# Towards Streams of Events with Temporally-Constrained Effects

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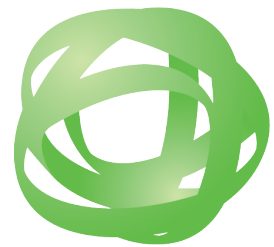


# Stream Reasoning

Problem:

- Continuous pattern matching over data streams
- Low latency
- Reasoning over complex temporal specifications:
  - deadlines

Approach:

- Complex temporal specifications $\Longrightarrow$ Event Calculus
- Efficient stream reasoning $\Longrightarrow$ Run-Time Event Calculus

# Applications

- Multi-Agent Systems (MAS) for:
  - Voting
  - Negotiation
  - Argumentation
- Complex Event Recognition (CER) for:
  - Maritime Situational Awareness
  - Commercial Fleet Management
  - Activity Recognition
  - City Transport Management

# Event Calculus[1]

- A logic programming language for representing and reasoning about events and their effects.
- Key components:
  - event (typically instantaneous).
  - fluent: a property that may have different values at different points in time.

[1] Robert A. Kowalski, Marek J. Sergot: A Logic-based Calculus of Events. New Gener. Comput. 4(1): 67-95 (1986)

# Event Calculus[1]

- A logic programming language for representing and reasoning about events and their effects.
- Key components:
  - event (typically instantaneous).
  - fluent: a property that may have different values at different points in time.
- Built-in representation of inertia:
  - $F = V$ holds at a particular time-point if $F = V$ has been *initiated* by an event at some earlier time-point, and not *terminated* by another event in the meantime.

[1] Robert A. Kowalski, Marek J. Sergot: A Logic-based Calculus of Events. New Gener. Comput. 4(1): 67-95 (1986)

# Run-Time Event Calculus (RTEC)[2]

A stream reasoning system based on the Event Calculus:

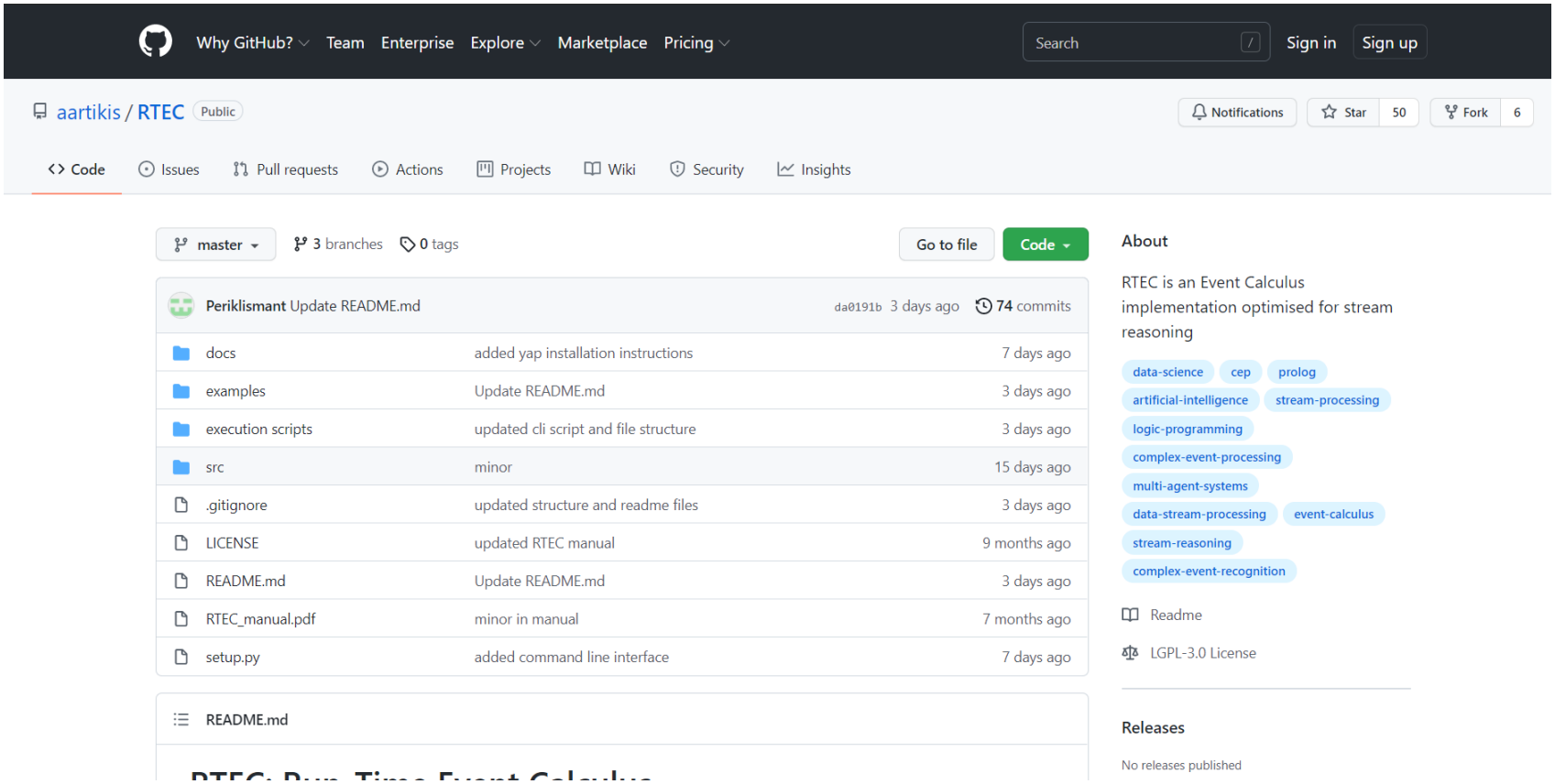
- windows
- caching and indexing
- interval manipulation constructs
- efficient handling of deadlines

