# Mildly Context-Sensitive Grammar Formalisms:

## Feature Structures and Dependencies

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**Overview**

1. Feature-structure based TAG (FTAG)

2. Constituency and Dependency

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**FTAG (1)**

Feature-structure based TAG (FTAG):
[Vijay-Shanker and Joshi, 1988].

Each node has a top and a bottom feature structure (except substitution nodes that have only a top). Nodes in the same elementary tree can share features (extended domain of locality).

Intuition:

- The top feature structure tells us something about what the node presents within the surrounding structure, and

- the bottom feature structure tells us something about what the tree below the node represents.
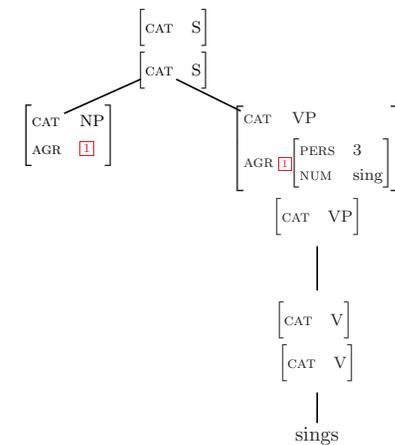
In the final derived tree, both must be the same.

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**FTAG (2)**

Example:

**FTAG (3)**

Example:

$$\begin{bmatrix} \text{CAT} & \text{S} \end{bmatrix}$$
$$\begin{bmatrix} \text{CAT} & \text{S} \end{bmatrix}$$

$$\begin{bmatrix} \text{CAT} & \text{NP} \\ \text{AGR} & \boxed{1} \end{bmatrix} \quad \begin{bmatrix} \text{CAT} & \text{VP} \\ \text{AGR} & \boxed{1} \\ \text{MODE} & \text{ind} \end{bmatrix}$$

$$\begin{bmatrix} \text{CAT} & \text{VP} \\ \text{MODE} & \text{ger} \end{bmatrix}$$

$$\begin{bmatrix} \text{CAT} & \text{V} \end{bmatrix}$$
$$\begin{bmatrix} \text{CAT} & \text{V} \end{bmatrix}$$

singing

**FTAG (4)**

Unification during derivation:

- **Substitution**: the top of the root of the new initial tree unifies with the top of the substitution node

- **Adjunction**: the top of the root of the new auxiliary tree unifies with the top of the adjunction site,

  and the bottom of the foot of the new tree unifies with the bottom of the adjunction site.

- In the final derived tree, top and bottom unify for all nodes.

**FTAG (5)**

Example:

$$\begin{bmatrix} \text{CAT} & \text{S} \end{bmatrix}$$
$$\begin{bmatrix} \text{CAT} & \text{S} \end{bmatrix}$$

$$\begin{bmatrix} \text{CAT} & \text{NP} \\ \text{AGR} & \boxed{1} \end{bmatrix} \quad \begin{bmatrix} \text{CAT} & \text{VP} \\ \text{AGR} & \boxed{1}\begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{sing} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \; \end{bmatrix}$$
$$\begin{bmatrix} \text{CAT} & \text{NP} \\ \text{AGR} & \begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{sing} \end{bmatrix} \end{bmatrix} \qquad \begin{bmatrix} \text{CAT} & \text{VP} \end{bmatrix}$$

John

$$\begin{bmatrix} \text{CAT} & \text{V} \end{bmatrix}$$
$$\begin{bmatrix} \text{CAT} & \text{V} \end{bmatrix}$$

sings

**FTAG (6)**

Example:

$$\begin{bmatrix} \text{CAT} & \text{S} \end{bmatrix}$$
$$\begin{bmatrix} \text{CAT} & \text{S} \end{bmatrix}$$

$$\begin{bmatrix} \text{CAT} & \text{VP} \end{bmatrix} \quad \begin{bmatrix} \text{CAT} & \text{NP} \\ \text{AGR} & \boxed{1} \end{bmatrix} \quad \begin{bmatrix} \text{CAT} & \text{VP} \\ \text{AGR} & \boxed{1} \\ \text{MODE} & \text{ind} \end{bmatrix}$$

$$\begin{bmatrix} \text{CAT} & \text{VP} \\ \text{AGR} & \boxed{2} \\ \text{MODE} & \text{ind} \end{bmatrix} \qquad \begin{bmatrix} \text{CAT} & \text{VP} \\ \text{MODE} & \text{ger} \end{bmatrix}$$

$$\begin{bmatrix} \text{CAT} & \text{V} \end{bmatrix} \qquad \begin{bmatrix} \text{CAT} & \text{VP} \end{bmatrix}^{*}$$

$$\begin{bmatrix} \text{CAT} & \text{V} \\ \text{AGR} & \boxed{2}\begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{sing} \end{bmatrix} \end{bmatrix}$$

is

$$\begin{bmatrix} \text{CAT} & \text{V} \end{bmatrix}$$
$$\begin{bmatrix} \text{CAT} & \text{V} \end{bmatrix}$$

singing

## FTAG (7)

In FTAG, there are no explicit adjunction constraints. Instead, adjunction constraints are expressed via feature unification requirements.

