Multi-agent System to deal with Emergency Requests

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1 MOTIVATION AND INTRODUCTION

The increasing number of people and, consequently, the increasing number of simultaneous medical emergencies, motivates us to distribute medical vehicles and resources in the most efficient way possible, in order to avoid deaths or long term injuries due to the lack of prompt responses [1].

If we're able to build a system that meets the previous criteria, we can hopefully save more lives and decrease the burden on our medical professionals.

With this in mind, our goal is to build an agent system that efficiently distributes medical vehicles and resources and effectively responds to emergency requests in accordance with their type, gravity, and spatiotemporal distribution.

2 MULTI-AGENT SYSTEM ARCHITECTURE

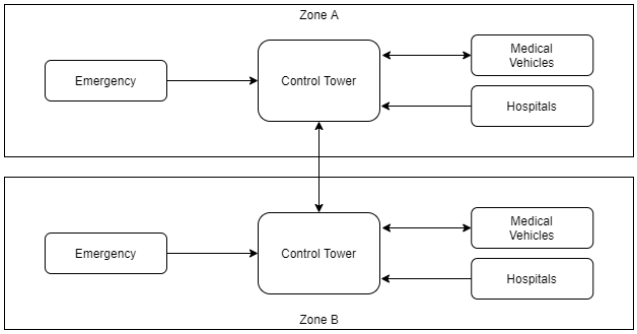

Figure 1: System Architecture

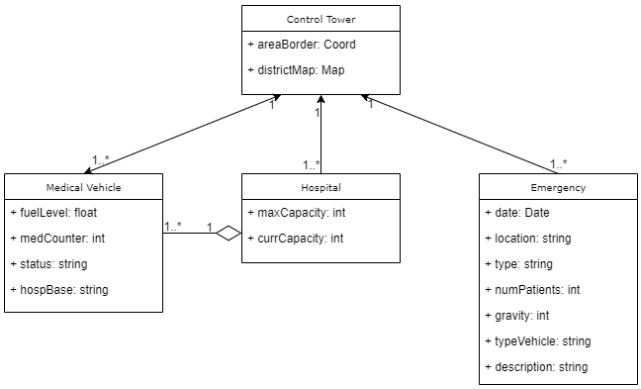

Figure 2: System Components Architecture

Our system will be a Multi-Agent System composed by multiple control towers (our Agents) that exchange information between them.

Each Agent controls a set of medical vehicles and assigns them, in a given area, to different emergencies, according to the utility it can earn.

To correctly allocate these medical means, we defined the following criteria:

- **Emergency types**:
  - Life-threatening emergency
  - Not life-threatening emergency
  - Contagious disease
- **Medical vehicles** [2]:
  - Basic life support ambulance (SBV)
  - INEM Car (VMER)
  - Immediate life support ambulance (SIV)
- **Resources**:
  - Medicine
  - Fuel

The utility is calculated considering the following characteristics:

- The **higher** the gravity, the **greater** the utility
- The **higher** the number of patients, the **greater** the utility
- The **smaller** the distance between the vehicle and the emergency, the **greater** the utility

Each area is monitored by a control tower and has multiple Hospitals. Each Hospital is a base for a set of ambulances and contains infinite supplies where all ambulances can replenish their resources. The hospitals also have a maximum capacity.

2.1 System Model

- **Emergency Data**
  - "Date" - When the emergency request was emitted
  - "Location" - The geographic coordinates of the request
  - "Type" - The type of emergency
  - "Patients" - The number of patients that need to be assisted / transported
  - "Gravity" - The gravity of the emergency on a scale of 1 to 10
  - "Vehicles" - The type of vehicles requested
  - "Description" - The description of the emergency
- **Medical Vehicle Data**
  - "Fuel Level" - Has the amount of fuel left on the vehicle
  - "Medicine Counter" - Saves the number of medicine left on the vehicle
  - "Status" - The vehicle's can have the following status:
    - Available - When the vehicle is ready to respond to an emergency
    - Assigned - When the vehicle is assigned to an emergency
    - Rest - When the vehicle has reached the maximum number of hours of active

