Police Officer Selection Process for Incident Response

Johanna M. Leigh, Sarah J. Dunnett, and Lisa M. Jackson

Abstract—**Due to the funding cuts the police are facing there is a growing need for increased resource efficiency. Current methods of officer dispatch do not use all the information available to make an informed decision on the most efficient officer to send to an incident. Automating the police officer selection for incident response can utilize this information to make an informed decision for which officer to send. The tool for selecting an officer described here, consists of mapping, routing, and decision making applications. The decision criteria used is officer availability, predicted possible response time, area coverage, and driving qualification. This increases the chance of selecting the most efficient officer to attend an incident. Through simulation it has been proved that making an informed decision can increase the efficiency significantly over random selection within the proximity.**

Index Terms—**Police response, vehicle routing, simulation, multi objective decision making**

I. INTRODUCTION

CURRENTLY Police Forces are being faced with major budget cuts from the government. This leads to an increasing need to streamline operations. One area to concentrate on is the police officer dispatch processes for incident response where a need for fast response is vital to the public's safety and trust in the police force. With limited resources using what is available to its highest potential is a high priority. Each Police Force has different processes of dispatching officers, though all end with someone directing an officer to an incident. A common issue with the dispatch process is the lack of information given to dispatchers to base decisions on. This leads to uncertainty in decisions which often leads to dispatchers asking officers who can attend an incident rather than making an informed decision. This project details an algorithm, implemented in a computer program, which has been developed to assist police officer dispatchers in the decision process by making best use of the information available to recommend appropriate officers to send.

The program is to be used in a control room by dispatchers to advice on officer selection. It contains three main areas a map of the area of concern, routing application, and decision making tool. The map details the paths possible to travel on and constraints such as one ways. The routing application determines the quickest path from an officer to an incident using the paths detailed on the map. The decision tool considers other factors affecting the selection such as availability of officers.

Previously dispatch tools have been developed for other services but not specifically for the police force. The police have many considerations to account for which are not considered in other dispatch services. The tool developed considers factors specific to the police dispatch process such as driving qualifications and area coverage which are not currently identified in other research.

To test the effects of using the selection tool discrete event simulation is used. This helps predict the changes that using the tool in a police dispatch environment will produce. The simulation runs through typical incidents and finds the appropriate officer to send to each. The results of this are then compared to random selection of officers to determine the difference in resource efficiency between each process.

Details of police processes are taken from Leicestershire police force. There may be variation in processes between different police forces. The tool developed will still be applicable to all forces.

II. BACKGROUND

There are a limited number of police officers who are required to attend incidents in need of response. The incidents reported are typically classified into four grades. Grade one incidents are emergencies where response is required within fifteen minutes. Emergency incidents which qualify include those where there is a danger to life or an immediate threat of violence. Grade two incidents are priority incidents which require response within sixty minutes. Typical incidents which qualify include those where vulnerable people are involved. Grade three and four can be resolved by scheduled appointments or over the phone.

As grades one and two require a timely response dispatchers are required to select which officer to send to these incidents. Dispatchers allocate police officers as they see fit. Generally basing decisions on what the officer is currently doing and how close they are to the incident. Often calls are put out on the radio for officers to choose if they are willing to attend incidents, rather than allocating an officer to an incident. This does not tend to lead to the most

efficient officer being chosen to attend an incident. The aim of dispatchers is to reduce response time, increase officer availabilityl and keep area coverage. There is much more information which could be relevant to the decision making processes which is not currently considered by dispatchers. The work developed here identifies factors which should be used to base the decision on and incorporates them into a dispatch tool.

Research in the area of police dispatch is limited, more extensive research has been done on ambulance dispatch. Though this does not contain the same decision criteria it is still relevant work and hence is reviewed below.

A. Ambulance Dispatch

Emergency service dispatch is a well-known problem. There has been research mainly in the field of ambulance dispatch. Studies of particular relevance include [1], [2], and [3]. Literature [1] produced an ambulance dispatch tool which includes a weighting system to priorities more severe incidents and relocation ability for when a new incident is reported with higher importance. The routing of the ambulances includes real time traffic information.

