A Case-study: DSLs and trusted communication in an IoT SmartCities scenario

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Kick off Meeting T-Ladies

T-Ladies background

T2.2: High-level abstractions for intelligent integrating behavior[CT,MR]: [...] We will further investigate how agents can exploit information about entities' trustworthiness to improve the "quality" of the interactions among the distributed entities.

T2.3: First-class interaction protocols for dynamic adaptation[CT,GE,MI,MR,PI]: [...] Finally, we will study how to integrate information about the "quality" of the interactions (represented by a kind of feedback) into the interaction protocols. Trust metrics rely on such information to provide trustworthiness values to be updated over time.

T4.4: Application scenarios [CT,GE,MI,MR,PI]: [...] Within the T-LADIES project, we aim to address three specific kind of scenarios: intelligent traffic management [...]

T4.4: Application scenarios - ITS

An IoT Sensor Network to manage traffic in a smart city

Three kind of Smart Objects:

- Car Monitors devices that detect BT addresses of cars travelling over key points of the city
- Smart Traffic Lights devices that control traffic lights handling them properly with the goal of avoiding queues and jams
- Smart Traffic Signals devices that control traffic displays present in large interchanges thus properly routing the cars

A Central Control Station is also present for human monitoring purposes, to gather and store samples data and to run specific data-anslysis algorithms

ITS - Objectives

1. To identify and implement the DSL for the given scenario and assess its validity
2. To detect malicious or mulfunctioning devices through a distributed reputation protocol

ITS - Objectives

Objective 1

To identify and implement the DSL

ITS - Objective 1

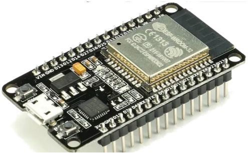
IoT device hardware implementation using ESP32 microcontrollers

- 32-bit LX6 CPU (up to 600 MIPS)
- 320 KB RAM, 448 KB ROM
- Wi-Fi 802.11 b/g/n
- Bluetooth BR/EDR and BLE
- GPIO, ADC, DAC, Timers, Touch, SPI, I^{2}C, I^{2}S, SD, Ethernet, CAN

ITS - Objective 1

IoT device software implementation using Python and PHIDIAS

- MicroPython Python port on MCU platforms
- PHIDIAS Python-based multi-agent BDI platform embedding an extensible declarative language [phi, LLS21, DLS19, FMPS17]



ITS - Objective 1 - PHIDIAS (1)

- Multi-agent plaform
- Belief-Desire-Intention paradigm
- Knowldge base to handle and manipulate **beliefs**, defined as Python objects
- Python-Embedded Declarative Language to program agent's behaviour

```
class cars_in_lane(Belief): pass
class lane_free(Reactor): pass
class lane_busy(Reactor): pass
class free(SingletonBelief): pass
class busy(SingletonBelief): pass
```

ITS - Objective 1 - PHIDIAS (2)

- Reactive rules
- Proactive rules
- Interaction via HTTP or other protocols using a gateway

```
class traffic_light(Agent):

    def main(self):

        +new_car_in_lane(1) / cars_in_lane(2, 0) >> \
            [ activate_lane(1, 2),
              +lane_free(1)[{’to’:’traffic_light_2’}],
              +lane_busy(2)[{’to’:’traffic_light_2’}] ]

        activate_lane(F, B) / (free(B) & busy(F)) >> \
            [ green_on(F), red_on(B), +free(F), +busy(B) ]
        activate_lane(F, B) / (free(F) & busy(B)) >> [ ]
```

ITS - Objective 1 - PHIDIAS and DSLs

- Identify requirements for a DSL specific for the ITS application
- Map statements and/or data into first-class PHIDIAS elements:
  - Actions
  - Sensors
  - Beliefs and Active beliefs (i.e. predicates)
  - (Prolog-like) Goals
  - Library Procedures (plans)
- Implement the device behaviour using the derived elements

```
class green_on(Action):
    def execute(self, lane):
       if lane == 1:
           pyb.Pin(’PB0’, pyb.Pin.OUT_PP).value(1)
           pyb.Pin(’PB1’, pyb.Pin.OUT_PP).value(0)
       elif lane == 2:
           pyb.Pin(’PB0’, pyb.Pin.OUT_PP.value(0)
           pyb.Pin(’PB1’, pyb.Pin.OUT_PP.value(1)
```

ITS - Objective 1 - PHIDIAS and DSLs

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```
class BTSensor(Sensor):

    def sense(self):
        while not(self.stopped()):
            if bluetooth_event:
                self.assert_belief(new_car_in_lane(...))
```

ITS - Objectives

Objective 2

To detect **malicious or mulfunctioning** devices through a distributed reputation protocol

ITS - Objective 2 - Premises

SIoT (Social internet of Things) is a paradigm where the two levels “people” and “things” are kept separated [AIMN12].

In a SIoT scenario:

- objects can have their own **social networks to have strict interactions**
- humans can protect their privacy and will access the result of autonomous inter-object interactions occurring in the objects social network.

SIoT paradigm can be adopted in T-Ladies to guarantee interactions between distributed entities.

Reputation and SIoT

We propose to **integrate information about reputation** of distributed entities to keep track of *their performances* [FFM$^+$20, FMRS20, FFM$^+$21, FFM$^+$22].

We will study on **how to design a reputation system** for distributed entities (or Smart Objects) in a SIoT scenario.

Reputation system can be used to create **clusters of Smart Objects** with *similar indeces of performances* (reputation scores).

Feedback

A reputation system is generally based on the concept of **feedback**, which is reciprocally released between two agents *after any interaction*.

Software agents can calculate *reputation scores* for Smart Object using feedbacks.

The feedback is a value in the interval $[0, 1]$, where high values have the meaning of “positive” feedbacks, and viceversa.

Reputation models

We will study different methods of *calculation* for the SOs reputations.

We will take into account several parameters of different nature:

- the **relevance of the interaction** which can be used to avoid collusive behaviours aimed at gaining high feedback;
- the **frequency of interactions** which can be used to limit the collusive behaviours release reciprocal (positive) feedbacks with high frequency;
- the **honesty** of Smart Objects in providing information about the performance of Smart objects to their peers.

Group formation (clustering) I

Distributed entities (SOs) can be **grouped into clusters.**

Members of clusters can be selected on **the basis of their reputation scores.**

Group formation can be performed by any clustering algorithm, as for instance k-means.

Group formation (clustering) II

Clustering smart objects may offer several advantages:

- **malicious Smart Objects** can be grouped together and, as a conseguence can be quickly identified and isolated;
- selection of peers for interactions can be performed more efficiently by **selecting members of the same groups**;
- Smart Objects with the same "level of effectiveness" can be included in the same group and can be selected to cooperate for similar tasks.

T-Ladies scenario I

The reputation system can help to recognize a few important critical issues:

- **malfunctioning devices.** For instance devices which sends unreliable signals about traffic;
- **malicious devices**: devices trying to cooperate for very simple tasks with high frequency to gain high reputation;

Moreover, as reputation can be used as index of effectiveness and/or efficiency, clustering of such devices can help to select those with a certain level of performance.

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