

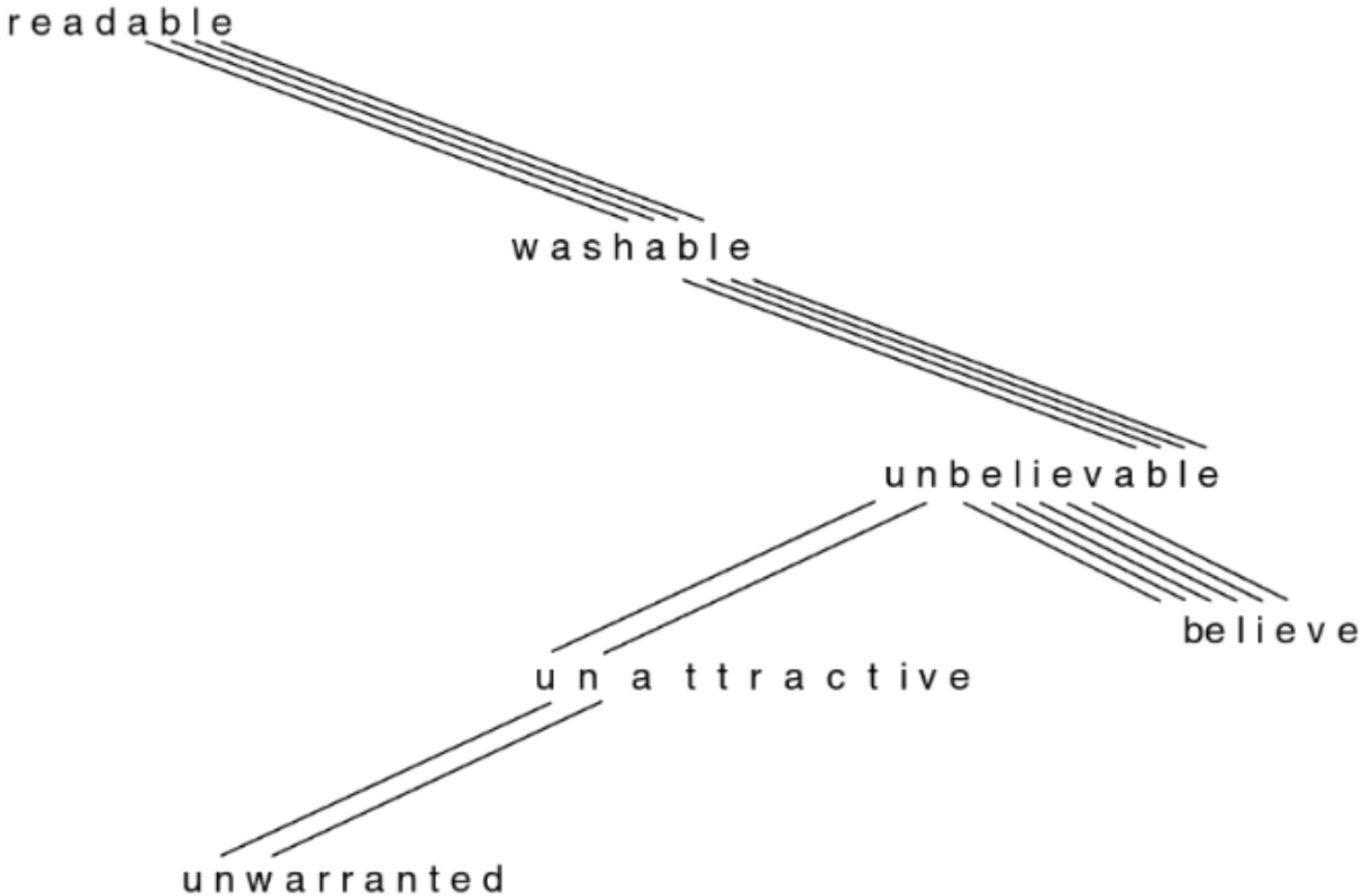
What is a “taxonomic network”?

On the relationship between hierarchies and networks

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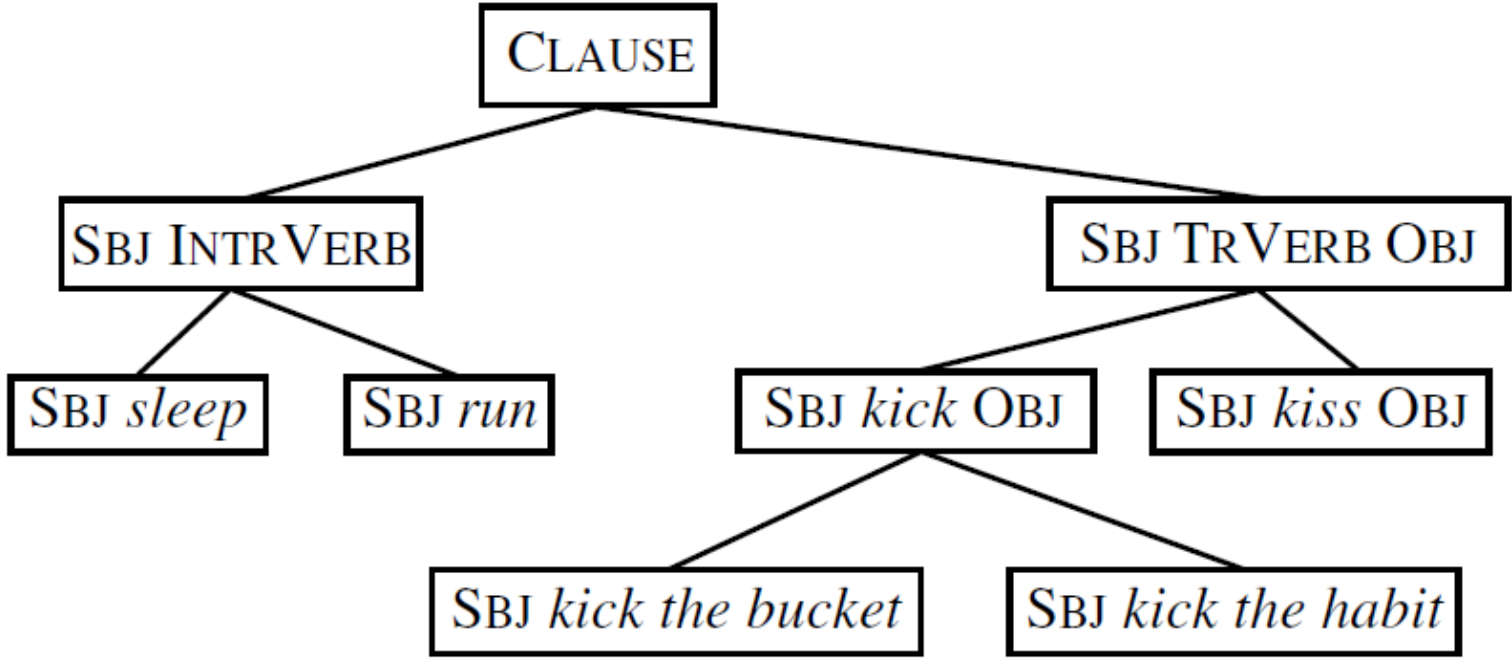
16th International Cognitive Linguistics Conference (ICLC16)
Düsseldorf, August 7-11, 2023

Intro: Is this a network? Does it have hierarchical structure?



