# Minimizing Average Response Times in a Dynamic Ambulance Management Model

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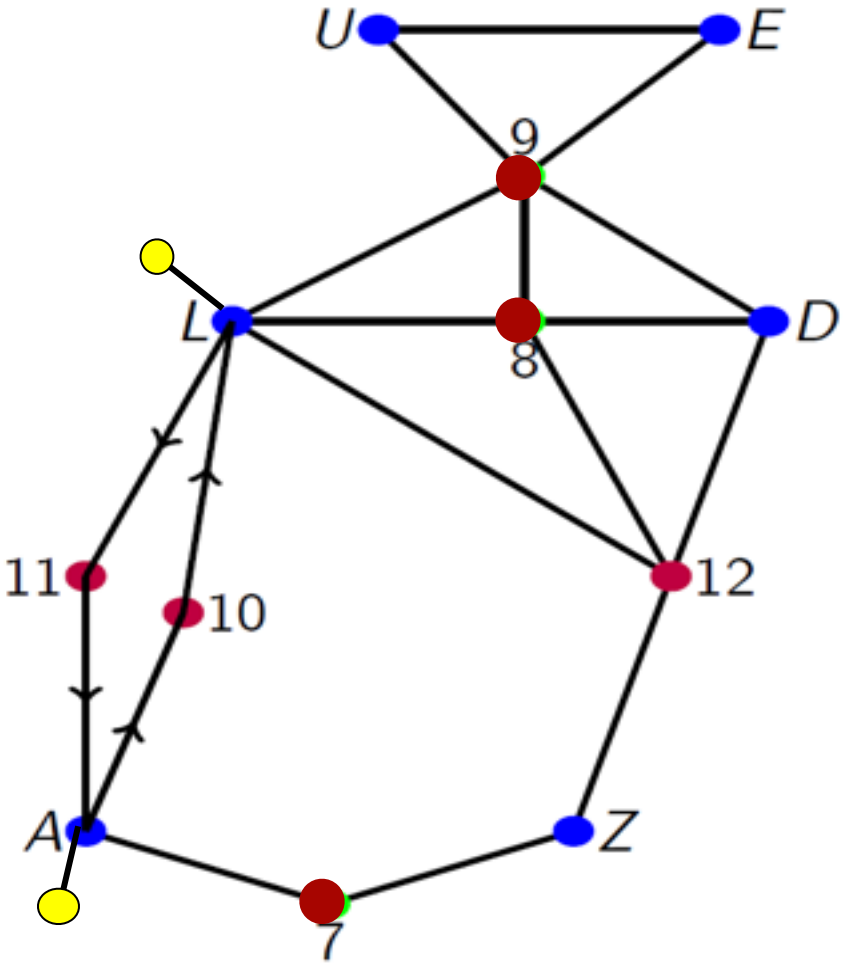
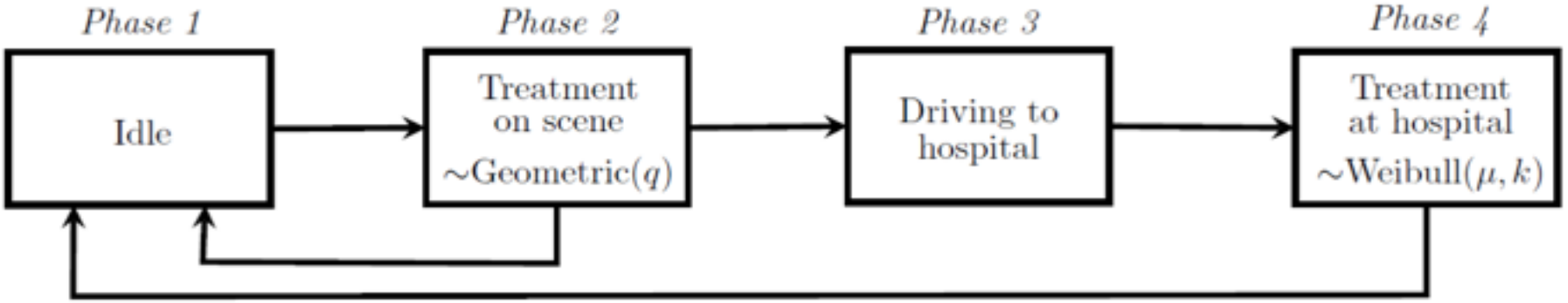
# Region




- **Equidistant graph**
- **Blue: Demand locations**
- **Yellow: Hospitals**
- **Red: Additional nodes**

