INTELLIGENT SCHEDULING AND DISPATCHING IN AN ITS-ENABLED WORLD

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ABSTRACT

Para-transit trips are scheduled, and on day of service, dispatched in response to changes in the trip set and unpredictable traffic conditions. With AVL/MDC on vehicles, ITS data flow represents 20-20 vision eyes for dispatchers to "see" the world in real-time, and powerful voice for dispatchers to "tell" drivers about potentially drastic and massive changes to their work in real-time. Prior polling of drivers via voice radio are analogous to blurred vision and hoarseness, limiting the scope of dispatching actions. For Transit Authorities of some size, automatic scheduling and dispatching systems are crucial to help dispatchers as they schedule requests and move trips around to maintain efficient fleet usage and honor all trip commitments. But with ITS, more is now possible. We present requirements to new, intelligent dispatching options in the ITS-enabled world, and how these requirements are being met by Adept, StrataGen's automatic scheduling and dispatching system.

Keywords – ITS, para-transit, AVL, MDC, automatic scheduling, dispatching, re-work

THE PARA-TRANSIT CHALLENGE

Para-transit service provides low-cost accessible mobility to elderly and handicapped, making a significant difference in their quality of life. A Transit Authority utilizes a fleet of finite-capacity vehicles to provide the rides. In accepting requests, the Authority gives the client a Promised Pickup window (e.g. "we will pick you up between 10:00 and 10:30 am") that must be honored. Drop off windows for appointment trips are also anchored.

In providing this essential service, the Authority must schedule the trips. As the trip set grows, it may be re-optimized for efficiency, subject to constraints such as enforcing Promised Pickup windows and appointment windows, finite vehicle capacity, wheelchair capability, shift start and end times, realistic driving speeds and rush hours, keeping client onboard times within policy, etc. Scheduling is combinatorially explosive. As the trip set grows, the space of possible schedules explodes. Also, trips are from anywhere to anywhere in the service area, at any time during service hours; thus the scheduling problem is new daily, and morphing minute by minute. Trip sets of any significant number require automated scheduling systems. The true measure of automation is the amount of manual manipulation of schedules required to fix undesirable patterns. This re-work takes time, is tedious as the same patterns recur, and is done every day because the schedule is different everyday.

The Authority must dispatch on day of service. Execution inevitably deviates from plan in an uncontrollable real world, and dispatchers respond. Deviations include drivers calling in sick, unpredictable traffic congestion jeopardizing downstream Promised Pickup and appointment commitments, trip cancellations or client no-shows, same-day trips to schedule, vehicle breakdowns, etc. For Authorities of any size, dispatchers rely on automated dispatching systems to schedule new requests and support their moving trips around to maintain efficient fleet usage and to try to honor all trip commitments.

BEFORE AND AFTER ITS

Before ITS, drivers started their days with paper manifests. Dispatchers tracked execution via frequent radio polling of drivers, marking their adherence to plan. Corrective actions, such as moving a trip from one vehicle to another, required a dispatcher to radio the affected drivers, who then marked their paper manifests. The manual activity to track, and the reliance of drivers on relatively non-fluid paper manifests limited the scope of dispatch actions to atomic corrections.

ITS receives the world state, automatically in real-time, and has the capability to send out potentially drastic and massive manifest changes, automatically in real-time, on the day of service. The reliance on radio polling is gone, as automatic vehicle location devices (AVL) transmits current location – perhaps minute by minute. The reliance on paper manifests is gone, as paperless manifests are stored on mobile data computers (MDC). The driver sees the next section of his manifest – perhaps the next hour's worth, or the next N stops.

ITS opens the door to broadening the scope of dispatching to encompass new actions, from atomic corrections to re-optimization on the day of service. To support this, a truly automated dispatching system must schedule at high speed and produce efficient results that dispatchers understand and agree with, therefore require little or no re-work on their part.

WHY RE-OPTIMIZE ON THE DAY OF SERVICE

On the day of service, opportunistic scenarios abound that might lead to fruitful re-optimization.

