Albuquerque Fire Department Wait Times

New Mexico Supercomputing Challenge
Final Report

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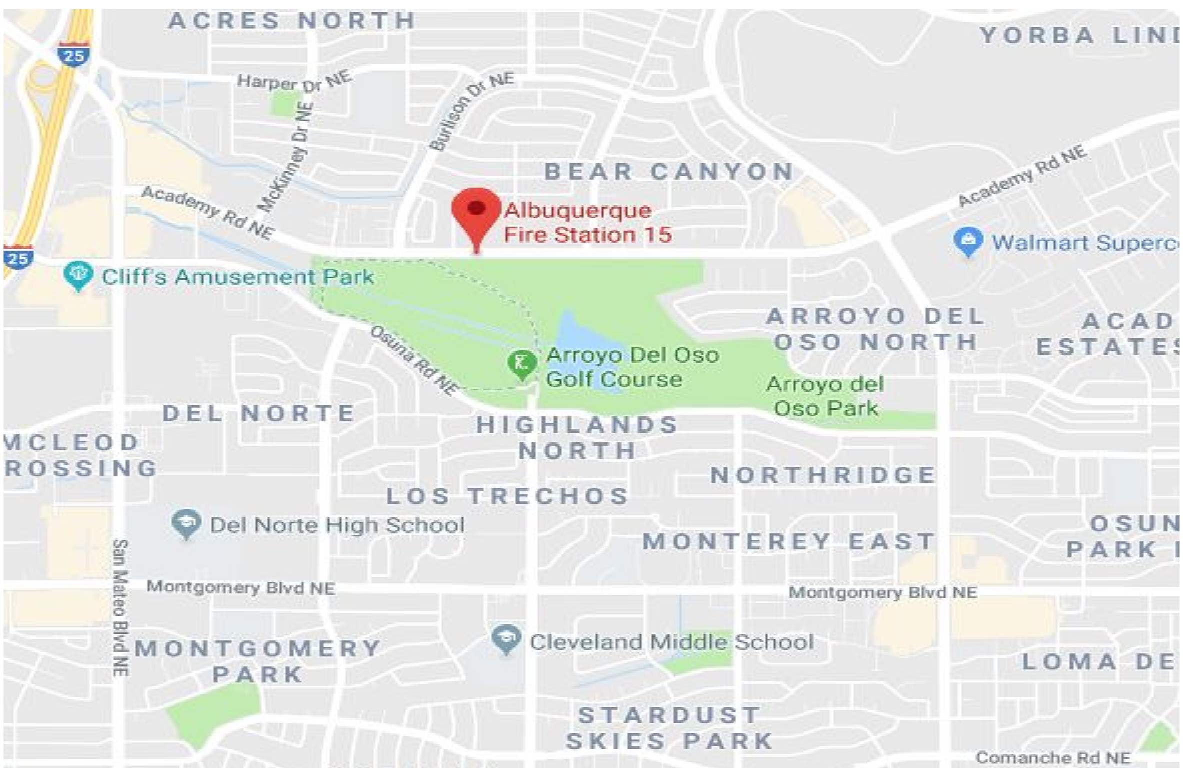
Executive Summary:

Every single day, fire departments all around Albuquerque are called to save people from emergencies. These include stopping fires, providing protection, and saving many lives from hazardous issues. Fire departments need to get to their desired location in less than 5 minutes or else many lives are in jeopardy. In Albuquerque, there are 22 main fire departments that are scattered throughout the city. Some departments can have difficulty getting to such locations in a quick time. For example, Fire Station 15 is a station that has difficulty getting to locations south of the Arroyo Del Oso golf course. This is because the station is located on Academy Rd which causes a big boundary between the neighborhoods and their assigned department, due to the golf course. Our team decided to make a simulation on Netlogo of this station and southern neighborhoods. Our program provided a station and accident node and used the networking extension to find the shortest amount of links possible to reach the location. In our research, we found many resources of traffic directors and battalions to help find our data. For example, we learned from Battalion Justin Staley about fire department regulations and how departments are controlled and Amanda Herrera, who is a traffic engineer, taught us about traffic regulations and standards. We also researched a lot about Dijkstra's algorithm and the traveling salesman theory. We used this algorithm to help us find the fastest route from the station to the emergency. All of these sources have helped us learn more about many different variables that are considered at fire departments and how many regulations go from the station to the location that needs help.

Problem:

Why does it take so long for fire departments to arrive at the destination once called? What can be changed to provide a remedy for the problem?

