

Modeling Concept Evolution: A Historical Perspective

Siarhei Bykau

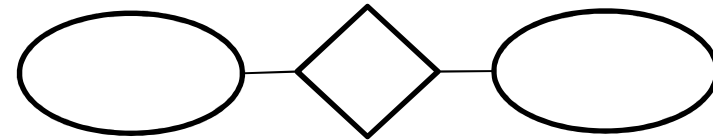
University of Trento

with Flavio Rizzolo, Yannis Velegrakis and John Mylopoulos

Flavio Rizzolo, Yannis Velegrakis, John Mylopoulos and Siarhei Bykau. Modeling Concept Evolution: A Historical Perspective. In Laender, A.H.F. et al. Conceptual Modeling - ER 2009. Lecture Notes in Computer Science, Vol. 5829, Springer 2009, pp. 331-345.

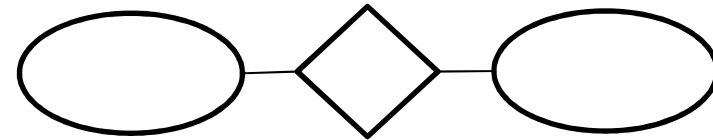
Introduction

- ER Model
- UML
- Description Logics
- ...



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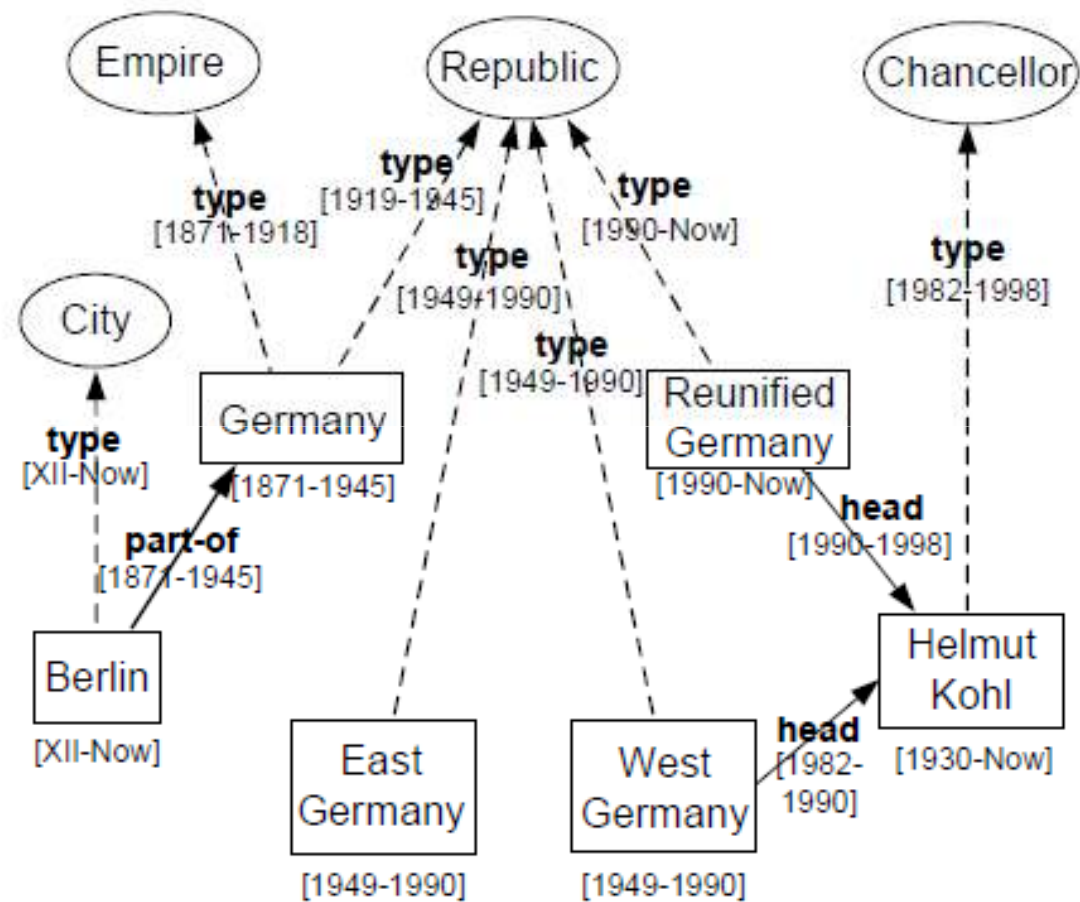
Evolution

- Phenomena of Evolution:
 - ◆ Historical Studies
 - ◆ Entity Management
 - ◆ Life Science

