Decision Support System for Urban Service Failures

Hasan Ali Akyürek, and İhsan Ömür Bucak

***Abstract*—**Urban service failures such as water, electricity and gas can be addressed and eliminated faster through workforce planning. Number of teams at work need to be planned flexibly and their assignments updated frequently to provide a considerable level of public satisfaction and a continued service at constant rate when the failure notification arrival rates show a great change during the day in those services. The objective of this paper is to provide an uninterrupted service to the public by creating a decision support system in proportion to reducing the need for human force in public institutions and organizations. Team's efficiency with actual system is 55 percent whereas with our proposed method it is 95 percent. In accordance with the results obtained, serious efficiency increases have been observed in the workforce management.

***Keywords*—**Artificial Intelligence, Decision Support System, Genetic Algorithms, Management Information Systems, Workforce Management.

I. Introduction

PUBLIC satisfaction is one of the important issues at urban services. To be able to satisfy a certain level on this, it does require to provide fast and high quality solutions to service problems. The objective of this paper is to provide constant services without interruption by reducing the need for man power in public institutions and organizations through the establishment of a decision support system. The decision support system seems promising for providing efficient services with no interruption, and shows a vital importance for the continuation of the daily life in the case of service breakdowns such as electricity, water, gas, emergency services, traffic, telecom, fire, etc. In this paper, a real-world application of a decision support system has been demonstrated efficiently in the case of water distribution network failures for a greater metropolitan city example by taking into consideration the urban sprawl. The proposed system promises hope for providing a great benefit and serious performance improvements in terms of meeting the necessity of making an urgent and a continuous planning and rapid intervention.

Right application of the decision support system will provide advantage to large enterprises in serving better with less resources. Two following parameters such as how much time is needed to troubleshoot any failure whose type and repair are not known at the time of occurrence, and time for teams to get to the failure spot play significant roles. Quick access to the failure scene and the fastest repair time are two major considerations to guarantee public satisfaction in the service sector. In this paper, a decision support system revolved around making use of personnel, contractors and other human assets more efficiently is designed through the use of best-suited artificial intelligence techniques [1].

II. Problem Definition

A service failure at any location within the service boundaries turns into a work order when customers call water distribution failure call line and inform about that particular failure as a result. A system-generated work order is dispatched to a pit boss interested in the failure type. Pit bosses aim to provide service continuity and target a problem resolution as soon as possible by assigning the task to the appropriate teams. In this context, the objective is to set up regional teams depending on the types of failures. Each team is expected to repair the failures of their own task and service field, and hence finalize the work orders. Fig. 1 shows a mobile task scheduling system.

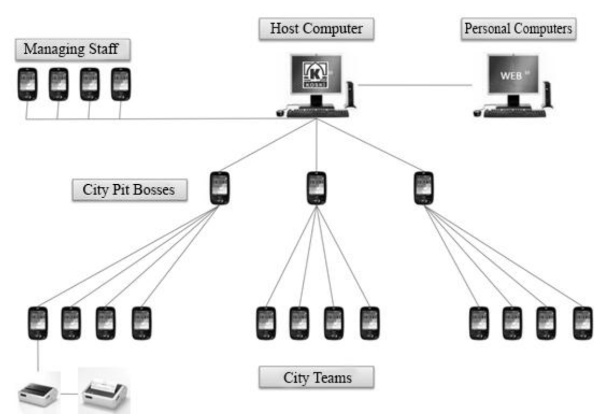

Fig. 1 A Mobile Task Scheduling System

Water distribution network tasks are the more severe field actions and therefore take a long time to finalize. For this reason, the tasks are primarily broken down into the zones and

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fallen into mobile devices of the pit bosses responsible for each zone. The pit bosses, depending on the work load of their own teams and the equipment owned by those teams, assign the work orders to the related teams.