Fire departments take too long to get to their Albuquerque destinations once they are called. In 2017, on average, it took around 6 minutes and 40 seconds for the firemen to arrive at their destinations. This response time is too long because fires progress quickly. Part of the problem is that it is hard for the fireman to get to some locations in a timely manner. For example, the houses by Arroyo Del Oso golf course take a long time to get to because there are not enough fire stations nearby. Fire Station 15 is on the North side of the golf course and has to go all the way around the golf course to get to the houses on the South side which causes a delay in response time.



The picture above shows the area we are looking at. The main neighborhoods that are important are Highlands North, Los Trechos, and Northridge.

In addition, traffic is very common when firemen are going to a location which makes a big impact on delayed response times. Another factor is that fireman have to make extended travel to out of district calls when they are busy which also makes response time slower. Navigating a way to a location also causes delays on response time because firemen have to spend the time to figure out the quickest way to a destination. These factors leave time for fires to get bigger and become more of a danger to the people nearby. Fires affect many people and those extra few minutes can make a big difference as fires can escalate rapidly.

Objectives:

Research:

- Research fire department response times
- Learn more about traffic flow
- Learn more about Network extension
- Learn more about Dijkstra's Algorithm
- Find resources from the Fire Department

Program:

- Add Network Extension to code
- Make one simulation
- Add incident node and station node

Research:

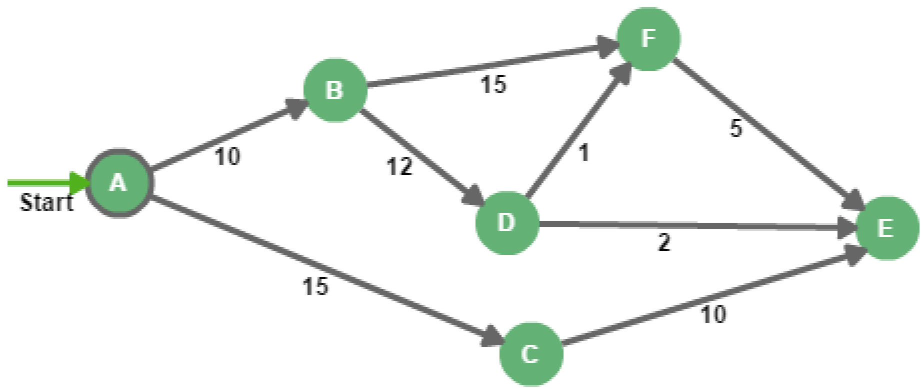
In our research, we wanted to mainly study traffic flow, variables that happen between the department to the destination, and theories as well as problems to help our simulation be accurate. This helped us get an idea of what kind of variables that need to go into a simulation to make it as accurate as possible. Our main resources come from Zak Cottrell, who is a civil engineer designer that has worked with us now for 3 years. He mainly helped us find the right people to look for more information on fire department wait times.

The first topic we wanted to study was different fire departments throughout Albuquerque. A resource we used to help with this was Battalion Chief, Justin Staley. He has given us a map of Albuquerque fire departments and the area that a specific department must correspond to. Justin Staley has also given us information on variables that affect response times, such as traffic, extended travel, navigation, construction, geographical locations, etc. This resource has helped us narrow down our choice of studying a specific fire department, which is Fire Station 15 since it already has difficulty with response times and has a geographical location (Arroyo Del Oso Golf Course) blocking the station and the southern neighborhoods.

Another resource that helped us was Amanda Herrera. She is in the Department of Municipal Development Traffic Engineering Division of Albuquerque. Amanda helped us learn more about traffic flow and how the roads are made/changed as it can relate to fire departments and other emergency systems. She also introduced us to the Opticom, which is a system that helps emergency vehicles change the traffic signals to get through quicker. However, we learned that they don't always work, and it would be helpful if these systems can detect the emergency vehicle from farther away, getting a faster response time.

Another topic that was helpful to study was Dijkstra's problem and traveling salesman theory. With the help of Nick Bennett, we decided to use these theories in our simulation. The traveling salesman theory is a problem that asks "*if given a list of locations and routes, which route is the fastest and most efficient way to get to that specific destination?* " This is helpful in our topic because the main goal of our problem is trying to find a solution for emergency systems to get to their desired location the fastest and most efficient way. We also learned more about the Dijkstra's problem which is finding the shortest path between nodes in a graph. This has helped us in our simulation since we are trying to find a path that will help the fire department trucks avoid as much traffic and negative variables as possible.

