



*Platform for European Medical Support  
During Major Emergencies*

## **D4.6 Post Crisis Evaluation Tool**





## ***PULSE***

### ***Platform for European Medical Support during major emergencies***

WP4 Tools

**Deliverable D4.6-Post Crisis Evaluation Tool**

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Abstract:
<p>This document is a report focused on the development of the <i>Post Crisis Evaluation Tool (PCET)</i>. This is an essential component of the PULSE Platform Architecture that provides integrated features tailored to help the evaluation of decisions and choices taken during past medical emergencies (e.g., SARS epidemics and Stadium crush).</p> <p>This report includes a description of the objective that <i>PCET</i> aims to achieve and provides important details on functionalities, architecture, technologies and underlying libraries used for its implementation.</p>

Keywords:
SARS epidemics, Stadium crush, Post Crisis Evaluation, Use Case, Architecture, Technology, Library, Web Service, RESTful Interface



## D4.6-Post Crisis Evaluation Tool

### Revisions

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1.0	29/10/2015	Internal SES Revision	Malmignati F. (Selex ES)
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## 1 List of acronyms

Acronym	Definition
DSVT	Decision Support and Validation Tool
GUI	Graphical User Interface
HTTP	HyperText Transfer Protocol
JSON	JavaScript Object Notation
MA	Message Adapter
PCET	Post Crisis Evaluation Tool
REST	Representational State Transfer
SAE	Search and Analytics Engine
WHO	World Health Organization





## 2 Executive Summary

This document is a report focused on the development of the PULSE *Post Crisis Evaluation Tool (PCET)*, one of the software components composing the PULSE Platform Architecture. This component implements specific functionalities that allows to overcome the current unorganized manner to carry out a post crisis evaluation of the decisions taken during medical emergencies. *PCET* provides integrated features that simplify the identification of past bad choices and, in such a way, it helps to understand where to intervene for addressing critical issues in future emergencies.

From the logical point of view, *PCET* functionalities can be subdivided in two categories: those used to store historical information and those used to retrieve that information through the elaboration of ad hoc correlations, analytics and statistics.

The architectural design of *PCET* is based on two main sub-modules:

1. *Message Adapter (MA)* that, among other things, implements a Web Service interface used to allow the *PCET* communication with the outside world;
2. *Search and Analytics Engine (SAE)* that is used to directly store and retrieve historical data in the *PCET* internal repository with high speed performances.

*PCET* has a precise role within the PULSE Platform Architecture: it maintains the story of what happened in past medical emergency. The *Decision Support and Validation Tool (DSVT)* is the only architectural component that directly interfaces the *PCET*; it is in charge of (i) storing via *PCET* the historical information when an emergency is ongoing and (ii) retrieving via *PCET* that information whenever agencies (e.g., National Authorities) decide to carry out a form of post crisis evaluation.



## 3 Introduction

### 3.1 Scope of the Document

This document is a report focused on the implementation of the *Post Crisis Evaluation Tool (PCET)*, one of the software components composing the PULSE Platform Architecture. As stated in [1], the development of a *PCET* is part of WP4 activities and this software component has to be delivered as 'D4.6 - Post Crisis Evaluation Tool'.

This report includes a description of the objective that *PCET* aims to achieve and provides important details on functionalities, architecture, technologies and underlying libraries used for its implementation.

### 3.2 Structure of the Document

This document is structured in different sections, each of which is focused on a specific theme concerning the *PCET* prototype. The list of covered themes is as follows:

- description of the *PCET* objective by highlighting how this component allows to overcome some limitations and improves the current post crisis analysis;
- enumeration of *PCET* features and functionalities by distinguishing between those used to store historical information and those needed to retrieve that information;
- description of the *PCET* internal architecture and relation of this component with other elements of the overall PULSE platform architecture;
- list of technologies adopted for the implementation of *PCET*;
- list of underlying 3<sup>rd</sup> party libraries used for *PCET* implementation and summary of the corresponding licenses.

### 3.3 Relations with other Deliverables

The topics covered in this document have some liaisons with those dealt in other PULSE deliverables:

- *D2.2-Use case specification* [2] – This document describes the use cases related to two PULSE reference scenarios: SARS-like epidemics and Stadium crush. Some of these use cases require the use of *PCET* functionalities, therefore this deliverable can be interesting for the reader.
- *D4.1-Decision Support Validation Tool* [3] – This document is a report describing the main functionalities, architecture and major technologies used for the implementation of the *Decision Support and Validation Tool (DSVT)*. This is the PULSE architectural component that directly interfaces with *PCET*, therefore the information reported in this deliverable should be known to better understand how the interaction between these two components works.



## 4 Tool description

### 4.1 Objective

PULSE project aims at developing a Platform for European Medical support in case of medical emergency. This consists in providing technological tools useful to manage both the “response” phase and the post crisis phase. In the latter case the involved agencies (e.g., National Authorities, World Health Organization (WHO), airports) evaluate the effectiveness of the decisions taken during the crisis, in order to understand how to improve the choices performed in terms of procedures, quality and quantity of employed resources.

Currently, this evaluation is not carried out in a structured, organized and functional manner, since often valid information describing the evolution of the emergency is not available and each analysis is only based on memories and testimonies of the people who attended, with different roles, the event. The objective of *PCET* is to overcome this lack through an integrated software solution which allows (i) to store information about the crisis when the emergency is ongoing and, subsequently, (ii) to recover and analyse that information with structured queries for functional post crisis evaluations.