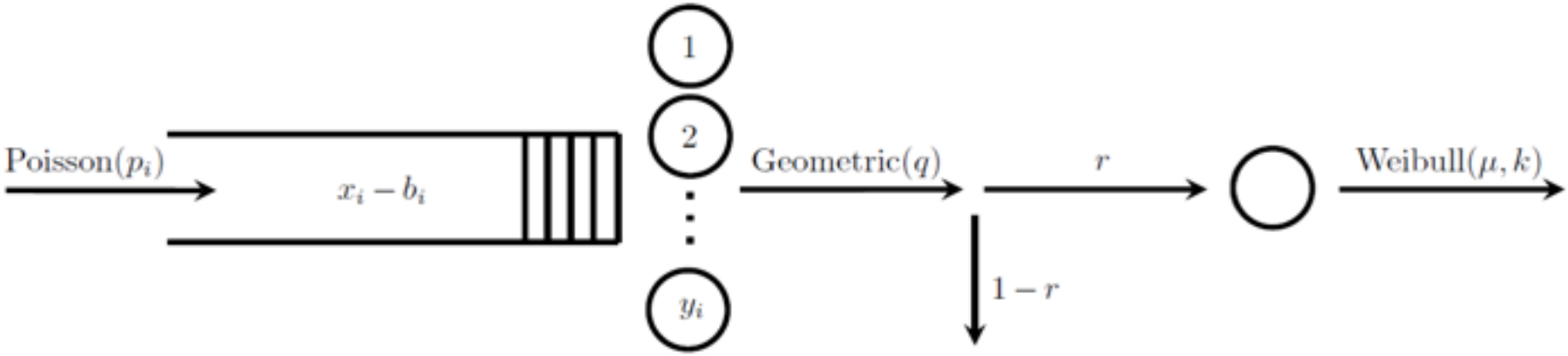
# Ambulance Phases




Different Stages of Ambulances.

- $q$: Parameter Geometric distribution
- $\mu$: Scale parameter Weibull distribution
- $k$: Shape parameter Weibull distribution

