The use of computerization in school bus routing and scheduling

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Abstract
During the early years of public school education, students were transported to and from school by their parents or family friends. However, by the end of the nineteenth century, the responsibility for transporting students began shifting from the parents to local school districts (Anthony and Inman, 1986). The second half of the twentieth century brought about changes in the services provided by student transportation programs. Services were expanded to include not only busing to and from school, but busing for desegregation purposes, transportation of students to and from athletic/extra-curricular activities, field trips for students, and the transportation of handicapped students as required by federal legislation. As a result of this multi-dimensional approach to student transportation, costs associated with the transportation of students have continued to rise and management of the transportation program has become more critical and complex (Anthony and Inman, 1986).
THE USE OF COMPUTERIZATION IN SCHOOL BUS ROUTING AND SCHEDULING

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Sharon Droste
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Entitled: The Use Of Computerization in School Bus Routing and Scheduling

has been approved as meeting the research paper requirement for the Degree of Master of Arts in Education

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During the early years of public school education, students were transported to and from school by their parents or family friends. However, by the end of the nineteenth century, the responsibility for transporting students began shifting from the parents to local school districts (Anthony and Inman, 1986).

The second half of the twentieth century brought about changes in the services provided by student transportation programs. Services were expanded to include not only busing to and from school, but busing for desegregation purposes, transportation of students to and from athletic/extra-curricular activities, field trips for students, and the transportation of handicapped students as required by federal legislation. As a result of this multi-dimensional approach to student transportation, costs associated with the transportation of students have continued to rise and management of the transportation program has become more critical and complex (Anthony and Inman, 1986).

With the introduction of computer technology into the field of education, transportation departments have begun utilizing computers to perform scheduling and routing tasks. Walcott, Hauser, and Iverson (1986) provide us with a working definition for the terms scheduling and routing:

"Scheduling refers to the specification of school opening and closing times along with the positioning of the school bus fleet to make the best use of the buses' capacities. Routing refers to the selection of the students to
be transported by a particular bus, the roads and streets
to be traveled, and the actual sequence (and location) of
stops to be followed" (p. 39).

Prior to 1981, the use of computers by school transportation
departments was limited. This was due in part to the fact that
computational speeds of most microprocessors were slow, disk storage
was too small, and software programs were unavailable. However,
since 1981, microprocessor speeds have improved, RAM memories have
increased storage capabilities, and a number of proprietary application
packages have emerged on the market (Freeman, 1986).

Creighton (1986) states that, "within five years, most school
systems with enrollments of more than 2,000 will use microcomputers
to design their school bus routes and help in the day-to-day management
of their transportation programs" (p. 8). Creighton (1986) further
states that there are two reasons why the use of computers in bus
scheduling will become commonplace. First, microcomputers have become
"fast, reliable, and inexpensive" with ample storage capabilities,
and secondly, "software is available that will group students into
bus loads and compute specific routes and schedules for each bus"
(p. 8).

Recent years have seen a revolution in the technology used in
the area of computerized transportation routing and scheduling programs.
Programs have evolved from strict usage on mainframes to being adaptable
for use with microcomputers. This evolution has provided a means
by which districts can perform the work on site rather than having to contract with outside consultants/firms to perform such tasks. The cost of these programs has declined significantly to a point where school district's can not afford not to have their operation computerized (Dembowski, 1988).

Garden and Liebermann (1989) have found that transportation algorithms, along with present-day computer speeds and mega-RAM storage at low dollar cost, have been instrumental in making computerized routing and scheduling available to school districts. These changes have resulted in improved operations and a significant reduction in busing costs.

Walcott, Hauser, and Iverson (1986) state that "satisfactory bus operations depend to a great extent upon establishing bus routes efficiently and in fairness to all students" (p. 39). With the current availability of computer-assisted routing and scheduling programs, Walcott, Hauser, and Iverson (1986) indicate that the time and drudgery involved in the scheduling and routing process can be reduced significantly.

**Criteria For Potential Users**

In a 1982 report prepared for the California Energy Commission on computerized transportation systems in California, Edwards (1983) stated that the following criteria were identified as factors to be considered by potential users:

1. Size of Bus Fleet. A local education agency should have
thirty-three (33) or more buses if street coding is required. If little or no street coding is necessary, a district with a fleet of twenty (20) or more buses would benefit from computerized routing and scheduling.

2. Geographic Factors. Urban educational agencies with high density populations and a wide variety of streets and highways would benefit from computerization more than rural districts with low density populations and a limited street network.

3. Accessibility To Computers. Transportation staff must have access to on-line computer time in order for benefits to the district to be realized.

4. Total Commitment. In order for a computerized transportation system to be effective, broad-based support from the board, administration, and the community must be secured. In addition, knowledgeable professional and technical staff assistance must be available to the adopter.