The last topic we wanted to learn more about in our project was using the networking extension for netlogo and what that means in our project. We were able to get information of how the networking system works by Nick Bennett. We used it in our code by finding a random route between two nodes on the network with the minimum weight. This helps generate a route that will allow the fastest way to get to our location node.



The image above shows Dijkstra's algorithm which is the shortest past from one node to another.

Methods:

Start

In the beginning of the year, we were not quite sure of the area we were going to simulate or even the way we were going to model our code. After talking to resources like Justin Staley, we were able to find an area in Albuquerque that was difficult for emergency systems to function in a quick amount of time. This has helped us get a general idea of how our NetLogo model will work. Another person that has helped with our NetLogo is Nick Bennett. He has helped us learn more about dijkstra's algorithm and how we can incorporate it in our model to make it as accurate as possible.

After evaluations

After evaluations, we got more feedback from Drew Einhorn, who gave us more ideas and helpful tips on our code, which helped point us to the right way and realize how our project can have a lot of layers to it. This makes us come to the overall conclusion that we want to continue on with this project next year and add more variables that can make this simulation a realistic idea of how the emergency functions function.

NetLogo Program:

In our NetLogo program we are showing the shortest route from one node to another. In this case, we have a station node that stays in the bottom left corner and an incident node that is randomly generated. We used Dijkstra's algorithm which is the shortest path from one node to another in our code. A link is created between the station node and the incident node showing the shortest way from the station to the randomly generated accident. This is a representation of the station, in our case Fire Station 15, to the fires on the South side of Arroyo Del Oso Golf course. We used the network extension in our code to find the route between two nodes on the network with the minimum weight.

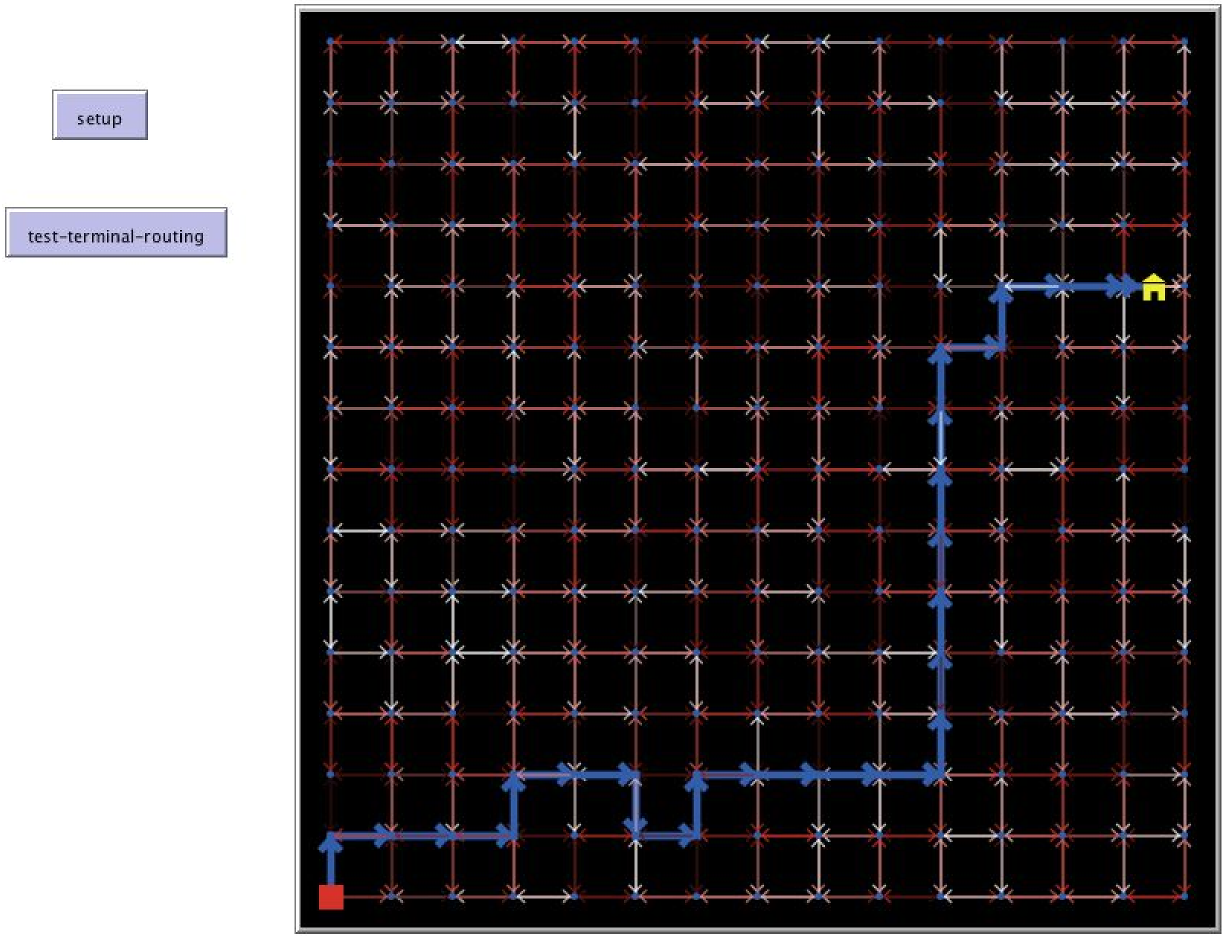
```
to test-terminal-routing
  ask incidents [
    die
  ]
  reset-link-display
  let intersection1 one-of intersections
  let intersection2 [one-of intersections-on neighbors4] of intersection1
  let x (([xcor] of intersection1) + ([xcor] of intersection2)) / 2
  let y (([ycor] of intersection1) + ([ycor] of intersection2)) / 2
  create-incidents 1 [
    setxy x y
    set size 0.5
    set color yellow
    create-roads-from (turtle-set intersection1 intersection2) [
      set transit-time 0.5 + random-float 4.5
      scale-link-color
    ]
  ]
  ask stations [
    find-route one-of incidents
  ]
end

to scale-link-color
  set color scale-color red transit-time 11 1
end

to reset-link-display
  ask roads [
    scale-link-color
    set thickness 0
  ]
end

to find-route [destination]
  let path nw:weighted-path-to destination transit-time
  show nw:weighted-distance-to destination transit-time
  foreach path [
    :link ->
    ask :link [
      set color blue
      set thickness 0.125
    ]
  ]
end
```