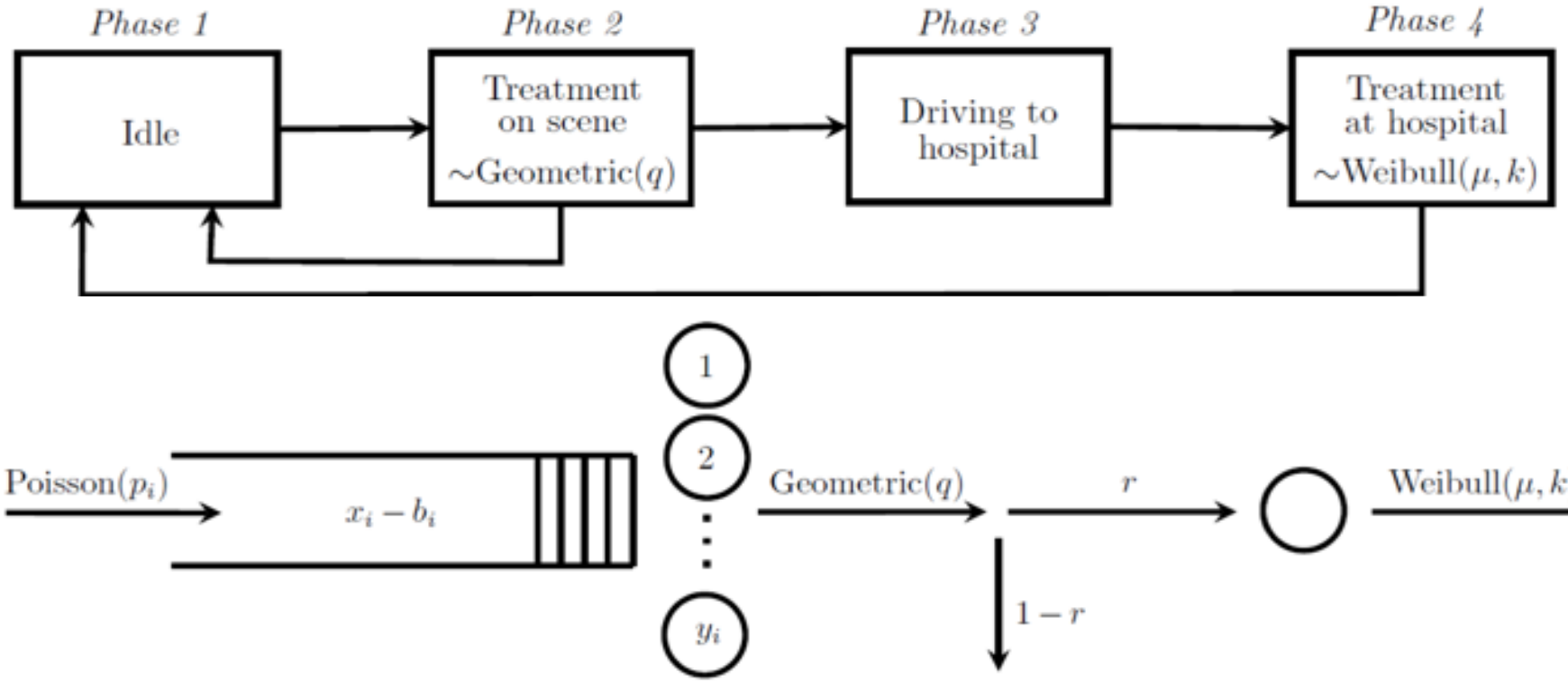
# "Life Cycle" of a Request




"Life Cycle" of a Request arriving at Location $i$.

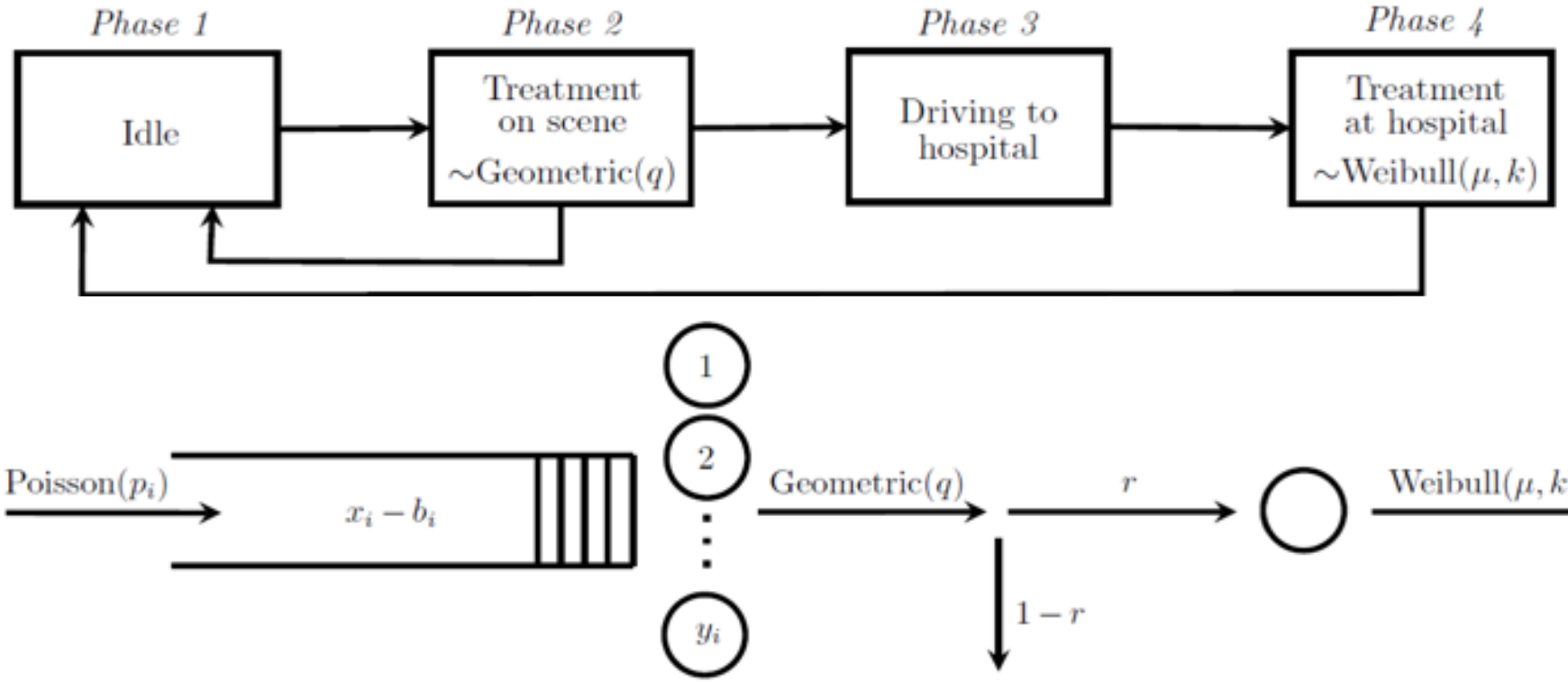
- $p_i$: Parameter Poisson distribution location $i$
- $x_i$: Total number of patients at demand location $i$
- $b_i$: Number of busy ambulances at location $i$
- $y_i$: Total number of ambulances at location $i$
- $r$: Probability to hospital