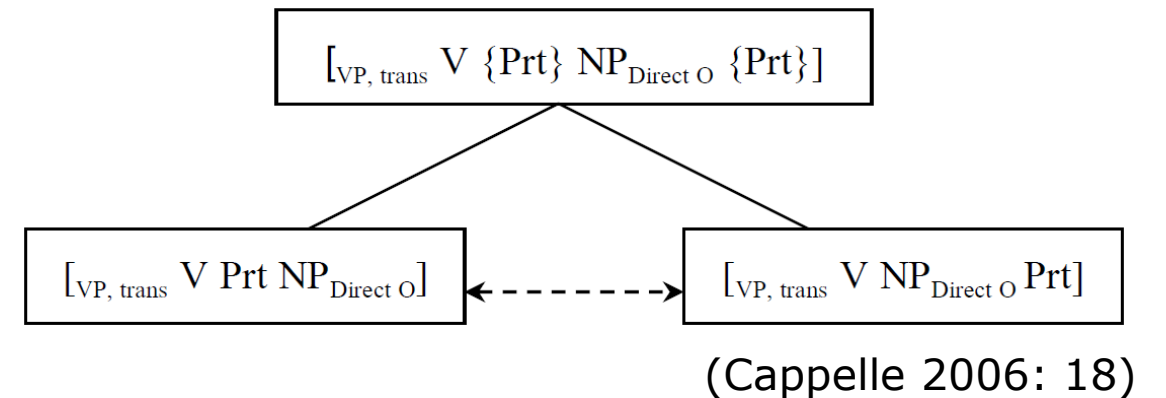
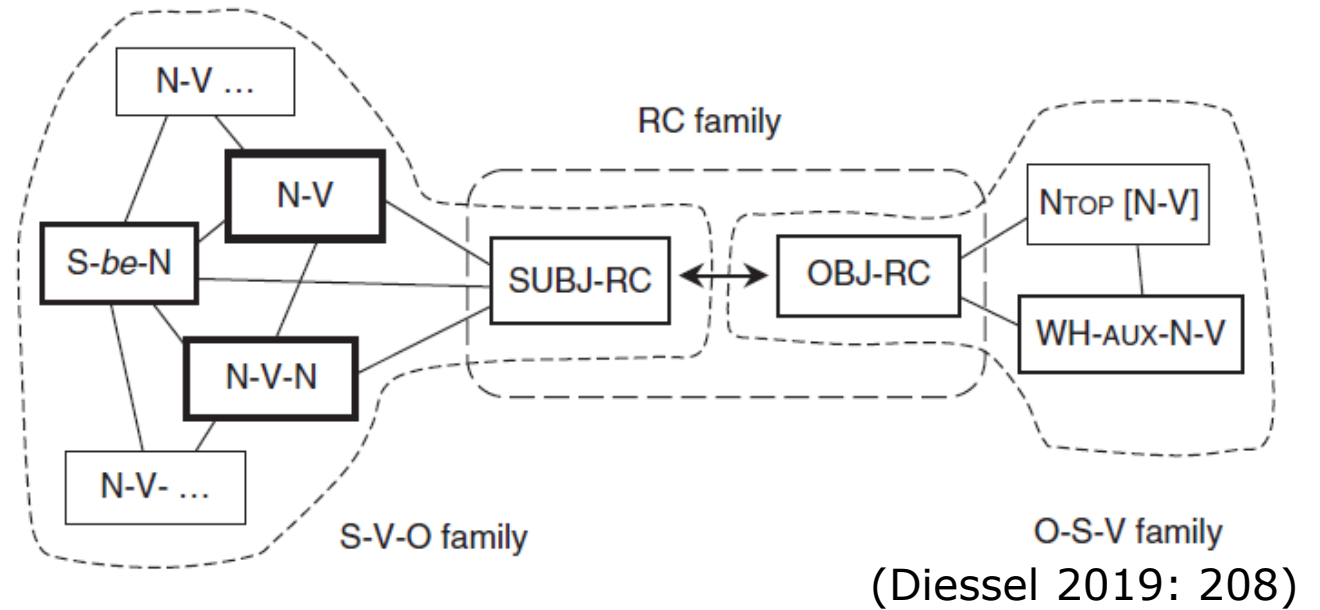
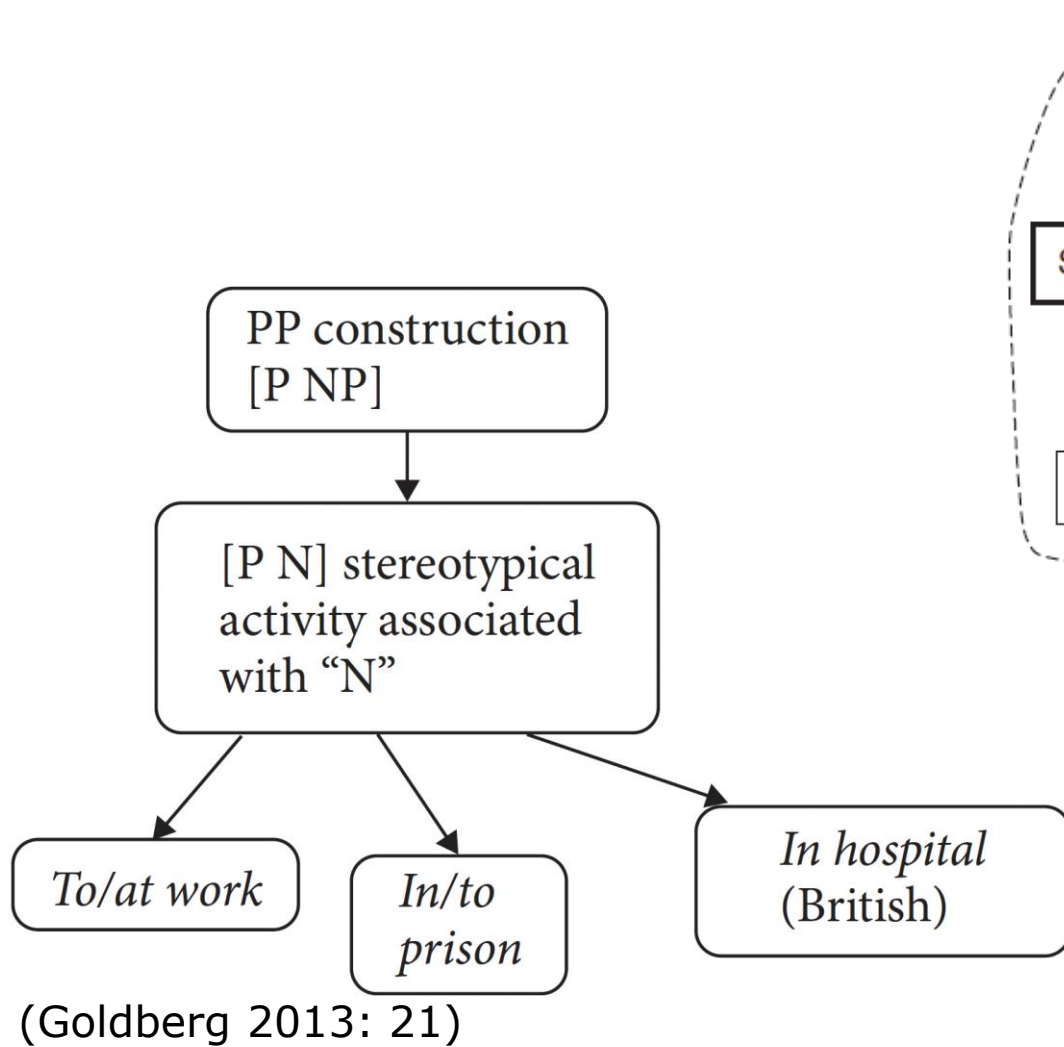
(Bybee 2010: 23)

Intro: Is this a network? Does it have hierarchical structure?



(Croft & Cruse 2004: 264)

Intro: Networks of varying types



Roadmap

QUESTION

Cognitive linguists typically model linguistic knowledge as “a **taxonomic network** of **hierarchically** related constructions” (Diessel 2019: 199; our emphasis).

But what is the relationship between hierarchies/taxonomies and networks?

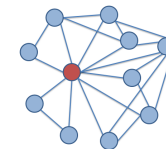
1. Terminology



2. How does hierarchical structure emerge in networks?



3. How can hierarchical structure be represented in networks?



4. What are the implications for cognitive-linguistic theory?





Terminology

Terminology

Networks...

“a catalog of a system’s components often called *nodes* or *vertices* and the direct interactions between them, called *links* or *edges*”

(Barabási 2016: 45)

... can have hierarchical structure, ...

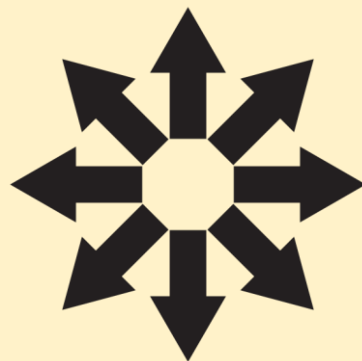
“an arrangement of items (objects, names, values, categories, etc.) that are represented as being "above", "below", or "at the same level as" one another”

(<https://en.wikipedia.org/wiki/Hierarchy>)

... with one type of hierarchy being a taxonomy.

