Intelligent Public Safety System

A Real-Time Safety Network for Smart Cities

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Problem Statement: The Need for Intelligent Public Safety

- Urban areas face rising safety challenges: fires, accidents, crime, and natural disasters.
- Delays in detection and response exacerbate damage and risk to human life.
- Smart cities require integrated systems for proactive safety management

Some Statistics

- **Fires in Urban Areas:**

According to the National Fire Protection Association (NFPA), approximately 60% of all fire deaths in the U.S. occur in homes, with a significant number of those being high-rise buildings in urban areas. Delayed responses are a key factor, with studies indicating that firefighting operations are slower and less effective in taller structures (NFPA, 2020).

Source: National Fire Protection Association (NFPA) "Fire Loss in the United States" (2020).

- **Car Accidents:**

The World Health Organization (WHO) reports that road traffic injuries are the leading cause of death globally among young people aged 5-29 years. In urban areas, the number of traffic-related deaths is disproportionately high due to congestion and high vehicle density. According to WHO, nearly 1.35 million people die each year in road traffic accidents, with a significant proportion occurring in cities.

Source: World Health Organization (WHO) "Global Status Report on Road Safety 2018."

Some Statistics

- **Crime in Urban Areas:**

The United Nations Office on Drugs and Crime (UNODC) reports that crime rates, particularly violent crime, are consistently higher in urban areas. Urbanization has been linked to an increase in both property crime and violent crime, including homicide and robbery. The UNODC's 2020 report highlights that crime rates are often exacerbated by factors like overcrowding, social inequality, and lack of sufficient law enforcement presence in high-risk urban areas.

Source: United Nations Office on Drugs and Crime (UNODC) "Global Study on Homicide 2019."

- **Natural Disasters:**

The United Nations Office for Disaster Risk Reduction (UNDRR) reports that urban areas are increasingly vulnerable to natural disasters, with floods, storms, and earthquakes causing billions of dollars in damage and displacing millions of people annually. Cities are particularly at risk due to population density, inadequate infrastructure, and climate change. The UNDRR's 2019 Global Assessment Report found that more than 70% of the world's population now lives in cities, which are hotspots for disaster risk.

Source: United Nations Office for Disaster Risk Reduction (UNDRR) "Global Assessment Report on Disaster Risk Reduction" (2019).

Infographic to show need of urban safety

Delayed firefighting response is a significant issue in taller structures.

1.35 million people die annually in road traffic accidents, with cities being at higher risk.

Urbanization directly links to a rise in both property and violent crimes.

Over 70% of the world's population now lives in cities, which are hotspots for disaster risk.

Solution Overview: Introducing the Intelligent Public Safety System

- A network of sensors and AI tools for real-time emergency detection.
- Alerts authorities instantly and guides residents to safety.
- Dynamically adapts public infrastructure during emergencies.
- Target population: City residents & emergency response teams

Sensors and Data Collection: Sensors Powering Public Safety

- **Cameras:** For detecting anomalies (fires, accidents, theft).
- **Microphones:** To capture gunshots or distress calls.
- **Environmental Sensors:** For earthquake and flood detection.

Cameras

- Thermal Imaging Cameras (Forest fire detection)
- AI-Powered Smart Cameras (Real-time anomaly/accident detection using machine learning algorithms)
- Camera trap (Automatically triggered by motion in its vicinity)

Microphones

- Shotgun Microphones (Gunshot detection in outdoor or noisy environments)
- Contact Microphones (Indoor surveillance for detecting distress signals)
- Parabolic Microphones (Long-range gunshot detection)
- Hydrophones (for underwater distress detection)