[2] Artikis A., Sergot M. and Paliouras G., An Event Calculus for Event Recognition. In IEEE Transactions on Knowledge and Data Engineering (TKDE), 27(4), 895–908, 2015.

# Deadlines

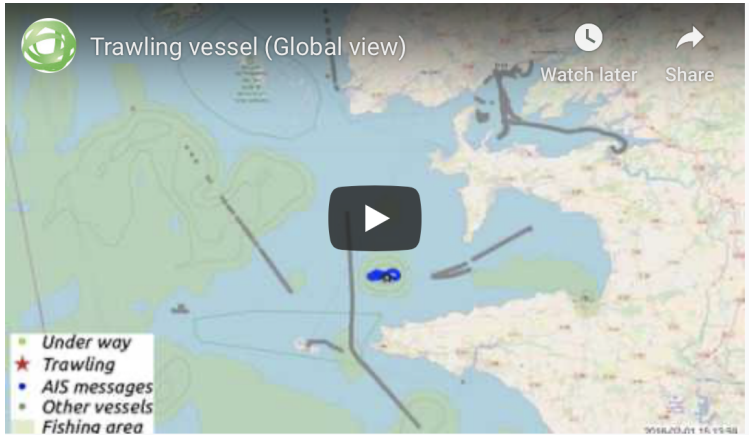
- Fluent-value pairs may be subject to deadlines
- E-commerce: an offer may be accepted at most by a specified time after being presented
- Maritime Situational Awareness: a fishing activity is terminated at a specified time after multiple changes in heading
- Multi-Agent Systems: agents may be suspended temporarily. Further violations may extend the period of suspension

# Open-Source Code

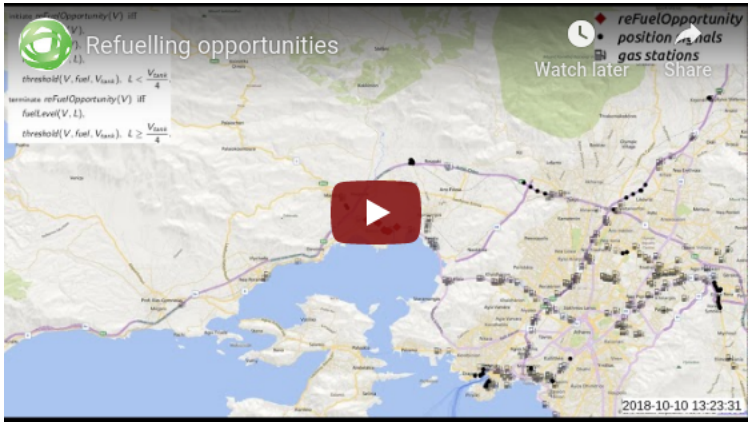


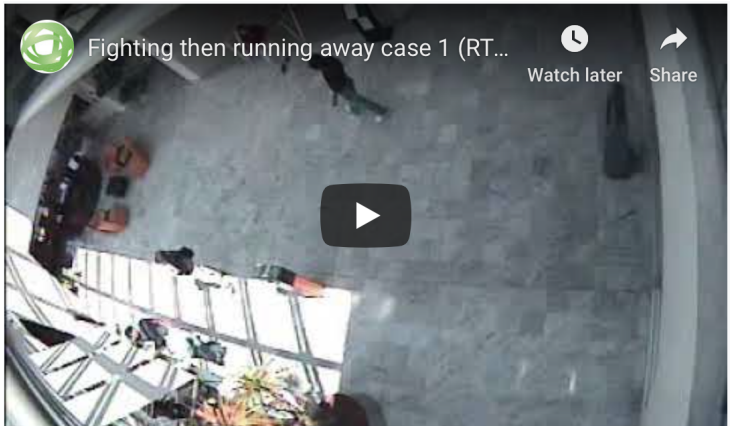

https://github.com/aartikis/RTEC

# Complex Event Recognition





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# Summary

- RTEC: an open-source stream reasoning system based on the Event Calculus.
- Optimisation techniques $\rightarrow$ e.g. 'forgetting' and caching
- Efficient treatment of deadlines