*PCET* is able to manage several historical data describing the evolution of current and past emergencies, such as:

- the decisions taken during the crisis;
- the resources employed in terms of (i) human-people intervened to help (e.g., doctors and nurses) and (ii) allocated medical assets (e.g., hospitals, ambulances, surgical masks, sterile gauzes);
- persons who have been injured, infected or recovered and persons who instead died during the crisis;
- information on whether conditions;
- information on traffic conditions;
- weak signals related to possible epidemic issues;
- communications from WHO;

The above data storage categories allow an operator (i) to put in place different approaches and procedures during an emergency and (ii) to carefully analyse quantity and quality of resources used to manage the crisis.

Most of the stored information is integrated with geospatial coordinates and time references. This allows the extraction of data related to specific time periods and, simultaneously, geospatial correlations among the information related to a certain event.

*PCET* is also able to elaborate the available historical data to calculate post crisis statistics on emergencies. Each statistic includes some indicators (e.g., number of wounded or dead persons at a specified time) that can be used to evaluate the evolution of the emergency. The trend of considered indicators in specific time periods can possibly be used to learn valuable lessons about the impact of the decisions taken to manage the crisis (e.g., sending an ambulance with particular medical resources to assist a seriously injured person). These lessons can in turn be used to improve the procedures adopted in the future emergencies.

*PCET* allows to recover historical data related to different crises; these data can be compared to analyse the evolution of emergencies related to the same cause (e.g., SARS epidemics) in order to identify both the choices resulted in benefits and those



that, on the contrary, have proven to be counterproductive. This allows to make corrections where necessary.

Since PULSE project is focused on two reference scenarios, i.e. SARS-like epidemics and Stadium crush, the actual implementation of the *PCET* has been carried out to allow post crisis evaluation of emergencies in compliance with such scenarios. For this reason, covered functionalities are specifically designed to make easier the advanced search for historical information in these two contexts.

## 4.2 Functionalities

*PCET* implements various functionalities supporting the evaluation of the decisions taken during emergency situations. From the logical point of view, these functionalities can be subdivided in two categories: those used to store historical information into the *PCET* internal repository and those which allow to retrieve that information through the elaboration of ad hoc correlations, analytics and statistics.

All the functionalities are made available to other components of the PULSE architecture (e.g., *DSVT*) through a standard Web Service which can be invoked by a RESTful interface. The messages exchanged with the *PCET* by means of this interface are HTTP-based requests and responses. They include a message body whose information content is represented in JavaScript Object Notation (JSON). Subsections 4.2.1 and 4.2.2 provide more details about the purpose of the main messages and the semantic of their internal bodies.

### 4.2.1 Crisis information storage

The first category of *PCET* functionalities includes those used to store historical data describing the evolution of a crisis into the *PCET* internal repository. At this aim, the *PCET* RESTful interface offers two main operations, one dedicated to SARS epidemic scenario and one for the Stadium crush scenario.

The first operation is used to capture, in a specified moment, the following information:

1. the status of the entities (e.g., medical resources, infected persons, hospitals) involved in a SARS epidemic event;
2. if required, a decision taken to manage that SARS emergency (e.g., an action to be performed).

This allows to store into the *PCET* internal repository a sort of 'snapshot' of the crisis situation correlated to a specified time. The evolution of the emergency is therefore traced by storing a set of these 'snapshots' that also include geolocalized information (i.e., latitude and longitude) related to most of the entities deployed in the field.

The described operation can be triggered with any RESTful client by calling the HTTP request method POST at the following URL:

- <http://hostname:8080/PostCrisisEvaluationToolWS/storeSARSSnapshot>.

Figure 1 shows an example of possible message body for this type of operation. More generally, the JSON members composing the message body are:

- *id\_event* that represents the identifier of the event which the snapshot is referring to;
- *time* which is the time instant when the snapshot is captured; the status of the other entities (e.g., decision, hospitals, persons) is referred to this instant;



```
{
  "id_event" : "123event",
  "id_decision" : "123decision",
  "time" : "2015-10-08T17:35:00",
  "decision" : {
    "description_code" : "start_event"
  },
  "hospitals" : [
    {
      "id_hospital" : "123hospital",
      "name" : "Hospital 'Lazzaro Spallanzani' ",
      "address" : "Via Portuense 292, 00149 Rome",
      "is_casualty_clearing_station" : false,
      "persons" : [
        {
          "id_person" : "123bianchi",
          "fullname" : "Andrea Bianchi",
          "health_condition" : "SARS confirmed case",
          "symptoms" : ["high fever", "stomach ache"],
          "triage" : "red code",
          "notifier_profile" : {
            "id_notifier" : "123notifier",
            "qualification" : "immunologist"
          }
        }
      ],
      "resources" : [
        {
          "type" : "immunologist",
          "quantity" : 9
        },
        {
          "type" : "neurosurgeon",
          "quantity" : 3
        },
        {
          "type" : "oxygen cylinders",
          "quantity" : 20
        }
      ],
      "coordinates" : {
        "latitude" : 41.82,
        "longitude" : 12.48
      }
    }
  ],
  "persons" : [
    {
      "id_person" : "123murphy",
      "fullname" : "Alex Murphy",
      "health_condition" : "dead",
      "symptoms" : ["high fever"],
      "triage" : "red code",
      "notifier_profile" : {
        "id_notifier" : "321notifier",
        "qualification" : "specialized nurse"
      },
      "coordinates" : {
        "latitude" : 41.92,
        "longitude" : 12.42
      }
    }
  ],
  "communications" : [
    {
      "id_communication" : "1234commun1",
      "content" : "Severe acute respiratory syndrome (SARS) – the first severe new disease of the 21st century – was a watershed event. It revealed how much the world has changed in terms of the impact that outbreaks can have in a highly mobile and closely interconnected world. During a fortunately brief stay in its new human host, the SARS virus travelled rapidly along the routes of international air travel to infect more than 8,000 people around the world. Of these people, SARS killed just under 800."
    }
  ],
  1.
}
```

```

"weak_signals" : [
  {
    "id_signal" : "123signal",
    "description" : "Possible SARS outbreak",
    "category" : "SARS",
    "keywords" : ["SARS", "fever", "headache"],
    "is_relevant" : true,
    "coordinates" : {
      "latitude" : 41.92,
      "longitude" : 12.42
    }
  }
]
}