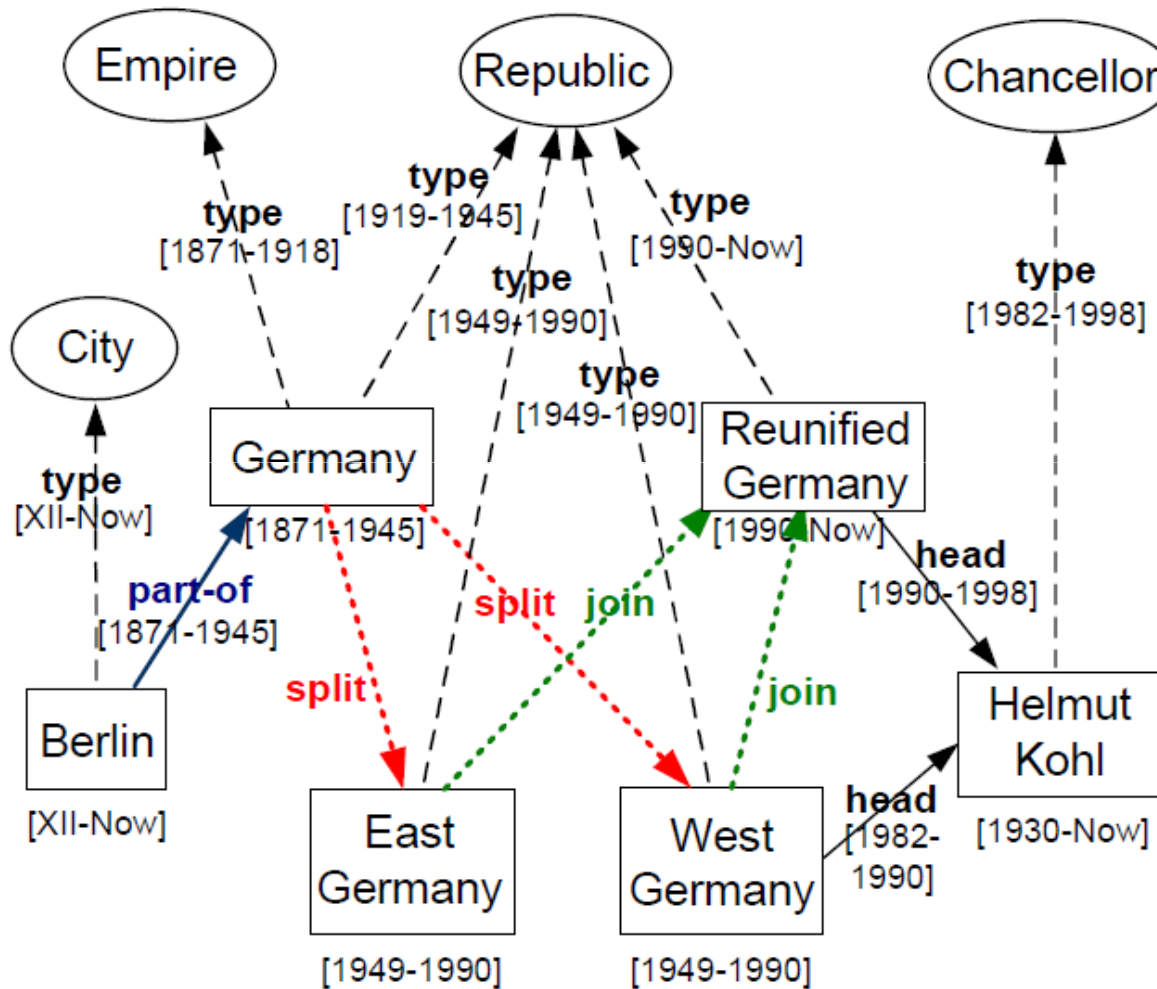
Managing Evolution

- Maintenance of views under changes [Blakeley86]
- Schema evolution [Lerner00]
- Temporal ER and relational models
[Soo91][Gregersen99]
- Temporal models for XML, RDF
[Rizzolo08][Gutierrez05]
- ...

Example: History of Germany



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Challenging Issues

Historian queries:

1. Who have been leaders of Germany throughout time?
2. Is Berlin a part of Reunified Germany?
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» **Temporal query** [Soo91]

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- » Keyword searching

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- » Temporal query [Soo91]
- » Keyword searching
- » Terminology evolution [Tahmasebi08]

Temporal Knowledge Base

- RDF-like data model:
 - ◆ Classes, Instances and Properties
 - ◆ `rdfs:type`, `rdfs:domain`, `rdfs:range`, `rdfs:subClassOf` and `rdfs:subPropertyOf` with the semantics as in RDFS
- Point-based temporal domain with the definition of intervals: $[a, b]$ and $a \leq b$
- Lifespan: a function τ that maps each class, instance or property to an interval
- We consider only valid time
 - ◆ As opposed to transaction time

Temporal Consistency

A temporal knowledge base is consistent if:

1.

$$\forall r \in L \cup \{Prop, Class, Thing, type, dom, rng, subc, subp\}: \\ \tau(r) = [0, Now];$$

2.

$$\forall \langle d, p, r \rangle \in T: \tau(\langle d, p, r \rangle) \subseteq \tau(d) \text{ and} \\ \tau(\langle d, p, r \rangle) \subseteq \tau(r)$$