# State components



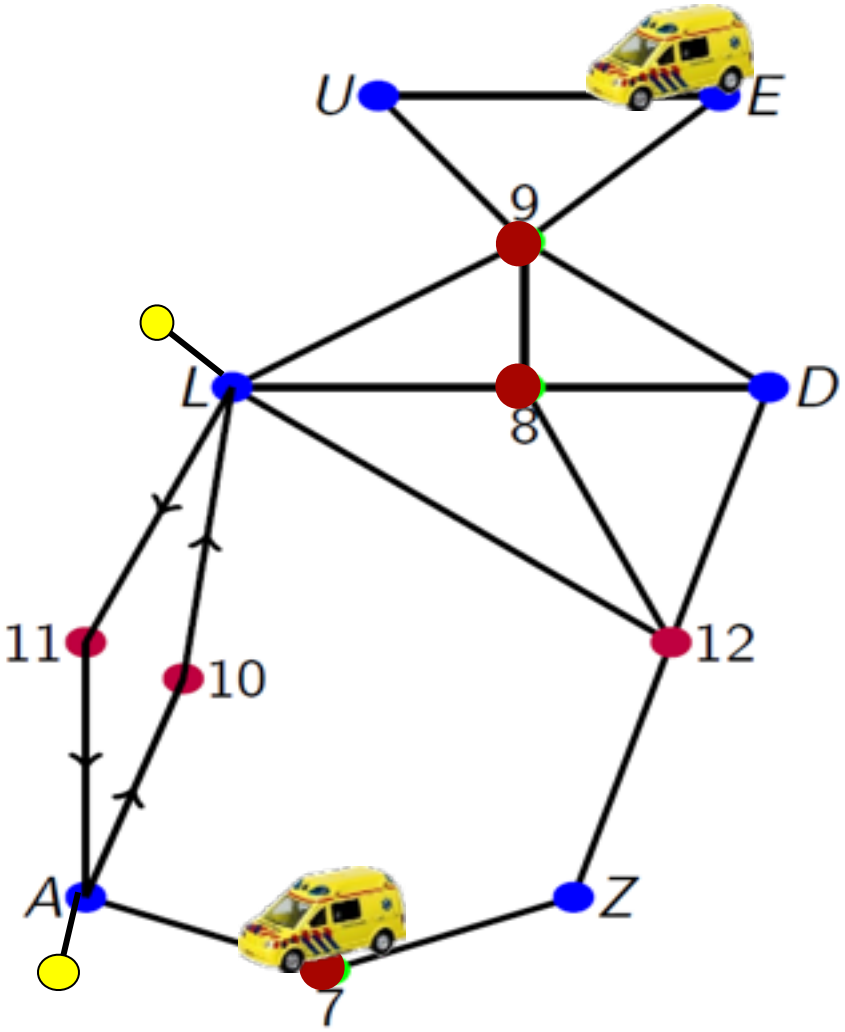

1. **Number of patients per demand location** $(x_i)$
2. **Number of ambulances either in phase 1, 2, 4 per demand location**
3. **Number of patients that needs transportation to hospital per demand location**

# State components




4. **Elapsed service time of ambulances in phase 4**
5. **Destinations and remaining driving times of phase 3 ambulances**

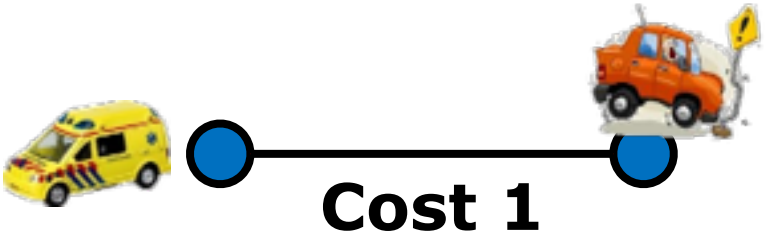
# Actions

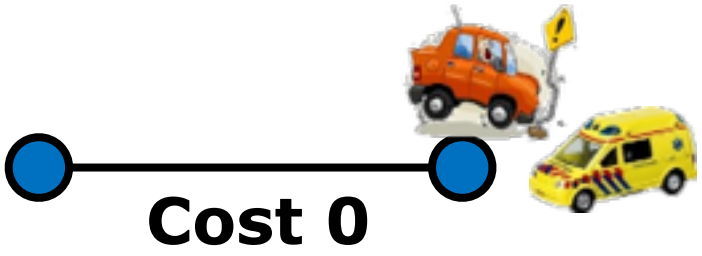



- **Dispatch nearest ambulance**
- **Change in ambulance configuration**

# Objective

- **Cost in a state: number of patients waiting**
- **Minimize costs: minimize the average number of patients waiting**
- **Minimize the average response time**