The teams can record the information such as the tools they use, the hours they work, and the positions of them step by step. In the case of a regional blackout resulted from the true nature of the failure, the teams can record the blackout and its field of influence while in the site, and this information is posted on-line by the system at the blackout section of the administration's official web site. In this context, innovation brought by this study can be explained as a decision support system in the form of an optimum way in which the historical data were interpreted and, from now on, it is going to be named as virtual pit boss to the teams as a replacement of the task directives issued by the actual pit bosses.

Konya Water and Sewer System Management (KOSKI) of Konya Greater Municipality work orders made in the year 2012 has been taught to the system and the newly formed work orders have been evaluated through this learning system in the estimation of task duration. Task assignment is done to the teams by minimizing the completion in minimum period of time upon the consideration of completion times of the tasks of the teams, transport times of the teams to the failure zone, and the estimated completion times of the tasks. Instead of dividing the teams regional, all the teams become directed by the virtual pit boss.

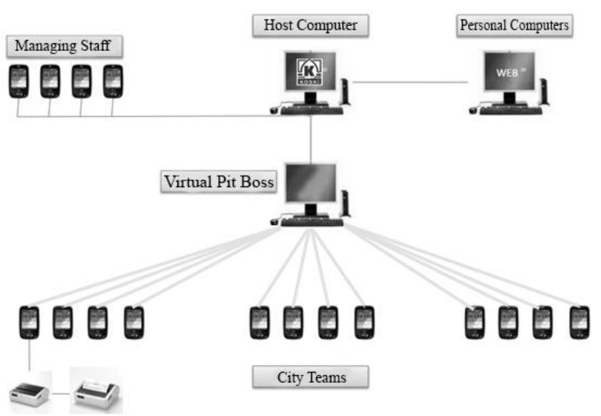

Fig. 2 A Mobile Task Scheduling System with Virtual Pit Boss

As shown in Fig. 2, the city pit bosses have already been replaced with the Decision Support System (DSS) named as virtual pit boss.

A reporter or caller transfers the information about the problem to the system by calling the failure line whose staff creates the work order by filling out the required information via the form. The system assigns a team or teams deemed appropriate by examining the demand.

Team(s) sends the result info back to the system by carrying out the assigned tasks. If the result is positive and the task is done, the system completes its task by finalizing the related work order without creating any further work orders and closes it. Fig. 3 shows the task flow diagram for these processes.

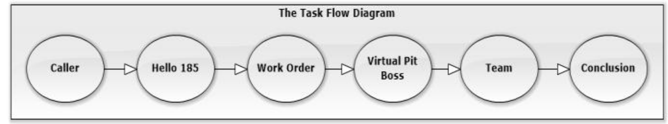

Fig. 3 The Task Flow Diagram

III. Material And Methods

A. Learning Model

Learning model in Fig. 4 is created upon using the old failures data for estimating the new work order's work time. The Artificial Neural Networks (ANN) is used for training model.

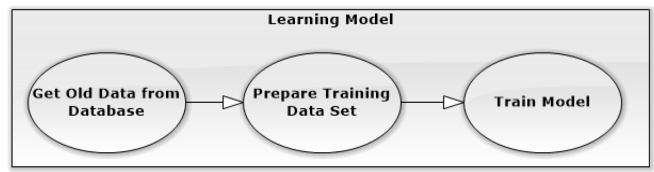

Fig. 4 Learning model diagram

ANNs, a branch of artificial intelligence, is the information processing systems that mimics the general working principles of a human brain or a central nervous system. ANN, formally and functionally, mimics the neuron which is the basic element of the human nervous system and forms a sound basis for the systems that can learn [2]-[6].

ANN model used in this study is a 3-layer model. These layers are called the input, the hidden, and the output layers. There are 10 neurons in the input layer, 11 neurons in the hidden layer, and lastly a single neuron in the output layer.

B. Decision Support System (DSS)

A Decision Support System is a computer-based information system, which supports a decision maker by utilizing the data and model to solve the unstructured problems. It also improves quality of decisions with capabilities of the computer [7]. The architecture of DSS is shown in Fig. 5.