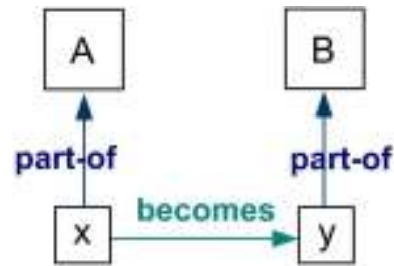
3.

$$\forall \langle d, p, r \rangle \in T \text{ with } p \in \{type, subc, subp\}: \tau(d) \in \tau(r)$$

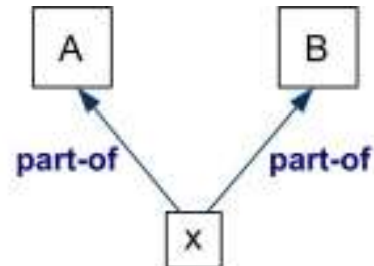
with L and T being sets of literals and triples respectively

Liaison

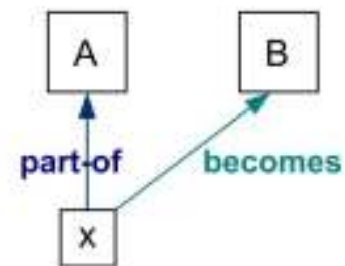
- Two primitives: *becomes* and *part-of*
- Liaison:



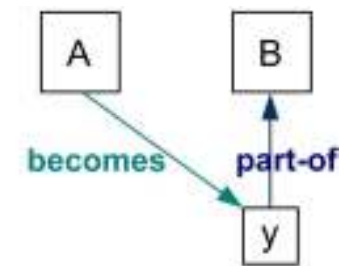
(a)



(b)



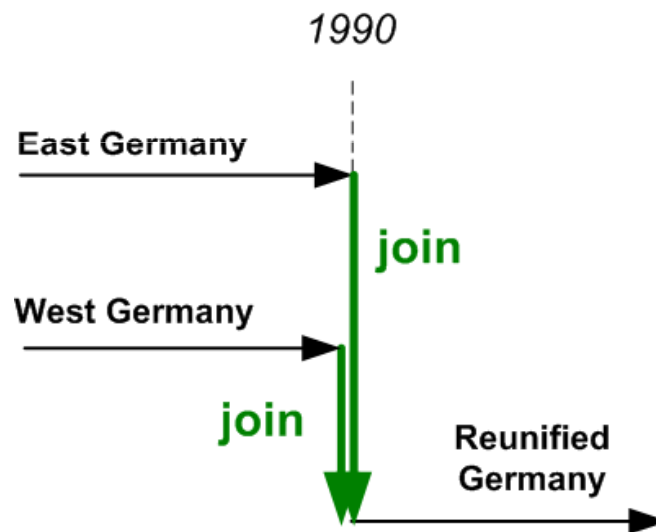
(c)



(d)

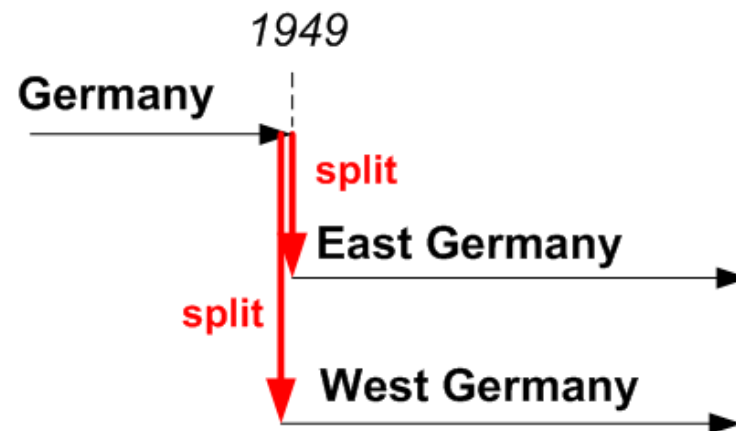
Join

- $\tau(c).start=t;$
- $\forall x$ s.t. $x \xrightarrow{\text{part-of}} c: \exists c_i$ s.t. x is a liaison between c_i and c , or $x = c_i$, with $1 \leq i \leq n$.



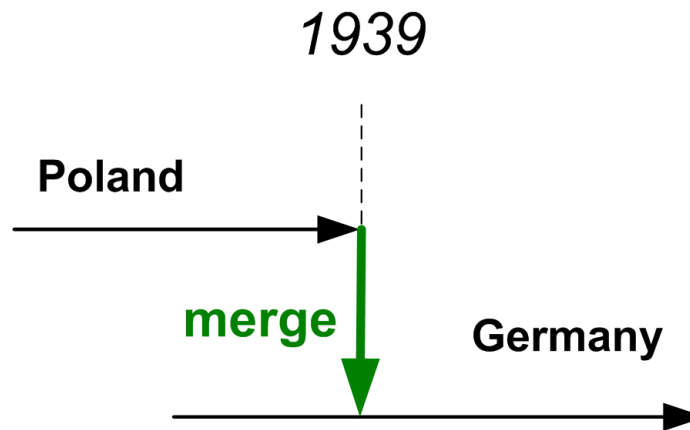
Split

- $\tau(c).end=t$;
- $\forall x$ s.t. $x \xrightarrow{\text{part-of}} c$: $\exists c_i$ s.t. x is a liaison between c and c_i , or $x = c_i$, with $1 \leq i \leq n$.