```

**Figure 1: ‘Store SARS Snapshot’ request – Example of message body**

- *id\_decision* which represents the identifier of a decision taken at the instant specified in *time*; a further description of that decision can be reported in the *decision* object;
- *hospitals* which captures the status of a list of hospitals involved in the SARS emergency at the instant specified in *time*; each hospital is characterized by different elements such as identifier, name, address, hospitalized persons, available medical resources and geolocalized position;
- *persons* which captures, at the *time* instant, the condition of the persons who have been infected by the SARS coronavirus or who have been classified as ‘probable case’; each person is characterized by different elements such as identifier, full name, health condition, symptoms, triage, profile of the person who notified the SARS case and geolocalized position;
- *communications* which represents the list of WHO communications available at the *time* instant and related to the ongoing SARS emergency;
- *weak\_signals* which contains the list of weak signals [4] available at the *time* instant and referred to the ongoing SARS emergency; each signal is characterized by different elements such as identifier, description, category, keywords and geolocalized position of the area interested by the reported phenomenon.

A particular mention is to be made for the *resources* element available for the hospitals. This element is used to state the available medical resources and refers to both medical staff (e.g., immunologists, neurosurgeons, nurses) and health care assets (e.g., oxygen cylinders, sterile gauzes, surgical masks). Each medical resource is characterized by two sub-elements: (i) *type* which includes a short description of the resource and (ii) *quantity* which represents the numerical availability of that resource.

Apart from *id\_event* and *time*, the other JSON members of the message body are optional as they may be included or not in the ‘snapshot’ depending on the situation of the emergency at the *time* instant.

The second operation offered by *PCET* is analogous to the previous one (i.e., *Store SARS Snapshot*), but it is used to capture, in a specified moment, information related to the Stadium crush event and in particular:

1. the status of the entities (e.g., medical resources, ambulances, hospitals, rescuers) involved in a Stadium crush event;
2. if required, a decision taken to manage that Stadium emergency (e.g., an action to be performed).