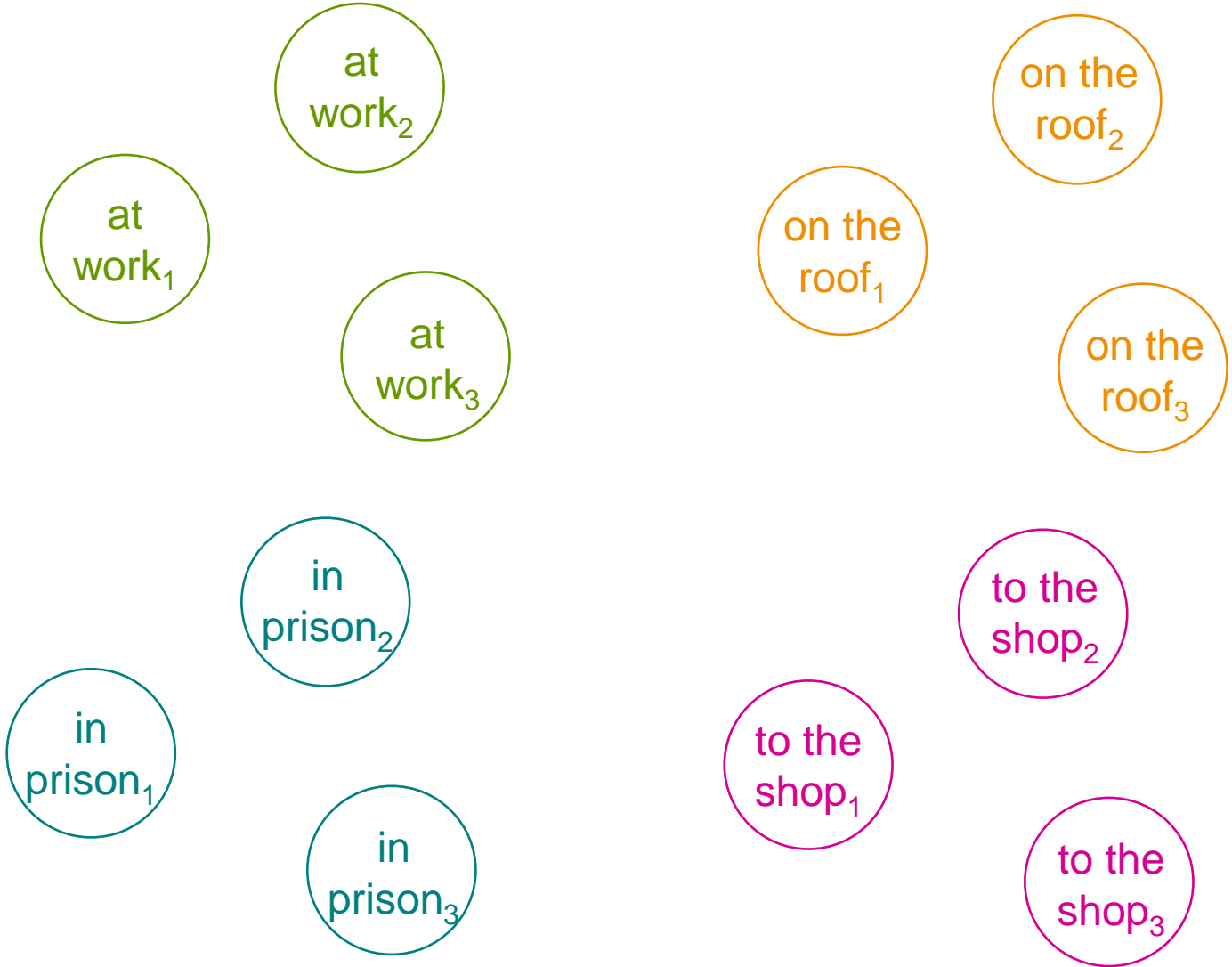
“a scheme of classification, especially a hierarchical classification, in which things are organized into groups or types”

(<https://en.wikipedia.org/wiki/Taxonomy>)

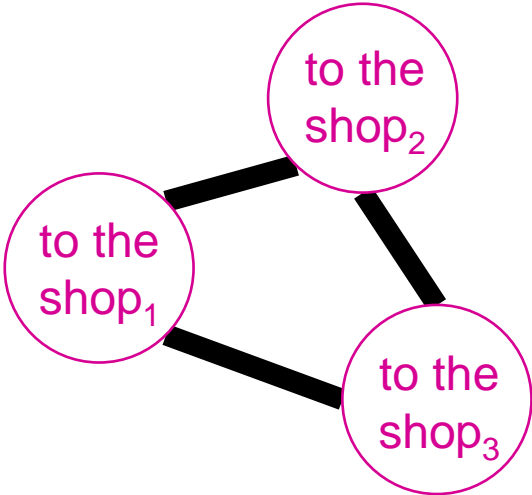
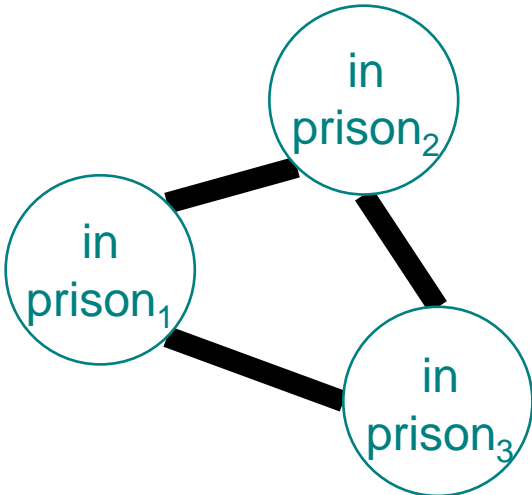
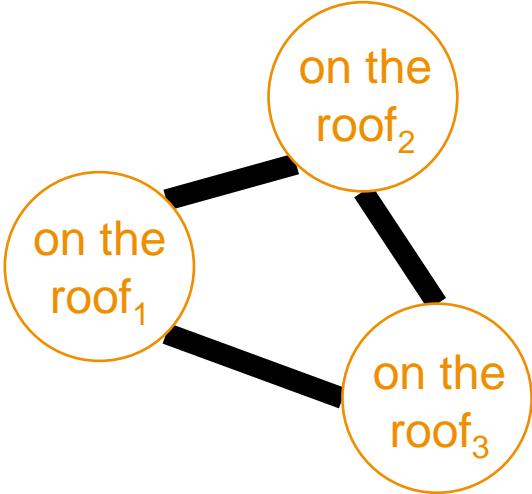
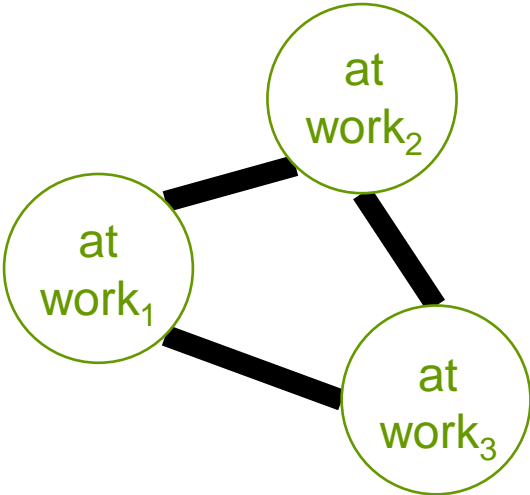


How does hierarchical structure emerge?

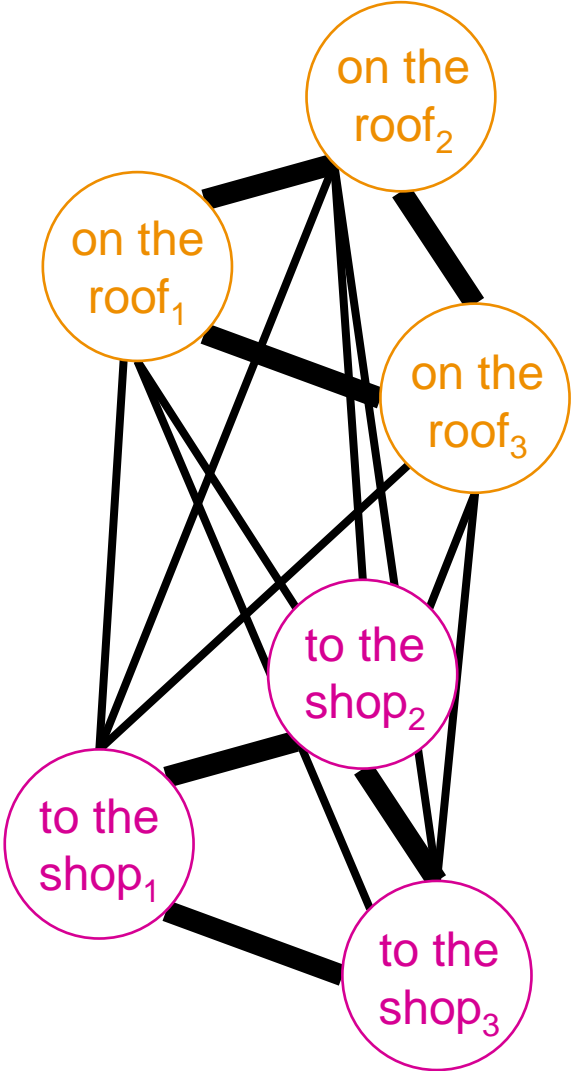
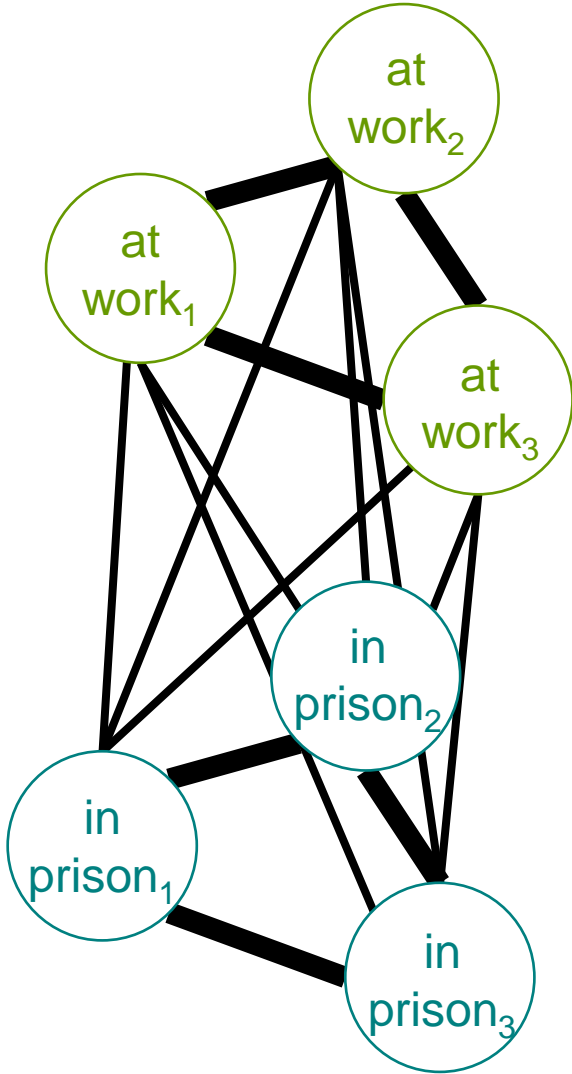
Starting from tokens/exemplars...