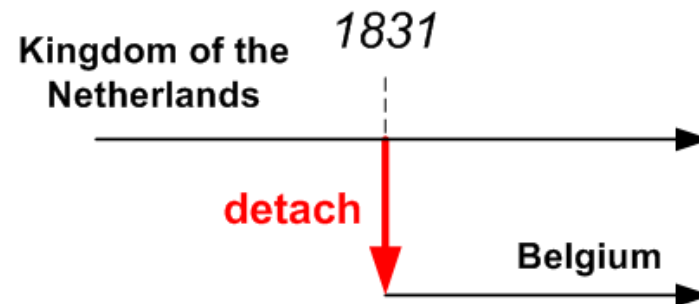
Merge

- $\tau(c).end=t$;
- $\exists x$ s.t. $x \xrightarrow{\text{part-of}} c'$ and x is a liaison between c and c' .



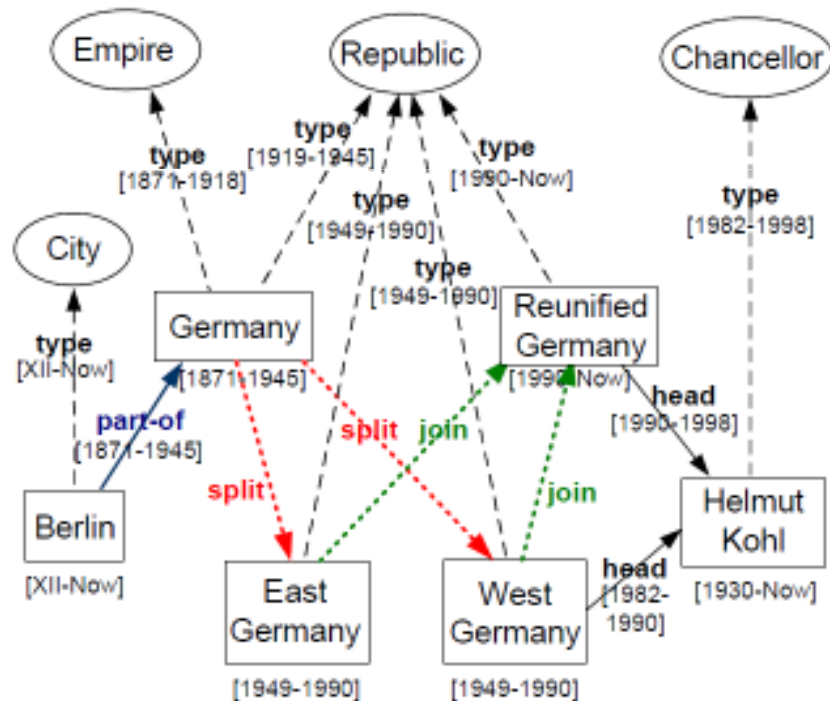
Detach

- $\tau(c').start=t;$
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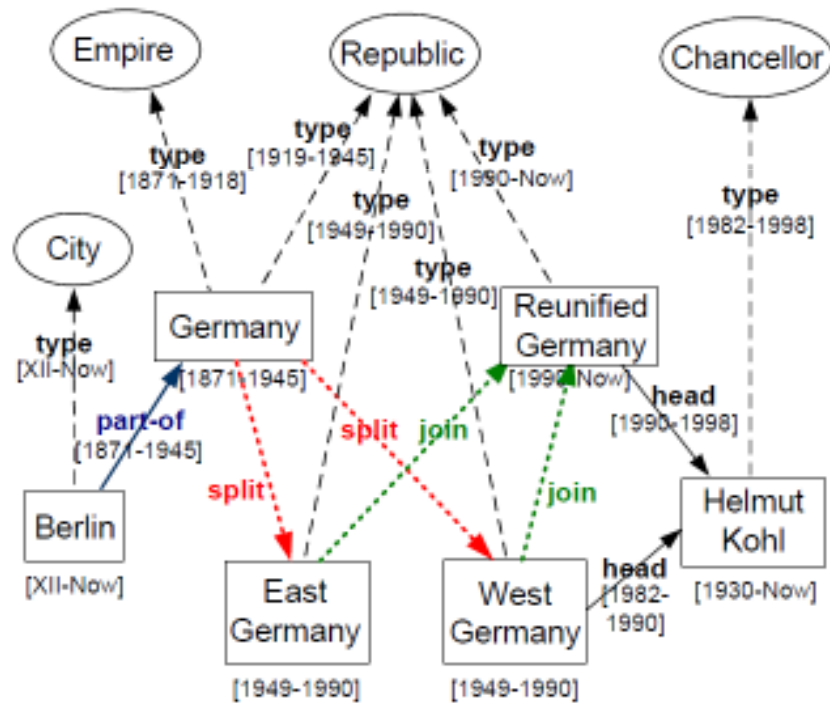
Query Language