Environmental Sensors

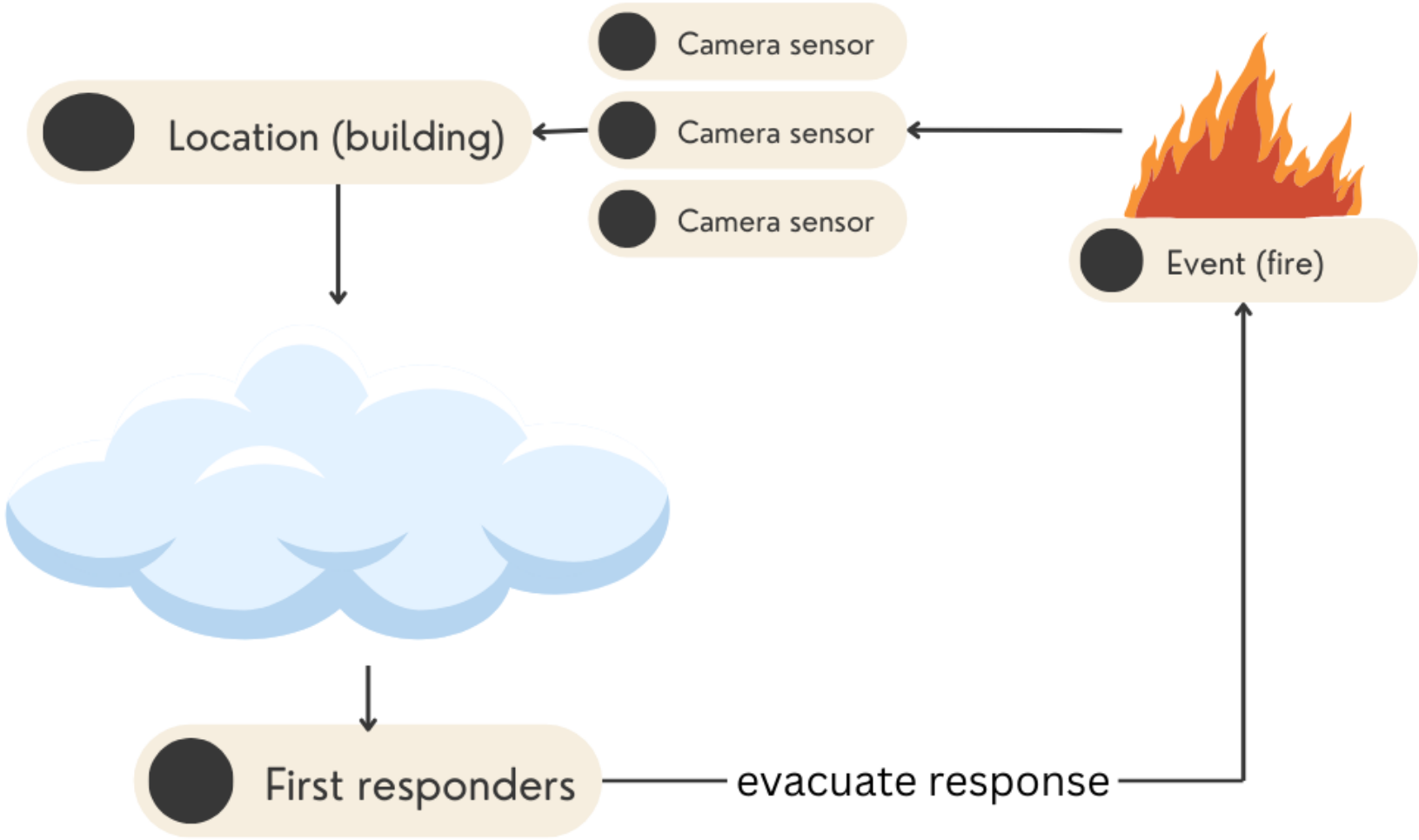
- Earthquake Detection
  - Seismometers (Detects vibrations in different frequency ranges)
  - Accelerometers (Measures rapid ground acceleration)
  - Geophones (Detects ground vibrations)
  - Inclinometers (Measures tilt or angular changes in ground surfaces)
- Flood Detection
  - Water Level Sensors (Measures changes in water levels)
  - Rain Gauges (Measures rainfall intensity)
  - Flow Meters (Measure water flow in rivers)
  - Soil Moisture Sensors (Measure moisture content in the soil)

Context Awareness: How the System is Context-Aware

- Integrates real-time environmental, visual, and auditory data.
- Responds dynamically to the situation:
  - Alerts emergency services.
  - Activates public screens and mobile apps for guidance.
  - Reroutes transportation during disasters. -> for example google map integration.