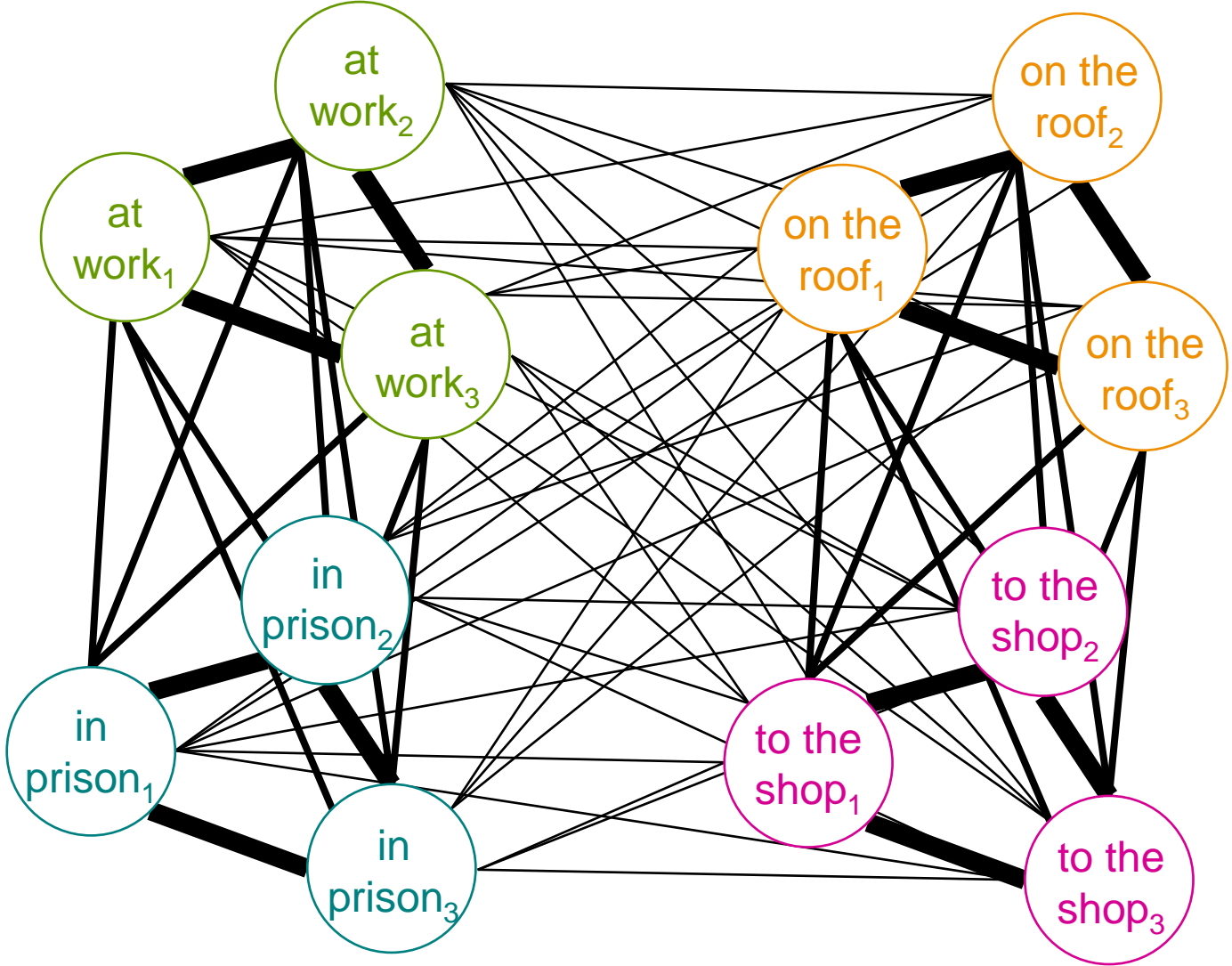
Similarity links



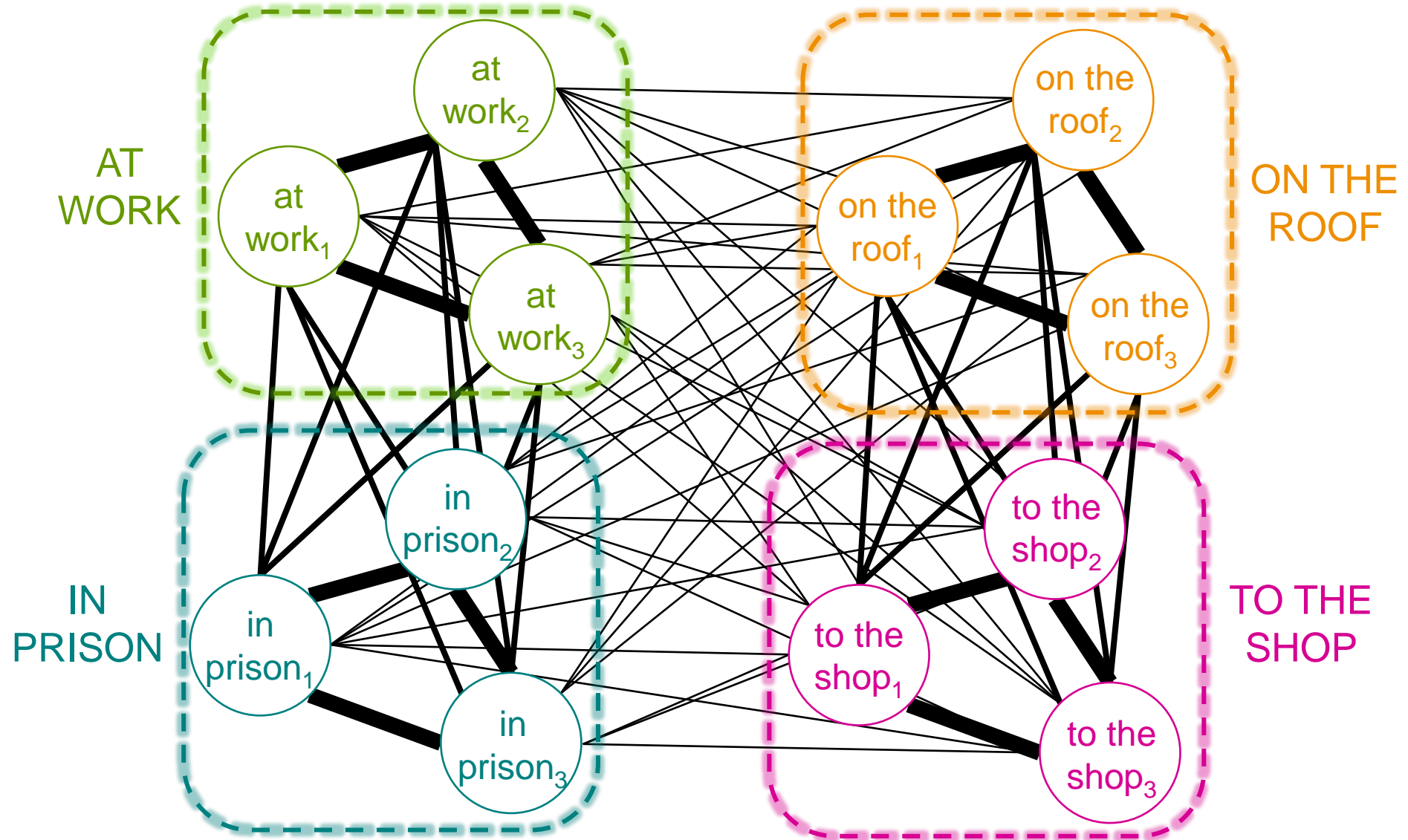
Similarity links



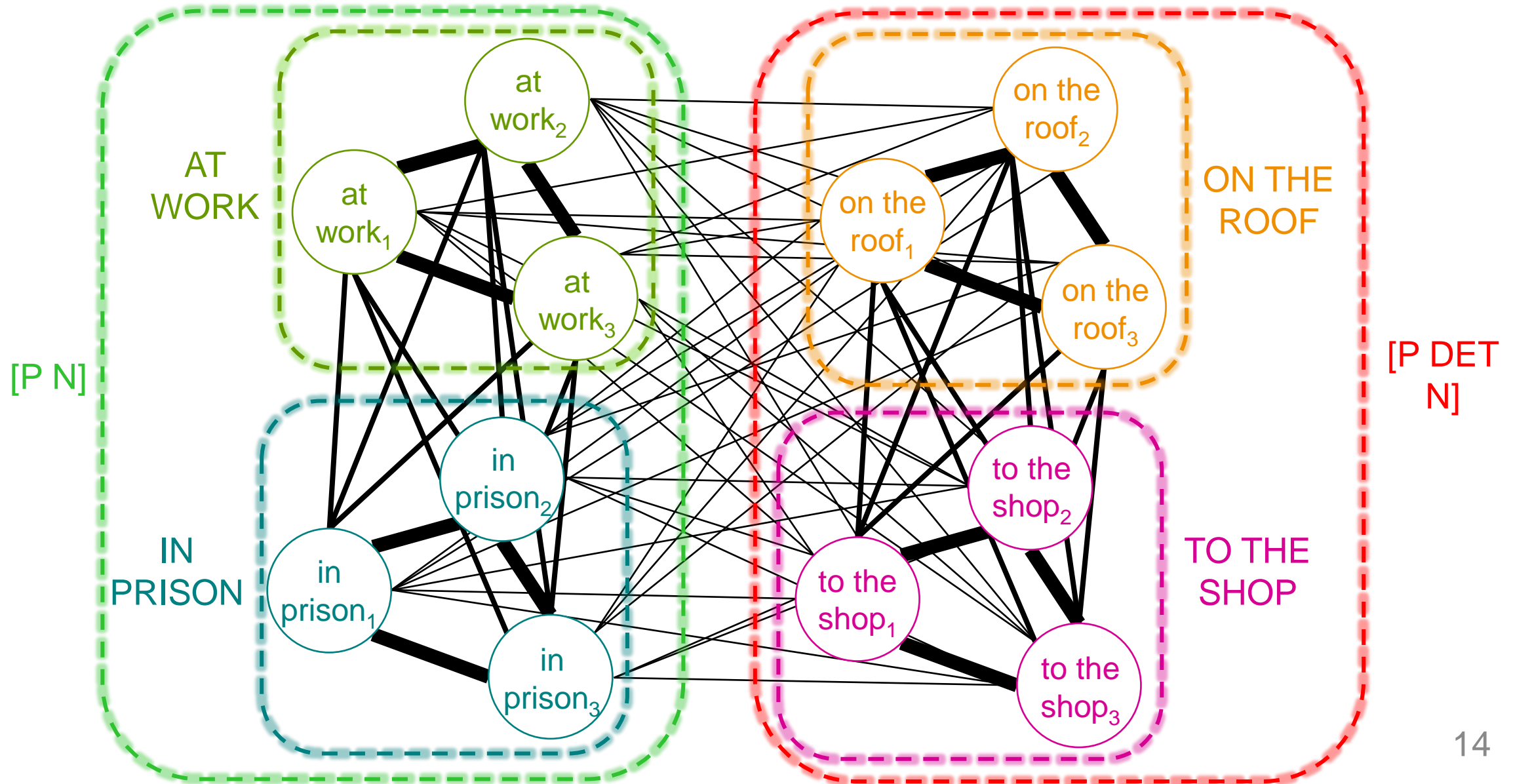
Similarity links



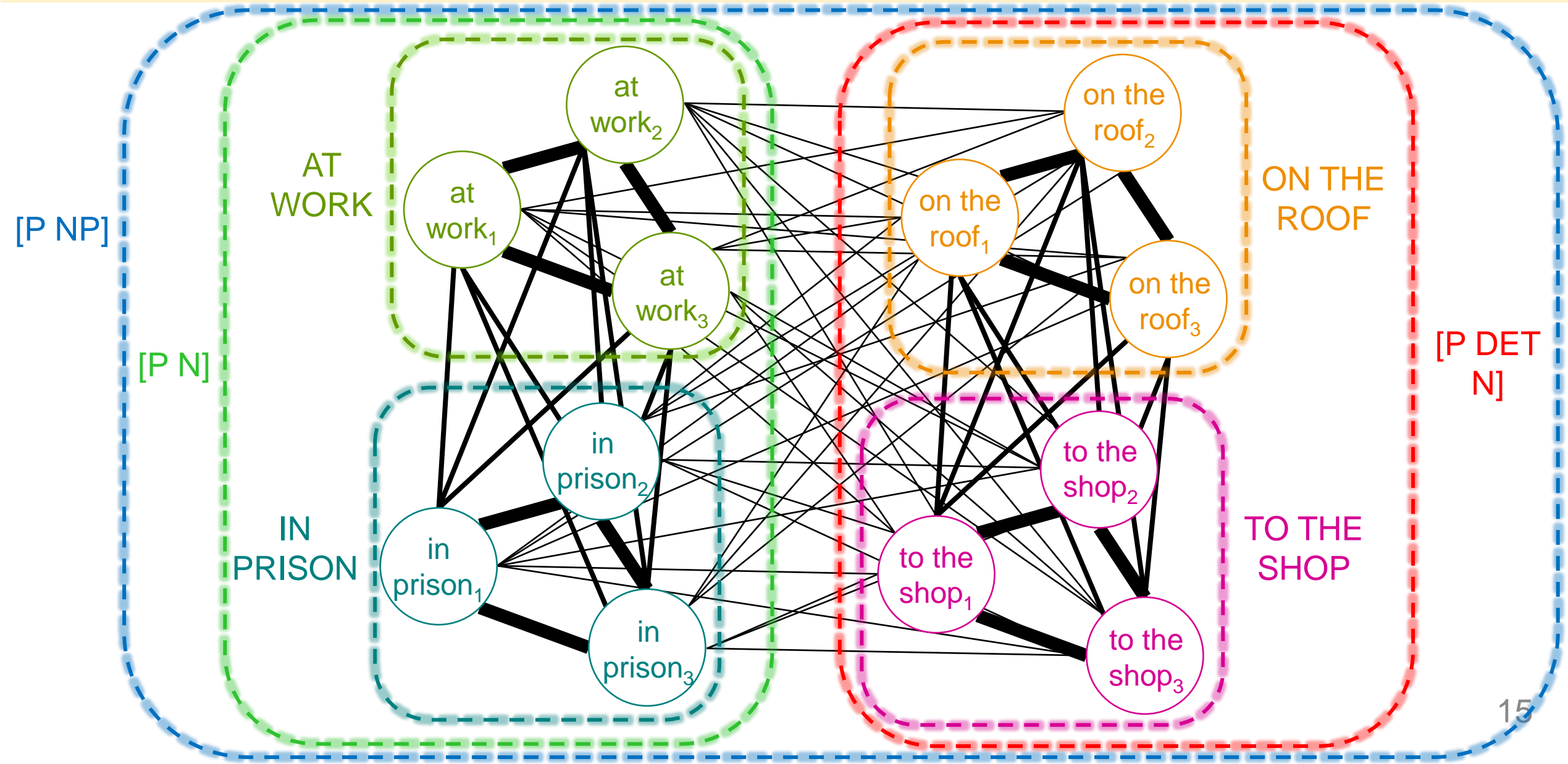
