

Emergency Response: A Multi-Agent System

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1 Introduction

2 Crew Design and Implementation

2.1 Emergency Services Crew

2.1.1 Process Definition

1. **Receive and Assess Call.** The *Emergency Call Agent* receives incoming calls and collects relevant details about the incident. This task requires human input for accurate interpretation and contextual understanding of the caller's description, ensuring critical information is gathered effectively. The information that this agent receives answers the following six questions and is saved in a report:
 - What type of fire is it? E.g. ordinary, electrical, gas, etc.
 - Where is it? The location is received as coordinates (x, y) .
 - Is anyone injured? How badly? The answer will be a list of strings, detailing the risk level of each person. If the list is empty then there will be no injured people and it will be unnecessary to report it to the *Medical Service Crew*.
 - How severe is the fire? It will be considered as low, medium or high.
 - Are there hazards? Examples of hazards could include gas cylinders, chemicals, explosions, etc.
 - Is it an indoor or outdoor fire? The answer will be either *outdoor* or *indoor*.
 - Is anyone inside or trapped? The answer will be an integer number M representing the number of trapped people. If $M > 0$, rescues are needed, and the *Notification Agent* will detail that to the Fire Fighters Crew.
2. **Notify Other Crews Decision.** The *Notification Agent* receives the details about the fire then it decides which crew should be notified and send all the information to the flow. It also decides whether the medical services are required or not, depending on the human input related to the injured individuals.

Task Dependencies: The sequential workflow for the Emergency Services Crew depends on task dependencies to ensure efficiency and coordination:

- The *Notify Other Crews Task* depends on the completion of the *Receive and Assess Call Task*, which involves human input to accurately assess and interpret the situation.

The task dependencies and agents who perform each task can be observed in Figure 1.

2.1.2 Implementation

2.1.3 Pydantic Outputs

Structured outputs ensure accurate information handling and effective communication within the Emergency Services Crew. Below are the Pydantic models designed for each task's output.

Receive and Assess Call Task Output

```
1 class EmergencyDetails(BaseModel):
2     fire_type: FireType # Type of fire (e.g., ordinary, electrical, gas, etc.)
3     location: Location # Coordinates (x, y)
4     injured_details: List[InjuryType] # List of risk levels of injured people
5     fire_severity: FireSeverity # Severity of fire: low, medium, or high
6     hazards: List[HazardType] # Hazards present, e.g., gas cylinders, chemicals
7     indoor: bool # True if fire is indoor, False otherwise
8     trapped_people: int # Number of people trapped (0 if none)
```

Listing 1: Pydantic model for Receive and Assess Call Task Output

Notify Other Crews Task Output

```
1 class CallAssessment(BaseModel):
2     fire_type: FireType
3     location: Location
4     injured_details: List[InjuryType]
5     fire_severity: FireSeverity
6     hazards: List[HazardType]
```

Sequential Process Flow with Agent Responsibility



Figure 1: Sequential Process Flow of the Medical Services Crew with Agent Responsibilities

```

7 indoor: bool
8 trapped_people: int
9 medical_services_required: bool # True if medical services are required, False
  otherwise
  
```

Listing 2: Pydantic model for Notify Other Crews Task Output

Summary of Outputs The Pydantic outputs for the *Emergency Services Crew* ensure structured data handling and effective communication between agents. Below is a summary of the outputs for each task:

- **Receive and Assess Call Task Output:** Captures critical incident details including fire type, location, injured details, severity, hazards, indoor/outdoor status, and trapped individuals.
- **Notify Other Crews Task Output:** Adds to the *Call Assessment* model to include information about whether medical services are required.

2.2 Firefighter Agent Crew

2.2.1 Process Definition

The Firefighter Agent Crew operates within a structured **sequential process** to ensure effective and coordinated response to fire emergencies. Each task is assigned to a specific agent with well-defined responsibilities, as detailed below:

1. **Receive Report:** The *Fire Chief* receives a fire assessment from the Emergency Service Operator. This serves as the starting point of the process, containing critical information such as the location and severity of the fire.
2. **Allocate Firefighting Resources:** The *Equipment Technician* determines if there exact resources required to combat the fire in question.
3. **Deploy Fire Combatants:** The *Fire Combatants* are deployed to the place of the fire, reporting an estimation of the time of arrival and a list of the fire fighting activities that will have to be performed.
4. **Report Firefighting Response:** The *Fire Chief* reports back a comprehensive summary of the firefighting activities.