Example Situation

Fire in a building

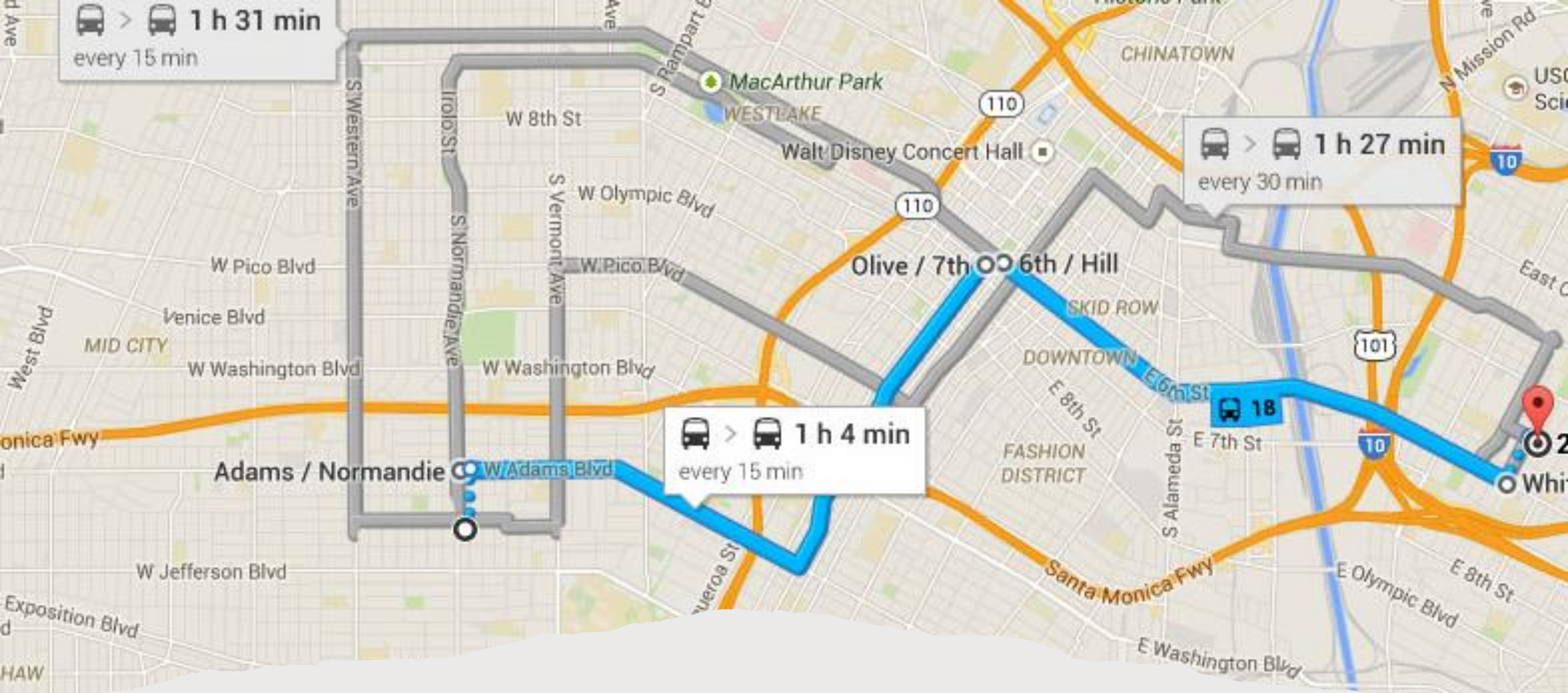


Algorithms and Intelligence: Smart Algorithms Driving Safety

- **Computer Vision:** Detecting fires, thefts, accidents using deep learning.
- **Graph-Based Algorithms:** Planning evacuation routes dynamically.
- **Audio Analysis:** Gunshot and distress signal detection with ML models.

Computer Vision – Fire Detection

- YOLO for detecting fire



Graph Based Algorithms – Dynamic Planning

Dynamic path planning for evacuation

Audio Analysis – Locating Gunshot

Gun is fired

When a gun is fired, the sound of a muzzle blast radiates outward.

2

Gunshot is Detected and Located

Acoustic sensors are triggered by the impulsive sound. The sound is classified as a gunshot using artificial intelligence and triangulation determines the precise location.

3

Gunshot is Reviewed

The data is relayed to the ShotSpotter Incident Review Center where analysts quickly audit the data and publish confirmed gunshots to police.

4

Police Respond

Alerts are sent to dispatch centers and patrol officers' smartphones and MDTs for immediate response. The entire process takes less than 60 seconds.

Ontology Design: Public Safety Ontology

The ontology defines relationships between actors, sensors, location, events, and responses.

