Ann Arbor's Dispatching System

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This paper attempts to describe in detail the operational procedures used in the computer-aided dispatching system installed at the Ann Arbor Transportation Authority facility in Ann Arbor, Michigan. It is designed to facilitate the needs of the demand-responsive mass transportation concept that has been introduced and is in operation in Ann Arbor. The system has two basic parts: the central control center and the mobile units that handle the digital transmission.

The Ann Arbor Transportation Authority (AATA) Teltran Communications and Dispatching System is a coordinated 81-bus (45 dial-a-ride buses and 36 express buses) computer-assisted dispatching system. It has been operating successfully since August 5, 1975. The system was designed on the basis of the previously used manual dispatching procedures.

The basic functions of the system are automatic assistance in order taking and the associated dispatcher functions, such as bus scheduling, status reports, emergency calling, and vehicle identification. In addition, there is provision for supervisory facilities with respect to start-up, organization, and off-line procedures.

Express routes in the city of Ann Arbor are designed so that express buses cover all major trip attractors and generators. The express vehicles run at 10-min headways during the peak periods Monday through Friday and at 20-min to 30-min headways during midday periods and Saturday hours.

Depending on the day and time of operation, the city is divided into a specified number of zones, with demand-responsive (dial-a-ride) vehicles assigned to each zone. During weekday peak hours there are approximately 20 zones, with from one to three demand-responsive vehicles assigned to each. These vehicles take care of intrazonal travel and also act as collectors and distributors for the express buses. Each demand-responsive vehicle proceeds on a 20-min to 30-min tour starting and ending at the express-bus-coordinated transfer point that corresponds to its zone. In off-peak hours, transfer points may also accommodate dial-a-ride to dial-a-ride transfers. Vehicles within each zone run out of phase, each of their schedules being coordinated with that of an express vehicle. Zones are redefined in the less busy times of the day into larger areas in order to correspond to their respective express-bus schedules.

In addition to the express-bus system and the demand-responsive or dial-a-ride service, the AATA provides a demand-responsive service for the handicapped that supplies door-to-door transportation service within the city limits during all operational hours. Subscription-service vehicles for school or work runs are also provided for groups of 20 or more persons going from the same general area to the same destinations at the same time. Charter vehicles are also offered for those groups that request such service.

Because of the nature of the service, a high percentage of trips start with a telephone request for pickup. This necessitates a highly sophisticated communications system to process telephone-demand trips into tours and to transmit tour rosters or other necessary information to and from the demand-responsive vehicles.

The central equipment consists of a processor, storage, peripheral equipment, and the interface units that connect to the radio channels. The processor is a 16-bit word-length machine with 48K word-core storage and a million-word disc-cartridge backup storage. Cathode-ray tube (CRT) display units, provided with special keyboards, provide for local input of information to the system, and local printers provide various hard-copy logs of the daily transactions handled by the system.

The central control system consists of nine work stations located in a single control room. Eight of these work stations are designated as call-taker or dispatcher stations and one is designated as a supervisory console.

There are basically three distinct functions of the dispatching procedure. The primary series of functions is that of call taker. The second series is the dispatcher and includes all the call-taker functions as well. The last series is the supervisor and can handle all the call-taker and dispatcher functions, as well as those specifically assigned to the supervisor.

The Teltran Dispatching System is a man-to-machine computer-assisted dispatching system. That is to say, there are virtually no decisions made by the computer. All decision making remains in the hands of the dispatcher. This part of the system will become more evident as we describe each of the functions in detail.

CALL TAKER

Incoming telephone calls from the public requesting service are processed at the dispatching center by call takers, each of whom has a CRT for entering relevant data into the system.

The trip-entry sequence is the basic function of the call taker and is presented as a series of cues from the computer. The call taker types in all the pertinent information from the customer, such as pickup point, destination, requested time, number of passengers, and additional information such as telephone number, handicap, back door, and so on, that may be relevant. The destination can be a specified transfer point (a two-character alpha designation) or another address within the pickup zone.

When all the pertinent data have been accumulated, the computer prompts for zone (the zone of the pickup address). Since there is no gazetteer file in the computer, it is the call taker's responsibility to determine the zone (a three-character alpha notation). A gazetteer file is essentially a map of the city. Although many systems include a gazetteer file, it was eliminated in Ann Arbor in order to allow for more flexibility and capability to cross zones. If the zone entry does not correspond to a valid zone, however, an error message will be displayed.

After the call taker has specified the zone, the computer responds with up to three available tours, along with the number of passengers already booked on each, that will satisfy all the requirements that have been accumulated by the call taker. If a transfer point has been specified, only tours with that transfer-point destination will be displayed. If the destination is another address, however, tours in both directions will be displayed and the call taker can determine the best direction for the trip.

