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## Event description

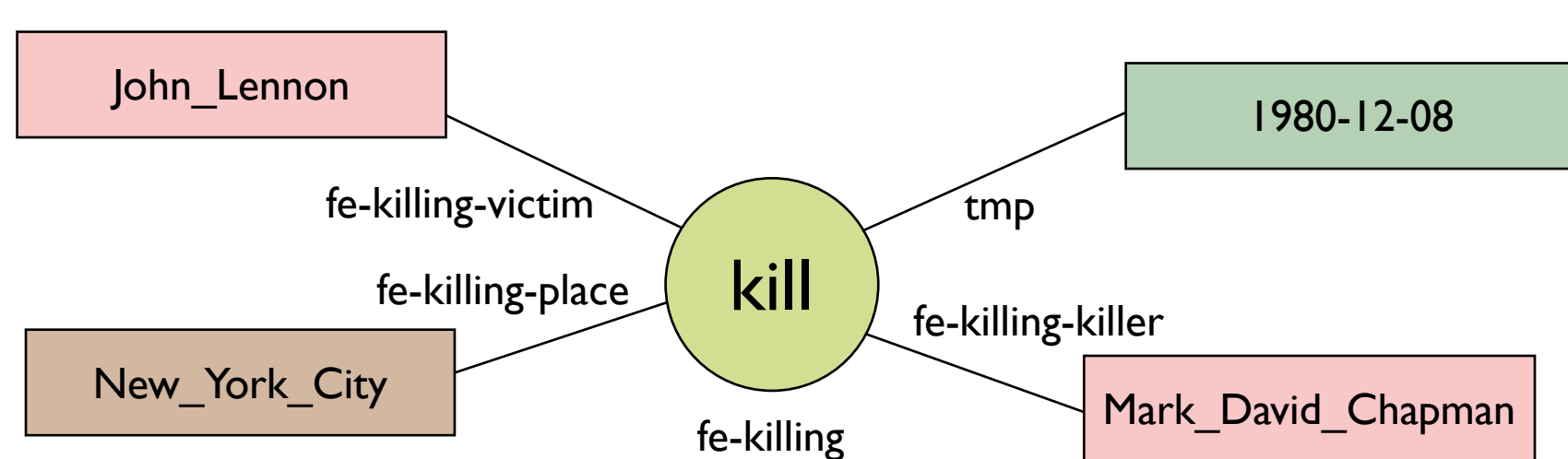
An Event identifies a spatio-temporal region, the participating entities, and a narrative of what happens.

We characterize events via four features:

1. Event type (e.g. killing, dying)
2. Participant(s) with their role
3. Time of happening (possibly generic)
4. Spatial location of happening (possibly generic)

Example:

On December 8, 1980, in NYC, Mark Chapman killed John Lennon.



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## Formal analysis of event types

We define features characterizing event types.

Example of instantiation for “killing”:

Ontological classification	Accomplishment
Active participant	Physical object (including agents)
Passive participant	Living entity
Tool participant	Physical object (including chemical and biological entities)
Subevents	Hitting (possible); start of the killing, dying (necessary)
Sovraevents	Murdering, colliding, starving, being infected (all possible)
Status: before	Passive participant is alive
Status: during	Passive participant is alive
Status: after	Passive participant is dead
Relationship among events	Killing causes: damaging
Symmetrical events	Dying for causes external to the passive participant
Incompatible events/state	-
Number of participants	Killing can have one or more active participants; one or more passive participants; one or more tool participants.
Spatial region	Killing happens in the location where the passive participants are located
Temporal region	Interval
Repeatability	There cannot be two killing events with the same passive participant; there can be more than one killing event with the active participant; there can be more than one killing event in the same spatio-temporal region.

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## Ontological-based reasoning tasks for events

Example of high-level reasoning tasks enabled by the formal ontological characterization of event types:

- **Pre- and Post-condition inference.** Reasoning on the states that enable the activation of an event (i.e. its pre-conditions), the effects that the event produces on the state (i.e. its post-conditions), and possibly the facts that are true during the event execution.
- **Completion of missing events.** Inferencing of missing or implicit events.
- **Completion of missing event relations.** Finding relations between events, e.g. coreference, temporal sequence, incompatibility and causation.
- **Event information refinement.** Refining the extracted information associated to an event in order to reach a more fine grained representation of the event local knowledge.