Scenario 1: In the natural course of the day, drivers fall behind or complete their stops earlier than scheduled. The overall schedule must be constantly rebalanced, through moving trips from vehicles running late to vehicles with new slack in their manifests. There is potentially a propagating series of such incremental actions. Periodic re-optimization performs the balancing actions in one step, and from a global perspective.

Scenario 2: Typically, 20-30% of the trips that are reserved and scheduled are then cancelled or no-showed before and during the day of service. It is not unusual at noon of the day of service to have many vehicles deployed that have significant gaps from cancellations and no-shows. The schedule is no longer as efficient. Re-optimization allows an Authority to automatically

consolidate remaining trips onto fewer vehicles, pull in the remaining unused vehicles, and thereby significantly cut costs.

Scenario 3: As new trips are requested on the day of service, they are singly inserted into the existing schedule with less efficiency. For example, a new trip may optimally be paired in location and time with a trip already scheduled on a sedan – the new trip goes from the same neighborhood to the same Senior Center at the same time as the scheduled trip. The new trip requires a wheelchair seat. Sedans have no wheelchair capability, so a van must be sent to pick up the new trip. On re-optimization, both trips would be scheduled onto one vehicle – a van.

Scenario 4: An unexpected snowstorm on the morning of service slows traffic by 25%, increasing trip cancellations and making the point-to-point drive times now unachievable. Reducing the speed factor in the system and re-optimizing produces a new, efficient, achievable schedule that reflects the new reality. And so on.

Re-optimization on the day of service is enabled by ITS – knowing the world state with accuracy, and being able to send wholesale changes in manifests to the drivers in real-time. It is now possible, but to make re-optimization acceptable to dispatchers and drivers, there are additional requirements.

Requirement 1: The system offers control over what is unscheduled for re-optimization. One control is a freeze window – e.g. only trips starting on or after 60 minutes from now are unscheduled for re-optimization. The driver typically sees his/her next hour of work. What comes after is not immediately visible, so undoing the rest of the driver's manifest is transparent. A second control is that the dispatcher can exempt selected manifests, those that are deemed still efficient, from being unscheduled. For those selected manifests, the dispatcher can further specify that trips can be added on opportunistically or that they are not to be changed in any way.

Requirement 2: The system must re-optimize quickly – e.g. re-optimizing 1,000 trips must take under 3 minutes. There simply isn't enough time on the day of service to wait for the system to take too long, because the action on the street does not stop. It is noteworthy that as the day progresses, the count of unexecuted trips that can be re-optimized is constantly decreasing. At noon, roughly half of the trips remain unexecuted.

Requirement 3: Most importantly, the system must produce efficient schedules that require little or no re-work on the part of the dispatchers. the schedules must pass their "eyeball" test. There simply isn't enough time on the day of service for dispatchers to fix undesirable patterns.

RE-WORK – FIXING RECURRING PATTERNS

There are many common examples of undesirable patterns in schedules that require manual re-work. These are instantly recognizable to all para-transit staffs and clients.

Bad Pattern 1: "Go North" – A client has an appointment due south of where he/she is picked up. But the vehicle heads far north to make another pickup. This leads to client dissatisfaction and a potential complaint to the Authority.

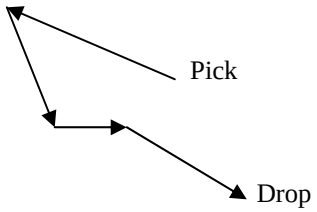

Figure 1. "Go North"

Bad Pattern 2: "Grand Tour" – A client is held onboard and taken for a very long ride, as many intervening stops are scheduled onto the same vehicle. This leads to client dissatisfaction and a potential complaint to the Authority.