This allows to store into the *PCET* internal repository a ‘snapshot’ of the stadium crisis situation correlated to a specified time.



```
{
  "id_event": "543event",
  "id_decision": "543decision",
  "time": "2015-10-13T10:30:00",
  "decision": {
    "description_code": "start_event"
  },
  "hospitals": [
    {
      "id_hospital": "543hospital",
      "name": "Azienda Ospedaliera San Giovanni Addolorata",
      "address": "Via dell'Amba Aradam 9, 00184 Rome",
      "is_casualty_clearing_station": false,
      "persons": [
        {
          "id_person": "543rossi",
          "fullname": "Giacchino Rossi",
          "health_condition": "wounded",
          "symptoms": ["fractured right arm", "head trauma"],
          "triage": "red code",
          "notifier_profile": {
            "id_notifier": "543notifierA",
            "qualification": "specialist nurse"
          }
        }
      ]
    },
    {
      "type": "orthopedist",
      "quantity": 6
    },
    {
      "type": "neurosurgeon",
      "quantity": 3
    },
    {
      "type": "oxygen cylinders",
      "quantity": 50
    }
  ],
  "coordinates": {
    "latitude": 41.82,
    "longitude": 12.48
  }
},
"ambulances": [
  {
    "id_ambulance": "543ambulance",
    "category": "B",
    "status": "busy",
    "persons": [
      {
        "id_person": "543giosue",
        "fullname": "Giosuè Vitali",
        "health_condition": "wounded",
        "symptoms": ["fractured left leg"],
        "triage": "red code",
        "notifier_profile": {
          "id_notifier": "543notifierB",
          "qualification": "nurse"
        }
      }
    ]
  },
  {
    "type": "orthopedist",
    "quantity": 1
  },
  {
    "type": "driver",
    "quantity": 1
  }
]
```



```
{
  "type": "oxygen cylinders",
  "quantity": 15
},
"route": {
  "origin": {
    "latitude": 41.93,
    "longitude": 12.45
  },
  "destination": {
    "latitude": 41.88,
    "longitude": 12.50
  },
  "traffic_parameters": {
    "severity": "medium"
  }
},
"coordinates": {
  "latitude": 41.93,
  "longitude": 12.50
}
},
"event": {
  "casualty_clearing_station": {
    "id_hospital": "543ccsA",
    "name": "Casualty Clearing Station Olympic Stadium of Rome",
    "address": "Viale dello Stadio Olimpico, Rome",
    "is_casualty_clearing_station": true,
    "persons": [
      {
        "id_person": "543furlan",
        "fullname": "Damiano Furlan",
        "health_condition": "wounded",
        "symptoms": ["head trauma"],
        "triage": "yellow code",
        "notifier_profile": {
          "id_notifier": "321notifierC",
          "qualification": "specialist nurse"
        }
      }
    ]
  },
  "resources": [
    {
      "type": "neurosurgeon",
      "quantity": 3
    },
    {
      "type": "oxygen cylinders",
      "quantity": 20
    },
    {
      "type": "bandages",
      "quantity": 43
    }
  ],
  "coordinates": {
    "latitude": 41.93,
    "longitude": 12.45
  }
},
"persons": [
  {
    "id_person": "543solenghi",
    "fullname": "Vasco Solenghi",
    "health_condition": "wounded",
    "symptoms": ["fractured right arm"],
    "triage": "yellow code",
  }
]
```





```
"notifier_profile": {
  "id_notifier": "458notifierD",
  "qualification": "specialist nurse"
}
],
"rescuers": [
  {
    "id_rescuer": "543yung",
    "fullname": "Cristina Yung",
    "qualification": "cardiologist",
    "category": "physician",
    "resources": [
      {
        "type": "oxygen cylinders",
        "quantity": 4
      },
      {
        "type": "bandages",
        "quantity": 5
      },
      {
        "type": "surgical mask",
        "quantity": 3
      }
    ]
  },
  {
    "description": "arriving at event location",
    "status": "completed"
  },
  {
    "description": "disinfection wounds",
    "status": "ongoing"
  }
]
],
"coordinates": {
  "latitude": 41.93,
  "longitude": 12.45
}
},
"meteo_zones": [
  {
    "coordinates": {
      "latitude": 41.9,
      "longitude": 12.45
    },
    "weather_parameters": {
      "coord": {
        "longitude": 12.45,
        "latitude": 41.9
      },
      "weather": [
        {
          "id": 500,
          "main": "Rain",
          "description": "light rain",
          "icon": "10d"
        }
      ]
    },
    "base": "stations",
    "main": {
      "temp": 291.97,
      "pressure": 1014,
      "humidity": 77,
      "temp_min": 288.71,
      "temp_max": 293.15
    },
    "visibility": 10000,
  }
]
```

```

"wind": {
  "speed": 7.2,
  "deg": 140
},
"rain": {
  "1h": 0.25
},
"clouds": {
  "all": 40
},
"dt": 1444730505,
"sys": {
  "type": 1,
  "id": 5848,
  "message": 0.0086,
  "country": "VA",
  "sunrise": 1444713611,
  "sunset": 1444753919
},
"id": 6691831,
"name": "Vatican City",
"cod": 200
}
]
}

```

**Figure 2: 'Store Stadium Snapshot' request - Example of message body**

Also in this case, the evolution of the emergency is traced by storing a set of these 'snapshots', including geolocalized information related to the entities in the event.

The operation can be triggered by calling the HTTP request method POST at the following URL:

- <http://hostname:8080/PostCrisisEvaluationToolWS/storeStadiumSnapshot>.

Figure 2 shows an example of possible message body for this type of operation.

Anyway, in general, the JSON members composing the message body are:

- *id\_event* that represents the identifier of the event which the snapshot is referring to;
- *time* which is the time instant when the snapshot is captured; the status of the other entities (e.g., decision, hospitals, ambulances, event) is referred to this instant;
- *id\_decision* which represents the identifier of a decision taken at the instant specified in *time*; a further description of that decision can be reported in the *decision* object;
- *hospitals* which captures the status of a list of hospitals involved in the Stadium crush emergency at the instant specified in *time*; each hospital is characterized by different elements such as identifier, name, address, hospitalized persons, available medical resources and geolocalized position;
- *ambulances* which captures the status of the set of ambulances intervened on the Stadium emergency at the *time* instant; each ambulance is described by different elements such as identifier, category, status, injured persons, available medical resources, route with traffic information and geolocalized position;
- *event* which contains information describing, at the *time* instant, the situation on the site where the Stadium emergency is occurred; an event is characterized by a possible casualty clearing station, injured persons, rescuers and geolocalized position of the site;



- *meteo\_zones* which provides a set of useful weather information related to different zones of interest for the stadium emergency; each zone is identified by its geospatial coordinates and the related whether parameters are referred to the *time* instant.

A particular mention is to be made for the *resources* element which is available for hospitals, ambulances and, in addition, for the casualty clearing station and rescuers deployed on the site where an emergency event is occurred. Also in the Stadium crush case, this element is used to state the availability of medical resources and refers to both medical staff and health care assets, specifying the relative amounts.

Similarly to the previous operation, only *id\_event* and *time* are always included in the message body, whereas the other JSON members are optional.