Task Dependencies The sequential process relies on strict task dependencies to maintain an organized workflow:

- *Allocate Firefighting Resources* depends on the completion of *Receive Report*.
- *Deploy Fire Combatants* depends on the completion of *Deploy Fire Combatants*.
- *Report Firefighting Response* depends on the completion of *Deploy Fire Combatants*.

The visual representation in Figure 2 highlights these dependencies and assigns colors to denote the responsible agents.

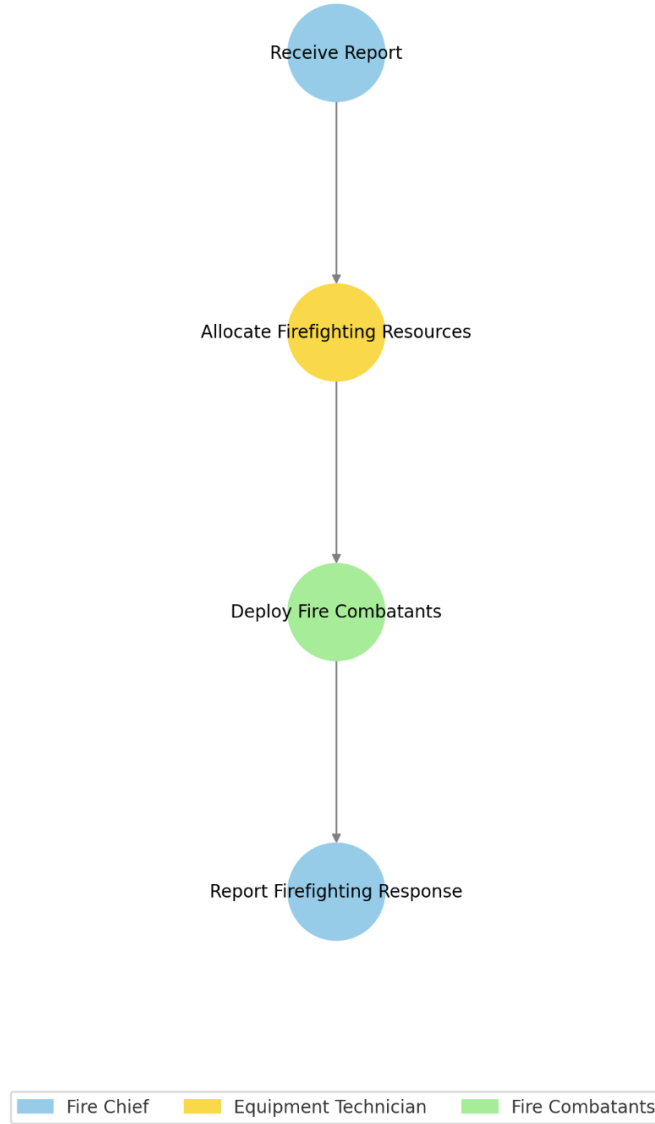


Figure 2: Sequential Process Flow of the Firefighter Crew with Agent Responsibilities

2.2.2 Implementation

2.2.3 Pydantic Outputs

Structured outputs ensure effective communication and accountability among team members in the Firefighter Agent Crew. Below are the Pydantic models designed to encapsulate outputs for each task in the firefighting process:

Receive Report Task Output

```

1 class FireAssessment(BaseModel):
2     location: Location # Coordinates (x, y)
3     fire_type: FireType # Type of fire fire_severity
  
```

```

4     fire_severity: FireSeverity # Severity of fire: low, medium, or high
5     trapped_people: int # Number of trapped individuals
6     hazards: List[HazardType] # Hazards present
7     hazards_present_indoor: bool # True if fire is indoor, False otherwise

```

Listing 3: Pydantic model for Receive Report Task Output

Allocate Firefighting Resources Task Output

```

1 class FireFightingMaterial(BaseModel):
2     material_name: Literal[
3         "pickup_truck",
4         "ladder_engine",
5         "water_tanker",
6         "foam_tanker",
7         "dry_chemical_tanker",
8         "air_tanker",
9     ]
10    material_quantity: int
11
12 class AllocatedFirefightingResources(BaseModel):
13     fire_assessment: FireAssessment
14     resources: List[FireFightingMaterial]

