EVENTS

- **Event calculus**, models how the truth value of relations changes because of events occurring at **certain times**.
- Event *E* occurring at time *T* is written as *event(E,T)*.
- It is designed to allow reasoning over intervals of time.

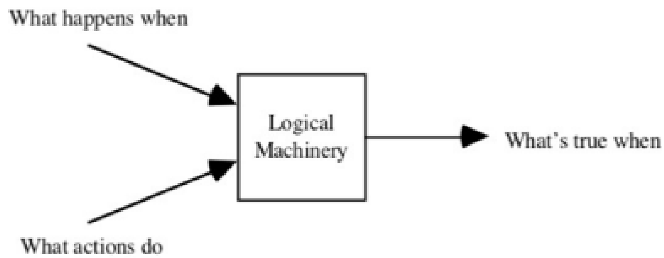


Figure 1: How the Event Calculus Functions

FLUENTS IN EVENT CALCULAS

Fluents: Is a condition that can change over time.

- In logical approach, fluent is a predicate or function that vary from one situation to the next.
  - "the box is on the table" - **On(box, table)**
  - if it can change over time - **On(box, table, t)**
  - Here "On" is a predicate.
- Fluents can also be represented by functions are said to be reification
- When using reified fluents, a separate predicate is necessary to tell when a fluent is actually true or not.
- For example, **HoldsAt(on(box,table), t)** means that the box is actually on the table at time t, where the predicate **HoldsAt** is the one that tells when fluents are true.
- This representation of reified fluents is used in the event calculus.

COMPLETE SET OF PREDICATED FOR ONE SET OF EVENT CALCULAS

- **HoldsAt(f,t)** - Fluent f is true at time t
- **Happens(e, i)** - Event e happens at time i
- **Initiates (e, f , t)** - Event e causes fluent f to be true after time t
- **Terminates (e, f , t)** - Event e causes fluent f to cease after time t
- **Clipped(t, f, t_2)** - Fluent f ceases to be true at some point during time interval between t and t_2
- **Restored(t, f, t_2)** - Fluent f becomes true sometime during time interval between t and t_2

PROCESSES

- Any subinterval of a process is also a member of same process category called process category or liquid category
- Any process e that happens over an interval also happens over any subinterval:

(e ∈ Processes) ∧ Happens(e, (t1, t4)) ∧ (t1 < t2 < t3 < t4) ⇒ Happens(e, (t2, t3))

Example:

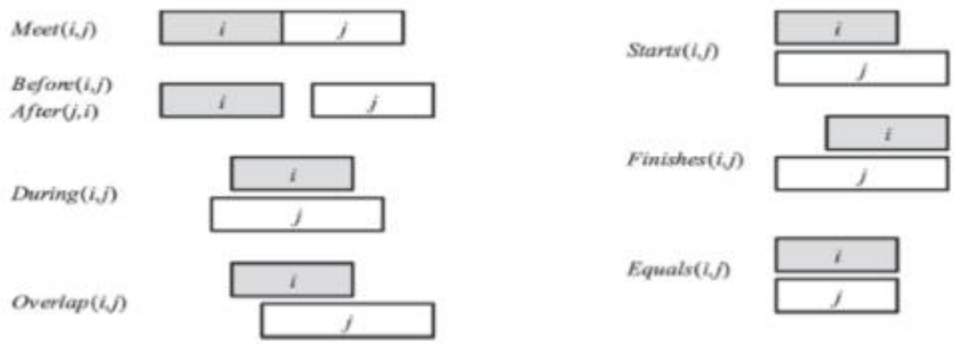
In(Shankar, New Delhi) – Shankar being in New Delhi

T(In(Shankar, New Delhi), Today) – He was in New Delhi all day

TIME INTERVAL

- Time is important to any agent that takes action
- 2 kinds of time intervals:
  1. moments
  2. extended intervals
- The distinction is that only moments have zero duration
  – **Partition ({Moments , ExtendedIntervals }, Intervals)**
  – **i∈Moments ⇔ Duration(i)=Seconds(0)**

PREDICATE OF TIME INTERVALS



$$
\begin{aligned}
Meet(i,j) &\Leftrightarrow End(i) = Begin(j)\\
Before(i,j) &\Leftrightarrow End(i) < Begin(j)\\
After(j,i) &\Leftrightarrow Before(i,j)\\
During(i,j) &\Leftrightarrow Begin(j) < Begin(i) < End(i) < End(j)\\
Overlap(i,j) &\Leftrightarrow Begin(i) < Begin(j) < End(i) < End(j)\\
Begins(i,j) &\Leftrightarrow Begin(i) = Begin(j)\\
Finishes(i,j) &\Leftrightarrow End(i) = End(j)\\
Equals(i,j) &\Leftrightarrow Begin(i) = Begin(j) \land End(i) = End(j)
\end{aligned}
$$

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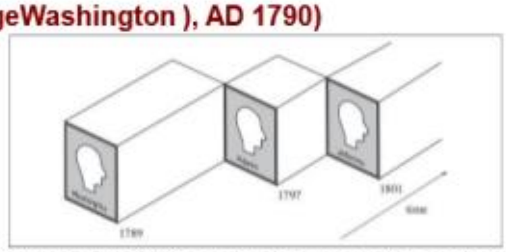
Logic of time intervals

FLUENTS AND OBJECTS

- Physical objects can be viewed as generalized events, in the sense that a physical object is a chunk of space–time.
- President(USA, t) is a logical term that denotes a different object at different times.
- To say that George Washington was president throughout 1790, we can write

T (Equals (President (USA), GeorgeWashington), AD 1790)



object President(USA) for the first 15 years of its existence

MENTAL EVENTS AND MENTAL OBJECTS

- For a single- agent domains, knowledge about one's own knowledge and reasoning processes is useful for controlling inference.
- In a multiagent domains, it becomes important for an agent to reason about the mental states of the other agents.
- Example Bob and Alice scenario
- It requires a model of the mental objects in someone's head(knowledge base) and the processes that manipulate these mental objects.

A FORMAL THEORY OF BELIEFS

- Relationships between agents and mental objects: believes, knows, wants, intends ... are called **propositional attitudes**
- Lois knows that Superman can fly:
  - Knows (Lois , CanFly (Superman))
- If Superman is Clark, then we must conclude that Lois knows that Clark can fly:
  - (Superman = Clark) $\wedge$ Knows (Lois , CanFly (Superman)) $\models$ Knows(Lois, CanFly(Clark))
- "Can Clark fly?" – No. Need descriptions
- If an agent knows that $2 + 2 = 4$ and $4 < 5$, then we want an agent to know that $2 + 2 < 5$. This property is called **referential transparency**

KNOWLEDGE AND BELIEF

- Knowledge in terms if AI is something which is always true
- Belief on the other hand deals more with probability
- After extensive study, it is commonly said that knowledge is justified true belief
- Example:
  - Eating food necessary for living, so we eat.
  - Gambling to gain money. Probability. Believe we will win
- **Knows(a, p)** – agent a knows that proposition p is true
- Lois knows whether Clark can fly if she either knows that Clark can fly or knows that he cannot
  - **Knowswhether(a, p) ⇔ knows(a, p) v knows(a, ¬p)**