#### 4.2.2 Crisis information retrieval

The second category of *PCET* functionalities includes those used to retrieve historical data describing the evolution of the crisis from the *PCET* internal repository. At this aim, the *PCET* RESTful interface offers a particular operation that allows to search the desired information and, contextually, to elaborate ad hoc correlations, analytics and statistics on the available data.

The use of search functionalities represents the primary tool for functional post crisis evaluation. The result of each query contributes to build a picture on the choices made during different emergencies occurred for the same cause (e.g., SARS epidemics). When this picture is completed, the information collected can be used to:

- identify possible procedural inefficiencies and update the protocols followed to manage the crisis accordingly;
- improve the efficiency and exploitation of the available medical resources, both in terms of quality and quantity.

The results of analyses carried out in such a structured and functional manner is expected to produce benefits in the management of the future emergencies with a significant reduction of patients who reported serious consequences due to injuries and SARS infections.

The operation used to search historical data in the *PCET* internal repository can be triggered by calling the HTTP request method POST at the following URL:

- <http://hostname:8080/PostCrisisEvaluationToolWS/historicalInformation>.

Figure 3 shows an example of possible message body for this type of operation. The JSON contained in that body represents the query to be submitted to the *PCET* in order to retrieve the desired information. The first line (highlighted in red in Figure 3) reports the name of the query. It is used by *PCET* to recognize the elaboration process to be executed to calculate the query result. The remaining JSON members instead represent the parameters associated to the query.

According to the this explanation, the example in Figure 3 is to be interpreted as follows:

- *query\_sars\_event\_statistics\_at\_location\_and\_time* is the query name; the objective of this query is to calculate the possible statistics related to a SARS epidemic crisis (e.g., number of probable and confirmed cases) by restricting the search to patients located in a certain area at a specified time instant;
- *id\_event* represents the identifier of the SARS crisis which the query refers to;



- *time* is the time instant which the computed statistics refers to;
- *area* is the territory where the patients considered in the statistics are located; it is a circular zone defined by a specified centre (identified by geospatial coordinates) and radius.

```
{
  "query_sars_event_statistics_at_location_and_time": {
    "id_event" : "123event",
    "time": "2015-10-08T17:35:00",
    "area": {
      "center":{
        "latitude": 41.92,
        "longitude": 12.42
      },
      "distance": "10km"
    }
  }
}
```

**Figure 3: 'Historical Information' request - Example of message body**

The result of this query is an HTTP response containing, in the message body, a JSON with the requested statistics (i.e., SARS probable and confirmed cases, deaths and healed persons).

In addition to the request reported in the previous example, *PCET* allows to perform many other queries that all together can be used to do a complete and functional post crisis evaluation of past emergencies. A detailed description of the overall set of queries is beyond the scope of this document. However, the main functionalities made available are:

- retrieving the information related to all the persons, involved in a certain SARS epidemic crisis, who have a specified health condition (e.g., SARS probable and confirmed case, dead and healed patients); this search is further restricted to patients located in a certain geographic area, at a specified time range;
- retrieving the list of decision identifiers related to a certain SARS epidemic crisis;
- retrieving the overall 'snapshot' related to a specified decision taken during a SARS epidemic crisis;
- retrieving the information related to all the hospitals, involved in a certain SARS epidemic crisis, at a specified time range;
- retrieving the WHO communications related to a certain SARS epidemic crisis, available at a specified time instant;
- retrieving the weak signals related to a certain SARS epidemic crisis; this search is restricted to signals concerning a certain geographic area, at a specified time instant;
- computing the statistics related to a certain Stadium crush crisis (e.g., number of wounded persons and deaths) by restricting the search to patients located in a certain geographic area, at a specified time instant;
- retrieving the information related to all the persons, involved in a certain Stadium crush crisis, who have a specified health condition (e.g., wounded, dead and healed patients); this search is further restricted to patients located in a certain geographic area, at a specified time range;
- retrieving the information related to all the ambulances intervened in a certain Stadium crush crisis; this search is restricted to ambulances located in a certain geographic area, at a specified time range;
- retrieving the information related to all the rescuers intervened in a certain



- Stadium crush crisis; also in this case, this search is restricted to rescuers located in a certain geographic area, at a specified time range;
- retrieving the list of decision identifiers related to a certain Stadium crush crisis;
  - retrieving the overall 'snapshot' related to a specified decision taken during a Stadium crush crisis;
  - retrieving the information related to all the hospitals, involved in a certain Stadium crush crisis, at a specified time range;
  - retrieving the available weather information related to a certain Stadium crisis; this search is restricted to a particular geographic area, at a specified time range.

*PCET*, through these functionalities, enables an operator to retrieve the historical data concerning one or more crises; these data can be compared to analyse the evolution of emergencies related to the same cause (e.g., SARS epidemics) in order to identify both the choices resulted in benefits and those that, on the contrary, have proven to be counterproductive. In such a way, approaches and procedures adopted to manage the future emergencies can be reviewed to correct the potential criticalities and to introduce the practices which have produced the best results on the field. *PCET* allows to design a clear picture of past emergencies: this picture includes detailed information on quality and quantity of resources allocated to manage the crisis. For example, in the case of a Stadium crush crisis, it is possible to retrieve data on (i) the rescuers rushed to the scene, (ii) the ambulances with their geospatial position, (iii) possible casualty clearing stations, (iv) medical staff and available health care assets. An operator can then use all this information to identify possible criticalities and to improve the emergency procedures.