Network communities



Network communities

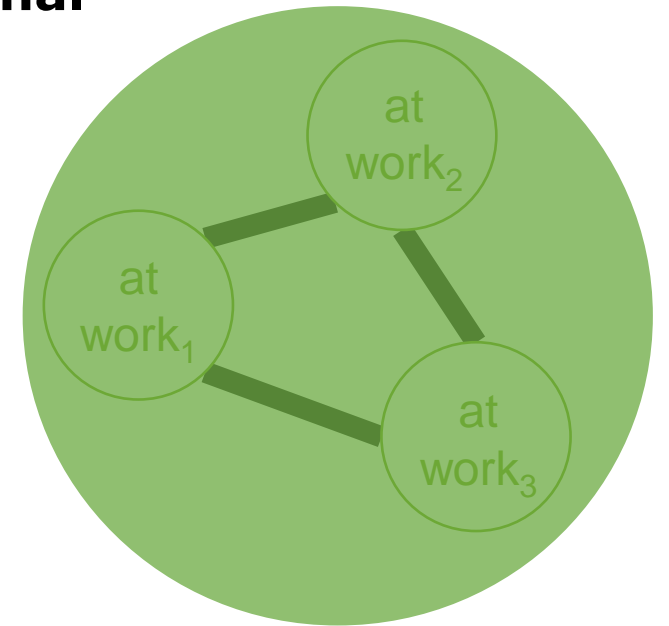


Network communities

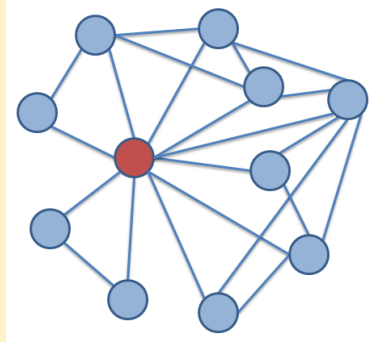


Summary: How does hierarchical structure emerge?