Study [2] aimed to provide a dispatch tool for ambulances and a positioning tool for ambulances and stations. The study discussed that off-the-shelf software would not be suitable for the application because it does not consider the decision criterea required. The tool produced was BARTSIM, it was implemented in an Australian ambulance service. Simulation was used to simulate incidents for the ambulances to react to, to determine whether ambulances could meet response times.

In [3] described the issue with ambulance dispatch being that the closest ambulance is not always the quickest, though that is what decisions are typically based on. A dispatch tool was produced considering response times, severity of incident, and effects on area coverage. Simulation is also used for this tool to prove considering severity decreases mortality rate.

B. Fire Service Dispatch

Studies into other emergency service include [4] which investigated the fire service. The study analyzed historical data and used the information to help decide how many fire engines would be required for future incidents. Simulation is used in this study to prove the method results in a decrease in response time.

C. Police Dispatch

Literature [5] investigates the patrol routes of state troopers, concerning the prevention of traffic incidents. The aim of their study was to determine the best locations for temporary stations and increase the effectiveness of patrols by increasing visibility in times of high incident demand whilst minimizing associated costs, which included price of state troopers, travelling costs, and station fees. The problem solved was similar to a multi-depot, dynamic location, and routing problem.

Similar to the dispatch tool produced in [3], in the work described here a dispatch tool has been developed which considers response times and area coverage. In this case

police dispatch is of concern. Other factors including availability and driving standards are also considered. The details of the tool are outlined in section III.

III. METHOD

The tool has three sections; mapping, routing and decision making. The mapping tool plots the roads and paths available to travel on within the police force boundaries. The routing application allows the quickest route from officer to incident to be found. The decision tool decides which officers to send to an incident based on factors such as availability, area coverage and driving qualification.

A. Mapping

The mapping tool forms a road and path map of an area of choice by using data from OpenStreetMaps [6]. The information gained from OpenStreetMaps includes locations of points along roads, road type, road names and traffic restrictions such as one-way roads. The information is used to form the map as a directed graph using Equation 1:

$$G = (V, E) \tag{1}$$

This equation uses a group of vertices (V) to represent the longitude and latitude points given as points along a road and uses edges (E) to represent the roads which join the vertices. Fig. 1 shows how roads in Leicestershire are represented in graph form.
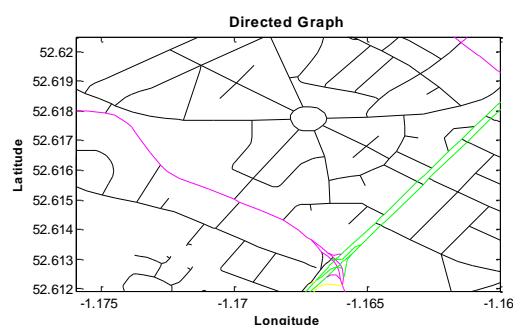

Fig. 1: Directed graph.

The edges have weightings associated to them to account for the cost of travelling on the edge. The cost in this case is time taken to travel the edge, which will be considered when finding the appropriate route to travel. The graph is directed because roads may be one-way and hence can only be travelled in one direction.

Information such as direction of the roads, type of road and weightings are contained within matrices within the mapping tool to allow road restrictions to be placed whilst routing.

The area considered in this study is the county of Leicestershire in the center of England, Fig. 2 is the road map of Leicestershire produced and Fig. 3 is a zoned in section of the main city in the county, Leicester.