### 4.3 Relations with WP2 Use Cases

Part of the work carried out in WP2, was focused on the definition of a set of interesting use cases for PULSE; these cases later have been detailed in the deliverable D2.2 [2]. As already stated, *PCET* functionalities described in section 4.2 can actually be used by *DSVT* in different situations for post crisis evaluations. Two of these situations are described in just as many use cases, let's see what.

1. [UC-SARS LIKE – 08] *Post emergency learning at national level.*

At the end of this use case (point 7), the *DSVT* shows a graph containing the trends of SARS epidemic data related to last and past SARS emergencies; the objective of this graph is

- a. comparing the trends of different valuable indicators (such as number of deaths or confirmed SARS cases) and, at the same time,
- b. identifying the decisions that have produced the best results in terms of healings and limited number of deaths;
- c. considering the efficiency in the exploitation of the available medical resources, both in terms of quality and quantity.

The historical data reported in that graph by *DSVT* and used for an overall post crisis evaluation, are preliminarily retrieved and calculated via *PCET* and then displayed on the GUI. Therefore, *PCET* plays an important role in this use case.

2. [UC-SARS LIKE – 09] *Post emergency learning at WHO level.*

Similarly to the previous case, the *PCET* is used by *DSVT* to retrieve and



calculate the historical data reported in the graph created in point 6.

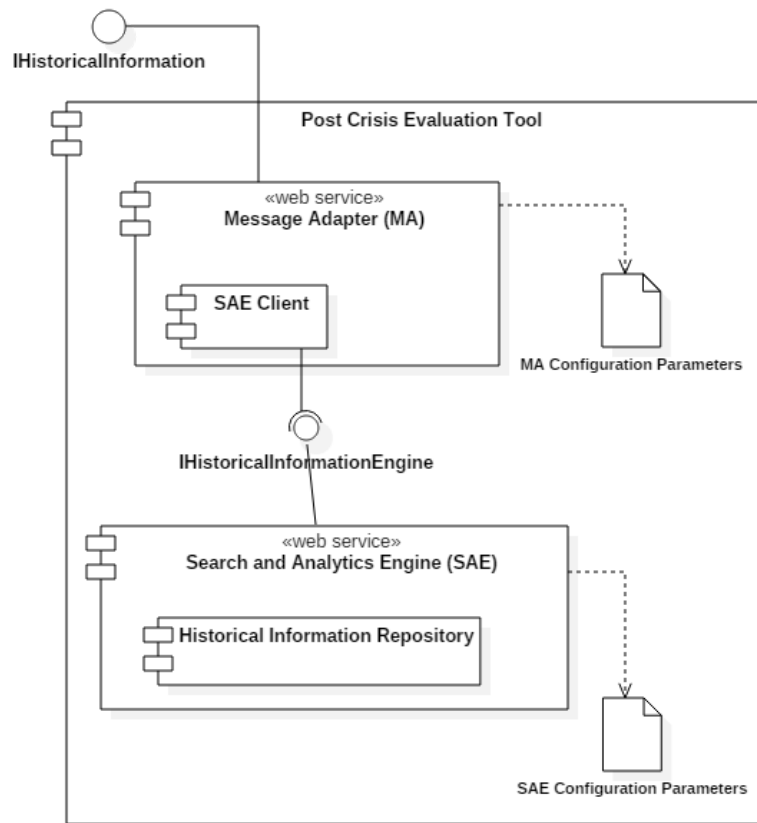
In addition, *PCET* intervenes in point 2c as follows:

- a. when the *DSVT* shows a list of decisions taken during a specified SARS emergency, this information is retrieved via *PCET* and then displayed on the GUI;
- b. when the *DSVT* opens a panel containing data related to the impact of the selected decision on the crisis evolution, the information used to build trends of valuable indicators (such as number of deaths or confirmed SARS cases) is retrieved via *PCET* and then organized by *DSVT*. *PCET* allows to obtain (i) the overall 'snapshot' describing the status of the SARS epidemic crisis at the time instant in which the decision is taken and, with further queries, (ii) the status of the crisis at time instants after the decision. In such a way, the effects of the decision can be carefully evaluated.

