Simulation of Allocation Schemes for Power Restoration Specialists in a Utility Company

Suleyman Tufekci and ALVA Team[1]

Department of Industrial and Systems Engineering
303 Weil Hall, University of Florida
Gainesville, FL 32611, e-mail: tufekci@ise.ufl.edu

Barry Anderson, Hector Artze, Brick Rule

Florida Power and Light
P.O. Box 025576, Miami, FL 33102, e-mail: Hector_Artze@fpl.com

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Abstract: Power interruptions to residential and commercial customers are a common occurrence in Florida. These interruptions come from four major sources: feeder-line problems, lateral-line problems, transformer problems, and single current (single home) problems. These interruptions affect approximately 20 million Florida Power and Light customers in a given year. The total hours of non-service reaches to 50 million hours. Total loss of potential sales amount to a staggering 386 million Kilowatt-hours. Currently, the allocation of restoration specialists to each one of these incidents is handled by "Dispatch Centers." These centers are manned by dispatchers whose duty is to allocate a restoration specialist (RS) to an incident. Each RS is assigned to a zone area, but they are only assigned to an incident if it is within their zoning area. In this paper, we call this allocation scheme the "fixed-zone allocation scheme." In order to improve the efficiency of the restoration specialists, we analyze different zoning schemes. Through simulation, we evaluate advantages and disadvantages of each zoning scheme.

I. Introduction

Power interruptions to residential and commercial customers are a common occurrence in any country and city. The reasons behind power interruptions come from several sources. The first and foremost is a feeder-line interruptions. Although the frequency of this type of interruption is approximately 5,000 per year, it affects 15 million customers. The second most important interruption comes from lateral interruptions. Although the frequency of these incidents is the highest among the four types, it only affects 5 million customers in a year. The third type of interruption comes from transformer problems. Each transformer breakdown affects 10 customers. Approximately 20,000 transformer interruptions take place in a given year, affecting 200,000 customers. Finally, approximately 20,000 single-current interruptions take place in a given year. These types of incidents affect only a single customer. Therefore, only 20,000 customers are affected each year. The overall frequency of incidents in a given year is approximately 95,000, affecting 20,200,000 customers.

[1] ALVA Team members include Nabila Achour, Mike Leclaire, Nexon Louis, Melissa Paik, and Jaime Randolph.

The total hours of power outages due to these four types of interruptions amount to 50,440,000 hours in a given year. When translated into Kilowatt-hours (kWh), this number is a staggering 386 million kWh.

From the customer's perspective, this is service unavailability and not desirable. From the utility company's perspective, this is an issue with customer satisfaction as well as lost revenues. Such losses in a given year may go as high as $15 million.

The above numbers indicate that an efficient method of marshalling and scheduling restoration specialists to attend these incidents may improve the customer satisfaction and reduce loss revenues.

In Section 2, we provide the current procedure for allocating RSs to incidents. Section 3 provides different zoning and ticket allocation models studied in this work. The architectural framework of the simulation model is presented in Section 4. Conclusions and recommendations are given in Section 5.

2. Current Method of RS Allocation

In its current form, a power interruption incident is processed in several stages. These stages are listed below:

1) A customer calls the "Customer Care Center" (CCC) to report an outage.
2) The CCC operator enters the locations of the outage into the computer.
3) This entry is transmitted to the "Trouble Analysis Engine," which is an expert system software that determines the true reason for the outage.
4) Based on similar calls coming from the same neighborhood the Engine analyzes the root cause of the outage and identifies the true location of the problem, generates a service ticket, and relays it to the Dispatch Center, which appears on a dispatcher's terminal.
5) The dispatcher who is in charge of assigning tickets to RSs assigns the ticket to an RS, who is in charge of that zone, using his expert judgement. This assignment is electronically relayed to the RS.
6) The RS who received the ticket attends to all tickets in his or her ticket queue one by one. In this process, information as to when the travel to the incident site is initiated, when the travel to the job site is ended, and when the repair has started and ended is recorded.
7) Once a ticket is successfully handled, the RS then moves to the next assignment.

There are a few minutes of delay from the time an outage is entered into the CCC computer until the ticket is generated and relayed to the Dispatch Center. This delay is due to Trouble Analysis Engine's need to analyze the incoming calls to determine the root causes of those incidents. If a home is calling to report an outage, it is possible that this may be due to an isolated problem at that home alone, or it may come from a transformer problem which regulates power to 10 other customers. Otherwise, it may be because of a problem on a lateral line, which affects 100 customers at the same time. Finally, if the problem is due to a feeder line failure, it affects 3,000 customers all at the same time. The Trouble Analysis Engine accumulates the calls coming in and by using its expert knowledge determines the root cause. This causes 4-5 minutes of delay to the entire restoration activity.

