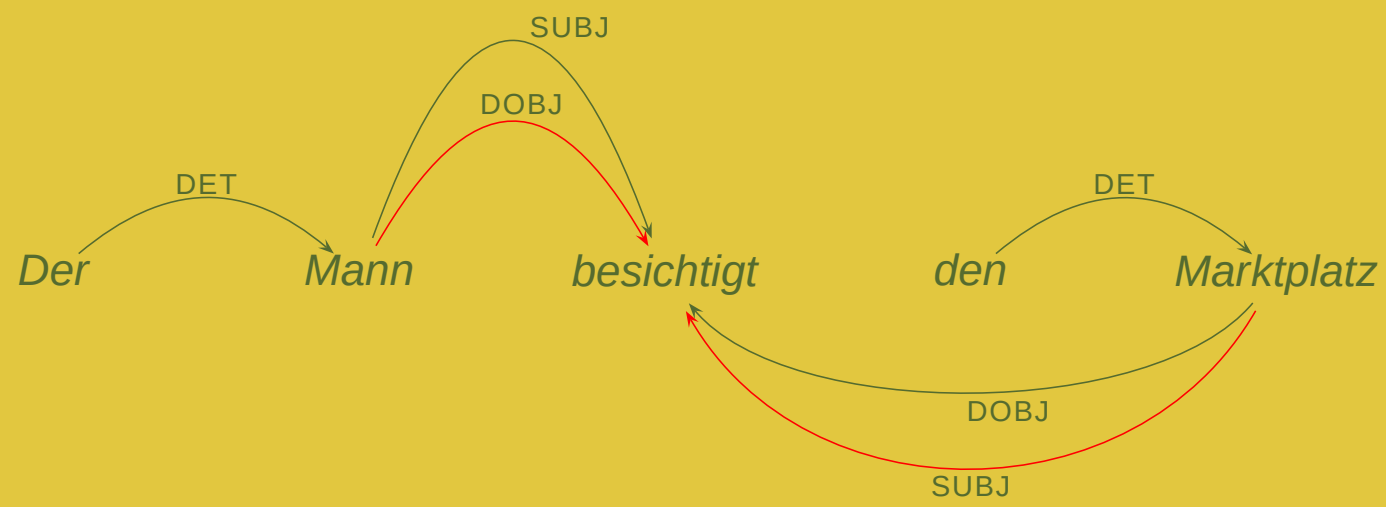

{X,Y} : SubjAgr : Subj : 0.0 :