To navigate through the road system a method of finding a path from a current location to a target location is required, this is found through routing which is detailed in the next section.
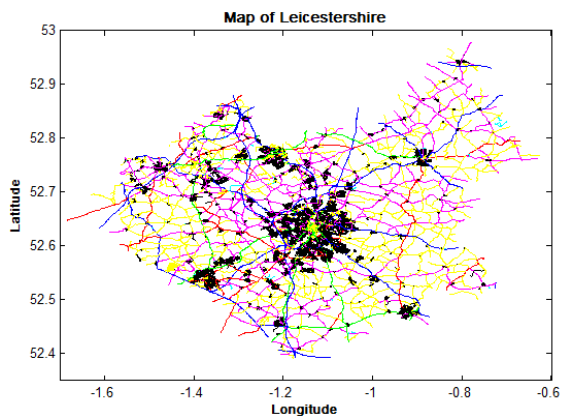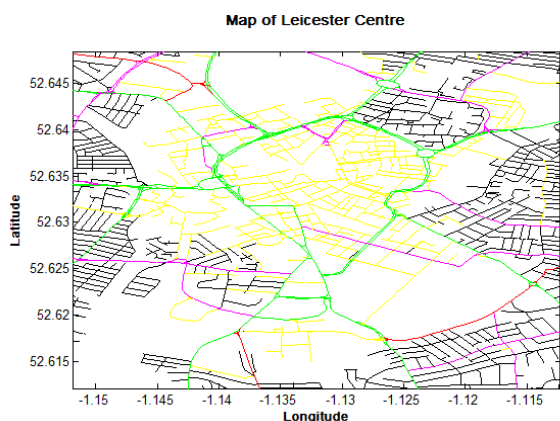
Fig. 2. Road map of Leicestershire.

Fig. 3. Map of central Leicester.

B. Routing

The routing tool uses the roads and paths identified by the map, a subset of the total number of officers in Leicestershire selected as described below, and the incident location to find the most efficient routes from each officer considered to the incident of concern. In this case the shortest response time is the main objective so the path is found based on shortest time. The predicted time for each officer to reach the incident of concern is calculated by finding the quickest path from officer to incident using Dijkstra's algorithm [7]. The possible paths considered are shown on the map. The time taken to travel along each section of the path is calculated using the distance travelled along the road and the weighting given to the road. The road weighting considers type of road and predicted traffic and is discussed further under Road Weightings.

To save computational time the route from every officer in Leicestershire to an incident is not calculated. The officer must meet certain criteria to be included in the routing process. For example, in an emergency situation officers which are unavailable, as they are busy with other duties, are excluded from the search. Of those available the n closest officers to the incident are found using the straight line distance from officer to incident. Where n is an integer dependent on the area in which the incident occurs. In city centers n is smaller than in county areas. The n closest available officers are the officers who are considered in the routing. n in this case is taken to be four but requires further testing to find the optimal value. Fig. 4 shows the route from

an officer to an incident determined by the tool. The route chosen utilises main roads due to the road weighting system.
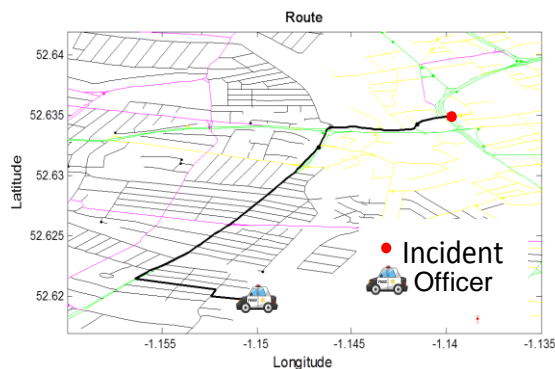

Fig. 4. Route from officer to incident.

The quickest route is not the only consideration when selecting an officer. Other criteria are considered in the decision making tool.

C. Decision Criteria

This part of the tool makes decisions based on information from the GPS locations of the officers, resource list and information gained from the routing tool. In this section information such as the officer availability and driving qualification are considered. How each of these factors impact the decision is discussed further in the following subsections. Fig. 5 shows the two different selection criteria for response situations. The first path is the criteria for emergency response and the second path is the criteria for priority response.
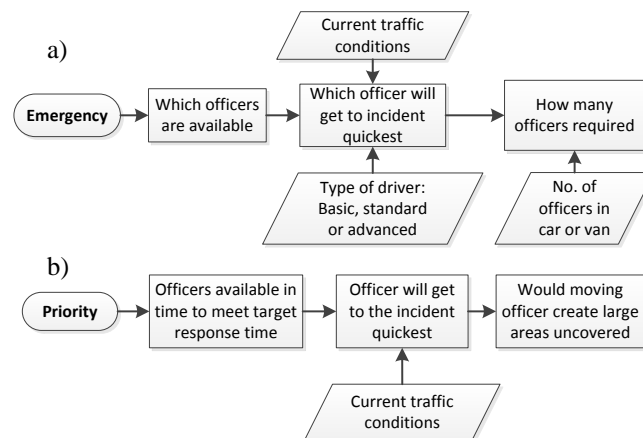

Fig 5. Selection criteria a) emergency b) priority.