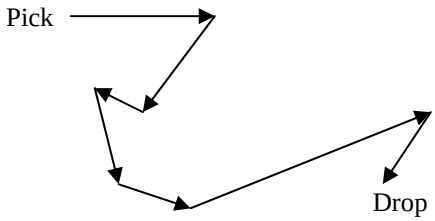

Figure 2. "Grand Tour"

Bad Pattern 3: "Roaming Vehicle" – A newer driver is familiar with the Northeast quadrant of the service area. But re-optimization sends the vehicle, in an efficient manner, through the Southeast and Southwest quadrants where the driver is more liable to run late or get lost. This leads to driver stress and client dissatisfaction for riders onboard that vehicle.

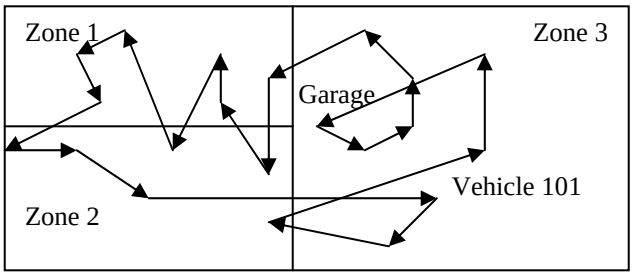

Figure 3. "Roaming Vehicle"

Bad Pattern 4: "Drive By" – A client is picked up and driven by his/her destination in order to make a 2nd pickup. The vehicle then doubles back to drop the 1st client off. The reason may be that the Promised Pickup window for the 2nd pickup made it mandatory to rush to the address, and the extra 5 minutes to stop and unload the 1st client wasn't available. This leads to client dissatisfaction and a potential complaint to the Authority. And so on.

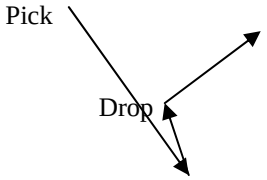

Figure 4. "Drive By"

KILLING RE-WORK – REMOVING RECURRING PATTERNS AUTOMATICALLY

Adept is the automatic scheduling and dispatching system from StrataGen Systems. Adept meets all of the requirements, and is leading the way to making re-optimization on the day of service a standard, normal dispatching action.

Adept offers a parameter allowing the dispatcher to specify the length of the freeze window, and the means to exempt selected manifests from being unscheduled.

Using GIS data-based street-level routing, Adept re-optimizes up to 1,000 trips in ½ to 3 minutes, depending on the size and complexity of the service area's street network. As an example, in Victoria, the Adept system from StrataGen can re-optimize 1,100 trips in ½ minute. Empirical data indicate that scheduling one-half as many trips takes one-fourth as much runtime.

The continuing objective for Adept is to kill all known common undesirable patterns that require manual re-work (1). As this process continues forward, the option to re-optimize on the day of service will become more and more acceptable to dispatchers who use Adept.

"Go North" and "Grand Tour"

Adept prevents occurrences of the "Go North" pattern and the "Grand Tour" pattern from appearing in the re-optimized schedule. Every client sees a "Direct Ride" – continuous progress to his/her drop.

Adept enforces "Direct Ride" through 3 control parameters:

1. "allowable go north %" – e.g. The next stop can "go north" by up to 15% of the current distance to the Drop.
2. "allowable overshoot %" – e.g. The next stop can "overshoot" the Drop by up to 10% of the current distance to the Drop.
3. "area of suspension" – e.g. Once the vehicle gets to the area within 1 mile of the Drop, the "go north" and "overshoot" constraints are suspended. The next stop can be anywhere in that area.

For every client, the net effect is that each intervening stop after his/her Pick is likely to be closer to his/her Drop, and at most a small detour in the "wrong" direction. Each intervening stop defines a new reference point for the parameters, so the allowable detour is constantly diminishing as well.

In multiple case studies, there is minimal to no effect on schedule efficiency (trips/hour) when "Direct Ride" is enforced. This is explainable by the fact that the space of possible schedules is almost infinite. "Direct Ride" presses Adept to look for schedules of a particular shape, but there are enough alternative schedules that this qualitative requirement does not impact efficiency.