X.label=SUBJ ∧ Y.label=DET ∧ X↓id=Y↑id → Y↑case=Y↓case=nom

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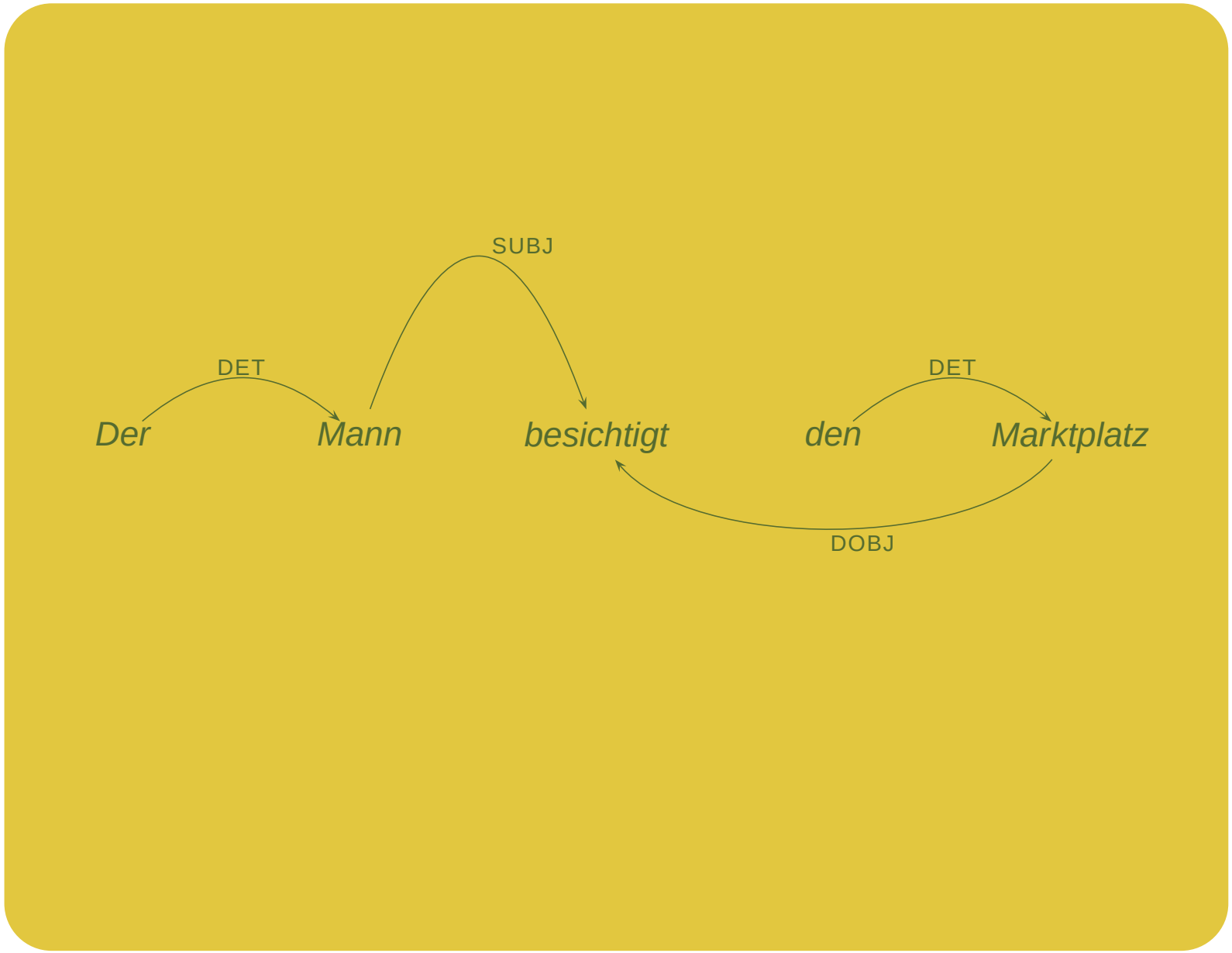

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- good synergy when used in combination