The emergency response decision considers availability and the predicted response times accounting for traffic and driving standard. The priority situation considers availability, predicted response time accounting for traffic, and area coverage.

Response times

As discussed previously the grade of the incident determines the response time target which needs to be met. For grade one (emergency situations) this is fifteen minutes

and for grade two (priority situations) this is sixty minutes. All other grades of incidents are resolved over the phone or in a scheduled meeting. The tool developed is used for grade one and two incident dispatch. There are different decisions taken depending on what grade the incident is as in emergency situations a timely response is the main priority whereas in priority situations there is more room to consider officer who are not immediately available.

Availability

Officers report their status to dispatchers so dispatchers know the availability of each officer. Their status describes what they are doing at that time and can include available, break, dealing with incident, dealing with arrest and paper work. Available officers are immediately available to attend to incidents. Other statuses mean the officer is currently not available but it is possible for certain statuses, such as break, to predict when the officer will become available. This information is stored on the resource list. The statuses and how long they have been on this status can be used to determine which officers will be available in time to meet the response time criteria.

The status markers are used to determine whether an officer can be selected to attend an incident. In emergency situations a response is required immediately hence available officers are the only option. In priority situations response is not required immediately hence officers who are predicted to become available in the time window can also be selected. Of all the status markers, officers on a break and those processing prisoners are the two for which the time at which they become available can be predicted. The use of this factor as a selection criterion depends on the reliability of officers remembering to update their status.

Driving standard

As part of training the officers must pass different driving qualifications. The most elementary qualification being the basic driving qualification, this allows an officer to drive a car but does not allow driving with blue lights and sirens. The qualification above this is the standard driving qualification which allows driving with blue lights and sirens. It also gives the drivers the option to exceed the speed limit when necessary and going through red lights. Above this is the advanced driving qualification which above the standard qualification allows pursuit of vehicles failing to stop. These qualifications are considered in emergency situations as they affect the speed at which an officer can reach an incident. In emergency situations flashing lights and sirens can be used when necessary to warn cars of the officer's presence, clear a path through traffic and allow speed limit to be exceeded. Basic drivers cannot utilise this asset hence it will take them longer to travel the same path as a standard or advanced driver. This is considered by only using emergency situation road weightings, discussed further under Road Weightings, for standard and advanced drivers. The priority situation road weightings are used for basic drivers as they would have to drive under the same conditions as they would for priority situations.

Road Weightings

Road weightings are used to allow for the difference in possible speeds on roads in order to give an accurate representation of how long it will take a vehicle to transverse a section of road. The higher the road weighting the longer it will take to travel down the road. The difference in speed can be caused by many factors including type of road, traffic, and grade of incident as for emergency incidents blue lights and sirens can be used. Road type determines the speed limit, this is a constant limiting factor for any particular road and is accounted for in the weighting by constant road weightings for each road type. For example typically the motorway speed limit is 70mph hence a low road weighting is used and in residential areas the typical speed limit is 30mph which will be given a high road weighting. Traffic is a varying factor, traffic caused by congestion can be predicted and usually affects certain roads at certain times of day on certain days. Road weightings can be increased on these roads during predicted congested times.

Road weightings are also given to officers travelling on foot or bike. These will not be affected by traffic or type of road. Weightings are based on the speed officers are expected to walk or cycle. Walking is only permitted on paths and cycling is not permitted on primary roads and motorways this is done by making certain roads unavailable to officers on foot or bike.

The cost of the route is determined using the equation

$$\min \sum_{K} \sum_{i,j} W_K(t) D_{K_{ij}}. \tag{2}$$

$W_K(t)$ is the road weighting of road K, depending on the time t. D is the distance travelled between nodes i and j on road K. In (2) the sum of the cost of travelling on an individual road is calculated and this cost is then added to the cost of the other roads used.

Area Coverage

Area coverage is the level of officers which are present in a reachable location to the region under consideration. The area coverage of a road is measured by the number of officers with the ability to reach the road within the set response times. The officers do not have to be available, only present in the reachable area. The demand in an area is determined using historical incident data from Leicestershire police.