Example SWRL Rule:

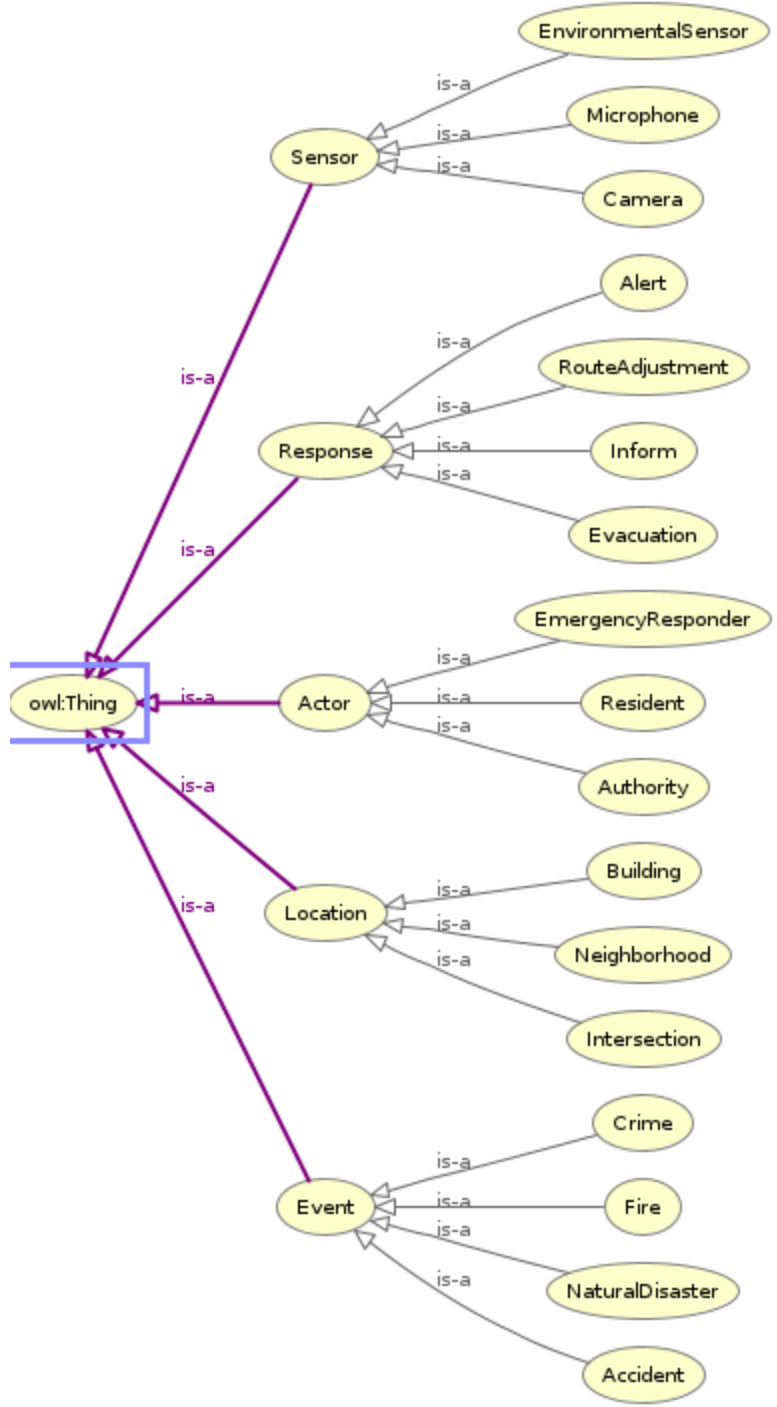
- Fire(?f) ^ hasSeverity(?f, "High") ^ Sensor(?s) ^ hasDetected(?s, "Yes") -> triggers(?f, FireAlert) ^ isTrigeredBy(FireAlert, ?f)
- triggers(?f, FireAlert) ^ isTrigeredBy(FireAlert, ?f) ^ hasStatus(FireAlert, "Pending") -> notifies(FireAlert, BuildingResidents) ^ notifies(FireAlert, FireFighterTeam)

These rules make sure if there is a fire and the severity is high it will trigger FireAlert and the Firealert will notify the FireFighterTeam and BuildingResidents(Evacuation)

If case the FireSeverity is low it only notifies the FireFighterTeam not to the Residents.

