Spatial - Temporal and Rule-based Analysis of the Maritime Traffic

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Five parts

• Maritime transportation: setting the scene
• Research Context: ITEA2 - RECONSURLVE
• Current research: a rule-based approach
• Architecture principles & main processes
• Production rules with Drools
A much cluttered place

- The maritime traffic is increasing by about 5% every year

- About 400,000 AIS messages received a day from more than 22,000 ships worldwide
Maritime situation awareness

- The maritime domain awareness is a prerequisite for:
  - Using the ocean effectively
  - Avoiding maritime disasters
  - Fighting against pollution
  - Preventing illegal immigration
  - Refraining terrorism
  - Saving lives
Maritime surveillance issues

- Vessel Traffic Services and Marine Rescue Coordination Centres have to face many different issues such as:
  - Limited resources (considering the area to monitor)
  - Cognitive overload
  - Interoperability between systems and services

Etel (France)  Vardo (Norway)  London (England)
RECONSURVE – ITEA2

- Addressing the need to control the rapidly increasing number and complexity of maritime surveillance issues using smarter and better integrated maritime surveillance decision-support systems

- 3 objectives:
  - Providing an integrated, interoperable and reconfigurable system
  - Detecting abnormal, dangerous and suspicious ships behaviors
  - Intelligent allocation of sensors and intelligent routing of UAV
A world wide project divided into 9 work packages. We belong to work package 5: **Developing Situation Awareness**
Currently developing…

- A multi-sensors integrated chart system based on S-57 electronic maps
- A multi-touch GUI through which the operator directly expresses his knowledge
- A real-time rule-based surveillance system in which the logic can be fully reconfigured
Why a rule engine?

1 - There is a mismatch between what expert needs and what developer does.
Why a rule engine?

2 - The business logic does not naturally fit into any object, but is rather better expressed as rules

Example of business logic:
Detecting a ship in a military area
Why a rule engine?

3 – Mixing bottom-up and top-down approach and provide a platform to integrate different algorithm.
Why a rule engine?

4 – Provide a reconfigurable system

Example of a reconfigurable system
Developed by our Turkish partner SRDC

The way we see things at ATOL
Main processes

Knowledge-based Approach

Data are retrieved from the Data Bases and inserted into typed lists, every 15 seconds. Eg.: a trajectory is inserted into a list of trajectories, a ship is inserted into a list of ships.

Objects that enter a list are transferred to the Working Memory of Drools.

Pattern matching is performed by using the Rete graph. Facts injected into the working memory propagate into a Rete graph.

Rules are inserted into the knowledge Base. The rules are then compiled into a Rete graph.

The surveillance operator defines rules by specific gestures (Not yet implemented). For now rules are entered declaratively using drools eclipse plugin.

AGENDA
Activated Rule 1
Activated Rule 2
Activated Rule 3
Activated Rule ...

A conflict resolution strategy is adopted by the rule engine to choose which rule to execute first.
• We want to detect situations such as:
  – Boats within a certain distance of a POI
  – Boats within a certain time of a POI
  – Boats in restricted area
  – Specific type of trajectory
  – Sudden acceleration
  – Boarding
  – Boat leaving a POI
  – …
Use Case: Check whether the ship named “Seagle” is around, and raise an alarm if you find it.

```
rule “Detect Seagle Ship”
salience 40
when
    $Seagle: Ship(name == “Seagle”)
then
    Alarm.On(kcontext);
end
```
Our contribution

- Writing **spatial rules** composed of:
  - Spatial objects of any geographical type (point, line, polygon) using the Java Topology Suite (JTS)
  - Spatial analysis using either JTS functions, Postgis procedures, or any other spatial algorithm as long as it returns a Boolean
**Spatial Rule Examples**

- **Objective**: Evaluating a Boolean expression calling a java function (JTS lib) reasoning over trajectories

- **Use Case**: Select all the trajectories that are within a restricted area and print a message for each

- **Objective**: Evaluating a Boolean expression calling a PostGIS function

- **Use Case**: Select all the ships that are at less than 5km from a specified gate and print a message for each

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**Rule for Selection in a Specific Area**

```
rule “Trajectory in a specific area”
salience 20
when
  $resare : Resare()
  $trajectory : AisTrajectory()
  eval($trajectory.getGeom().intersects($resare.getWkb_geometry()))
then
  logger.logMessage(“”);
end
```

**Rule for Selecting Approaching Ship**

```
rule “Select approaching ship”
salience 10
when
  $ship : Ship()
  $resare : Resare()
  eval(SqlTools.computeDistance($ship.getMmsi(),
    $resare.getWkb_fid()) < 5000)
then
  logger.logMessage(“”);
end
```
Some more contribution?

- A spatially extended Rete algorithm?
- Spatial (temporal) inference?

The Rete graph generated by the previous scenario.
CONCLUSION & perspectives

• The system presently work in **static mode** with simple rules

• We would like to:
  – Make the system **fully reconfigurable**
  – Implement some more **complicated analysis**
  – Achieve some level of **inference**
ARE THERE ANY QUESTIONS?