Query language is an extension of nSPARQL and has the following grammar:

$$exp := axis \mid t\text{-axis} :: a \mid t\text{-axis} :: [exp] \mid exp[I] \mid exp/exp \mid exp|exp \mid exp^*$$


Query Language

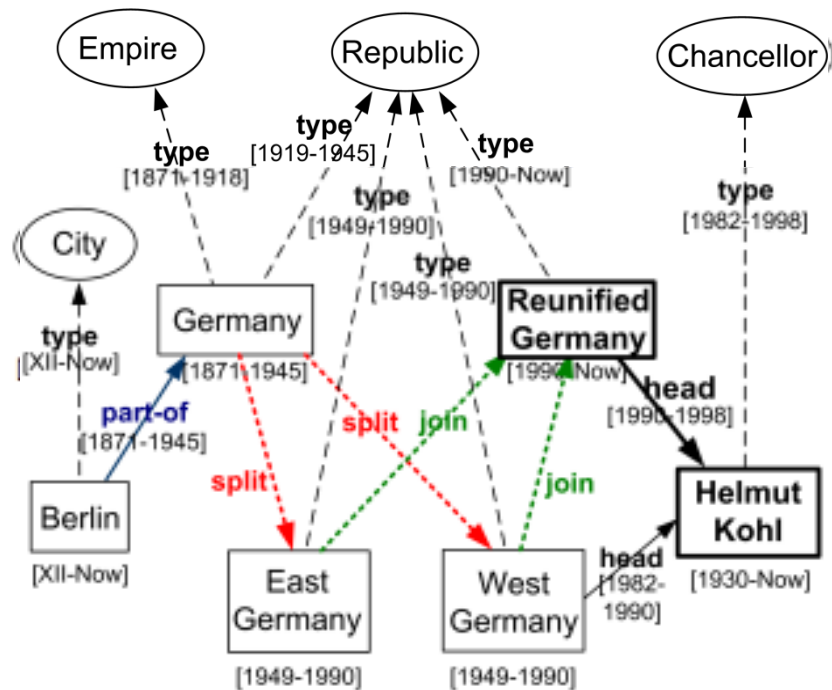
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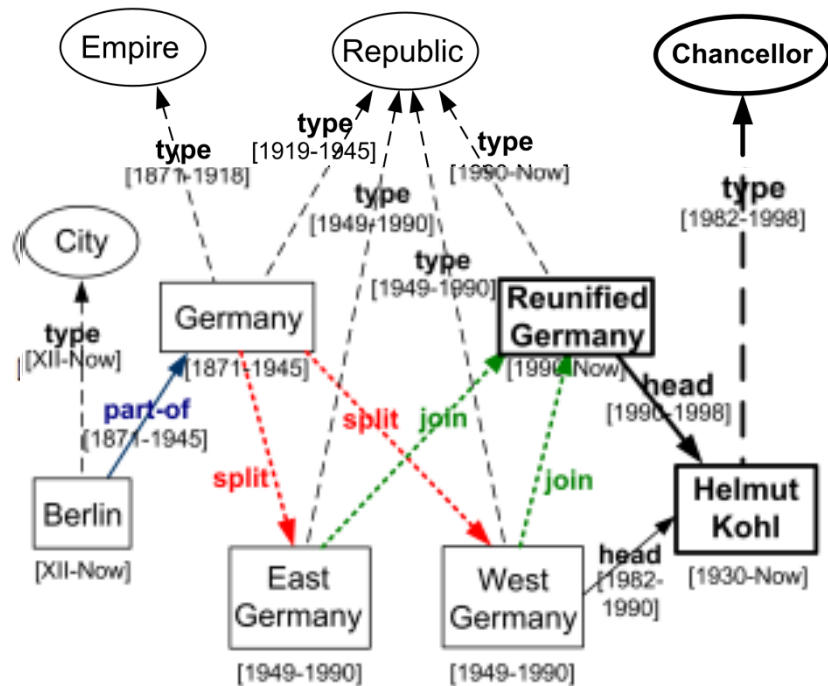
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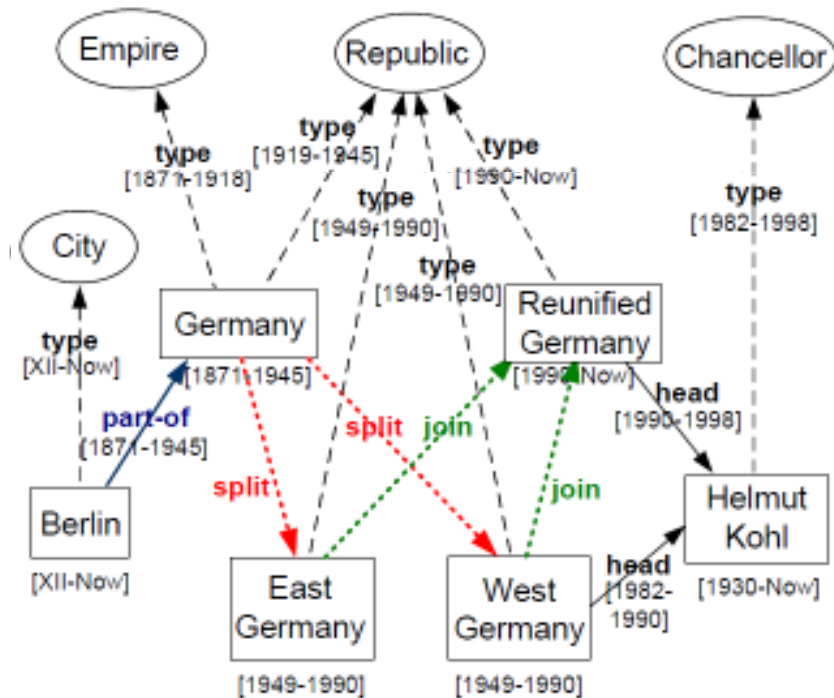
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 $\langle Germany, Chancellor, [1990; 1998] \rangle$