When selecting an officer in a priority situation the coverage of the area which the officer would leave to attend the incident is considered. Where it can be avoided, large areas will not be left uncovered. The decision tool will choose officers from where there is a higher coverage to attend an incident rather than removing an officer from an area leaving it uncovered. In emergency situations response time is the main factor and hence area coverage is not a decision factor.

IV. SIMULATION

Simulation is a technique used to simulate real life situations to predict the outcome of situations. This is a
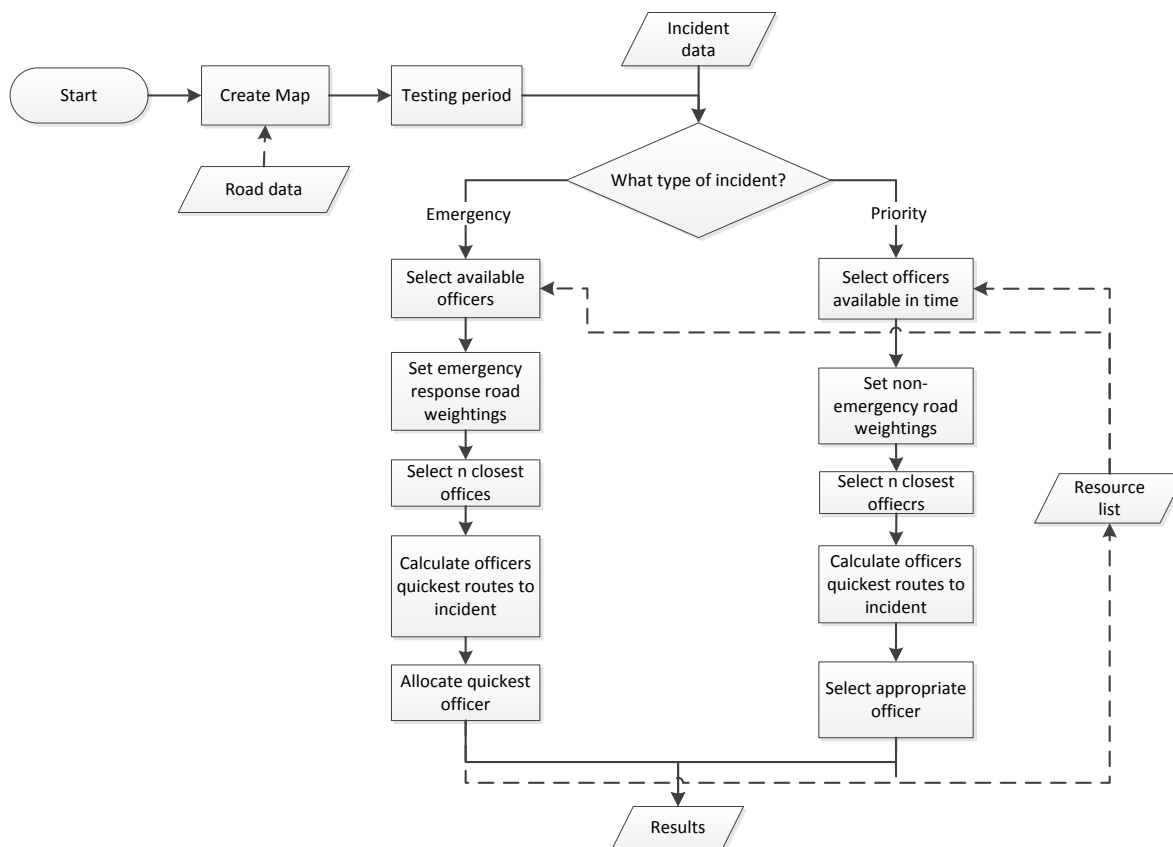
Fig. 6. Simulation process.

useful way to test the officer selection tool as implementation into a police force requires proof of its effectiveness. Also the service it would be used for is vital and disruptions to this service could lead to devastating results, hence testing cannot be done in the police dispatch environment.

To test the application of the tool a discrete event simulation has been set up in MATLAB [8]. The events are incidents which are generated by the simulation. The tool analysis the events, determining their location, and grade, as well as available information from the resource list, such as officer locations and statuses, to decide the most efficient officer to send to the incident. The resource list is then updated to account for the change of location of the officer and the availability status of the officer. The simulation runs for a randomly selected time period where incidents are generated using historical data to give a realistic view of the demand officers will face at particular times of day.