```

Listing 4: Pydantic model for Allocate Firefighting Resources Task Output

Deploy Fire Combatants Task Output

```

1 class FirefightingActivity(BaseModel):
2     firefighting_activity: str
3     priority: Literal["low", "medium", "high"]
4
5 class DeployedFireCombatants(BaseModel):
6     fire_assessment: FireAssessment
7     firecombatants_deployed: int
8     estimated_arrival_time: datetime
9     firefighting_activities: List[FirefightingActivity]

```

Listing 5: Pydantic model for Deploy Fire Combatants Task Output

Report Firefighting Response Task Output

```

1 class FirefightersResponseReport(BaseModel):
2     summary: str
3     timestamp: datetime

```

Listing 6: Pydantic model for Report Firefighting Response Task Output

Summary of Outputs

- **Receive Fire Report Task Output:** Captures the essential details from the initial fire report, including fire type, severity, hazards, and any trapped individuals.
- **Allocate Firefighting Resources Task Output:** Documents the allocation of firefighting materials, including quantities and resource types.
- **Deploy Fire Combatants Task Output:** Tracks the deployment of personnel, estimated arrival times, and prioritized firefighting activities.
- **Report Firefighting Response Task Output:** Summarizes the firefighting response plan.

2.3 Medical Services Crew

2.3.1 Process Definition

The Medical Services Crew operates follows a **sequential** task structure to plan the treatment and evacuation of injured people from the emergency site. The tasks included within the Medical Services are:

1. **Receive Report:** The *Medical Services Operator* receives the medical assessment of the fire incident, and parses key information, such as the location, the number of injured, and the severity of injuries.
2. **Rank Hospitals:** The *Hospital Coordinator* ranks the city's hospitals based on distance to the emergency location.
3. **Allocate Hospital Resources:** The *Hospital Coordinator* assesses the available resources (beds, ambulances, paramedics) at the hospitals, and allocates their resources according to the needs of the emergency.
4. **Deploy Paramedics:** The *Paramedics* plan their deployment to the place of the incident, reporting the total number of paramedics and ambulances dispatched, as well as their estimated times of arrival, and any special equipment that they could need.
5. **Report Medical Response:** The *Medical Services Operator* reports back a comprehensive summary of the response plan.

Task Dependencies The sequential nature of the process requires to establish task dependencies to define the crew's workflow:

- The *Rank Hospitals* task depends on the completion of the *Recieve Report* task.
- The *Allocate Hospital Resources* task depends on the completion of *Rank Hospitals*.
- The *Deploy Paramedics* task depends on the completion of *Allocate Hospital Resources*.
- The *Report Medical Response* task depends on the completion of *Deploy Paramedics*.

The task dependencies and agents who perform each task can be observed in Figure 3.

2.3.2 Implementation

2.3.3 Pydantic Outputs

Structured outputs ensure consistency and facilitate effective collaboration among agents within the Medical Services Crew. Below are the Pydantic models for each task's output:

Receive Report Task Output

```

1 class MedicalAssessment(BaseModel):
2     location: Location # Coordinates (x, y)
3     injured_details: List[InjuryType] # List of risk levels of injured people
4     fire_severity: FireSeverity # Severity of fire: low, medium, or high
5     hazards: List[HazardType] # Hazards present, e.g., gas cylinders, chemicals

```

Listing 7: Pydantic model for Receive Report Task Output

Rank Hospitals Task Output

```

1 class Hospital(BaseModel):
2     hospital_id: str
3     location: Location
4     available_beds: int
5     available_ambulances: int
6     available_paramedics: int
7
8 class RankedHospitals(BaseModel):
9     medical_assessment: MedicalAssessment
10    ranked_hospitals: List[Hospital]
11    timestamp: datetime