## 5 Architecture

### 5.1 Software Component Architecture

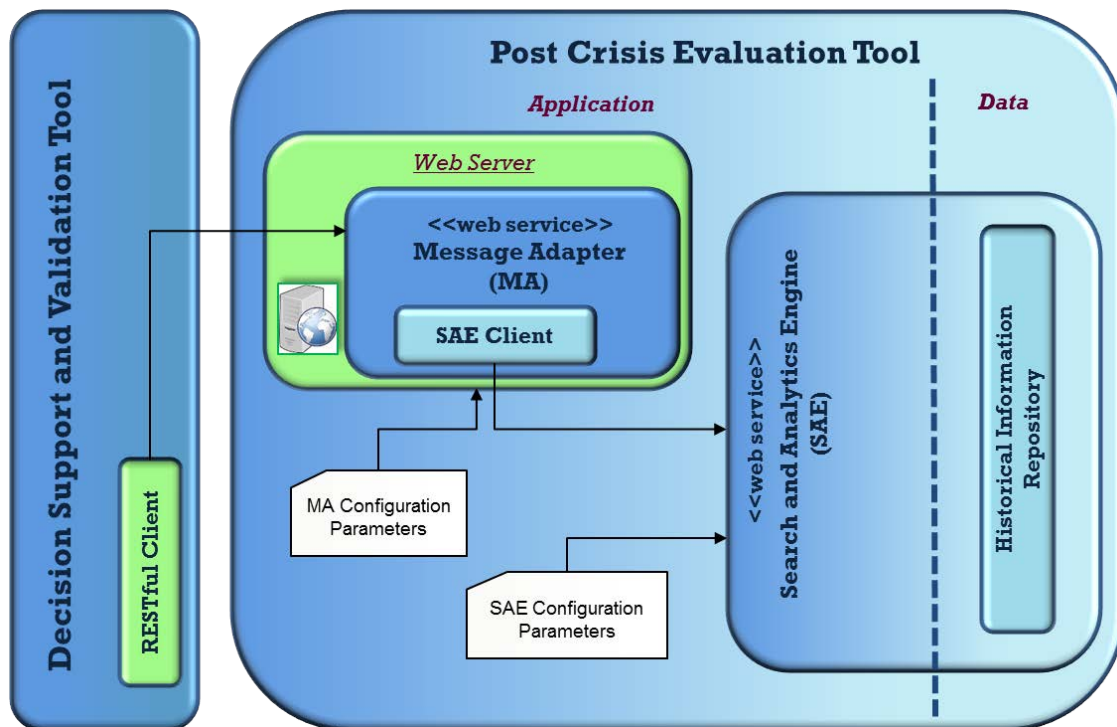
The component diagram and the schema in Figure 4 e Figure 5 show the internal architecture of *PCET*. This software component is composed of two core sub-modules that interact each other to offer to the outside world the functionalities described in section 4.2.



**Figure 4: Post Crisis Evaluation Tool Architecture – Component diagram**

The *Message Adapter* is the first of these internal sub-modules; it implements a Web Service equipped with a RESTful interface that allows the invocation of the *PCET* operations offered (i) to store and retrieve historical information and (ii) to compute related statistics. As highlighted in Figure 5, a dedicated Web Server is in charge to make available online the *Message Adapter's* Web Service. The related RESTful interface, indicated as *IHistoricalInformation* in Figure 4, in PULSE is invoked by the *DSVT* through its *DSVT Manager* which acts as a RESTful client.

When each operation is invoked, the *Message Adapter* recognizes the incoming MA request and translates it in a corresponding set of SAE requests to be forwarded to the *Search and Analytics Engine*. This process is required because often a single MA request received from the *Message Adapter*, needs to be subdivided into more than one SAE request created for the *Search and analytics Engine*, in order to obtain the expected result. Vice versa, the SAE responses produced by the *Search and Analytics Engine* for a set of SAE requests, have to be merged by the *Message Adapter* to build the overall MA response corresponding to the original MA request.



**Figure 5: Post Crisis Evaluation Tool Architecture - Schema**

The mentioned *Search and Analytics Engine* is the second core sub-module of the *PCET*; it allows to explore historical data with high speed performances and is able to elaborate real-time structured searches, analytics and geolocation queries. This sub-module is responsible for managing the operations aiming at storing and retrieving information into the *Historical Information Repository* that contains all the data used for the post crisis evaluation.

The data stored into that repository can scale in a cluster composed of multiple nodes and, if necessary, a certain number of replicas can also be maintained to improve the robustness of the software solution in case of default of one or more nodes.

Similarly to the *Message Adapter*, the *Search and Analytics Engine* can be controlled through a *Web Service* equipped with a *RESTful* interface. This interface can be invoked by the *Message Adapter*, through its internal *SAE Client*, whenever a *SAE* request for storing or retrieving historical information needs to be sent to the *Search and Analytics Engine*.

As depicted in Figure 5, both the *PCET* sub-modules have their reference configuration file. The settings decided for the parameters listed in these files determine the overall behavior of the *PCET* component in terms of network and data management.

## 5.2 Component relation to overall PULSE architecture

Figure 6 shows a component diagram of the *PULSE* Platform Architecture where the relation between *PCET* and *DSVT* is highlighted. As already mentioned in section 5.1, these two components interact each other through the *IHistoricalInformation* interface. In particular, *DSVT* invokes the *PCET* *Web Service* in the following cases:

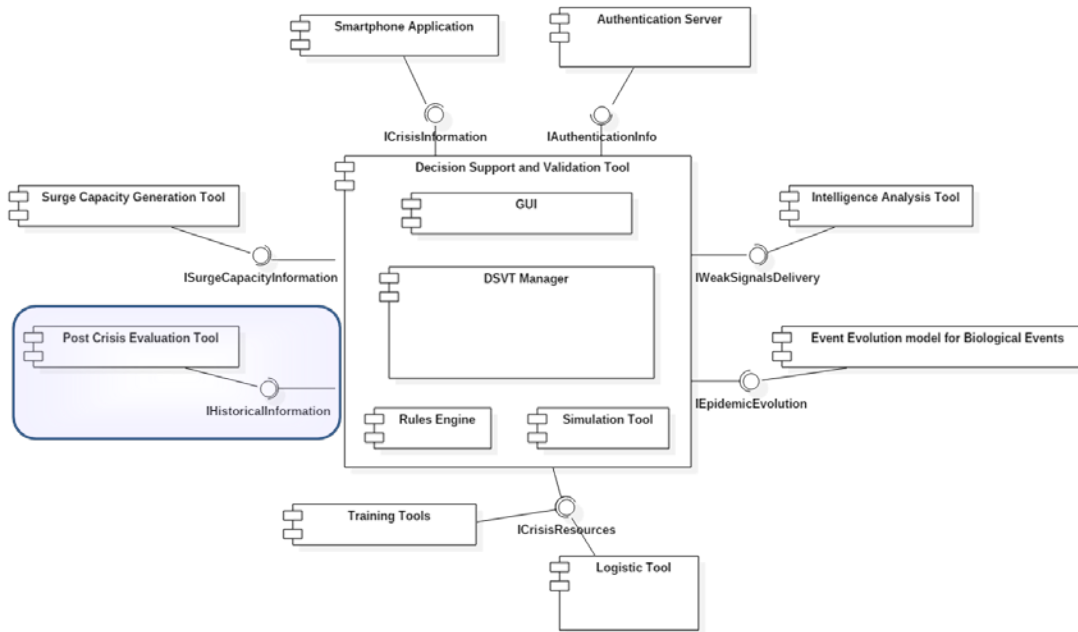
- periodically, for storing the ‘snapshots’ containing data that describes the status of the emergency in a specified time instant (for more details, refer to



section 4.2.1);

- whenever a decision related to the ongoing emergency is taken; also in this case the information sent to the *PCET* is provided in the form of ‘snapshot’;
- every time that a query or a set of queries needs to be performed in order to obtain information for the post crisis evaluation.

The interactions between *DSVT* and *PCET*, de facto, represent and summarize the actual relation of *PCET* with rest of the PULSE Platform Architecture.



**Figure 6: PULSE Platform Architecture – Component diagram**



## 6 Component Technologies

### 6.1 List of core technologies

As stated in section 5.1, *PCET* is composed of two core sub-modules: *Message Adapter* and *Search and Analytics Engine*. The core technologies adopted for the implementation of these sub-modules are:

- *Jetty* – It is a Java-based Web Server used to make available online the *Message Adapter’s* Web Service. It implements an HTTP server and servlet container capable of serving static and dynamic content either from a standalone or embedded instantiations. This technology is developed as a free and open source project as part of the Eclipse Foundation [5].
- *Jersey* – It is an open source framework [6] that provides an API extending the JAX-RS toolkit [7] with additional functionalities, with the purpose of simplifying the implementation of RESTful services. This technology is used to build the Web Service RESTful interface offered by the *Message Adapter*.
- *Elasticsearch* - It is an open source search engine built on top of *Apache Lucene* [8] and is used to implement the *Search and Analytics Engine*. *Elasticsearch* represents the core technology used in *PCET* and acts as:
  - a distributed and real-time document store where every field is indexed and searchable;
  - a distributed search engine elaborating real-time analytics;
  - a solution capable of scaling to hundreds of servers and petabytes of structured and unstructured data.

All these capabilities are packaged into a stand-alone server that can be invoked via a simple RESTful API [9].

- *Elasticsearch Java Client* – It is a Java-based client that allows to execute all the *Elasticsearch* operations. Each operation may be accumulated and executed in a ‘bulk’ together to other operations [10]. *Elasticsearch Java Client* is used to implement the *Message Adapter’s* *SAE Client*.

### 6.2 3<sup>rd</sup> Party libraries and licenses

Table 1 reports a list of third party libraries/frameworks used for the *PCET* implementation and the licenses under which they are distributed.

**Table 1 - 3<sup>rd</sup> party libraries and licenses**

Product	Version	Vendor	License
<b>Jetty</b>	9.2.10	Eclipse	Apache 2.0
<b>Jersey</b>	2.17	Oracle Corporation	Dual License: - CDDL 1.1 - GNU GPL 2
<b>Elasticsearch</b>	1.6.0	Elastic	Apache 2.0
<b>Elasticsearch Java API</b>	1.6.0	Elastic	Apache 2.0
<b>Java JSON</b>	1.6.0	Sun Microsystems	Copyright 2002 JSON.org



## References

- [1] PULSE Project – Description of Work, version 1.0, October 2013.
- [2] PULSE Project Deliverable – D2.2 Use case specification.
- [3] PULSE Project Deliverable – D4.1 Decision Support Validation Tool.
- [4] PULSE Project Deliverable – D4.2 IAT Tool.
- [5] Jetty Project by Eclipse Foundation – Homepage – <http://www.eclipse.org/jetty>.
- [6] Jersey by Oracle Corporation – Homepage – <https://jersey.java.net>.
- [7] JAX-RS Project by Oracle Corporation, Project Kenai and Cognisync – Homepage – <https://jax-rs-spec.java.net>.
- [8] Apache Lucene Project by Apache Software Foundation – Homepage – <https://lucene.apache.org>.
- [9] Elasticsearch by Elastic – Definitive Guide: ‘*You Know, for Search...*’ – <https://www.elastic.co/guide/en/elasticsearch/guide/current/intro.html>.
- [10] Elasticsearch by Elastic – Java API: ‘*Preface*’ – <https://www.elastic.co/guide/en/elasticsearch/client/java-api/current/java-api.html>.