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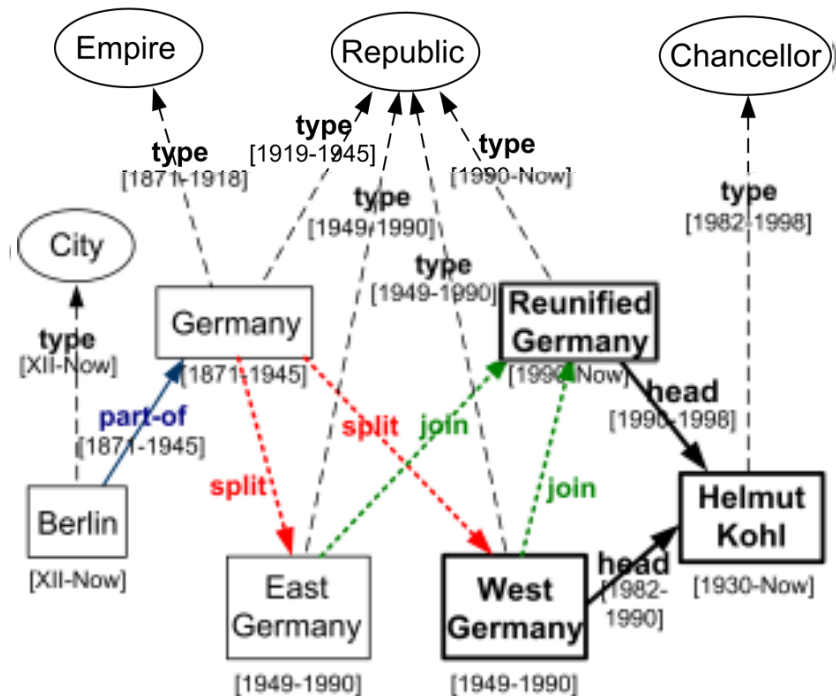
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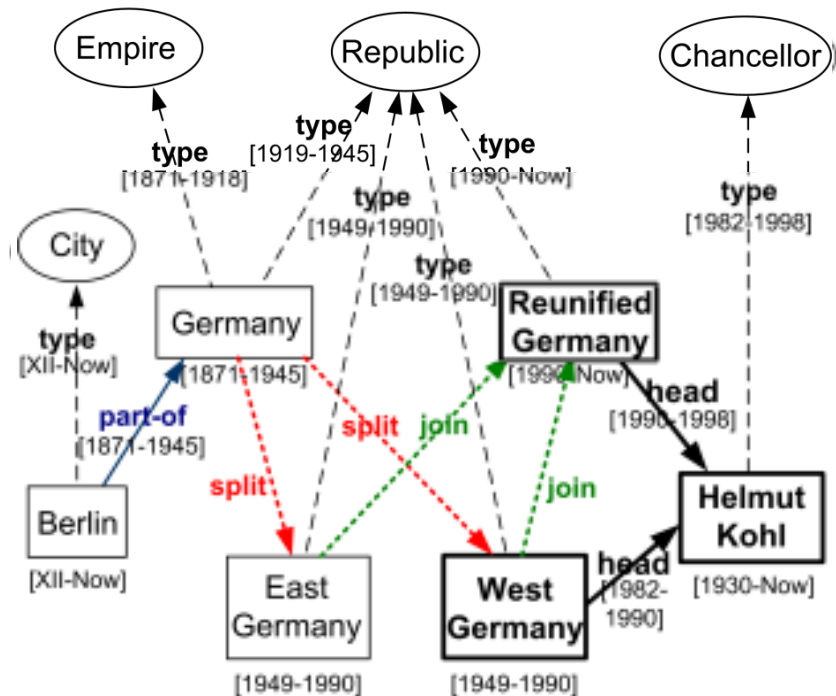