Anthony and Inman (1986) identified a fifth criterion from the same 1982 report prepared for the California Energy Commission. They stated that the topography of a district should also be considered when determining whether to utilize a computerized transportation system. They indicated that because computerized routing and scheduling are dependent upon maps, terrain which was difficult to input into
the computer can have a negative impact on the efficiency of the system.

According to Walcott, Hauser, and Iverson (1986), school districts with complex scheduling and routing problems, districts with special education programs, magnet schools, or busing for desegregation purposes find computer-assisted routing and scheduling programs useful. They further state that "the time to use computers is when the cost, time, and effort of doing so is more than compensated by benefits gained" (p. 40).

Creighton (1986) outlines two intangible things that he feels are necessary to implement a computerized transportation system successfully. First of all a district must have "an interest in trying new and better ways to do a job," and secondly, they must have "a determination to save money" (p. 33).

Benefits And Potential Cost Savings

One of the major uses of computer-assisted transportation systems identified by the literature is routing and scheduling. Any school district which operates a school bus fleet must establish student pickup stops and develop routes to transport students to and from school (Spitzer, 1986). According to Spitzer (1986), two primary economic considerations must be considered whether route calculations are done by hand or by computer. First, routes must be found that allow for students to be transported within established time constraints, using the minimum number of buses. Secondly, using this
minimum number of buses, routes must be developed which reflect the lowest possible operating costs. He further states that "optimized calculation" of school bus routes is regarded by mathematicians as "extremely difficult" because there can be an astronomical number of pickup stops to form routes (p. 32). However, he concludes that technological advances in computer software programs have now made the calculation of optimal routes easier and that costs have been reduced to an affordable level for virtually all school districts.

According to Creighton (1986), "doing the same job by hand is time-consuming, to say the least. In fact, it can be so laborious a task that existing routes - even if they're no longer the most efficient sometimes simply are perpetuated" (p. 8). He adds that with the hardware and software now available, it makes sense to think about computerizing school district bus routes.

Walcott, Hauser and Iverson (1986) have identified several district needs that are affected by computerized scheduling and routing techniques:

1. Safety of the Students. The safety of students riding buses is critical to any district transportation program. It is known that safety can be improved by reducing the number of bus stops and by having students ride the buses for shorter periods of time. Therefore, computer-assisted programs which offer more efficient scheduling and routing can increase the potential for student safety. Also, many computer-assisted scheduling and routing systems have built into them ways
to avoid hazardous highways, streets, bridges, intersections, and railroad tracks, thus increasing the possibility of improved student safety.

2. Cost Factors. Computer-aided scheduling and routing can save money by reducing the size of the bus fleet; reducing fuel consumption, wear and tear on the buses and other operating costs through the reduction of the number of bus stops and miles driven daily; and by reducing driver expense due to less driver time needed.

3. Student Convenience and Fairness. Most school districts mandate that students spend the least amount of time riding a bus as possible. However, convenience and fairness almost always mean higher costs to districts. "One of the simplest tasks for the computer is to arrange and compare student rides according to cost, convenience, and fairness" (p. 40). Computers can choose the best routes among several alternatives at very little cost to the user.

4. Special Needs. In many local educational agencies, busing students enrolled in special programs at selected schools creates problems for transportation programs. However, these problems can be resolved very easily by computer-aided routing and scheduling procedures.

The cost effectiveness of computerized routing and scheduling is further demonstrated by Creighton (1986). He states that "with
microcomputer routing and scheduling, you can be sure that if a way exists to save on the number of buses you deploy and how many miles they must travel, the computer will find it" (p. 8). With the typical cost to maintain a single school bus averaging $17,000 to $25,000 a year, Creighton (1986) says that the right computer program can save that much in a year, thus paying for the upfront costs of the system over a short period of time.

Freeman (1986) cites several examples of cost savings to districts implementing a computerized routing and scheduling system. The Cornwall-Lebanon School District in Lebanon, Pennsylvania retired eight buses and reduced bus travel by 87,000 miles during a one-year period of time. An initial investment of $50,000 in the Cornwall-Lebanon School District resulted in $250,000 in savings, a "return of five to one" (p. 28). He further relates that the Upper Merion Area School District in Pennsylvania utilized a computer-assisted routing and scheduling system to reroute the districts high school students. Three to four vehicles were saved by performing the routing and scheduling procedures by computer. Since 1983, the Upper Merion District, through the use of computer-aided routing and scheduling, has also reduced both the number of vehicles used and the annual mileage for serving non-public students.

Edwards (1983) states that the 1982 study prepared for the California Energy Commission found that "over one million gallons of motor fuel and $20 million in capital and operating expenses could be saved
annually in California if computer management was applied to fleets of 20 or more buses." The study further concluded that educational agencies operating bus fleets of 33 or more buses "could achieve statewide cost and energy savings of $14,190 and 730,000 gallons of fuel per year." In addition, "if fleets of 20-32 buses were to use computerized transportation systems, an additional potential annual savings of $6,235,000 and 325,000 gallons of fuel would be realized." The study team's estimates of "10 percent reduction of fuel and travel time and an 8 percent reduction in school bus fleet size" would result in a total statewide annual savings of $20,425,000" (p. 49).