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# Heuristic Solution - Idea

- **Observe state**
- **Consider all actions**
- **Consider possible scenarios**
- **Combine each action with each scenario**
- **Classify each action and optimize**

# Scenarios

- **Possible next state**
- **One new request**
- **Ambulances that finish service**

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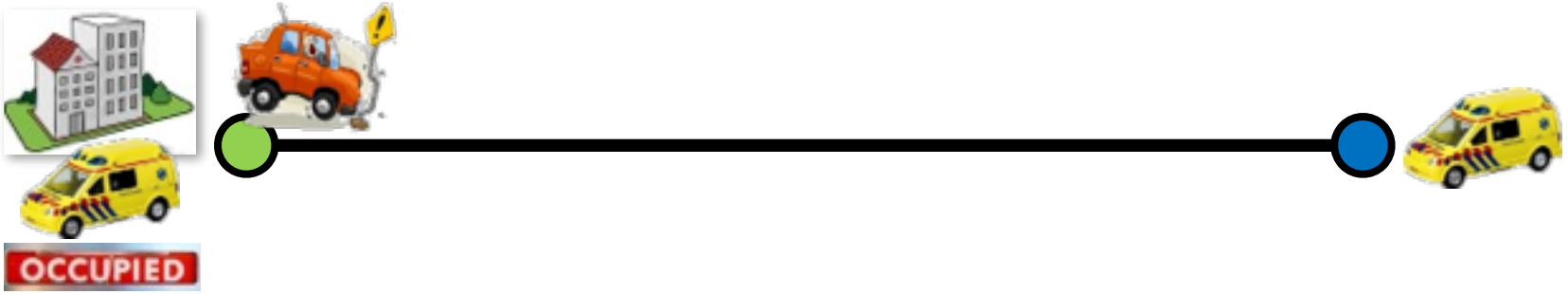

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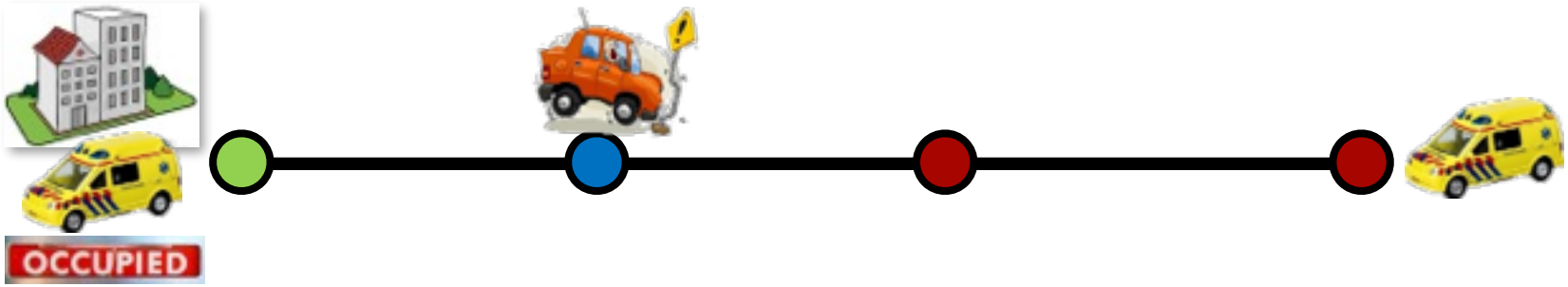
# Eligible ambulances

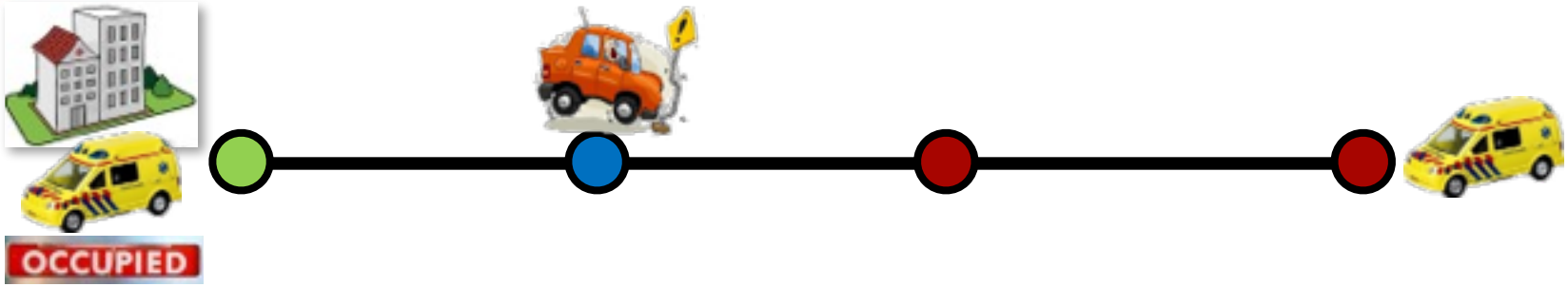
**Eligible for responding to new request:**