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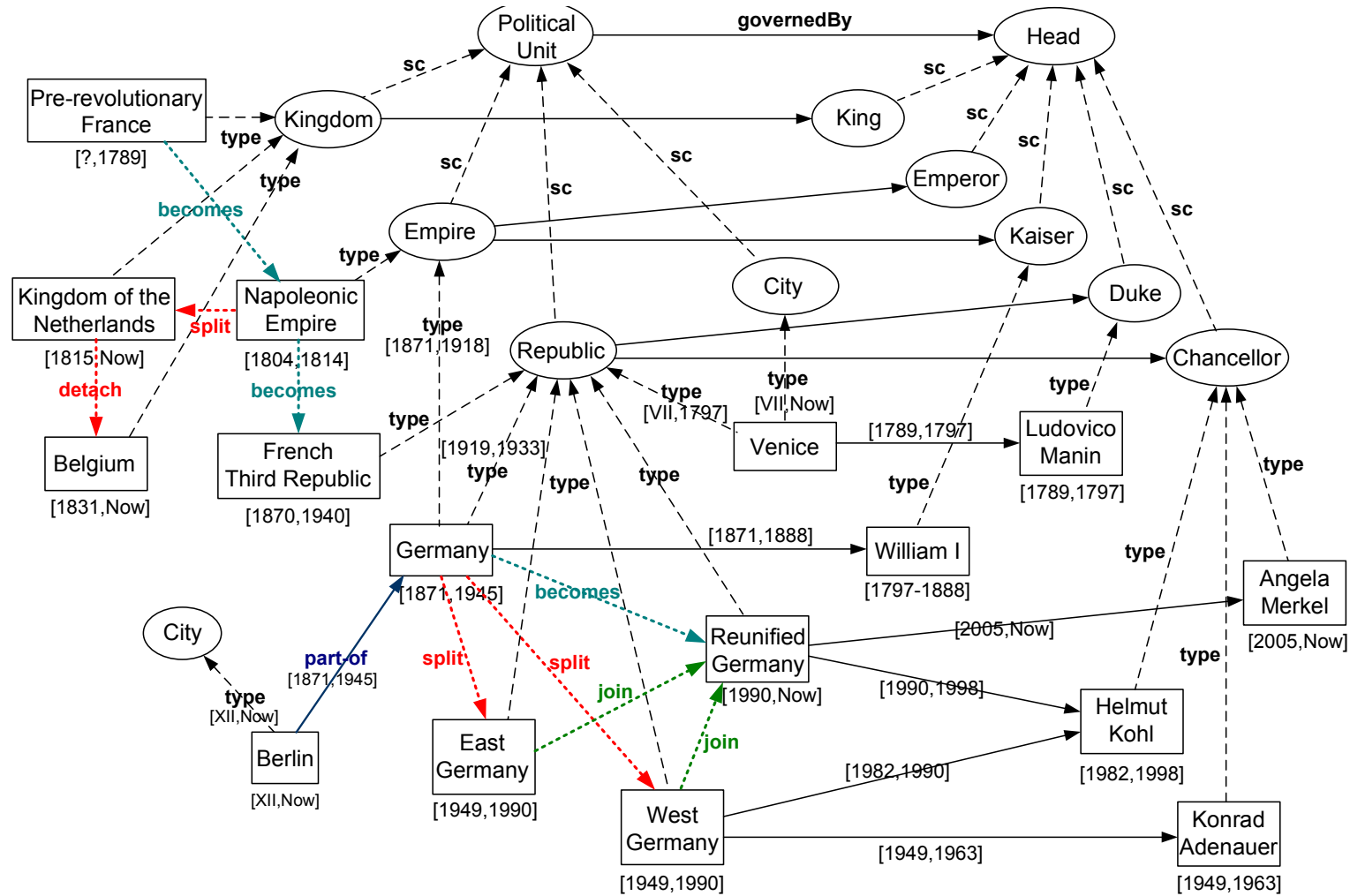
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<Germany, Chancellor, [1990; 1998]>