Zisserson (1982) cites another specific example of cost savings generated by computerized bus scheduling. The Fort Worth, Texas school system reduced the number of buses used from 329 to 275 and experienced a cost savings of $975,000 during the first year of operation. The Los Angeles County (California) Office of Education has utilized a state-of-the-art computerized transportation management system for several years. Direct results of the system are "complete administrative control of the transportation function, $2 million annual net savings, and prompt, accurate bus service for the students, parents, and teachers" (Caswell and Hall, 1987, p. 32).

According to Freeman (1986), "most suburban and rural districts can save ten to twenty percent of its annual mileage as well as reduce their fleets by five to ten vehicles." Further, because these savings
recur every year, he says that districts "can reasonably expect to repay their automation investments in their first year, then hold operating costs low with little staff commitment" (p. 31).

Disadvantages And Implementation Problems

One of the major disadvantages of computer-assisted transportation routing and scheduling is the initial capital outlay needed to implement the system. The total cost of implementing these programs can start at about $20,000 and go as high as $100,000 (Dembowski, 1988). In addition, because of the complexity of implementing such systems, "few districts have been able to automate transportation planning without assistance from a reputable firm with proven experience in this specialized area" (Freeman, 1986, p. 31).

Another disadvantage of computerized routing and scheduling is the time it takes to collect and input data necessary to the efficient operation of the system. According to Freeman (1986), accurate geographic files must be built. These files include the location of all schools and current bus stops, stop distances and travel times, formatted street addresses, and a street directory to help assign students to stops safely and efficiently. "Substantial disk storage is required for this detailed directory, plus painstaking clerical effort to enter the house-number ranges for each street and the corresponding bus stops" (p. 31).

The implementation and success of any computerized transportation system requires a great deal of interdepartmental cooperation. For
change to work, people must be accepting of the change and understand completely what their role will be in the change process (Carriedo and Others, 1986).

The San Diego Unified School District (California) implemented a computerized routing and scheduling system during the 1985-86 school year. The computerized system in the district experienced a significant number of implementation problems. A study team set up to review the system found that failure to define the complexity of the implementation process, the lack of pre-implementation planning and training, and a decision to implement the system district-wide rather than gradually phasing it in, contributed to the heavy workloads experienced by many people involved in the implementation process, initial resistance by key staff members to the system, and overall ineffectiveness of the routing and scheduling process (Carriedo and Others, 1986).

Finally, some school districts have experienced problems with implementing computerized routing and scheduling systems because they have chosen the wrong software for their district. The market for school district routing and scheduling programs is large, therefore, many companies have begun offering software to meet this need. Many of these companies offer quality programs and services, but some do not. Products should be examined carefully and informed decisions made as to the type of software implemented (Dembowski, 1988). Freeman (1986) states that "although several overly optimistic vendors have advertised 'shrink-wrapped' software diskettes for routing schoolbuses,
most of these offerings do not meet district needs..." (p. 31). Freeman further suggests that vendor support is the key factor to be considered when selecting a computerized system for planning bus routes. He states that "districts should beware of mail-order software; the task of building accurate geography files is much larger and more complex than the typical school district staff has time to handle" (p. 37).

In summary, changes in services provided by school transportation departments in recent years have resulted in higher transportation costs to districts and increased complexity in the scheduling and routing process. Freeman (1987) points out that "pupil transportation now costs many districts from seven percent to 11 percent of their total budgets - 30 percent or more of their noninstructional budgets. Transportation often costs as much as building operations" (p. 37).

Technological advances in transportation algorithms, present-day computer speeds, mega-RAM storage capabilities, and low-dollar costs of computer hardware have made it possible for districts to computerize their routing and scheduling processes, thereby, positively affecting total transportation operations and significantly reducing busing costs (Garden and Lieberman, 1989).

Safety of students, transportation costs, student convenience and fairness, and special district needs such as busing students enrolled in special programs at selected schools can be addressed
effectively and easily by computer-assisted scheduling and routing programs (Walcott, Hauser, and Iverson, 1986).

To facilitate the successful implementation of a computerized routing and scheduling system, districts should recognize that there is an initial upfront capital outlay to be expended for hardware, software, and consultant time (Freeman, 1986). Staff involved in the implementation of the system should be made aware of the impending changes and involved in the change process (Carriedo and Others, 1986). Further, districts must plan sufficiently for the implementation of the system if it is to be effective and successful (Carriedo and Others, 1986). Also, established, reputable vendors must be utilized in an effort to eliminate some of the potential for failure of the system Dembowski, 1988).

Walcott, Hauser, and Iverson (1986) state:

"It may seem a long and involved process to get to the point of using the computer for routing and scheduling. But the benefits in terms of cost reduction, greater efficiency, and student safety should far outweigh the costs of getting started..." (p. 43).
REFERENCES