Important: LTAG feature structures are restricted; there is only a finite set of possible feature structures.

Therefore, the following can be shown:

For each FTAG there exists a weakly equivalent TAG with adjunction constraints and vice versa. The two TAGs generate even the same sets of trees, only with different node labels.

## Constituency and Dependency (1)

The derived tree gives the constituent structure.

The derivation tree records the history of how the elementary trees are put together.
⇒ the edges in the derivation tree represent predicate-argument dependencies; the derivation tree is close to a semantic dependency graph.

⇒ compute semantics on derivation tree

[Gardent and Kallmeyer, 2003, Kallmeyer and Joshi, 2003, Kallmeyer and Romero, 2008, Nesson and Shieber, 2006]

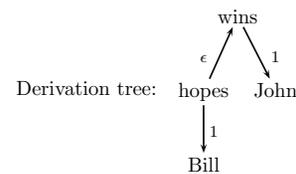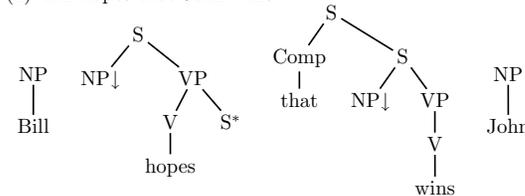## Constituency and Dependency (2)
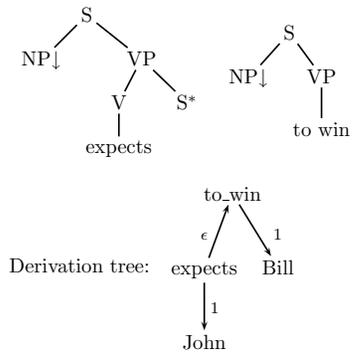
(1) John buys Bill a book

Elementary trees:



Derivation tree:
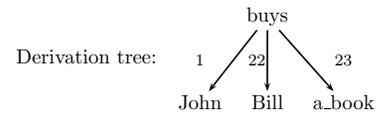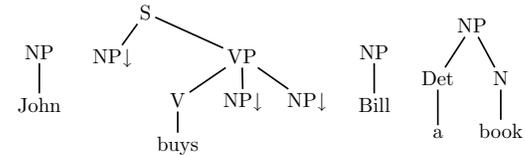
## Constituency and Dependency (3)

(2) Bill hopes that John wins



Derivation tree:

## Constituency and Dependency (4)

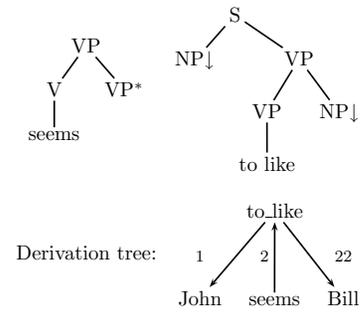(3) John expects [ Bill to win ]



Derivation tree:

## Constituency and Dependency (5)

(4) John persuades Bill [ PRO to leave ]
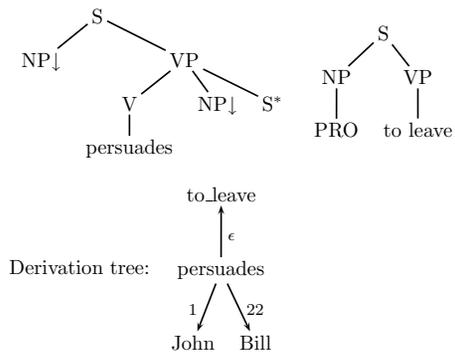


Derivation tree:

## Constituency and Dependency (6)

(5) John seems to like Bill



Derivation tree:

## Constituency and Dependency (7)

The derivation tree is not always the semantic dependency structure:

(6) John claims Bill is likely to win

# References

[Gardent and Kallmeyer, 2003] Gardent, C. and Kallmeyer, L. (2003). Semantic Construction in FTAG. In *Proceedings of EACL 2003*, pages 123–130, Budapest.

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[Kallmeyer and Romero, 2008] Kallmeyer, L. and Romero, M. (2008). Scope and situation binding in LTAG using semantic unification. *Research on Language and Computation*, 6(1):3–52.

[Nesson and Shieber, 2006] Nesson, R. and Shieber, S. M. (2006). Simpler TAG semantics through synchronization. In *Proceedings of the 11th Conference on Formal Grammar*, Malaga, Spain.

[Vijay-Shanker and Joshi, 1988] Vijay-Shanker, K. and Joshi, A. K. (1988). Feature structures based tree adjoining grammar. In *Proceedings of COLING*, pages 714–719, Budapest.