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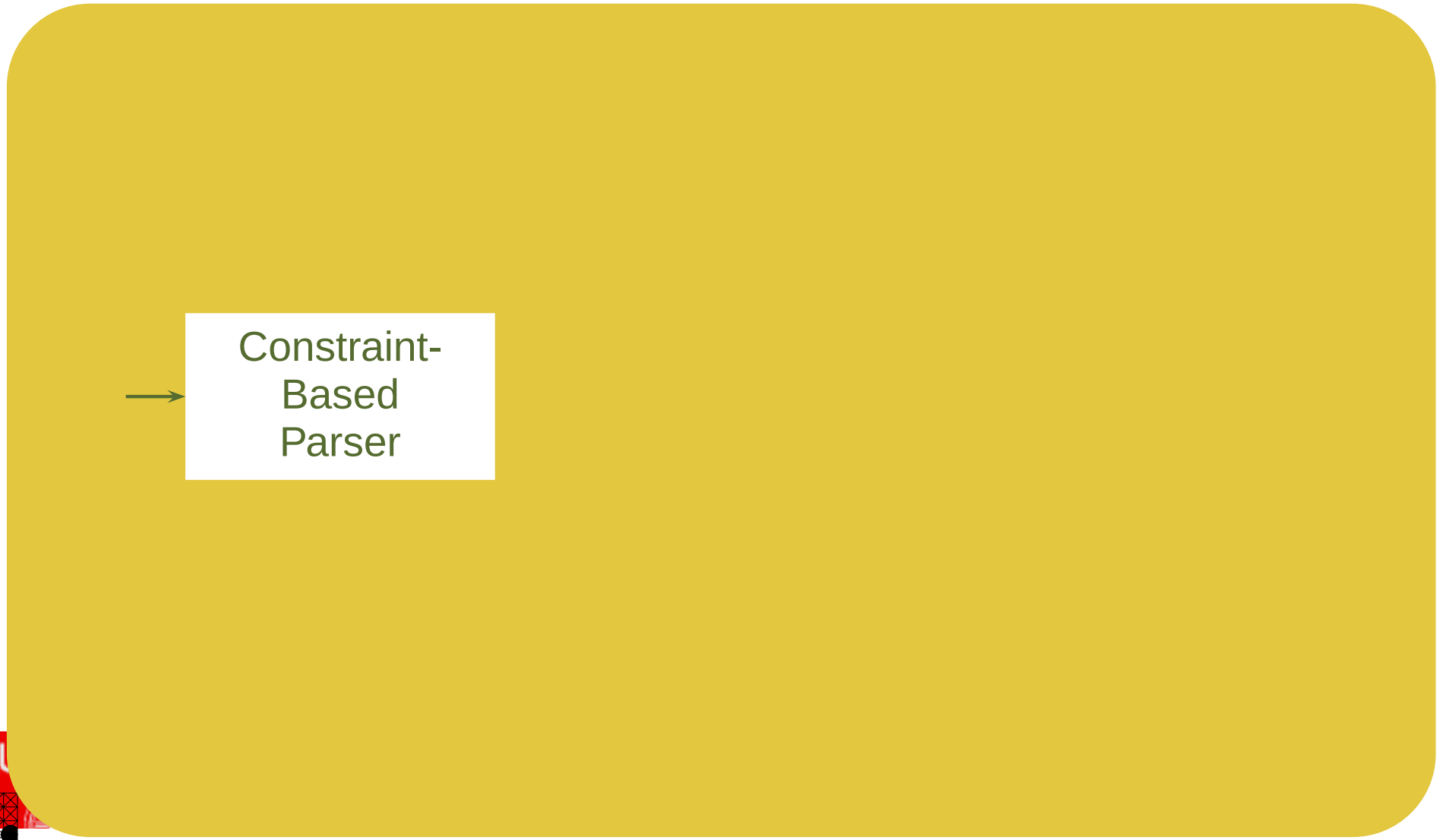

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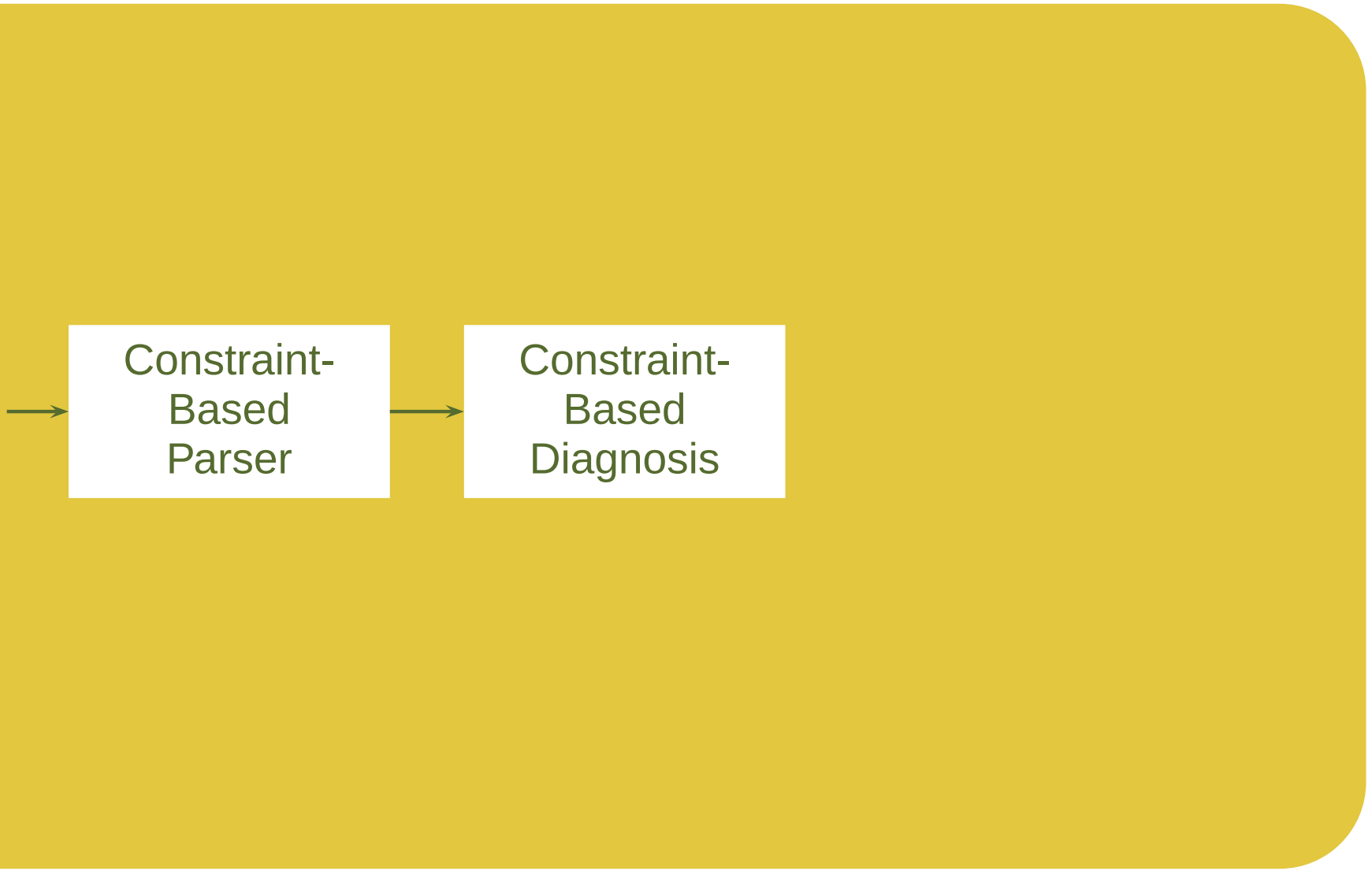