- Fire(?f) ^ hasSeverity(?f, "Low") ^ Sensor(?s) ^ hasDetected(?s, "Yes") -> triggers(?f, FireAlertLow) ^ isTrigeredBy(FireAlertLow, ?f)
- triggers(?f, FireAlertLow) ^ isTrigeredBy(FireAlertLow, ?f) ^ hasStatus(FireAlertLow, "Pending") -> notifies(FireAlertLow, FireFighterTeam)

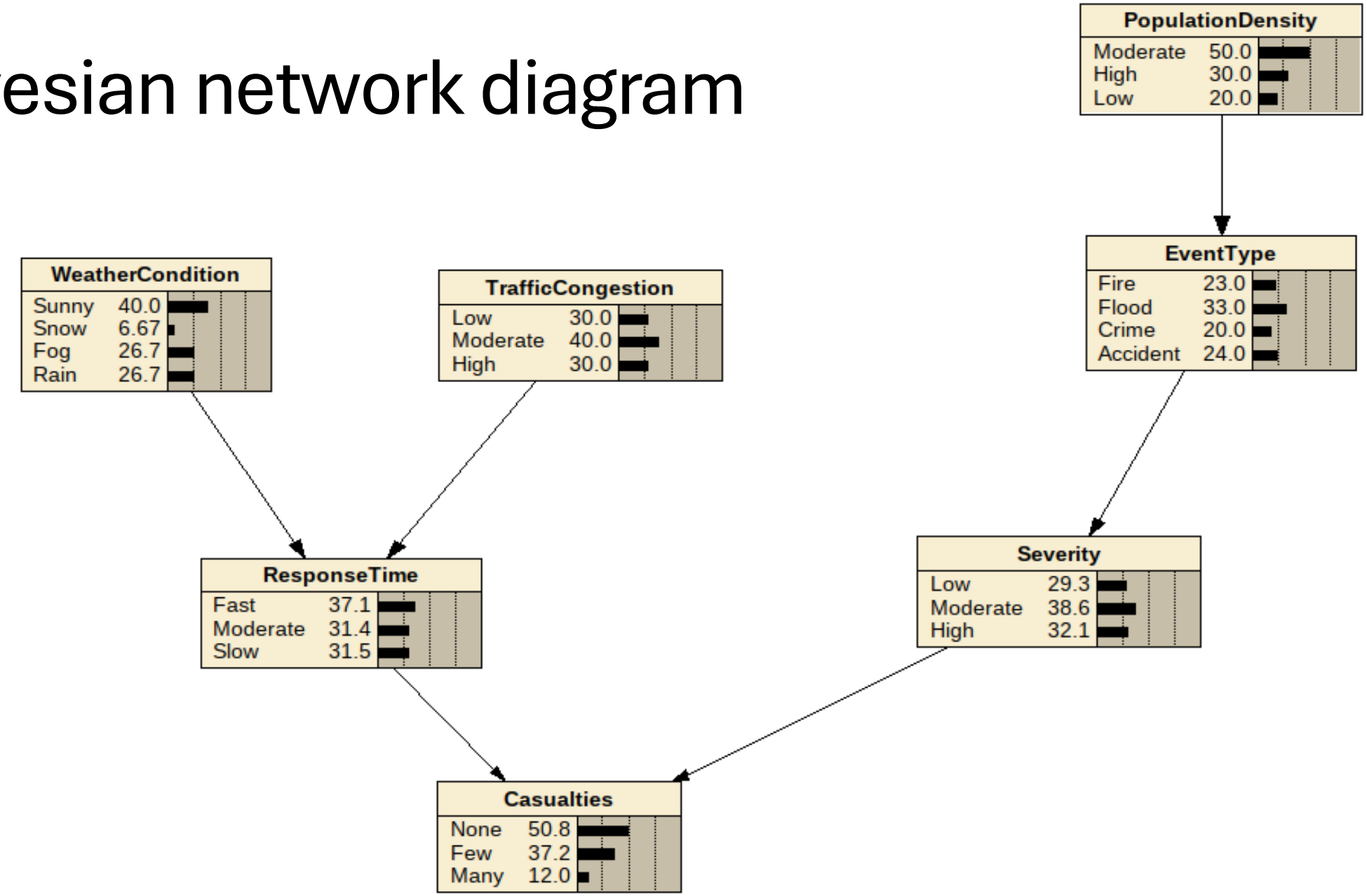
This was one example how the ontology takes actions according to the curcumstance.