1. **Nearest idle unassigned ambulance**
2. **Nearest busy ambulance at hospital**
3. **Nearest busy ambulance on scene, not required to transport**

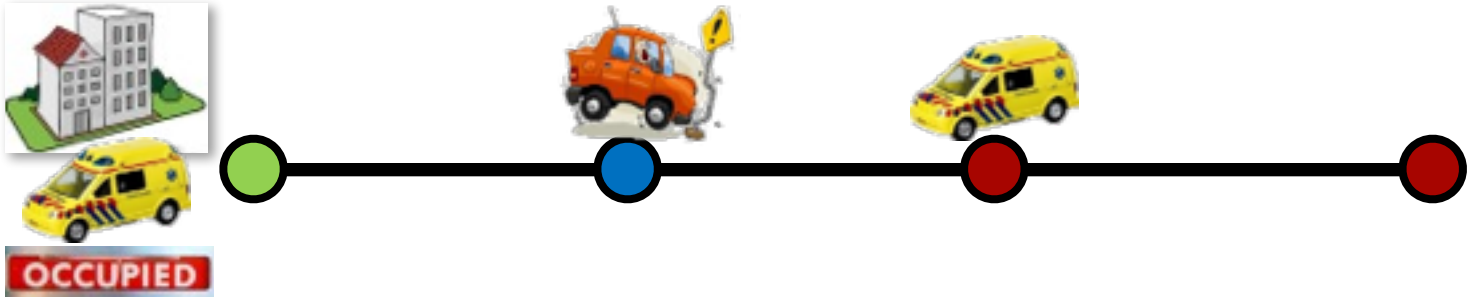



**Expected shortest response time**

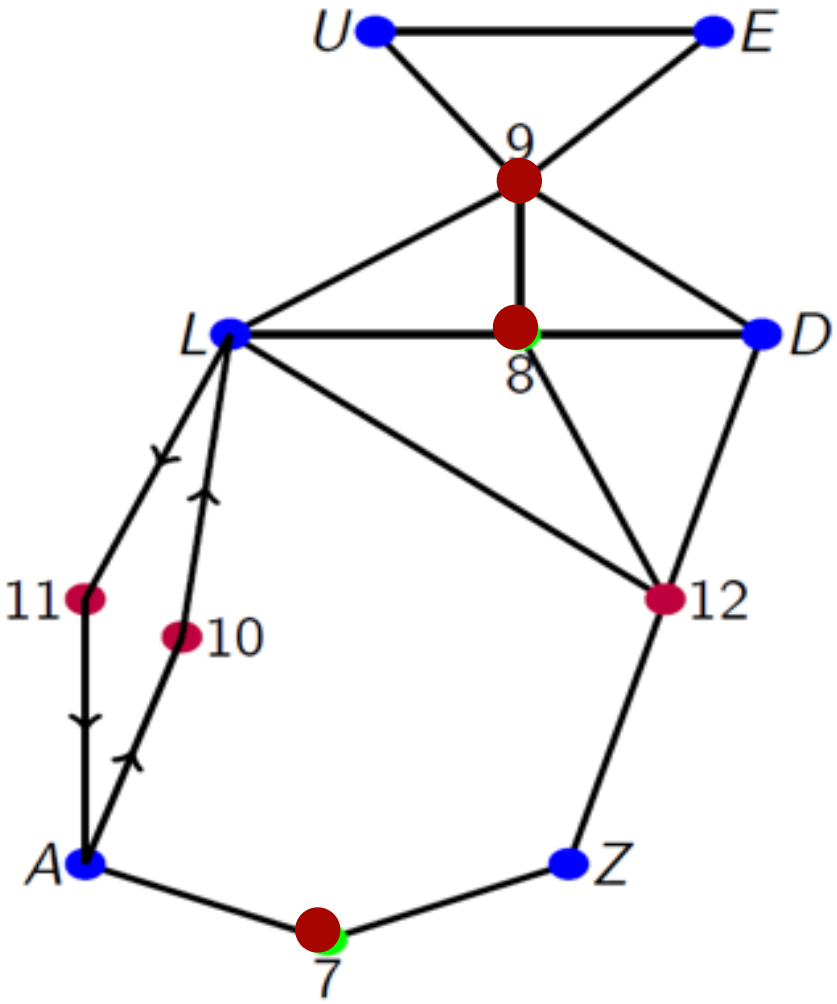
# Example



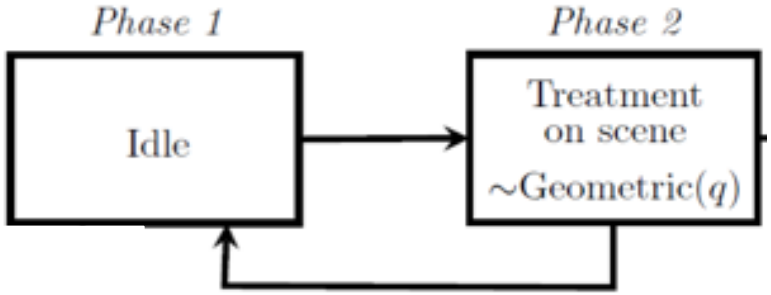

- Classify action:
  - Scenario probability × Expected shortest response time to request
  - Sum over scenarios
  - Take best classified action