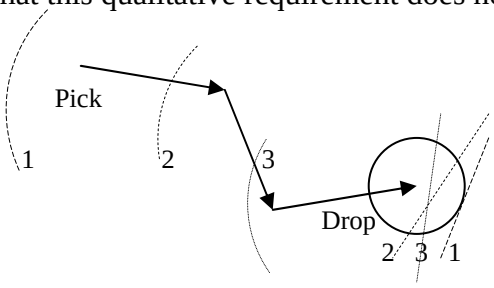

Figure 5. "Direct Ride"

"Roaming Vehicle"

Adept prevents occurrences of the "Roaming Vehicle" pattern from appearing in the re-optimized schedule. The Authority partitions the Service Area into Zones, and can control fleet deployment on a high level by assigning each vehicle individual affinities for each Zone.

Each vehicle is assigned an affinity for each Zone:

- "primary" – the vehicle is primarily to work in this Zone(s).
- "secondary" – the vehicle is to secondarily work in this Zone(s), supporting those vehicles having this as their "primary" Zone(s).
- "if needed" – the vehicle is the last resort for this Zone(s), supporting those vehicles having this as their "primary" or "secondary" Zone(s).
- "prohibited" – the vehicle cannot work in this Zone(s).

Zone affinity serves many purposes. For example, if historical trip demand is dense in Zone X, the Authority can dedicate a subfleet to only work in Zone X and go into selected adjacent Zones "if needed". New drivers are easily restricted to work only in Zones they are familiar with in the re-optimized schedule.

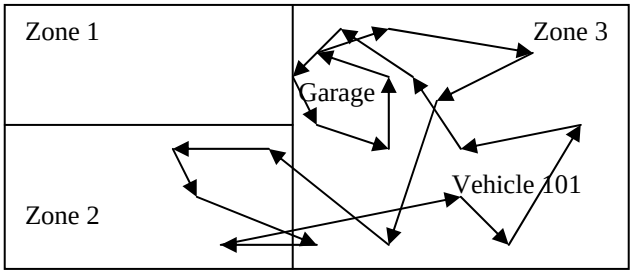

Figure 6. Vehicle 101 assigned {“prohibited”, “secondary”, “primary”} for Zone {1, 2, 3}

“Drive By”

Adept prevents occurrences of the “Drive By” pattern from appearing in the re-optimized schedule.

Adept patches “Drive By” through a control parameter, “drive by distance”, defining what constitutes a “Drive By”. For example, if “drive by distance” is set to 0.25 miles, then if the vehicle passes within 0.25 miles of the drop address, that is a “Drive By” pattern.

“Drive By” patterns are allowed to occur during schedule construction in order not to unduly bound striving for efficiency. But once scheduling is complete, Adept reviews the schedule, spots such patterns, and automatically fixes them as part of the re-optimization process. The manifest is changed by “bending the rules” a little to drop the 1st client off even if it introduces a 1 or 2 minute violation of the 2nd pickup’s Promised Pickup window. Adept does exactly what the dispatcher would do – fixes the manifest to pass the “eyeball” test.

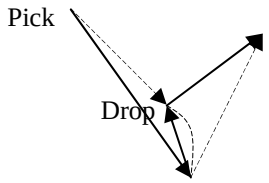

Figure 7. Automatically fixed “Drive By”

SUMMARY

Information is power. ITS opens up a whole new world, enabling an expansion of the scope of dispatching actions on the day of service to include re-optimization. But to make re-optimization an acceptable option to dispatchers, the automatic scheduling and dispatching system must offer the means for the dispatcher to:

1. Control what is re-optimized,
2. Re-optimize large numbers of trips in a few minutes, and
3. Produce efficient schedules that require no re-work by dispatchers.

Adept, from StrataGen Systems, meets the first 2 requirements, and is making strides to meet the third requirement by precluding recognizable bad patterns from appearing in re-optimized schedules. And as other such patterns requiring re-work are identified, StrataGen is dedicated to extending Adept to kill them automatically as well so dispatchers don’t have to do re-work.

REFERENCES

(1) William Ho, “Addressing Recurring Paratransit Issues Automatically”, APTA TransITech 2007, February 13-15, 2007.