- (Taxonomic) hierarchies emerge through **clustering** of nodes based on their **link weights** (= degree of similarity)
- The hierarchical structure is implicit in the network's **community structure**
- Formally, network communities can be detected by **computational algorithms** such as the Louvain algorithm (Blondel et al. 2008)
 - Step 1: subdivide the network into optimal communities (using a "modularity" metric)
 - Step 2: create a new network that contains those communities as its nodes
 - Repeat Step 1 and Step 2 until no further communities can be found

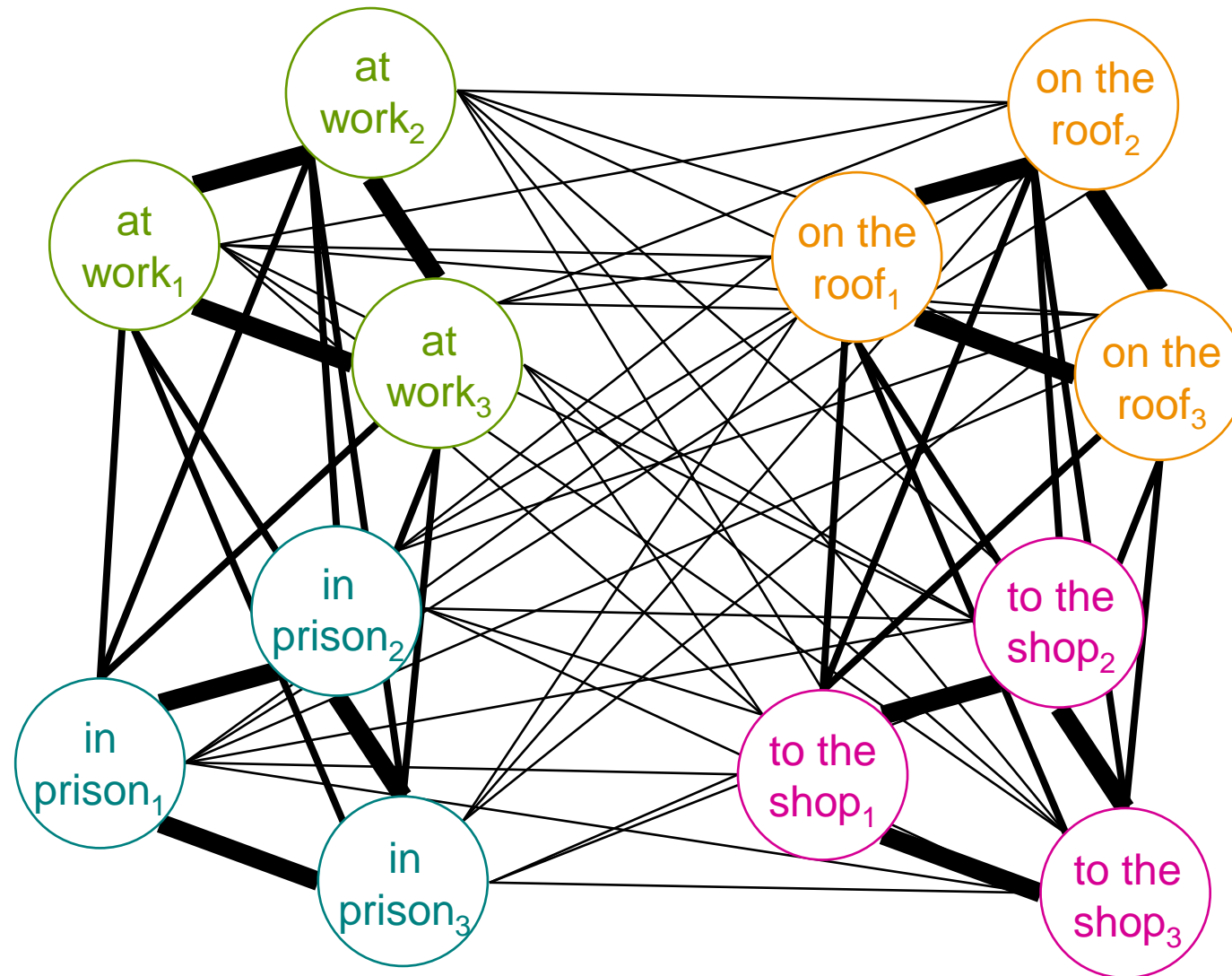


(Barabási 2016: Ch. 9; Ibbotson et al. 2019; Quick, Hartmann, Koch & Ibbotson, ICLC16)

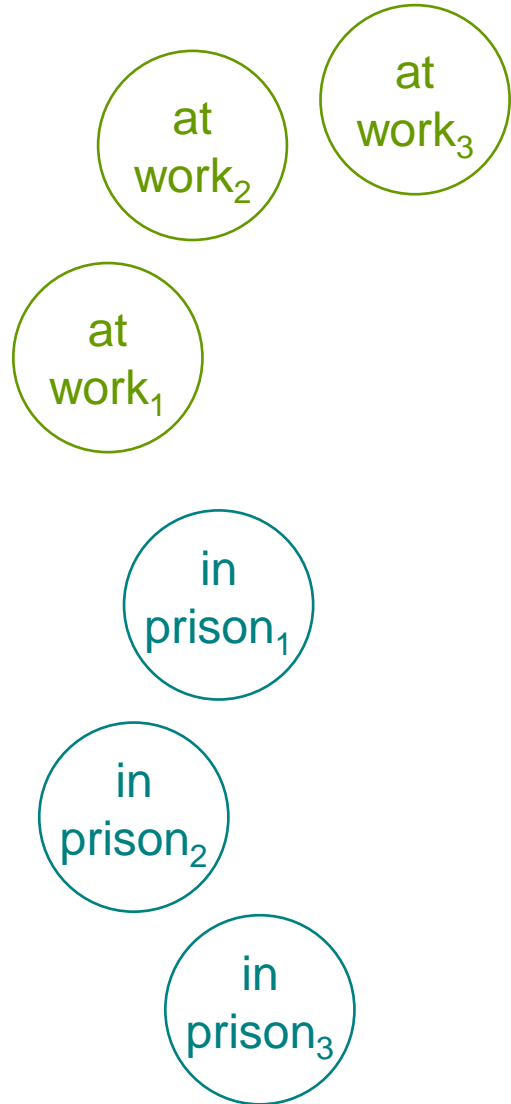


How can hierarchical structure be represented?

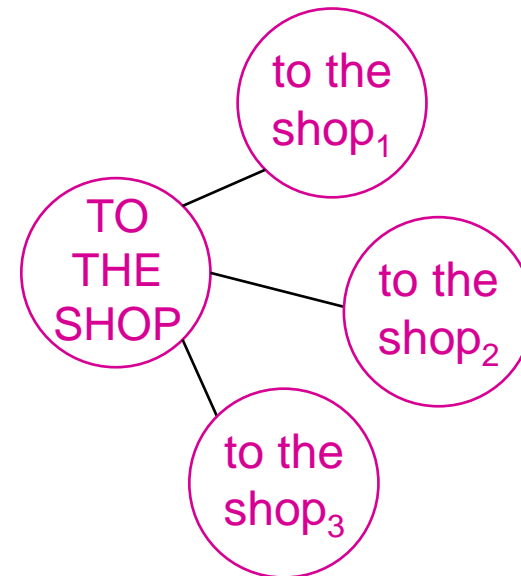
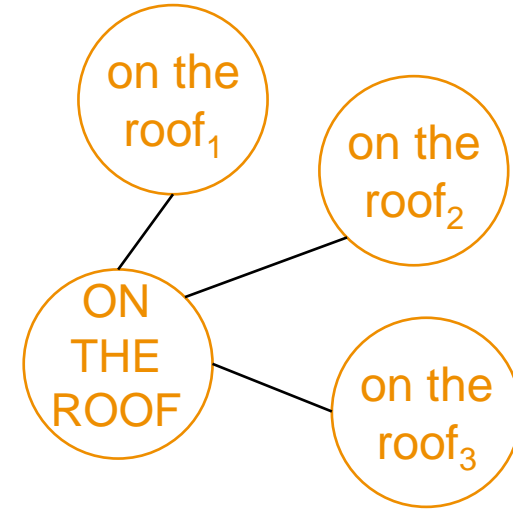
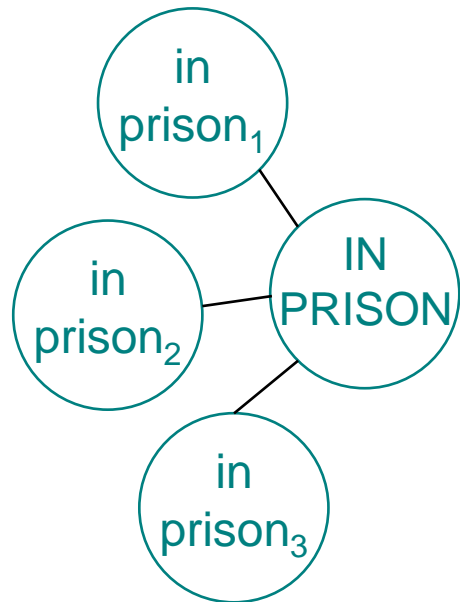
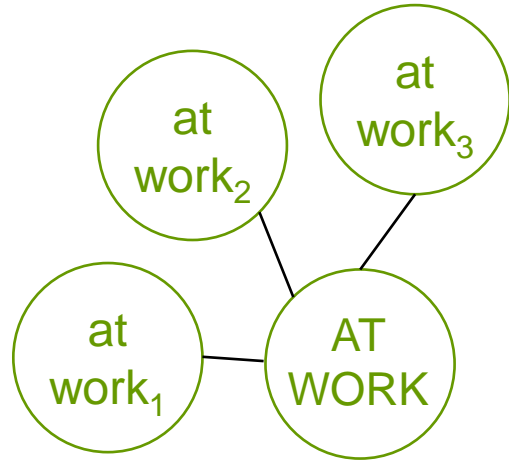
Either through **implicitly** hierarchical networks...