$$\varepsilon \parallel self :: [next :: head / self :: Helmut\ Kohl] \parallel$$

<Reunified Germany, Reunified Germany, [1990; 1998]>
 <West Germany, West Germany, [1982; 1990]>

History Application



History Application (cont.)

- How has the notion of Germany changed over the last two centuries in terms of its constituents, government, etc.?

Select ?Y, ?Z, ?W

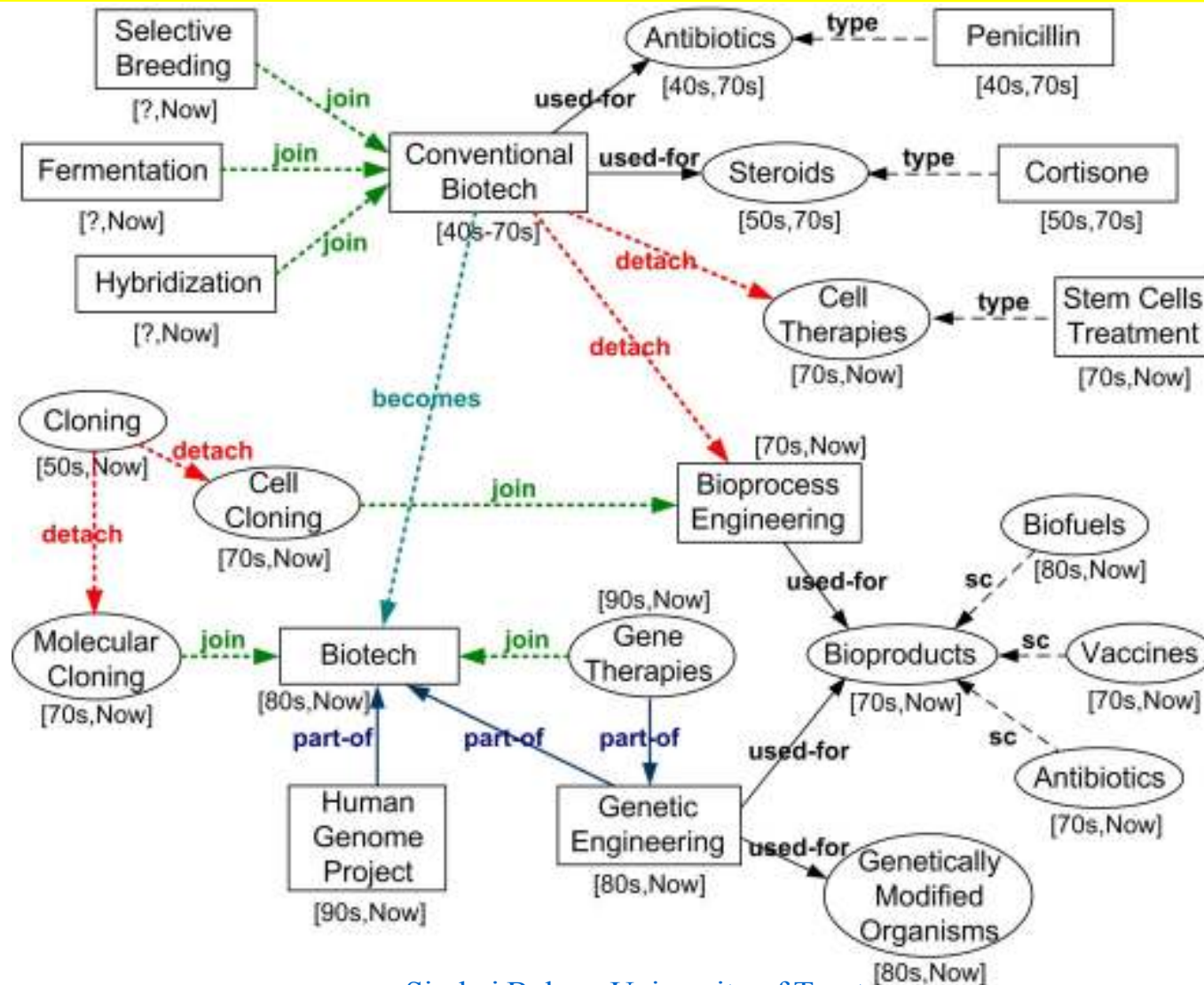
(?X, self :: Reunified Germany / backward* [1800, 2000] /, ?Y) AND
(?Y, edge, ?Z) AND (?Z, edge, ?W)

- Who was the head of the German government before and after the unification of 1990?

Select ?Y

(?X, self :: Reunified Germany / join⁻¹ [1990] / next :: head [1990], ?Y) AND
(?Z, self :: Reunified Germany / next :: head [1990], ?Y)

A Biotechnology Use Case



A Biotechnology Use Case (cont.)

- Is the academic discipline of biotechnology a wholly new technology branch or has it derived from the combination of other disciplines?

Select ?Y, ?Z, ?W

(?X, self :: Biotechnology/backward*, ?Y) AND
(?Y, e-edge/self, ?Z) AND (?Z, e-node, ?W)

- Which scientific and engineering concepts and disciplines are related to the emergence of cell cloning?

Select ?Y, ?Z, ?W

(?X, self :: Cell Cloning, ?Y) AND ?(Y, backward | backward/forward, ?Z)
AND (?Y, forward | forward/backward, ?W)

Conclusion

- Evolution framework:
 - ◆ Temporal Knowledge Base
 - ◆ Evolution operators
 - ◆ Query Language

- Example Applications

- Future work:
 - ◆ Implementation
 - ◆ Reasoning in DL

Thank you !

Questions?