The picture above shows how we made the station and incident node and the intersections between them. In testing terminal routing a link is made between the two of them showing the shortest path.



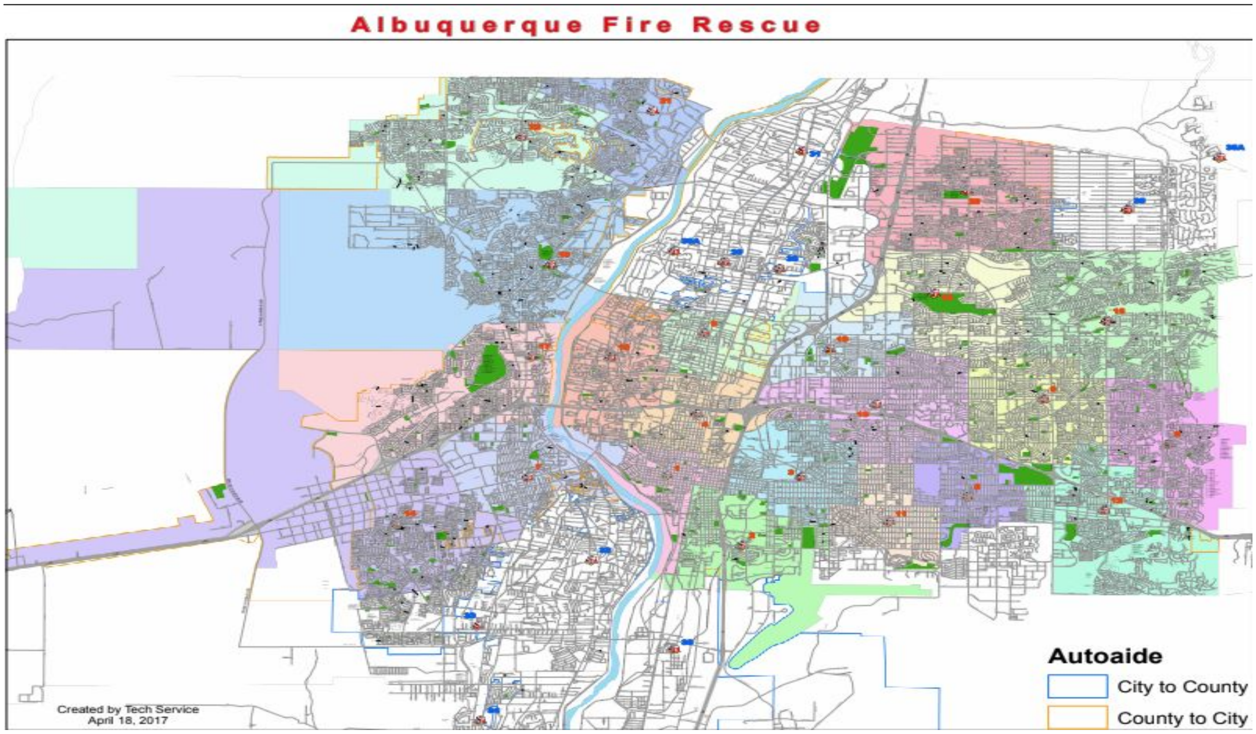
This image shows the interface of our code. When test-terminal-routing is clicked a link between the station node in the bottom left corner to the randomly generated incident node is created.

