CASE STUDY OF THE USE OF THE TRANSPORTATION ALGORITHM FOR SCHOOL DISTRICTING UNDER FEDERAL INTEGRATION GUIDELINES

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Abstract—One part of the problem of school districting is the assignment of children to schools in such a manner as to minimize the overall cost of the system. This is a simple transportation problem and transportation procedures have been used in the past so as to minimize such things as total student-miles traveled (both straight line and actual travel distance), cost of transportation and many other measures of “Cost”.

Even with the introduction of minimum and/or maximum Federal integration limits, the problem can be stated as a transportation problem with suitable alterations. This paper presents a case study of the application of the transportation procedure to school districting under integration guidelines along with some observations on the results.

The problem of neighborhood school assignments may be solved by the use of the transportation procedure of operations research as outlined by Franklin and Koenigsberg[3], which is concerned with the transportation of goods from point to point. In the school assignment problem, the goods are the students and the origin and destination of our transportation system are the population blocks and schools, respectively. Another complication appears when the necessity of adherence to integration limits is added, consisting of the need to consider different racial groups separately, thereby creating as many “neighborhoods” as there are racial groups. With suitable alterations as suggested by McDaniel[9] the transportation algorithm can be used efficiently with the added complication.

With the addition of the minimum/maximum integration limit constraints to the school districting problem the necessary adaption of the problem consists of several steps. First, one must artificially divide the population blocks into N distinct entities, one for each population type. In addition, the same must be done for the schools. By definition, students of a population type must attend the artificially created schools for that population type. An “allowable” capacity for each population type for each school is set up as the school capacity multiplied by the maximum allowable percentage for the population type. As the sum of these “allowable” capacities for a school are always greater than the actual school capacity, a number of fictitious blocks are created to provide true school capacities not to be exceeded.

To investigate some of the questions which seem to arise in connection with large-scale busing, a large problem was examined. Due to availability of data and the recent expression of interest by the head of the Board of Education, the selected problem was concerned with the school system of Milwaukee, Wisconsin and confines itself to only two population groups, whites and blacks.

The city of Milwaukee has a population pattern similar to many large cities, consisting of a large central black population area (some census tracts show 98% blacks) and outlying areas of predominantly white neighborhoods. For population block data, the available data of 218 census tracts was used. Data available for each tract consisted of population, P, percentage black, Pb, and percentage of population under 19 years of age, Pu. The number of black and white students of high school age on each block was computed as P Pu and P(1 - Pu) Pu/6. These figures were assumed accurate enough for a test example and should be of approximately the right magnitude.

For school capacities, the 1972 enrollment figures were used for the 15 high schools in the Milwaukee school system. Again, this was considered accurate enough for a test case.

A problem with I, blocks, M schools and N population types will result in a transportation problem with NL + (N - 1)M sources and NM destinations. In the test problem this is 451 rows and 30 columns.

A computer program was developed to take advantage of the special structure of the problem. The program adjusts the school capacities (either upward or downward) so that the total block population will equal the total School Capacity and to provide equal percentage over-crowding or under-utilization of schools.

On problems of the size mentioned, solution was obtained on a UNIVAC 1108 in less than two minutes in all cases.

Two cost vectors were used in the testing of the procedure. One was a distance vector from the center of the population block to the school. The other was a busing distance vector (the same as the first, except that any distance less than 2 miles is set to zero). Any other cost vectors desired could be used, such as cost of busing per mile, actual busing distance, etc. In addition, more complicated criteria such as dangerous intersections and infeasible routing could be included in the problem by school planners with little problem.

There were 3 sets of P B max and P B min selected. These were: 0 ≤ Pb ≤ 1, 0.4 ≤ Pb ≤ 0.34 and 0.16 ≤ Pb ≤ 0.22, where Pb is the percentage of blacks. The first of these was selected as it gave base figures for a system without integration guidelines (but with school capacity restric-
tions). The second follows actual guidelines for California (percentage blacks in a school cannot be more than 15% variance from the communities' population mix). The last gives an extreme example of forced integration where the minimum and maximum percentages of blacks in each school must be within 3% of the community population mix.

Some factors which came to light in solving these problems proved to be of interest. First, the more closely the integration guidelines were drawn to the actual black population percentage, the more schools are forced to either the minimum or maximum percentage allowable. Second, it was found that by using a situation where guidelines were especially stringent and another where they were completely loosened, it was possible to tell how much effect integration restrictions had compared to school capacity restrictions. For example, it was found that of the total additional distance traveled by children when tight guidelines were enforced, 32% came about because of the need to observe school capacity restrictions and not because of the integration limits.

Under loose guidelines it was found that white students traveled farther to school on the average than black students. This is due, no doubt, to the fact that more white students live in suburbs where distances to facilities are greater. When integration limits are tightened, however, the average amount of travel for blacks increases drastically (reaching over two times that of white students).

In considering the difference generated in a system with severe guidelines versus one with no integration guidelines, an interesting fact came to light in that the amount of increase in distance traveled by white students is only about 1%. If California guidelines are followed, the difference is approx. 1%. Thus, white children would be traveling fewer total miles under California guidelines than under no guidelines.

Black children, on the other hand, traveled 2 1/2 times as far under severe guidelines as under no guidelines and 1 1/2 times as far under California guidelines. Apparently, to achieve integration, it is the black student who will have to be put at prohibitive distances and not the white student.

Under no restrictions other than school capacities, it was found that 59% of black students went to the school closest them and 79% went to either the closest or second closest. Only 1% of them were forced to attend a school farther away than the 5th closest. The corresponding figures for white students were 80%, 95% and 0%. Under California guidelines, the figures are: blacks—29%, 47% and 21%; whites—78%, 95% and 0%.

Of interest was the fact that under California guidelines, of the 218 census tracts, only 48 (22%) had their white children and black children assigned to the same school. That is, even though the schools might be integrated, the whites or blacks associated with in one's school were necessarily those who lived in one's neighborhood.

REFERENCES