Once the ticket appears on a dispatcher's screen, it is the dispatcher's duty to assign the task to a restoration specialist. In assigning each ticket, the dispatcher looks at the current loads of all RSs in that zone and, by using his subjective judgement, assigns them to a restoration specialist. In doing so, a dispatcher not only has to keep track of the number of tickets in each RS's queue, but also must determine the RS's current and future locations, before deciding on the final ticket allocation.

As mentioned before, the State of Florida is divided into eight zones. Each zone is serviced by 4-10 service centers. Each service center is divided into 2-12 truck areas, based on the density of the population. Finally, each truck area is composed of poly-zones, which are approximately 1,500x1500 feet square areas. A ticket is assigned to the appropriate truck zone and the restoration specialist if its coordinates fall within the truck area. Occasionally a ticket may be assigned to a restoration specialist whose truck area does not include the coordinates of the current ticket.

This current scheme of ticket allocation is called the "fixed zone allocation scheme." In this paper, we study different zoning schemes to improve the service efficiency for the Florida Power and Light (FP&L) customers in Florida. To this end, we developed a simulation program that will test different zoning and ticket allocation schemes and compare the desired performance measures provided to us by the FP&L liaison engineers. The following list provides different objectives listed by FP&L.

1. Performance

- Minimizes ticket queue time
- Allocates tickets equitably among the RSs
- Minimizes response time (time to reach to a site)
- Minimizes resources needed
- Minimizes overtime
- Minimizes the maximum response time
- Minimizes average outage
- Minimizes total outage time

2. Reliability

- No loss of records
- No corruption of data
- System will not crash
- Data are properly handled
- Accurate

3. Features

- User-friendly
- Easy to learn
- Easy to use
- Provides graphical user interface
- Performs statistical analysis and extensive charting
- Displays RS movements on a map
- Uses available company databases
- Adaptable to different regions in the state
- Runs on a PC

3. Different Zoning Schemes Used in the Simulator

In order to improve the customer service, we built different zoning schemes for restoration specialists in the simulator. These schemes are listed below:

a) Current zoning scheme used by FP&L (fixed zoning)
b) No zoning
c) Overlapping zones
d) Fixed zones plus free agents
e) Distance-limited incursions to a neighboring zone

In order to simulate different zoning schemes with real data, FP&L provided us with a two-week period of past restoration activities that took place in 1999. Each ticket generated and handled is stored in the FP&L database with additional information including time of assignment, travel time, and repair time. Instead of generating repair times randomly, we decided to use the actual repair time on each ticket. For the new schemes, since the tickets are allocated in different order and possibly to different restoration specialists, we needed to generate travel times through our simulator. We used rectilinear distance between the last location of the RS and the location of the ticket. We then used an average speed of 35 miles per hour to estimate the travel time.

In all zoning schemes, we used the following formula in estimating the first available time of a restoration specialist.

RS first available time = (current time) + (time to finish all jobs in RS queue including the current job being attended to).

This first available time is used for making the ticket allocation to an RS. In general, an RS who can attend to an arriving ticket the earliest is given the assignment. That ticket is then included in the appropriate RS's queue. In the case of multiple criteria, we also looked at different measures such as the number of tickets handled so far, distance from the ticket, etc., before making the final assignment.

In the case of no zoning scheme, the restoration specialists are freely allowed to travel to any ticket as long as they are the closest in terms of response time. In the case of limited distance allocation, the restoration specialist receives the ticket, which is within his maximum circle of travel distance, and is the earliest who can reach there.

In case of neighboring zone schemes, we define zones that are the primary responsibility of an RS. In addition, we defined the neighboring zones as this RS's secondary responsibility. In making assignments. the simulator first checks the availability of the primary RS. Then it estimates the availability of the secondary RSs for the ticket. A ticket is assigned to a secondary RS only if the primary RS cannot reach it earlier.

In the case of overlapping zone schemes, we define overlapping zones between two neighboring zones defined by some distance measure. Any restoration specialist regardless of his true zone assignment can attend any ticket, which originates in overlapping zones, as long as his true zone assignment covers the overlapping zone. We note here that an RS may travel to different overlapping zones between his own zone and the overlapping zones around his base zone.