```

Listing 8: Pydantic model for Rank Hospitals Task Output

Medical Services Crew Task Flow

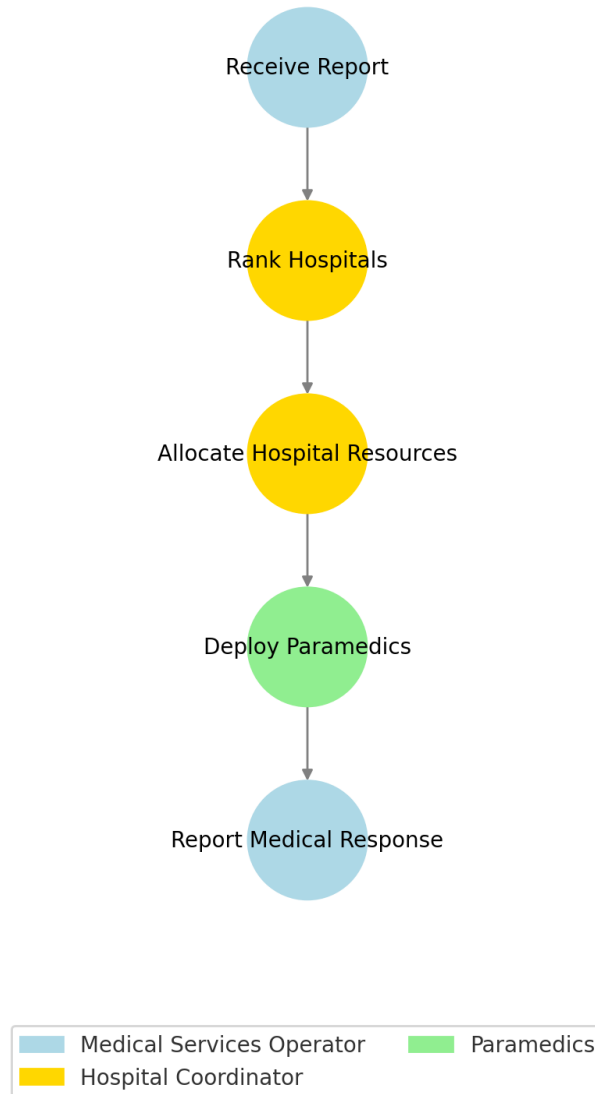


Figure 3: Sequential Process Flow of the Medical Services Crew with Agent Responsibilities

Allocate Hospital Resources Task Output

```

1 class HospitalResources(BaseModel):
2     hospital_id: str
3     beds_reserved: int
4     ambulances_dispatched: int
5     paramedics_deployed: int
6
7 class AllocatedHospitalResources(BaseModel):
8     medical_assessment: MedicalAssessment
9     hospital_resource_allocation: List[HospitalResources]
10    timestamp: datetime
  
```

Listing 9: Pydantic model for Allocate Hospital Resources Task Output

Deploy Paramedics Task Output

```

1 class MedicalEquipment(BaseModel):
2     equipment_name: Literal[
3         "oxygen_mask",
4         "stretcher",
5         "defibrillator",
6         "IV_drip",
7         "other",
  
```

```

8     ]
9     use_case: str
10
11
12 class DeployedParamedics(BaseModel):
13     medical_assessment: MedicalAssessment
14     total_paramedics_deployed: int
15     total_ambulances_dispatched: int
16     estimated_arrival_times: List[datetime]
17     equipment: List[MedicalEquipment]

```

Listing 10: Pydantic model for Deploy Paramedics Task Output

```

1 class MedicalResponseReport(BaseModel):
2     summary: str
3     timestamp: datetime

```

Listing 11: Pydantic model for Report Medical Response Task Output

Summary of Outputs

- **Receive Report Task Output:** Captures the key details of the fire incident, including injury data.
- **Rank Hospitals Task Output:** Ranks the available hospital based on distance to the emergency site.
- **Allocate Hospital Resources Task Output:** Summarizes the resources provided by each hospital for emergency medical care.
- **Deploy Paramedics Task Output:** Reports the deployment plan, estimated times of arrival of each ambulance, and special medical equipment to be brought.
- **Report Medical Response Task Output:** Provides an overall response plan.

2.4 Public Communication Crew

2.4.1 Process Definition

The Public Communication Crew operates within a structured **sequential process** to ensure efficient and accurate communication of fire incident reports to the public. Each task is assigned to a specific agent with well-defined responsibilities, as detailed below:

1. **Receive Report:** The *Communication Operator* obtains the call assessment, fire report, and medical report in Markdown format. This serves as the starting point for the process and can filter any information that is not relevant for this crew.
2. **Search Related Cases:** The *Archive Keeper* searches for past incidents with similar locations or fire types. This task depends on the completion of the *Receive Report* task.
3. **Draft Initial Article:** The *Article Writer* drafts an initial article based on the current report. This task also depends on the completion of the *Receive Report* task.
4. **Integrate Additional Information:** The *Article Writer* integrates insights from related cases into the draft. This task requires the completion of both the *Search Related Cases* and *Draft Initial Article* tasks.
5. **Review and Authorize Publication:** The *Mayor* reviews the article and either authorizes publication or provides feedback for revisions. This task depends on the completion of the *Integrate Additional Information* task.
6. **Provide Social Media Feedback:** The *Social Media Commentator* critiques the emergency response in a humorous yet constructive manner. This task depends on the approval of the article by the *Mayor*.