# Results

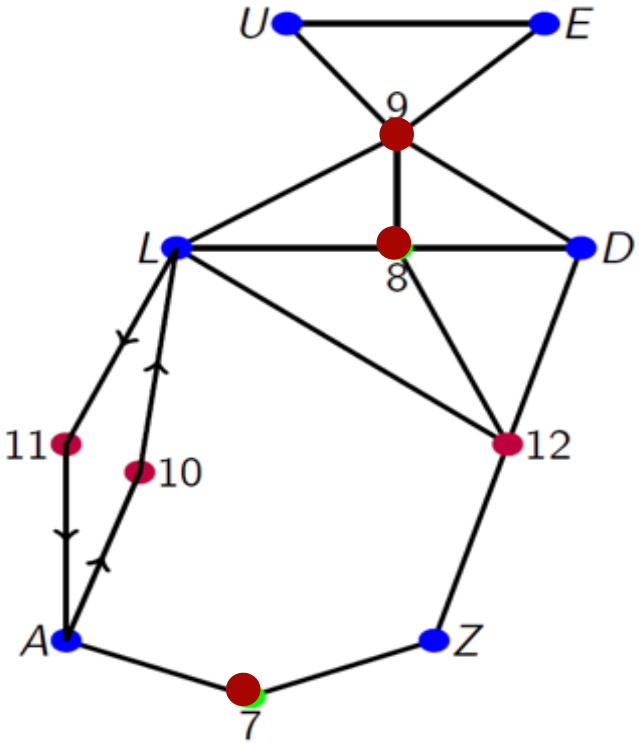



- $p_i$'s estimated using historical data
- No hospitals
- $q = 0.3$
- 4 ambulances



# Results

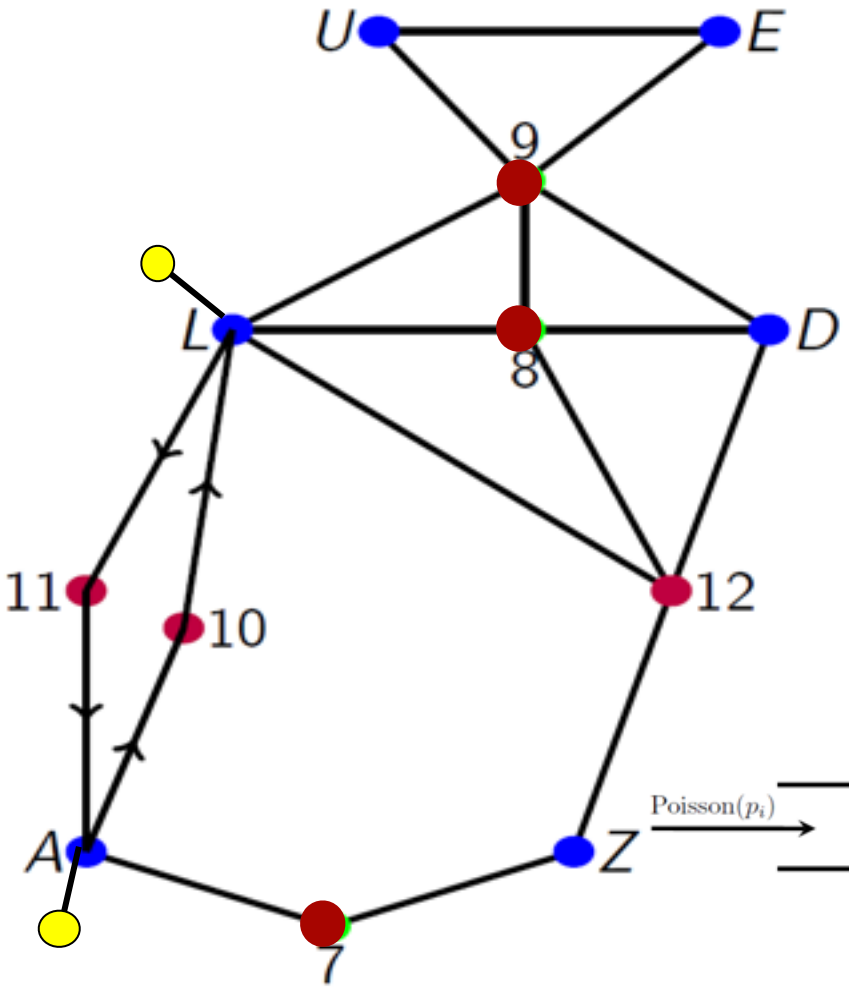
| | Mean Response Time | 95% Confidence Interval | Compared to Optimal |
|---|---|---|---|
| Heuristic | 0.6901 | [0.6818, 0.6984] | 4.01% |
| Optimal | 0.6624 | [0.6547, 0.6701] | - |
| Compliance Table | 0.7521 | [0.7437, 0.7605] | 11.93% |