Each tour is specified by a six-character name; the first four (numeric) characters signify the starting time of the tour and the last two (alphabetic) characters signify the destination transfer point. This kind of identification makes it very simple to make an intelligent decision as to which tour is most applicable.

In order to further facilitate the choice of the tour, the call taker may make the decision from the display of tours or may choose to look at the tour roster itself. The tour roster displays all the pertinent information about the tour including the zone, tour name, bus number, and number of passengers. The roster also contains a list of the addresses and pickup times for all the trips that are already booked on that tour. The call taker may cycle all three available tours and then choose the one that is most convenient for the trip in question. In this operation, the call taker may also change the estimated time of arrival of the trip or choose three other tours if none of the three previously displayed are satisfactory.

It is through this trip-entry sequence, and only through this sequence, that a trip may be deleted from a tour roster. The deletion of a trip has deliberately been made rather cumbersome in order to avoid the possibility of deleting a trip accidentally.

Another major function of the call taker is entering a standing order into the system. Once a standing order has been entered into the system, it is automatically put onto the specified tour roster at start-up of the designated day.

In order to enter a standing order into the system, the call taker starts the procedure in the same way as for trip entry. The pickup point and destination are determined. When the time is requested, however, the call taker depresses the STO key and the display for the last name of the customer. Once the last name and initials are entered, there appears a matrix representing the 7 days of the week. The call taker then fills in the zone and time for each applicable day while the computer responds with up to three available tours for each day specified, as well as the number of standing-order customers already booked on each of those tours.

When the matrix is complete, the call taker continues with the pertinent data, number of passengers, and telephone number until ready to specify the tours for each trip. If there is a common tour that is satisfactory for two or more trips, the call taker may enter these trips cumulatively, in one step, or individually if he or she so desires.

In order to complete the standing order there are three more cues—expiration date of the order (optional), the "go live" date (required), and up to three "ignore" dates (optional). The standing order is now entered into the system and is automatically taken care of by the computer at the beginning of the day. If, however, a particular standing order needs to be amended or deleted, the call taker need only recall that standing order and make the specified changes or remove the order from the files.

An advance-order entry is very similar to a standing order entry. Since an advance order is simply a one-trip entry for any time other than today, it does not require as much information as the standing order. The call taker starts the procedure in the same way by entering the last name and the initials of the customer. The computer responds with the same 7-day matrix. The call taker need only enter the zone, the time, and the date of the requested trip on the one line set aside for Monday's entry. The computer designates the three tours available on that day and at that time and also indicates to the call taker the day of the week the trip applies. Passenger and information cues follow; the call taker chooses the tour and the advance order is then entered into the system and will appear on the specified tour roster on the particular day requested. Advance orders may also be amended or deleted from the system in the same way as standing orders.

There are, then, basically five functions in the call-taker mode: trip entry, standing-order entry, advance-order entry, standing-order examine, and advance-order examine. These five functions tend to cover all the possibilities that might arise from an incoming telephone call from the public.

DISPATCHER

Let us now turn to the dispatcher functions. How do all these trips and tour rosters reach the bus to be expedited? The dispatcher's directory lists three function modes: trip entry, tour roster, and bus status. The trip-entry mode includes all of the functions described above for the call taker. The tour-roster mode includes editing tour rosters and organizing them so that they are ready for automatic transmission to the bus. In the bus-status mode, the dispatcher may check the next tour coming up for a specified bus.

When the dispatcher specifies the tour-roster mode, the computer requests the zone and tour name. Once this information has been provided, the tour roster that has been requested is displayed. Again, the tour roster has all the information about the tour as well as a list of trips already booked on that tour. If the dispatcher decides that the roster he is looking at is not satisfactory, he chooses to enter the edit mode. In this edit mode, the dispatcher may cycle from one roster to another and has the ability to remove a trip from one roster and add it to another. Up to three trips from one or more rosters

may be removed at any one time. However, each trip must be assigned or added to another tour before the dispatcher can leave the edit mode. This fact prevents the loss of any trip from the files.

Once a tour roster has been edited to the dispatcher's satisfaction, which is to say that all trips on the roster are meaningful geographically, the roster is ready to be ordered or organized. Ordering requires setting up pickup and drop-off points in such a sequence that the tour can be completed from the bus's starting point to the point of destination in a logical and effective manner. The ordering process can be completed in one or several steps according to the dispatcher's needs.