owl:Thing
is-a
Sensor
EnvironmentalSensor
Microphone
Camera
Response
Alert
RouteAdjustment
Inform
Evacuation
Actor
EmergencyResponder
Resident
Authority
Location
Building
Neighborhood
Intersection
Event
Crime
Fire
NaturalDisaster
Accident

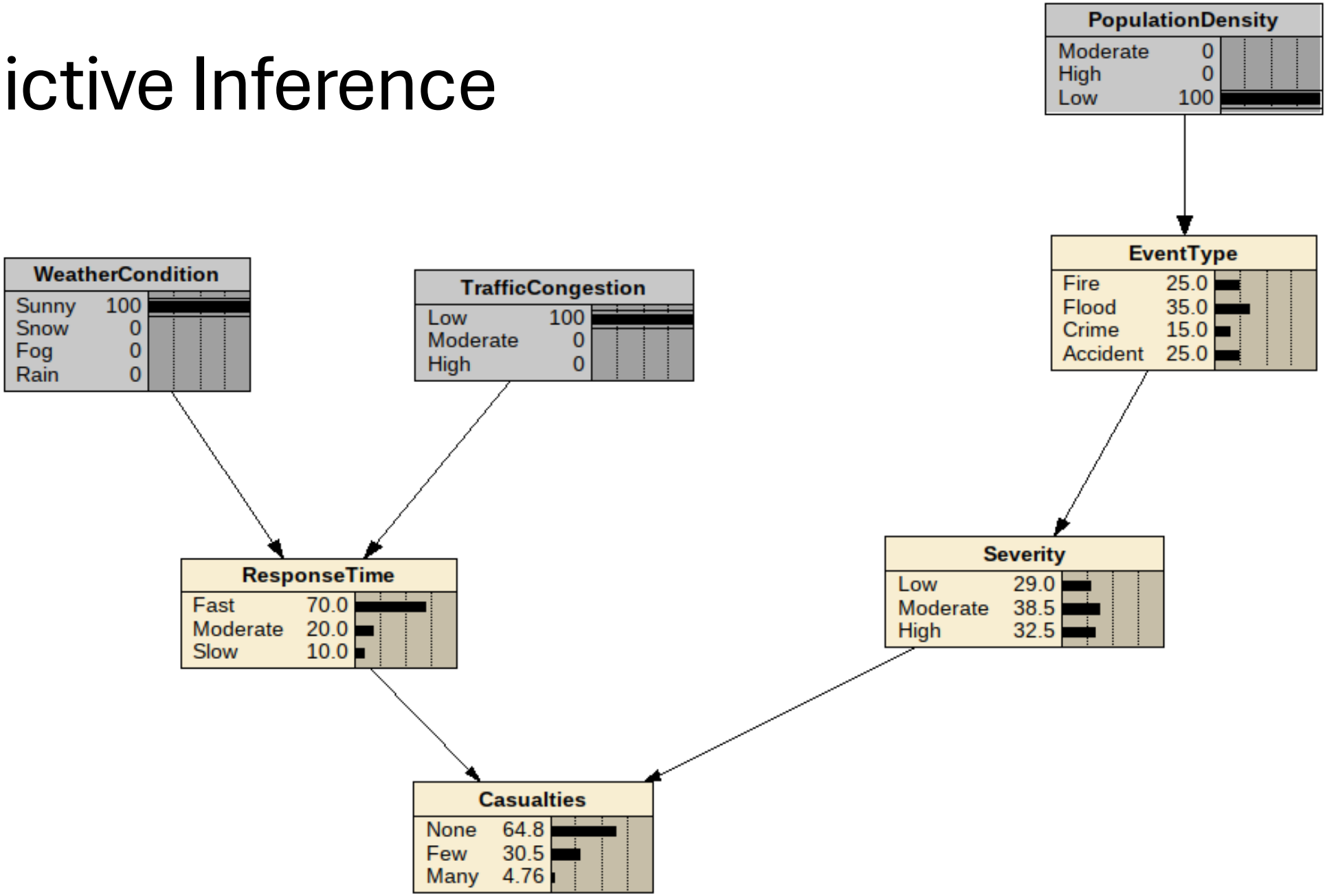
Bayesian Network: Bayesian Network for Risk Assessment

- Predicts the severity of an emergency based on inputs like sensor readings.
- **Nodes:**
  - Incident Type (fire, flood, theft).
  - Response Time.
  - Casualties.
  - Weather Condition
  - Traffic Congestion
  - Population Density