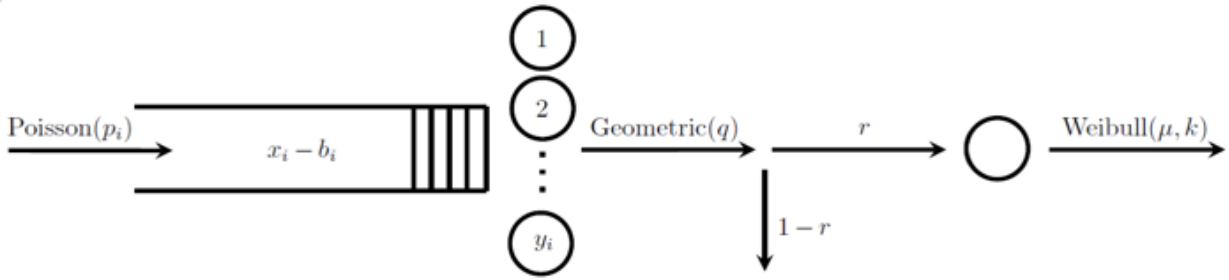

- $p_A = 0.1568$
- $p_L = 0.0743$
- $p_Z = 0.0167$
- $p_D = 0.0223$
- $p_U = 0.0120$
- $p_E = 0.0162$

| # | Compliance Table |
|---|---|
| *1* | *A* |
| *2* | *A, L* |
| *3* | *A, L, 9* |
| *4* | *A, L, D, E* |

# Results

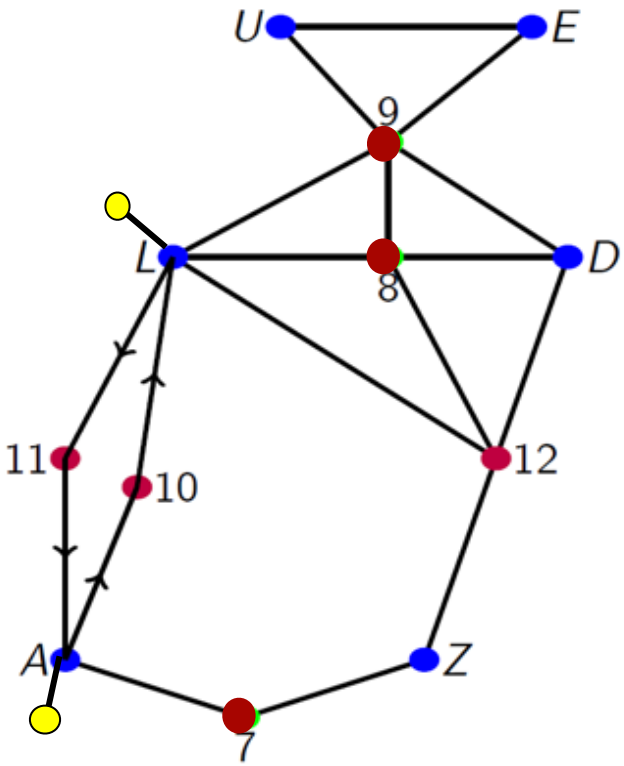



- $p_i$'s as before
- 2 hospitals:
- $q = r = 0.75$
- $\mu = 3.1,\ k = 2.5$
- 6 ambulances



# Results

| | Mean Response Time | 95% Confidence Interval |
|---|---|---|
| Heuristic | 0.3110 | [0.3076, 0.3144] |
| Compliance Table | 0.3448 | [0.3406, 0.3489] |

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# Questions?