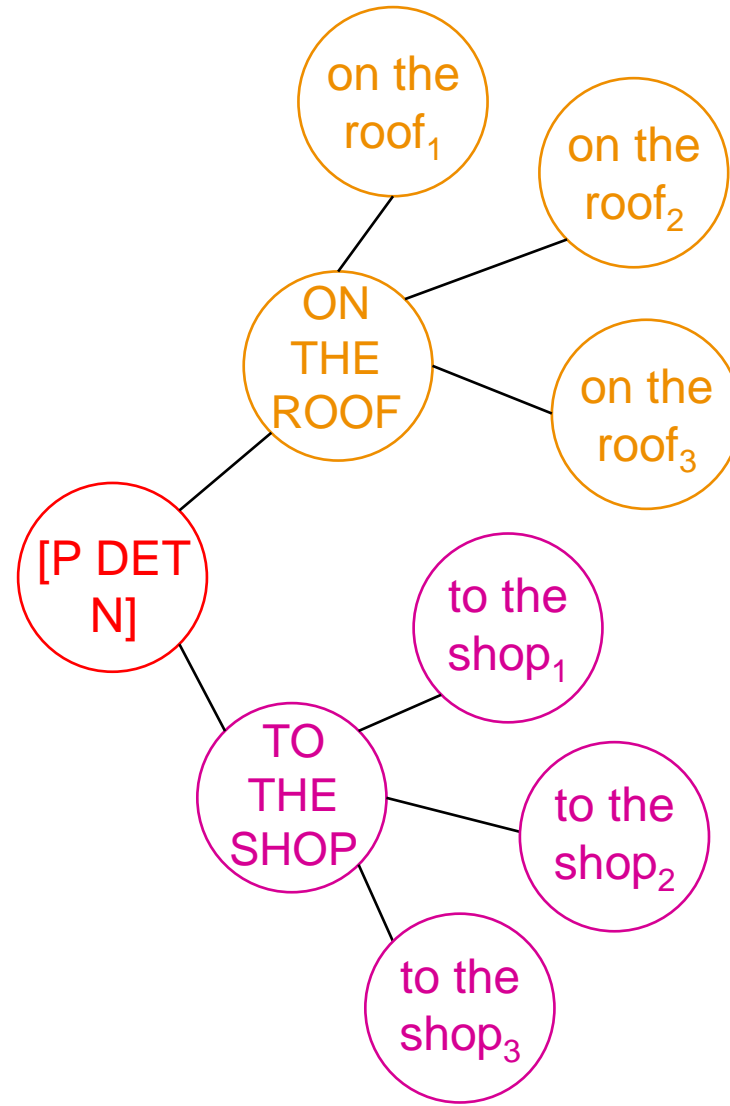
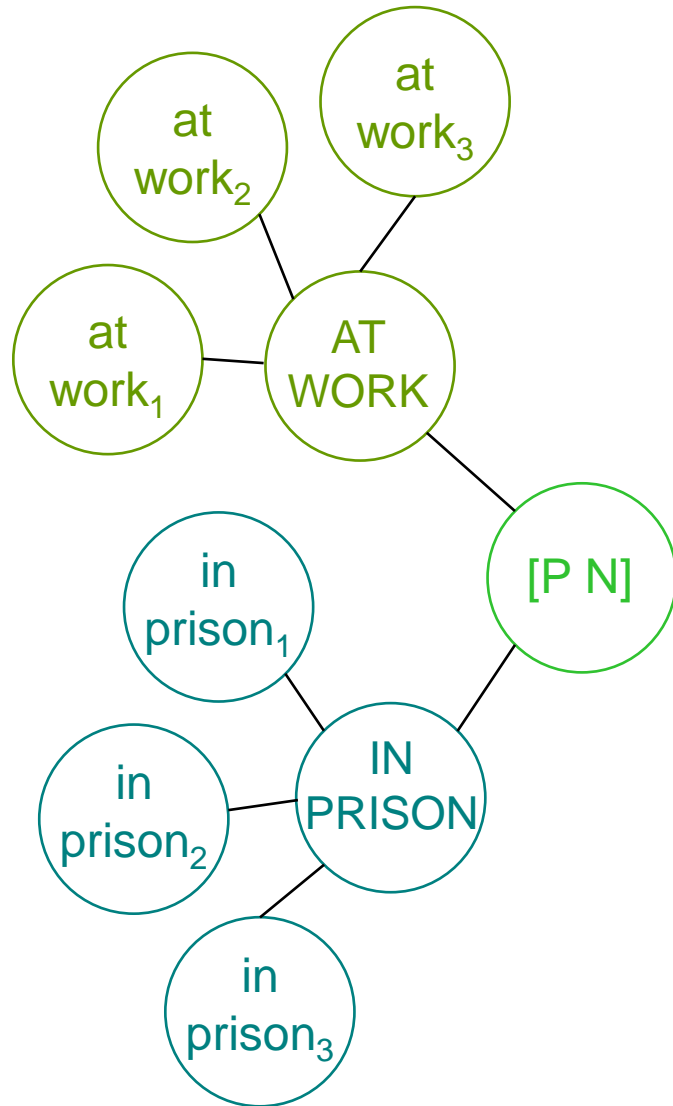
... or through **explicitly** hierarchical networks



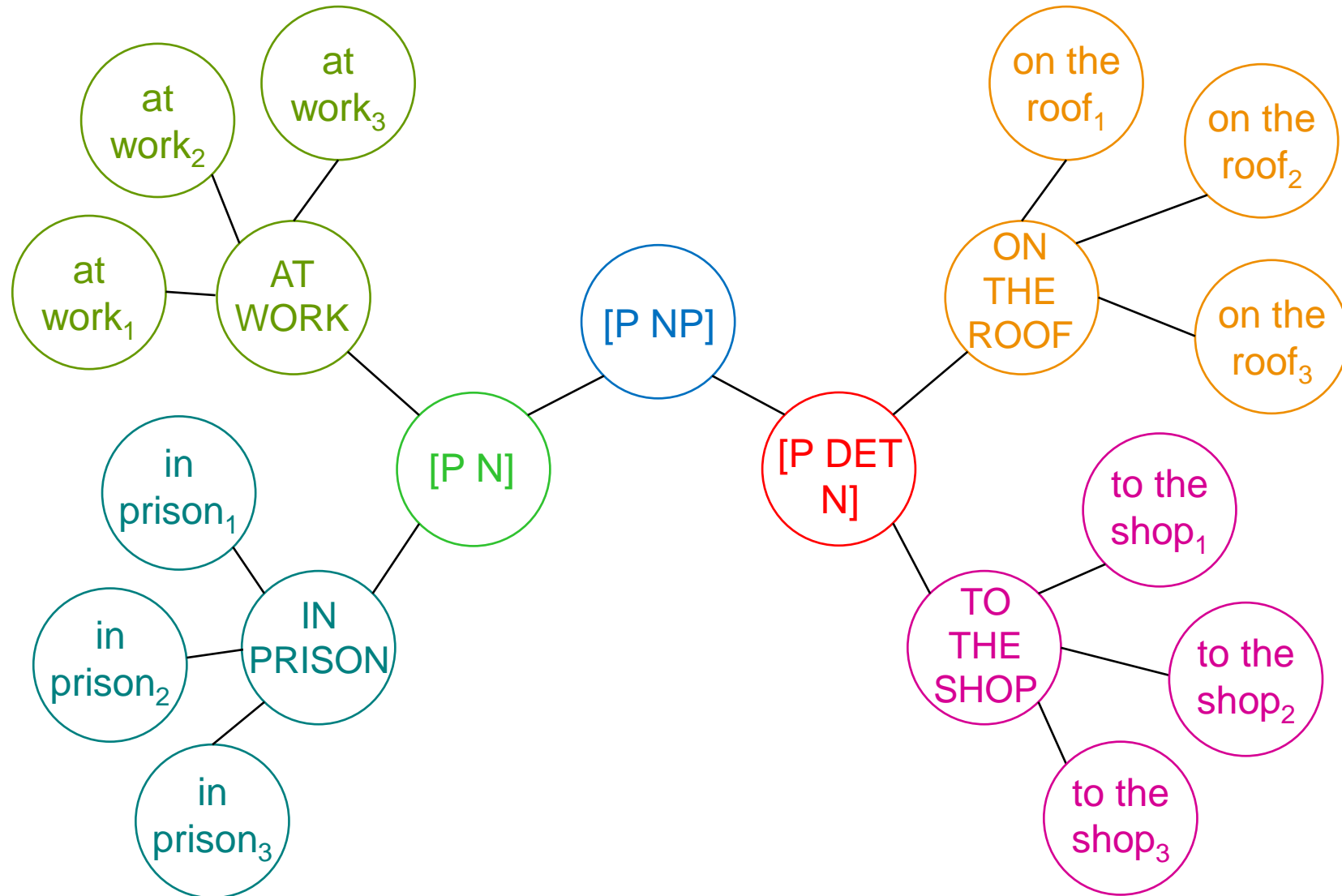
... or through **explicitly** hierarchical networks