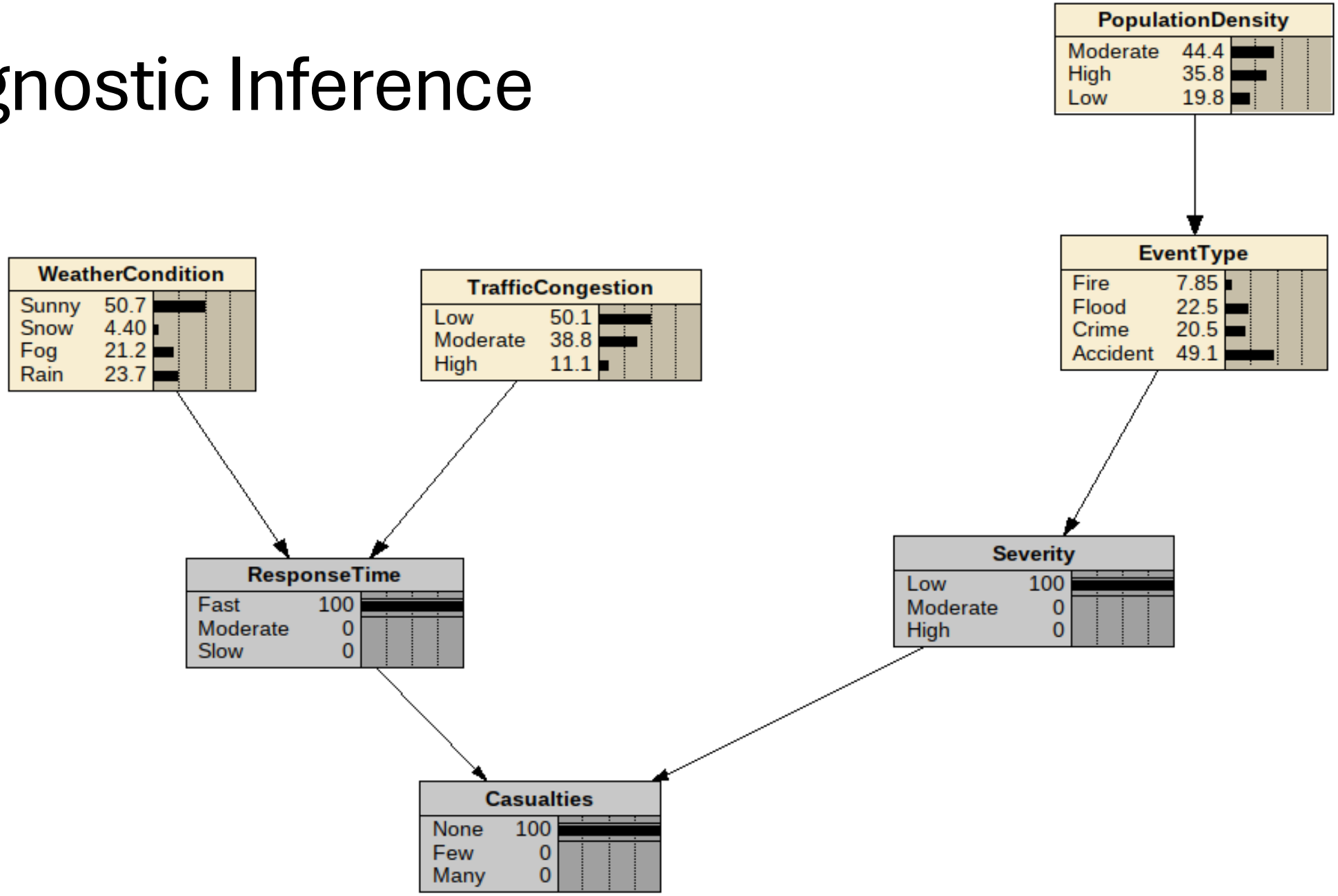
Bayesian network diagram



Predictive Inference



Diagnostic Inference



Benefits and Impact: Transforming Urban Safety

- **For Residents:** Faster alerts, safer evacuation, peace of mind.
- **For Authorities:** Enhanced coordination and situational awareness.
- **For Cities:** Reduced damages and increased resilience.

Conclusion and Future Scope: Toward Smarter and Safer Cities

- Summary: The system makes the environment intelligently respond to safety concerns.
- Future Additions: Predictive analytics, integration with healthcare, automated drones for emergency response.

Any questions?

Thank you!