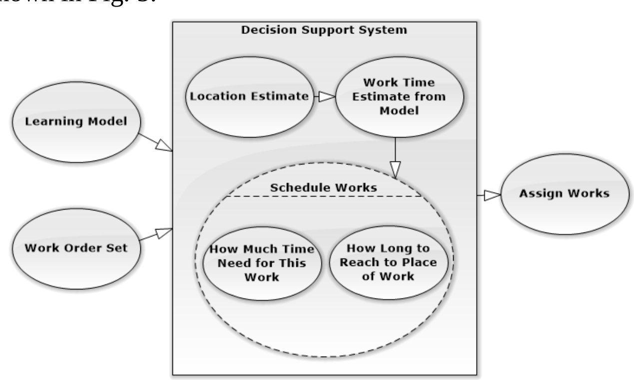

Fig. 5 Decision support system diagram

As shown in Fig. 5, DSS uses the learning model and the new work orders as inputs, and as a result, assigns tasks to the teams. In the decision support system, the learning model is used for estimating work time of the new work order, and Google geo-coding interface is used for calculating time to reach the place of work [8]. Geo-coding API (Application Programming Interface) presents services that are accessed via http and in which we will receive the output as XML or JSON. Geo-coding is the process of converting human-readable addresses to geographical coordinates in order to find the route between team and place of work [9].

Genetic algorithms (Gas) is employed to assign the tasks on the basis that minimizes the work time of the teams [10].

As the new work orders are added to the system, the work orders which were planned earlier but not activated yet by the teams along with those lately added work orders are planned again by the genetic algorithm. The work order completion time along with the new work orders upon calculating through the ANN algorithms is given as a parameter to the genetic algorithm in conjunction with the team list. For each team in the list, the algorithm will schedule works by optimizing the total work time with the transport time.

Therefore, it is aimed for the teams to work as much equal as possible.

IV. Research Results

All the work orders made in 2012 belonging to KOSKI of Konya Greater Municipality have been taken into considerations. The extreme values have been eliminated through the use of five number summary algorithm, and a clean training data set upon the well-established data integrity have been built [11]-[13].

Around 9000 work orders within the training data set have been subjected to training with ANN algorithms.

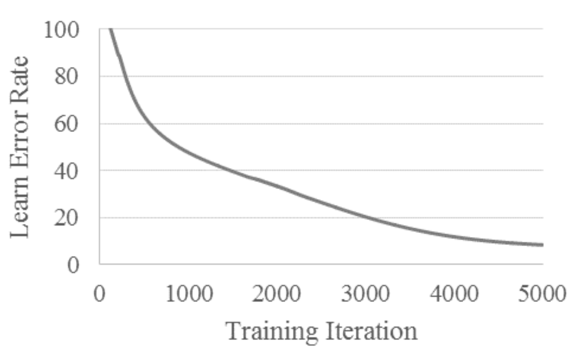

Fig. 6 Learn Error – Iteration

As shown in Fig. 6, the system has learned the data of the year 2012 with 8 percent error rate.

The work orders made within a randomly selected day in 2013 have been used as test data. This test data has been provided input to the system, and the results produced have been compared. For the related work orders, firstly the information about how much time is required to do the task is calculated.

When the task assignment is done to the teams, the work orders at the hands of each team and their end times; for how long the teams did stay idle if there was no work order; the distance of the teams to the location of the incoming new work order from the location while the teams being idle, or from the location of their last work site while the teams being not idle have all been calculated. Reassignment of the tasks which are not initiated yet by the teams, along with the new work orders is carried out upon sending the calculated information above to the genetic algorithm. The new works are informed to the teams and the required updates are done. Before DSS, 11 teams work on this problem. The average efficiency was 55 percent. With DSS number of teams have been kept 5 for algorithm. If a new work order is overload the teams, new team will assign to problem.

Table I shows actual system limited with 5 teams and overtime cost will pay to overloaded teams and efficiency become 100 percent. The break time which is up to 10 percent of the entire task duration have been provided for the teams.