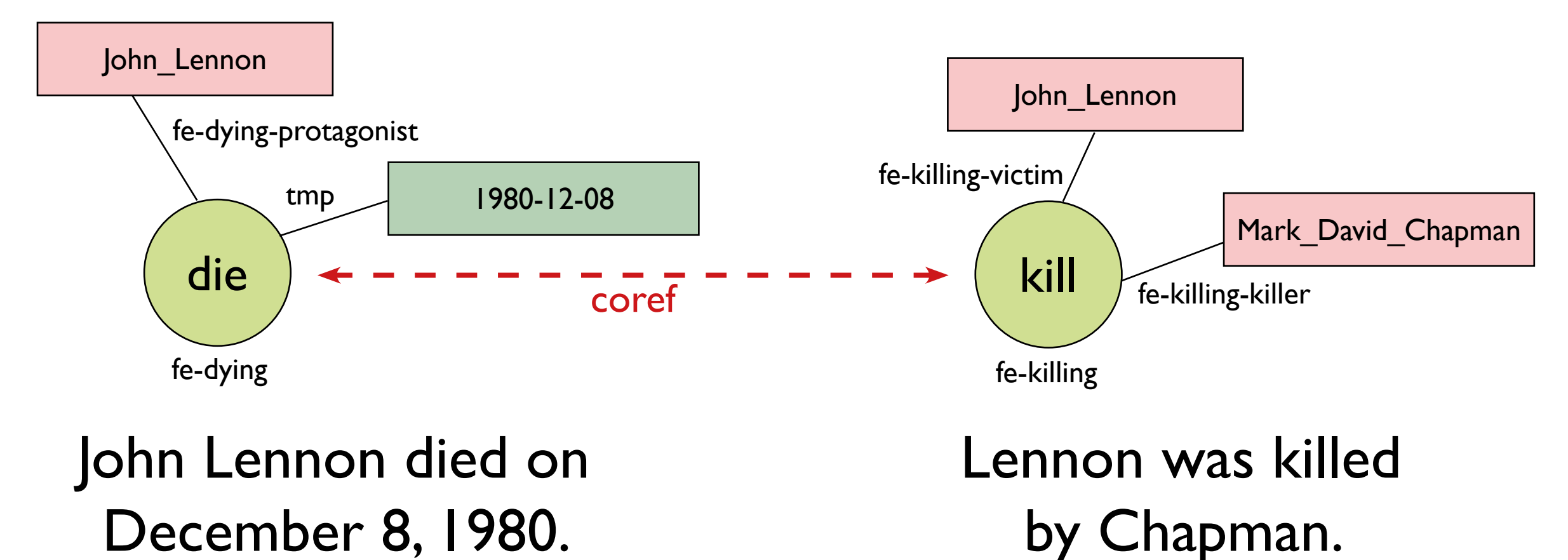
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## Event coreference

Two events corefer when they share some qualified combination of their four characterizing features.

Goal: determine the existence and degree of truth to which a coreference relation exists based on the related data on the events.

Example:



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## Coreference rules from formal analysis

Rules for event coreference derived from the ontological analysis of events. We provided rules for certain and possible coreference:

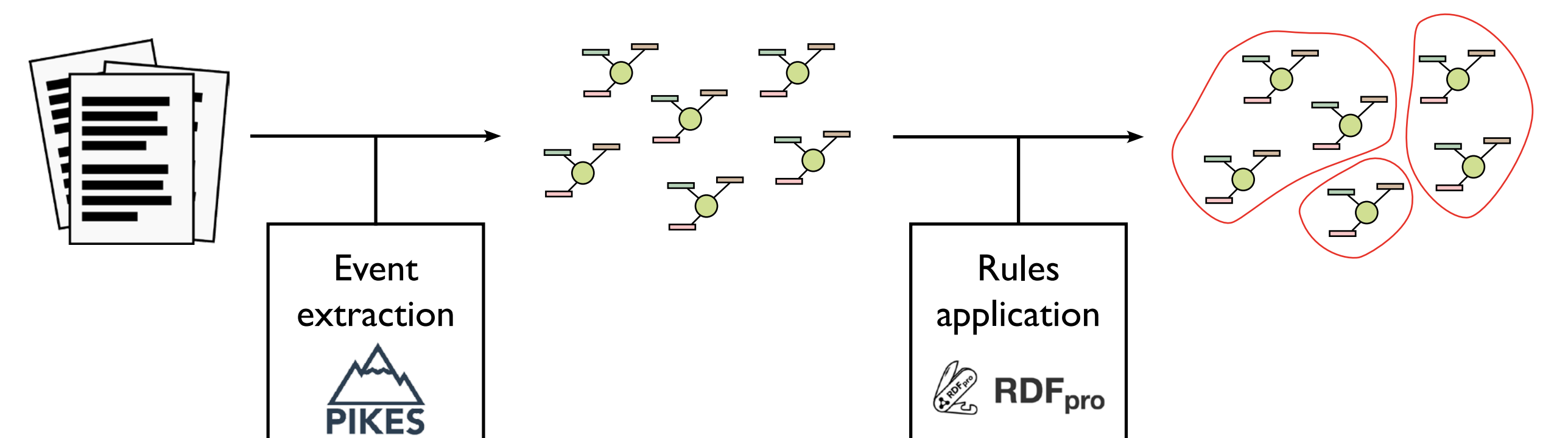
- **certain coreference:** sufficient and necessary conditions (for each event type) for coreference existence
- **possible coreference:** only necessary conditions, providing an evidence for possible existence of coreference.

Example:

certain coref.	$(E1.Victim == E2.Victim)$ $(E1.SubEvent hasCoref E2.SubEvent)$
possible coref.	$(E1.Killer == E2.Killer) \& (E1.Time \sim E2.Time)$ $(E1.Killer == E2.Killer) \& (E1.Place \sim E2.Place)$ $(E1.Killer == E2.Killer) \& (E1.Tool == E2.Tool)$ $(E1.Tool == E2.Tool) \& (E1.Time \sim E2.Time)$ $(E1.Place \sim E2.Place) \& (E1.Time \sim E2.Time)$

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## Evaluation



Evaluation on EventCorefBank (ECB)  
482 news texts, 43 topics, 1744 event mentions, 339 distinct events

Evaluation restricted to 6 event (facts) types:  
Arresting, Killing, Dying, Charging, Shooting, Attacking.

	MUC			B <sup>3</sup>			CEAF (M)			BLANC		
	p	r	F1	p	r	F1	p	r	F1	p	r	F1
lemma baseline	81.78	89.14	85.30	39.87	73.46	51.69	45.48	45.48	62.45	76.08	66.14	
only certain	100	7.39	13.77	100	2.76	5.38	86.34	6.96	12.88	96.47	88.38	91.6
only possible	100	6.08	11.46	100	3.35	6.5	82.14	5.84	10.91	95.07	90.54	92.18
possible + certain	100	13.48	23.75	100	6.12	11.54	84.37	12.8	22.23	98.23	89.6	93.29