Tour rosters are designated as either organized or unorganized. After editing and ordering a roster, the dispatcher organizes or "blesses" a tour roster. If it is designated as organized and stored accordingly, the tour is automatically transmitted to the bus through the central system when the bus to which it has been assigned signals that it is ready for the next tour. However, the time at which such a transmission is sent to a bus is regulated to coincide with the scheduled starting time of the tour. This control of tour transmission time is provided so that no bus shall start its tour too early and to allow for the implementation of last-minute trips. Conversely, if a particular bus is running late or has had some mechanical difficulties, the dispatcher can override the predetermined system and transmit the tour to another bus.

The third function in the dispatcher's directory is the bus-status mode. Through this mode, the dispatcher can check the next tour coming up for a specific bus or for a number of buses. This operation enables the dispatcher to make sure that the tour roster is ready for transmission to the bus or buses he is responsible for. When the bus-status mode is indicated, the computer asks for the bus number. When the bus number has been specified, the computer responds with the zone, tour name, and number of passengers booked on the tour and, if a minus sign is present, it informs the dispatcher that the tour has already been organized. If a bus that has no tours is specified, a message to that effect is displayed. The dispatcher can specify up to nine buses on one page; the tenth bus clears that screen and starts a new page.

Dispatchers are responsible for up to 20 demand-responsive vehicles. That is to say, it is their responsibility to check on the status of each of these 20 buses and to act upon the status accordingly. For this purpose, the last three lines on the dispatcher's display screen are reserved for bus-status messages and voice communication information. No matter what the operation, the last three lines will constantly supply this information. An update of the information will occur every 10 s if the directory is being displayed or every time the screen is blanked during general operating procedures.

The bottom two lines of the screen are reserved for status messages that relate to the buses within the jurisdiction of the particular dispatcher. These messages are activated by the drivers by means of the mobile equipment in the bus, which automatically transmits these messages to the central system for the dispatcher's attention. The dispatcher's responsibility lies in the interpretation of these status messages and subsequent action if any is required.

Similarly, the third line from the bottom of the screen is reserved for voice-communication information. It shows which buses are currently on voice communication and which buses are awaiting voice communication. The display shows the radio channel on which a particular bus is engaged, as well as a listing of all buses that have requested voice communication, in order by longest waiting time. This line is also reserved for emergency calls. If a driver signals an emergency, voice communication queues are obliterated and an emergency signal is displayed. This display will remain until action is taken by the supervisor.

To summarize, the dispatcher has three function modes available: trip entry, tour roster, and bus status. In addition to these function modes, he is responsible for status and voice communication for up to 20 demand-responsive vehicles.

SUPERVISOR

The supervisor can perform all the functions of the call taker and dispatcher. Under software control the supervisor can also check and control the system status; handle bus assignments; create, amend, or delete tours for today; and handle the daily bulletin. In all, the supervisor's directory lists eight function modes: dispatcher's directory, shut down, bus reassignment, bus-to-radio assignment, change tours, system status, daily bulletin, and dispatcher-to-bus assignment.

The shut-down mode should only be selected when it is necessary to shut the computer down at the end of the day or if an automatic restart is required. If the supervisor enters shut down and there are still some dispatching positions in operation, the computer responds with a warning (still dispatching) and waits for instructions for a normal shutdown or an automatic restart. If a normal shutdown is requested, the system goes into set up and sets up the discs for tomorrow. Otherwise, the supervisor may request a copy of the master disc or restart without a copy.

The bus-reassignment display enables the supervisor to switch buses. A very important feature is that the supervisor has the ability to examine the effects of bus switching before committing himself. During system start-up for the day, a hard-copy report of the day's tours is provided, sequenced by assigned vehicle number. When the bus-assignment display is requested, the system provides a list of spare vehicles (those not assigned to any of the day's tours) and a display of vehicles that are currently down. The supervisor can amend this list by entering as spare any bus listed as down that is now available or entering any bus that is newly down. The system responds to any such additions or the transfer of buses from tours with a list of unassigned tours in a chronological sequence, along with the vehicle that was assigned to that tour. The supervisor may assess the effect of changes in bus assignments by obtaining a list of the unassigned tours that would result without actually implementing these changes. He may then reassign tours to available buses and produce a hard-copy report of current bus assignments.

In order for the computer to communicate digitally with the vehicles, it must keep track of the radio-channel assignments of every bus equipped with digital equipment. By calling for the bus-to-radio assignment display, the supervisor assigns vehicles to radio channels and stores this information in the computer. The computer cannot cause a radio channel to be changed in the vehicle. Therefore, the supervisor must vocally instruct a driver to switch channels before informing the computer of the change. However, this table of bus-to-radio assignment is automatically updated if an incoming message from a bus is detected and the channel is different from that held in the table.