    - * Replenish - When the vehicle has reached a minimum number of medicine or fuel and needs to replenish them on a hospital
  - "Hospital Base Location" - Has the location of the base hospital of the vehicle
- **Hospital Data**
  - "Maximum Capacity" - The maximum number of patients it can treat simultaneously
  - "Current Capacity" - The current number of patients that are in the hospital being treated
- **Agent Data**
  - "Zone/Area border" - The zone's geographic coordinates
  - "District map" - The map of the district. Each agent knows where all zone's vehicles and hospitals are, but it doesn't have access to other zones' information (these other zones are controlled by other agents)

2.1.1 *Functional Requirements.*

- All emergencies will *eventually* be responded according to their priority
- Each control tower has a map of its area
- All ambulances have a maximum number of hours during which they can work.
- If an ambulance surpasses a frontier between zones A and B, the control tower of the zone B will be able to control this vehicle
- Each hospital has a maximum number of patients that it can treat simultaneously
  - Before driving to the hospital, the control tower guarantees that there's enough space for all the ambulance's patients
- When a vehicle achieves the limit number of hours in active service the vehicle places itself in rest mode and returns to it's base hospital
- If the fuel or the medicine of a vehicle reaches a minimum defined level, then the vehicle will go to the nearest hospital to replenish it's resources and places itself in replenish mode

3 ENVIRONMENT PROPERTIES

- **Accessible** - Agents know where all vehicles are at all times
- **Deterministic** - Each action has a single guaranteed effect.
- **Dynamic** - While our agent is allocating vehicles to an emergency, a new emergency might appear, which can change the agent's deliberation/decision
- **Discrete** - There's a fixed number of possible actions
- **Non-episodic** - Each ambulance's actions depends on the other ambulances' actions (if an ambulance was already sent to an emergency, we don't want to send another one, unless it is needed)

4 AGENT PROPERTIES

- **Autonomous** - Since it can determine what to do in each situation without help from the exterior.
- **Adaptive** - Since it needs to adapt to the ever-changing environment (patients can appear at any moment).
- **Rational** - Since it has a utility function (save as many patients as possible) to maximise.
- **Reactive** - Since it has to keep reacting, in an effective way, to new patients showing up.
- **Proactive** - Since it has goal-directed behaviour, and takes initiative to keep on saving patients.
- **Collaborative** - Since every agent has the same goal (wanting to maximize the same utility function) and need each other's help to do it.

4.1 Sensors

In regards to our agent - control tower - the sensors are:

- **Emergency signal** - To know if there is a new emergency
- **Communication System** - To receive information from the medical vehicles and hospitals of each agent's area

When it comes to medical vehicles, we have the following sensors:

- **GPS** - to be able to calculate the routes to the emergencies. Also, the control towers use the vehicles' GPS to know their location at all times.
- **Fuel Meter** - to monitor the fuel levels.
- **Keyboard entry** - to register the resources that were spent, in order to keep track of the ones that are still available and to change the vehicle's status.

4.2 Actuators

In regards to our agent - control tower - the actuators are:

- **Process Emergency** - The ability to understand the components of the emergency and process them in an efficient way
- **Dispatch Vehicles** - To communicate with the medical vehicles giving them a specific location to go to
- **Help Request** - Being able to communicate with other control towers to ask for help (more vehicles) or to send help from one area to another

When it comes to medical vehicles, we have the following actuators:

- **Drive** - The ability to drive to a designated place
- **Change Status** - It changes the vehicles status to "available" / "assigned" / "rest" / "replenish" mode
- **Replenish** - Go to the nearest hospital to replenish it's resources

REFERENCES

[1] Paula Freitas Ferreira. *Queixas sobre tempo de espera aumentam. INEM tenta melhorar com recurso ao SIRESP.* URL: https://www.dn.pt/edicao-do-dia/29-ago-2018/queixas-sobre-tempo-de-espera-aumentam-inem-tenta-melhorar-com-recurso-ao-siresp-9770989.html. (accessed: 29.08.2018).

[2] INEM. *Sistema Integrado de Emergência Médica.* URL: https://www.inem.pt/wp-content / uploads / 2017 / 06 / Sistema - Integrado - de - Emerg % C3 % AAncia - M%C3%A9dica.pdf.