TABLE I
Actual System Team – Work Order With 5 Team

	Team 1	Team 2	Team 3	Team 4	Team 5
Total Work Order	6	6	6	6	7
Total Work Time (min.)	214	266	318	582	652
Total Transport Time (min.)	58	70	61	153	186
Total Rest Time (min)	21	27	32	58	65
Total (min.)	293	363	411	793	903
Shift Time (min.)	540	540	540	540	540
Total Efficiency	54%	67%	76%	100%	100%

The total efficiency becomes 79 percent in total as well. The graph in Fig. 7 shows the outputs of the decision support system in terms of work order completion time (minute) against several work order IDs after running with ANN algorithm. This overlapping ratio is 90 percent for artificial neural networks algorithm.

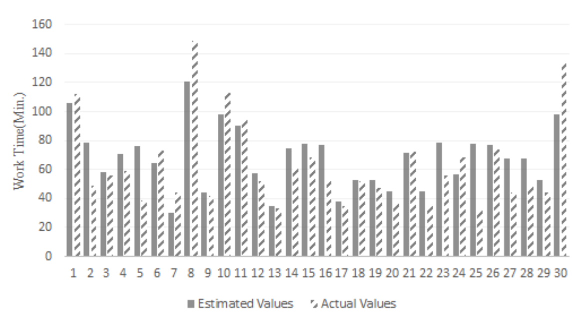

Fig. 7 Estimated Values - Actual Values

Fig. 8 shows the result of genetic algorithm for optimal schedule.

Fig. 8 Optimal Schedule Curve

Table II shows the teams' work order as a result of the work order assigned by the decision support system, their working time periods, their resting time periods and their transportation time periods along with the efficiency of the decision support system calculated as based on those time periods aforementioned above.

TABLE II
DSS TEAM – WORK ORDER WITH 5 TEAM

	Team 1	Team 2	Team 3	Team 4	Team 5
Total Work Order	6	5	6	6	8
Total Work Time (min.)	423	411	419	390	389
Total Transport Time (min.)	39	51	47	71	74
Total Rest Time (min)	43	41	42	40	39
Total (min.)	505	503	508	501	502
Shift Time (min.)	540	540	540	540	540
Total Efficiency	94%	93%	94%	93%	93%

The total efficiency becomes 94 percent in total as well.

V. EVALUATIONS AND SUGGESTIONS

Information concerning on how much time the task is required for the tasks such as repair and maintenance can only be reached with an estimation or as a result of a past experience. The most important factor in the workforce planning is how long the task process will take. In addition to this, transportation or getting to the work site and availability are also other important factors to consider.

Considering the fact that there were no tasks at the hands of the teams at the start of the morning shift, the incoming work orders during the day have been assigned to the appropriate teams by the system.

The main purpose of this case study is to minimize costs while maximizing the service standards by using the teams more efficiently. Although it does seem that the work currently being done by eleven teams can also be done by five teams.

Fig. 9 shows the efficiencies according to the actual pit boss with 5 and 11 teams vs. virtual pit bosses.

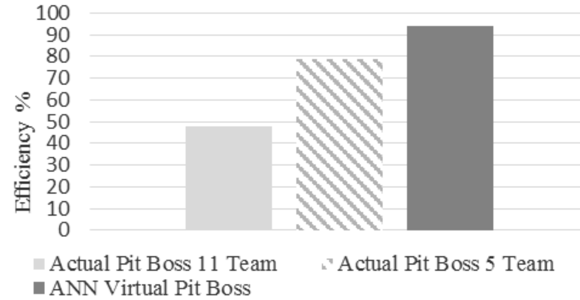

Fig. 9 Efficiency Graphics

As a result, the virtual pit boss operates with a higher efficiency compared to the actual values. Both the public and private sector organizations, institutions and agencies are along with artificial intelligence and intelligent systems within the framework of the everyday changing and developing technology. Better quality of service can become reality with more intelligent systems.

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