In order to determine the effectiveness of the developed tool the simulation is also run using random officer selection within a given radius of the incident. This resembles the culture of asking officers to attend rather than allocating officers. The results of the two simulations are then compared to show the difference using the selection tool can have on the efficient use of resources.

Fig. 6 shows the simulation process. The simulation starts by creating the map of the area of concern in this case Leicestershire and then setting a random testing period and generating list of incidents which are to be used as events in the simulation. After this each time an incident is inserted into the simulation. The grade of the incident determines which decision process the tool will use. The decision tool selects an officer to send to the incident reading from the resource list to gain information on officers and then updating the resource list. The officers are then made unavailable for a predetermined length of time based on historical time taken dealing with that type of event. The simulation records the response times, distance travelled by each officer, and availability of officers. This information is used to determine the efficiency of the use of the officers. The simulation is run again using random officer selection within a given proximity of the incident and the same results are recorded for comparison.

V. RESULTS

The tool picks the most effective route from each officer to incident and then selects the officer it predicts to be the most efficient. Fig. 7 shows one emergency situation generated from the simulation, the officers in the proximity, and the most efficient routes from each officer deemed appropriate to the incident. The recommendations of the order which officers should be selected are shown in the textbox. In this case officer D should be selected above other officers as it has the quickest route to the incident with their advance driving qualification. The route for officer B is not calculated as the officers status is attending incident and as it an emergency situation the officer cannot be selected to attend the incident.
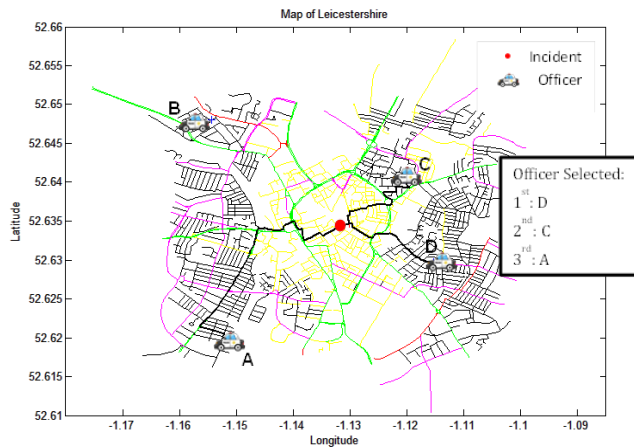
Fig 7. Result of emergency situation.

The simulation tested random periods of time where incidents are created and officers are selected to send to each incident. Using the decision tool compared to random selection resulted in approximately a 22% decrease in distance travelled by officers. This decrease represents the use of decision based selection compared to random selection of officers to attend incidents. Random selection is not used in every case by dispatchers, this simulation illustrates the savings made over time using the selection tool. The simulation also showed decrease in response time of approximately 13%. The decrease in distance travelled and response times also gave officers an increased availability of approximately 6%. The time saved can then be used to patrol or deal with other incidents. These results show an increase in efficiency of officers compared to random selection.

All results are subject to change depending on information used in the simulation. Results vary with factors such as the number of officers on shift, time spent at incidents, and road weightings. The number of officers on shift varies in different police forces. The time taken to deal with incidents is predicted using historical data from Leicestershire police and hence may be different in other police forces. The road weightings are subject to change altering these to suit a particular area will affect the results.

Future work will include development of road weightings to account for live traffic information. This can use live traffic data from services such as TrafficMaster. Also a user friendly graphical interface is required to allow easy use by police dispatchers. To allow the program to be used by dispatchers a simple interface with low interaction is required so they do not waste time.

VI. CONCLUSION

A need for a police officer dispatch tool is clear, any means of increasing police resource efficiency is necessary in the current climate. The tool outlined has proved its worthiness in selecting efficient officers through simulation giving it a place in the current police dispatch environment. It uses information not currently used in the officer selection process, such as driving qualification, and quickest route, which proves to result in a more efficient officer selection. When the future work highlighted above has been carried out the implementation of the tool into a police dispatch area

will be possible.

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