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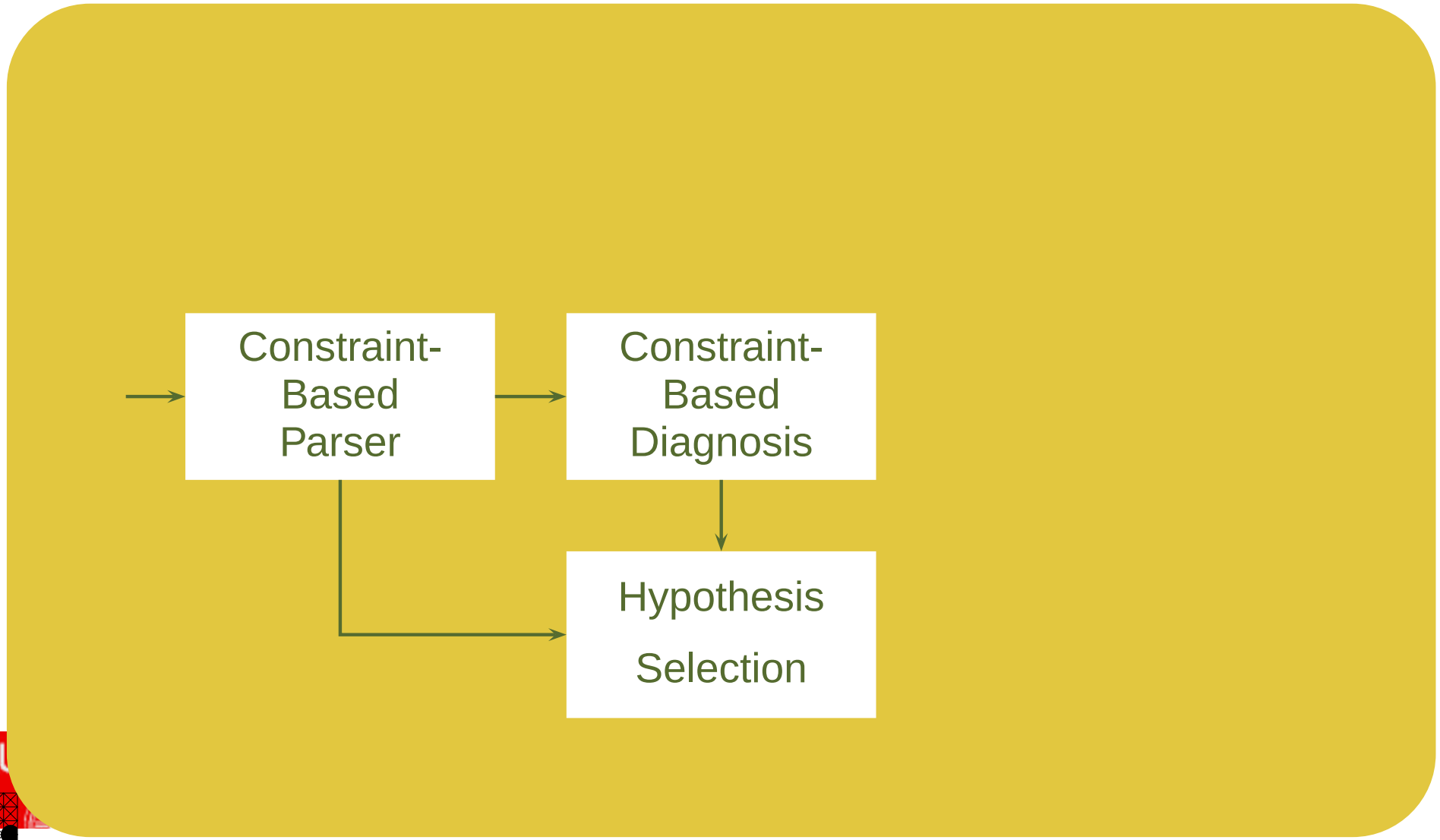