We are planning to add GIS (Geographical Information Systems) to our code to show the actual streets. In addition, we will add real time traffic information by creating a slider to show car density on the roads and unexpected delays. With the car density we will be able to show the actual amount of time it will take for the fire department to get to the accident. This will allow us to gain more accurate data by using real information to simulate how Fire Station 15 could make response times quicker.

Tables/Graphs:

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	188	13	68	62	18	134
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.41	0.45	0.74	0.38	0.52
Hourly flow rate (vph)	211	32	151	84	47	258
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						

The table above was given to us from Amanda Herrera. This image shows what standards are looked for in her specific division. On the left, it explains the types of movement many lanes and intersections have. Examples can be the different configurations that the lane may have in its intersections or the volume/number of vehicles in these lanes. The top of the table shows examples of lanes and how they are graded according to these standards.



This picture shows the fire departments in Albuquerque and the corresponding area they work for. This was given to us by Battalion Chief Justin Staley, who works in the departments. This has helped us get a general idea of what fire department to study and the neighborhoods that specific fire department has to go to.

Results:

In our results we were able to learn more about finding the distances and possible outcomes that go with our model. Although, we were not able to find a final verdict or conclusion in our code, we have found possible solutions that could potentially help the fire trucks to move more smoothly. These solutions were hypothesized from our interviews with Justin Staley and Amanda Herrera. One of their ideas is to possibly add some sort of bridge/lane that goes through the golf course that is open only to emergency systems. This will help the systems reach the southern destinations easier with little to no traffic in the way instead of using bigger roads like Seagull St, Wyoming Blvd, and San Mateo Blvd. Another idea that came up was using the OptiCom for the fire trucks. This will cause the streetlights to automatically turn green if an emergency system is there. This can potentially speed up the process, but there is always the likelihood that other cars/traffic variables will be in the way.

Conclusion:

In conclusion, emergency systems need a solution to help them find a way to get to their destinations quicker. We believe that the solutions that can help the traffic move more smoothly is to either add OptiComs to more streetlights to provide emergency systems the option to change the lights or make some sort of lane that is only for emergency vehicles. Both of these options will have disadvantages such as the lane also being used by vehicles not for the emergencies or opticoms not always being a reliable solution, since they do not always work. However these disadvantages are outweighed by the advantages since these actions can potentially save a life or house. It is important to somehow find a solution for emergency vehicles to get to their locations more efficiently to save someone who is in danger. Next year we want to focus more on our code and try to see if we can somehow achieve a realistic simulation with outcomes that can be possible and see if it slows or quickens the flow of the traffic.

Significant Achievements:

The most significant achievement that our team has achieved this year is talking to a number of resources. For our project we had to communicate with a number of people that have helped us understand our topic better. This has not only helped us learn more about these peoples jobs but has provided us to bring more voice to our topic. We got to talk to a number of people in our community, which made us feel like this project is realistic and could actually have potential in being a real life problem. That's why talking to these people helps make us feel more accomplished with who we are sharing these ideas with.

Ayvree Urrea:

A significant achievement that I had this year was not only getting better at presenting, but being able to talk to and come up with questions for resources. With the amount of people resources we used this year I had to learn how to research what that person's job was and what kind of questions pertained to that job and could be used for our project. In addition, I have gotten better at explaining and giving more information about our project when presenting. This year I have been able to become more confident in what I am saying and provide more information and thinking on the spot to come up with questions.

Kiara Onomoto:

My significant achievement for this year in SuperComputing, is that I have been able to talk and present more easily. This is because after interviewing our many resources I got to present them a variety of questions to help us understand what they do in their jobs and how it can help us with our project. This not only helps us since we get more information, but helps us connect with the person we are talking to since we learn with them. Overall, I have seen a significant improvement from the beginning of the year. I was able to practice speaking therefore I feel more confident whenever I speak and I am able to talk in more depth, when explaining something to someone.

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Amanda Herrera, Department of Municipal Development Traffic Engineering Division

Nick Bennett

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