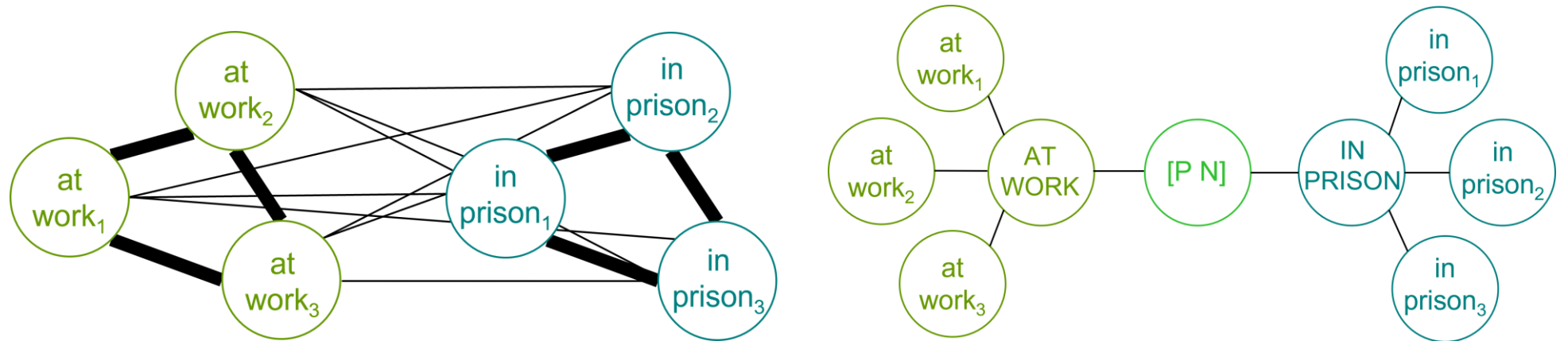
... or through **explicitly** hierarchical networks



... or through **explicitly** hierarchical networks



Summary: How can hierarchical structure be represented?



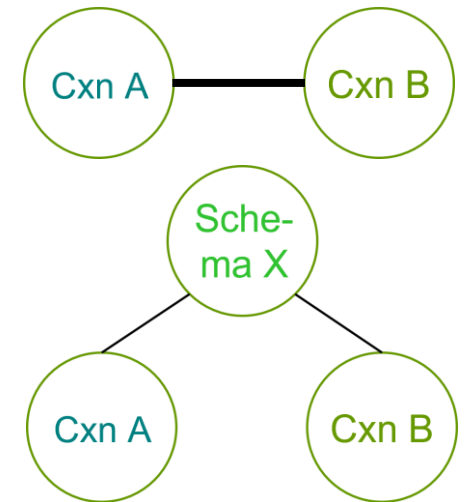
	Implicitly hierarchical networks	Explicitly hierarchical networks
Nodes represent...	exemplars	categories at varying levels of abstraction
Links represent...	degrees of similarity ("horizontal")	category membership ("vertical")
Links are...	weighted	unweighted
Hierarchy can be inferred via...	clustering algorithms	node centrality



Implications for cognitive-linguistic theory

What type of network is better?

- Implicitly and explicitly hierarchical networks are alternative representations of **a single cognitive reality**
- Each representation has specific **advantages and disadvantages**:
 - Implicitly hierarchical networks highlight varying degrees of similarity and may be easier to interpret in psychological terms (e.g., priming effects)
 - Explicitly hierarchical networks represent the hierarchical structure more clearly and allow researchers to label the categories
- No dichotomy between **connection-centred** and **node-centred** approaches (Hilpert 2018; Ungerer & Hartmann 2023)
- No dichotomy between **vertical** and **horizontal** representations (Ungerer in press)

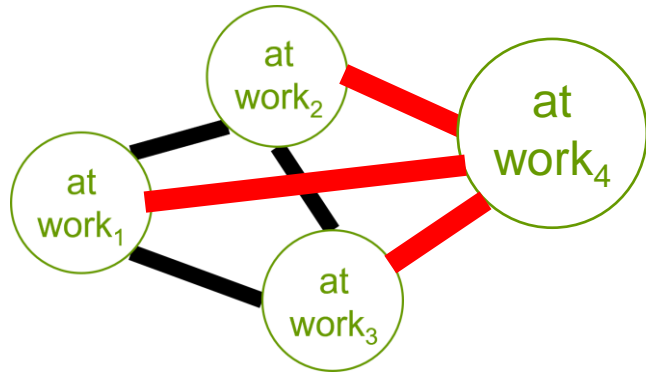


How is information stored and added to the network?

Exemplar-based approaches

(e.g., Ambridge 2020a; Nosofsky 1988)

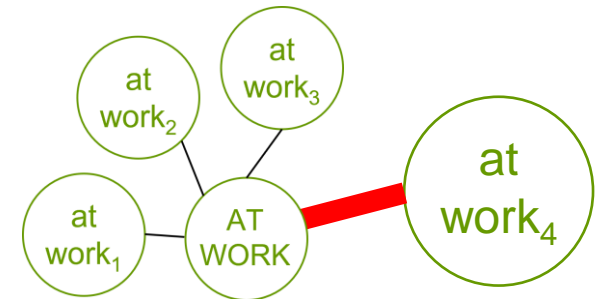
- Only exemplars are stored
- New tokens are **analogised** to similar existing instances



Abstraction-based approaches

(e.g., Hilpert 2014; Hudson 2007)

- Categories are stored (at the highest level OR at multiple levels)
- New tokens are **categorised** as instances of an existing schema



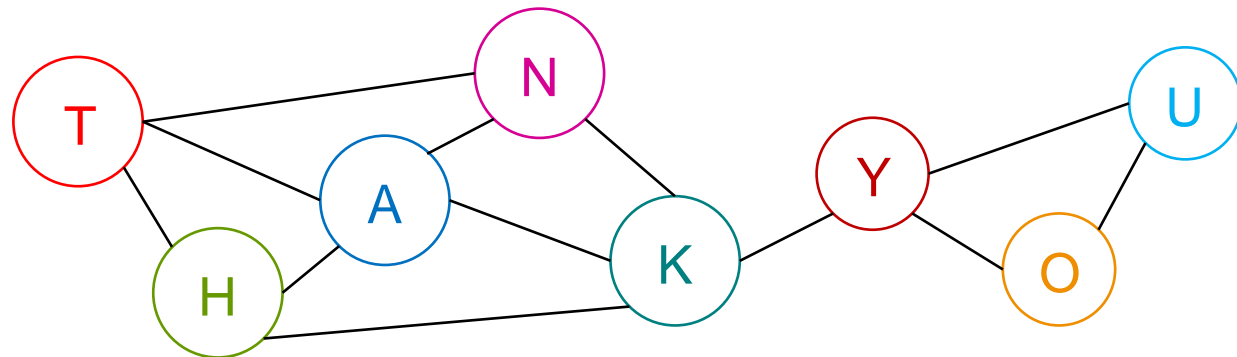
Can these two be reconciled?

(Abbot-Smith & Tomasello 2006; Ambridge 2020b; Bybee & Beckner 2010; Langacker 2006; Ramsar 1999)

- Schemas are stored **via** the similarities of their instances (→ no redundancy?)
- Categorisation and analogy may be two aspects of the same cognitive process

Conclusion

- Hierarchical structure can be **explicitly** or **implicitly** represented in networks
- But both types of networks capture **the same cognitive reality**, and they can both be useful for linguistic analyses
- This casts **doubt on some popular dichotomies**:
 - Connection- vs. node-centred approaches
 - Vertical vs. horizontal representations
 - Schema-based categorisation vs. exemplar-based analogy
- **Representation ≠ psychological reality!**



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