In the case of fixed zones with free agents, we define some zones and allocate some RSs into these zones as primary RSs. These people only allowed attending tickets in their own zone. In addition, we assign several free RSs who are free to attend any ticket as long as they are closer to that ticket in time. The basic idea behind this scheme is to support the areas that are inundated by excessive tickets by sending free agents for help.

4. The Software Architecture

The simulation program is written in Microsoft Visual Basic using MS Access 2000 for handling databases and queries. The program is modular. A high level description of each module is provided. The software architecture and modular structure is given in figure 1 below.

Ticket Generator

This module sends the actual tickets in the database to the main program. Tickets are sent in the chronological order they are received.

Travel Time Estimator

This module estimates the expected travel time between the last location of the restoration specialist and the next ticket he has to attend. By modularizing this function, we will be able to use different travel time estimation functions. In its current form, the module computes the coordinates of the incoming ticket from the TLN number recorded on the ticket. The TLN numbers are translated into State Coordinate System. By using the state coordinates, the rectilinear distance is calculated between the two points. This distance is then used in estimating the travel time.

Ticket Allocation Module

In this module, each incoming ticket is allocated to a restoration specialist based on the zoning scheme used and allocation scheme selected. Ticket priorities as well as fair allocation schemes are included in the allocation process. In the case of overlapping zones and neighboring zone schemes, primary and secondary lists are checked to find the right restoration specialist to allocate the ticket.

RS parameter Update Module

This module keeps statistics on RS utilization, RS queues, their current position, and other relevant information. It also updates the first available time for each restoration specialist.

Repair Time Estimator

This module estimates the time it will take to repair the received ticket. In running the simulator using the historical data, the repair times are pulled directly from the ticket database. For Monte Carlo simulation, where tickets are generated randomly, it will generate repair time by using the repair time distribution for each ticket type. The distribution parameters are estimated from the historical data.

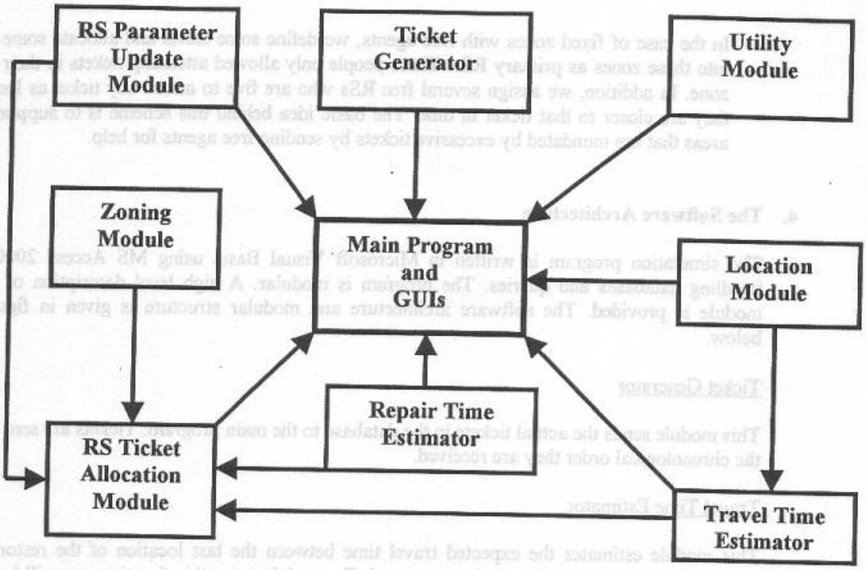

Figure 1. The Software Architecture of the RS Allocation Simulator

5. Conclusions

The software development and testing activities are continuing at the time of writing this article. Some limited testing has already started. This project has been sponsored by Florida Power and Light Corporation, in Miami, Florida, under the Integrated Product and Process Design (IPPD) program at the University of Florida. The IPPD Program at the University of Florida is a College of Engineering program sponsored by the National Science Foundation and the Southeastern University and College Coalition for Engineering Education (SUCCEED) and the partner companies that participate in the program. The SUCCEED program is in its sixth successful year in 1999-2000 academic calendar year. Currently, 23 industry-sponsored projects are handled through this program.

The final delivery of the RS allocation simulator will be on April 27, 2000. We expect to present the entire findings of our simulation results at the TIEMS' 2000 conference in Orlando, Florida, on May 16-19, 2000. Our limited simulation results show that the no-zone scheme of ticket allocation may provide better service to customers compared to the fixed zone scheme currently in use. The results of other zoning schemes will be reported at the conference.

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