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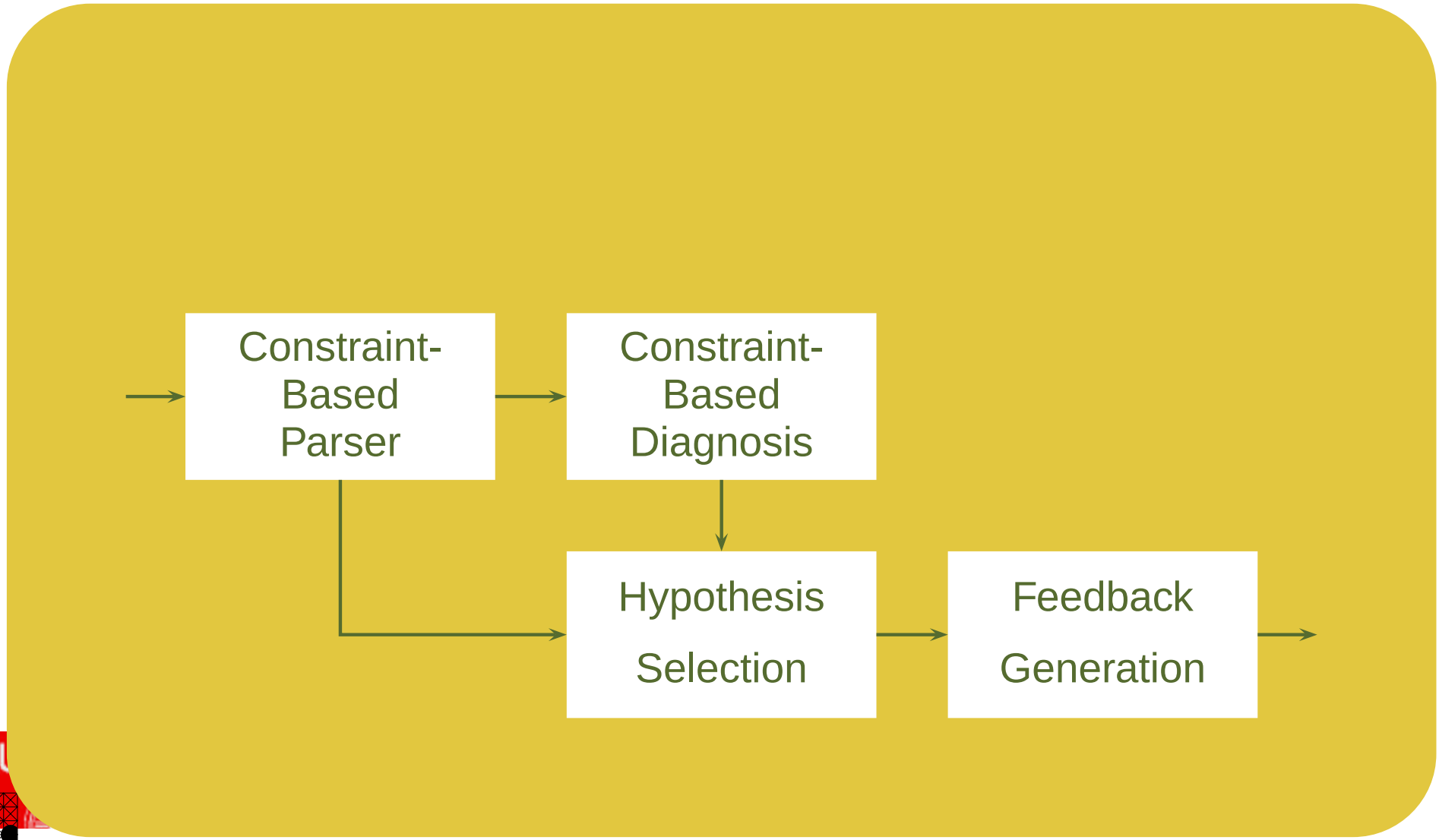