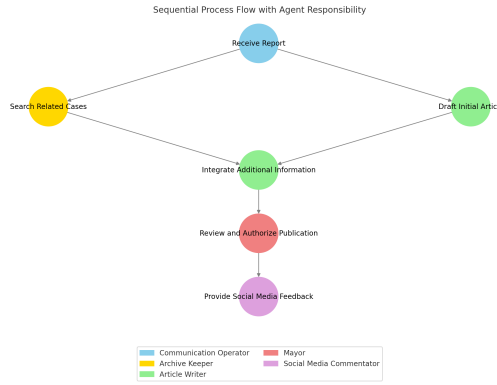


Figure 4: Sequential Process Flow of the Public Communication Crew with Agent Responsibilities

Task Dependencies The sequential process relies on strict task dependencies to ensure an organized workflow:

- *Search Related Cases* and *Draft Initial Article* can be executed in parallel but both depend on *Receive Report*.
- *Integrate Additional Information* requires the completion of both *Search Related Cases* and *Draft Initial Article*.
- *Review and Authorize Publication* depends on *Integrate Additional Information*.
- *Provide Social Media Feedback* requires article approval from the *Mayor*.

The visual representation in Figure 4 highlights these dependencies and assigns colors to denote the responsible agents, ensuring clarity and accountability.

2.4.2 Implementation

2.4.3 Pydantic Outputs

Structured outputs are crucial for ensuring clarity, consistency, and seamless integration across tasks. Below are the Pydantic models designed for the tasks in the Public Communication Crew process:

Receive Report Task Output

```

1 class EmergencyReport(BaseModel):
2     call_assessment: CallAssessment
3     firefighters_response_report: FirefightersResponseReport
4     medical_response_report: MedicalResponseReport
5     timestamp: datetime
6     fire_severity: FireSeverity
7     location_x: float
8     location_y: float

```

Listing 12: Pydantic model for Receive Report Task Output

Search Related Cases Task Output

```

1 class RelatedCase(BaseModel):
2     case_id: int
3     fire_severity: FireSeverity
4     location_x: float
5     location_y: float
6     summary: str
7
8
9 class RelatedCases(BaseModel):
10     related_cases: List[RelatedCase]

```

Listing 13: Pydantic model for Search Related Cases Task Output

Draft Initial Article Task Output

```
1 class DraftArticle(BaseModel):  
2     title: str  
3     public_communication_report: str
```

Listing 14: Pydantic model for Draft Initial Article Task Output

Integrate Additional Information Task Output

```
1 class IntegratedArticle(BaseModel):  
2     public_communication_report: str  
3     integrated_sources: List[str]
```

Listing 15: Pydantic model for Integrate Additional Information Task Output

Review and Authorize Publication Task Output

```
1 class ReviewedArticle(BaseModel):  
2     public_communication_report: str  
3     mayor_approved: bool  
4     mayor_comments: str
```

Listing 16: Pydantic model for Review and Authorize Publication Task Output

Provide Social Media Feedback Task Output

```
1 class PublicCommunicationReport(BaseModel):  
2     public_communication_report: str  
3     mayor_approved: bool  
4     mayor_comments: str  
5     social_media_feedback: str
```

Listing 17: Pydantic model for Provide Social Media Feedback Task Output

Summary of Outputs

- **Receive Report Task Output:** Captures the initial fire incident report relevant details from *Emergency Services Crew*, *Firefighters Crew*, and *Medical Services Crew*.
- **Search Related Cases Task Output:** Retrieves relevant historical cases for contextualization and save this case.
- **Draft Initial Article Task Output:** Records the initial draft content.
- **Integrate Additional Information Task Output:** Updates the draft with integrated sources and revisions.
- **Review and Authorize Publication Task Output:** Specifies the review status and comments from the Mayor.
- **Provide Social Media Feedback Task Output:** Details feedback posted on social media platforms, he can criticize the mayor's decision.

3 Crew Interaction

3.1 CrewAI Flow

4 Results

5 Conclusion

6 References

References