In the change-tours mode, the supervisor can create a new tour, delete an existing tour, or amend an existing tour. In order to create a new tour, the supervisor supplies the computer with the zone, starting time, ending

transfer point, and ending time. A three-digit bus number indicates which bus is assigned to the new tour. To delete a tour, on the other hand, the supervisor need only supply the zone and tour number. The trips affected by a tour deletion are printed out as unassigned trips and must be reentered by means of the normal trip-entry sequence. To amend a tour, the supervisor enters the zone and tour name and follows the combination of procedures used in the creation or deletion of a tour.

The system-status program deals with the status of the computer system itself. Peripheral failures, if detected by the software, are logged on both printers and are noted on the supervisor's CRT if a system-status report is requested. All logging can be switched to either of the two line printers, and backup facilities can be inhibited if one disc or disc drive should fail. In such a case, the system will carry on unaffected using only one disc. It is not necessary to use this routine to switch printing for paper change, ribbon change, or so forth. The only time the supervisor need use the system-status routine and must switch printers is in the case of a physical breakdown of one printer.

The daily bulletin is a 128-character free-form message that can be transmitted to one, some, or all buses or stored for transmission at some future time. Vehicles cannot request that a bulletin be sent automatically. It must be transmitted from the supervisor's console.

As has been mentioned before, dispatchers are responsible for selected dial-a-ride vans. The supervisor makes these assignments from the dispatcher-to-bus assignment display. As the supervisor makes these assignments, the bus numbers appear on the bottom of the dispatcher's screen. Once a vehicle is assigned to a particular dispatcher, all status messages from that vehicle are directly transmitted to the console screen.

HARDWARE

What we have been discussing up to this point are the various software techniques that we are using to produce an efficient and meaningful way to solve the dispatching problems encountered when dealing with a highly sophisticated demand-responsive transportation system like the one we have in Ann Arbor. I think we should now take a look at some of the hardware that ties everything together.

The radio system uses high-quality two-way base and mobile radio equipment operating in the UHF spectrum. This system includes mobile fixed-message reporting equipment, mobile selective calling, and mobile data-display equipment, as well as two-way voice equipment. This combination in each vehicle enables information to be entered directly from the buses into the central system and, in the other direction, messages are transmitted under computer control and displayed in the buses by means of the light-emission diode (LED) display for the driver's attention.

The radio is equipped with a six-pushbutton channel selector even though, in fact, there are only three channels used in this system. All three channels are used for both voice and data transmission, with channel 3 reserved for express buses and bus-to-bus voice communication. When a particular channel is being used for voice transmission, all data being sent on that channel are held in storage until the channel is cleared. Conversely, when the driver or dispatcher wish to go to voice transmission, the speakers in the bus must be activated from the central system. All voice transmission is muted; that is, only the bus cleared for voice transmission will receive the message.

The status panel contains an LED display-page switch, three call-sign binary plugs that denote vehicle number, two thumbwheel switches that are used to enter "ten" codes (two-digit numeric codes that have specific predetermined meanings), and the call and transmit light buttons. The transmit button is depressed whenever a driver wishes to send a message. If another message is being sent simultaneously, the message will be stored until the channel is cleared. Upon satisfactory receipt of the message by the system, the transmit button will go off, signifying that the message has been properly registered. After the voice button has been depressed, the transmit button will light and go off to inform the driver that the dispatcher is ready for vocal communication.

The LED displayed is a 128-character message-display unit divided into four lines. Each of these lines displays two 16-character trips per line. There are two pages to the display, however, so that the total capacity of the display is 256 characters. The normal procedure is for a driver to signal that he is ready for the next tour, at which point, if the time is suitable, the tour information is displayed. The first 16 characters of the display are reserved for such tour information as the number of passengers and the number of trips, from which the driver can determine whether there is more information than appears on the first page of the display. If it is required, the driver can, by means of the paging switch on the status box, display the next page of information. The information remains on display until the driver signals that he is ready for the next tour and receives the information relevant to that tour. The display contains pickup and drop-off information for each trip on the roster, along with the number of passengers on each trip. The status box is also equipped with a dimmer switch that adjusts for brightness and contrast on the LED display for easy readability.

SUMMARY

Automatic assistance in the order-taking, dispatching, and transmission of information between buses and the dispatching center offers many advantages. There is immediate accessibility of tour and tour-roster information.

The use of data transmission rather than voice whenever possible results in efficient use of radio channels. The provision of comprehensive supervisory facilities simplifies overall control of the system and helps to achieve optimum deployment and efficiency of buses. There is improved trip-to-tour matching and virtually no loss of any trip request, which increases the public's satisfaction with the service. The automatic logging of all transactions handled by the system and the automatic handling of advance and standing orders leave more time to handle increased demand and ridership.

The AATA's Teltran Communications and Dispatching System represents a combination of advanced hardware and software techniques that are particularly suited to the complexities of an urban mass transportation operation.