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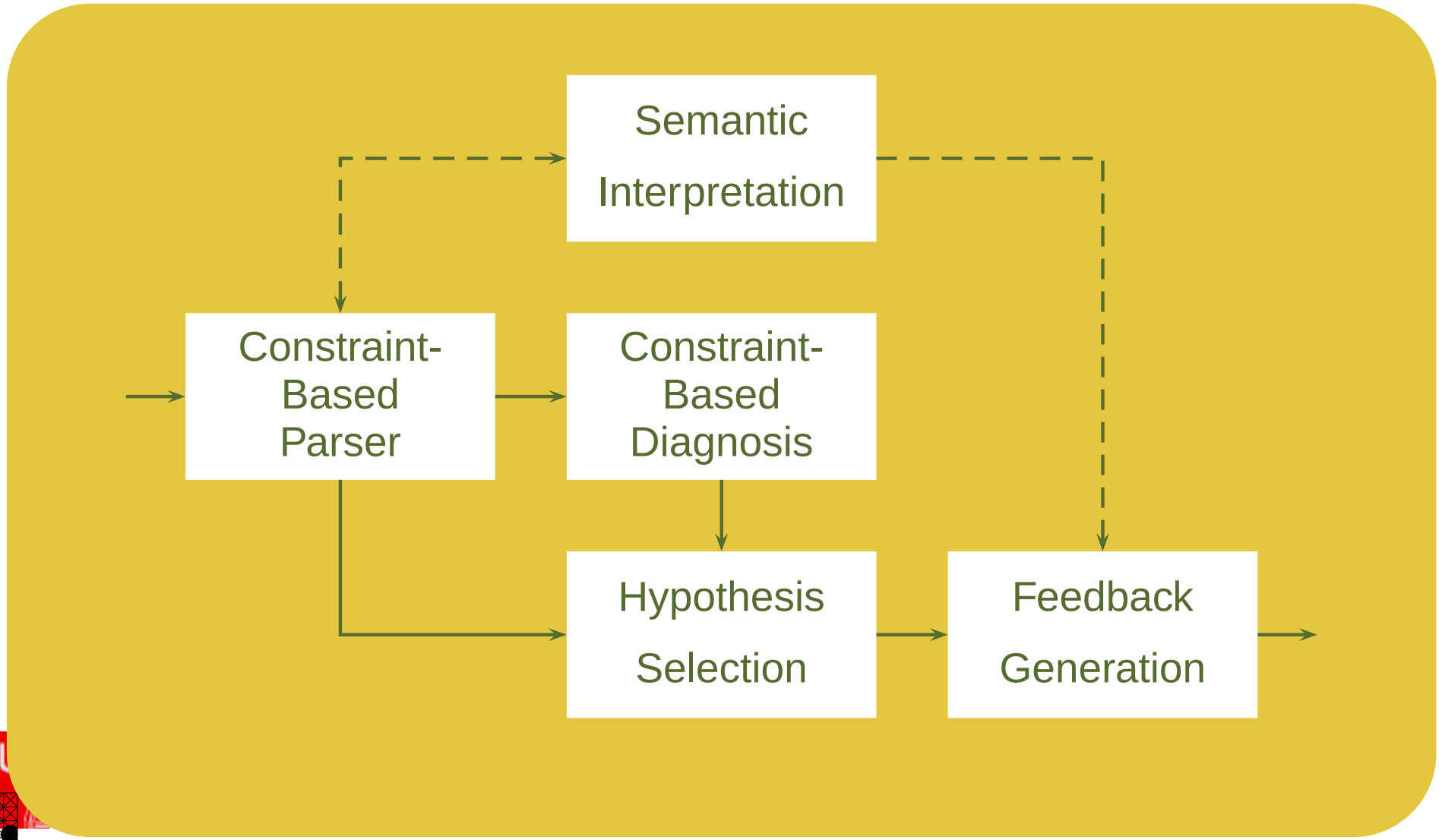
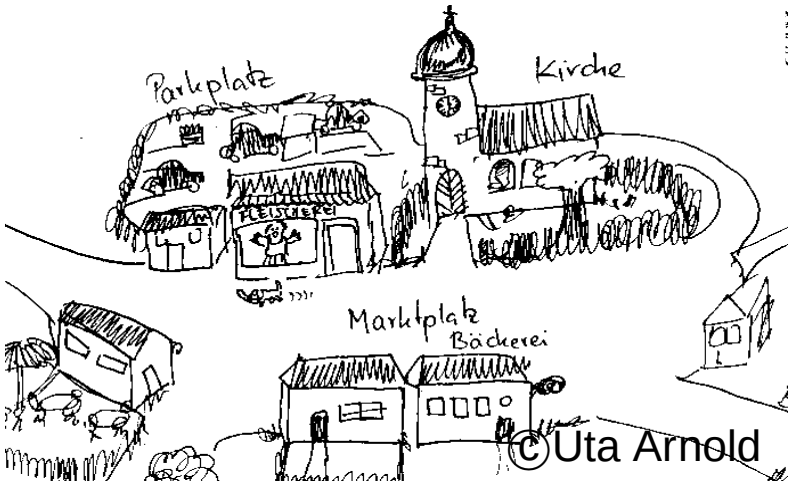


Structural Constraints

- semantic preferences, world knowledge and context information can be integrated into the optimisation process



in_front_of(church,marketplace).
left_of(church,parking_lot).
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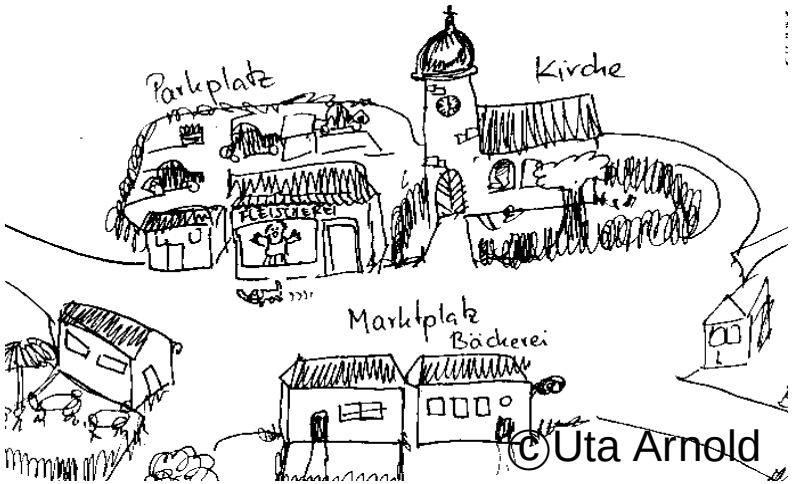

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- if the ”world” contains just a single church, prefer the singular reading

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- dynamic scenarios allow to focus on the changing aspects of a scene (Reuer 2003)

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  - virtual world can become an alternative communication channel if the verbal communication breaks down

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$\rightarrow$ requires integrated system solutions