StrataGen

IMPLEMENTING ITS AT NEW YORK CITY FOR PARA-TRANSIT SERVICE

William Ho
Chief Technical Officer
StrataGen Systems
12413 Willows Rd NE, Kirkland, WA 98034
425-821-8454, billho@stratagen.com

Brian Altschul
Director, TIS, Paratransit Division
New York City Transit
33-00 Northern Blvd, Long Island City, NY 11101
718-393-4225, Brian.Altschul@nyct.com

ABSTRACT

New York City Transit provides the largest para-transit service in the world, scheduling up to 22,500 trips on weekdays with Adept, StrataGen's automatic scheduling & dispatching system. On the day of service, execution deviates from plan due to changes in the trip set and unpredictable traffic conditions. Previously, dispatchers manually updated Adept on execution status, and responded through Adept to re-adjust plan as deviations required. In 2007, NYCT kicked off the ITS AVLM project to equip all vehicles with AVL/MDC, to automatically update Adept with the actual world state in real-time, free dispatchers to take corrective action based on accurate data, and communicate manifest changes to drivers in real-time. This paper reports AVLM project status, and enhancements to the Adept system to maintain responsiveness in light of the unprecedented volume of ITS information flow associated with dispatching up to 22,500 trips.

Keywords – ITS, para-transit, demand-response, AVL, MDC, automatic scheduling, dispatching

PARA-TRANSIT – THE DEMAND-RESPONSE CHALLENGE

Para-transit service is mandated in the United States by the American with Disabilities Act (ADA). Municipalities offer heavily subsidized door-to-door transit service for the elderly and handicapped who are unable to use the fixed-route bus system. Providing low-cost accessible mobility makes a significant difference in the quality of life for those who come to depend on it. Clients are screened for eligibility, and call with trip requests typically from 2 days to 2 weeks in advance. The 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. If the request is for an appointment trip, the appointment time must be honored as well.

In providing this essential service, the Authority faces two challenges. The first is scheduling prior to day of service. As the trip set grows, it may be re-optimized for efficiency, subject to constraints such as enforcing Promised Pickup windows, finite vehicle capacity, realistic driving speeds & rush hours, keeping client onboard times within policy. 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. Trip sets of any significant number require automated scheduling systems.

The second challenge is dispatching on day of service. Execution invariably deviates from plan, requiring dispatchers to respond. Deviations include drivers calling in sick, unpredictable traffic congestion jeopardizing downstream Promised Pickup and Appointment commitments, trip cancellations and "no shows", same-day trips to schedule, etc. Providing para-transit service is a challenge requiring constant information exchange between dispatchers and drivers – status received from the field cause modification of the ETA's of unexecuted stops; dispatchers must take corrective action to keep trip commitments; and manifest changes are sent to the drivers in the field. Dispatching is where ITS can make the greatest impact on providing better, real-time responsive para-transit service.

NEW YORK CITY PARA-TRANSIT SERVICE – LARGEST IN THE WORLD

In trips scheduled daily, New York City Transit (NYCT) provides the largest para-transit service in the world by a factor of at least 2. The service area encompasses all 5 boroughs, with service from 4 am to past midnight. With well over 100,000 eligible clients, NYCT schedules up to 22,500 trips on weekdays, and over 10,000 trips on weekend days – as of July, 2008. Nearly 2,000 vehicles are contracted to provide service. The volume of information required to dispatch is unmatched anywhere else.

In early 2002, NYCT installed Adept, the intelligent automated scheduling & dispatching system from StrataGen Systems – trip count was at approximately 8,000 trips per weekday. The growth in rides per day over 6 years is attributable to an aging population, rising cost of transportation (including gasoline cost), more traffic congestion, improved customer service, and increased scheduling efficiency (1). NYCT has maintained a "zero denial" policy since March, 2003 with no eligible trip request denied.

New challenges come with growth into unprecedented numbers. StrataGen Systems has worked in continuous collaboration with NYCT to add industry-leading functionality, and maintain Adept efficiency and responsiveness for this scale of operation, even as the trip count more than doubled. The rate of double-digit service growth is projected to continue.

DISPATCHING PRIOR TO AVLM

Drivers are given paper manifests at the start of their work day – execution invariably deviates from plan. In the normal course of operational execution, schedule status and deviations fall into 3 categories. The first is associated with the drivers' perspective – they radio at time T that they have "performed" a stop S, or that a client is a "no show" or a "late cancel" at the door, or various other event statuses in the execution world. The second is associated with the clients' perspective – they call to cancel a trip or request a new trip or check status of an upcoming trip (i. e. "where's my ride"). The third is associated with the dispatchers' perspective – they update schedules to reflect driver input, and take corrective actions such as transferring trips from a late-running vehicle or extending a vehicle's shift, or various other responses to events. All status and deviations are communicated to Adept to keep its schedule representation as complete and current as possible to support accurate dispatching. Deviations cause Adept to add stops, or remove stops from manifests, and always to update ETA's of as yet unexecuted stops to reflect the new reality on the streets. Dispatchers must radio manifest changes to drivers.

This process based on voice communication through radio is not optimal. Dispatchers spend a large amount of time asking for status from drivers and manually entering the information into Adept. Drivers spend considerable time answering radio calls, reporting status, and marking their paper manifests to keep them usefully up to date. Even so, not all stops are explicitly reported and timestamped.

Potential inaccuracy is a more serious issue. If a dispatcher has responsibility for 15 vehicles, and he gets status from one driver each minute, vehicles have a 15 minute window of uncertain status between updates. Dispatchers may make assumptions about normal operation in that window when the driver might be encountering traffic congestion and falling behind. Dispatchers may take corrective actions based on assumptions that are inaccurate. For example, a dispatcher may transfer a trip from late-running vehicle X onto vehicle Y assuming that vehicle Y is on schedule. In actuality, vehicle Y may have started running late as well.

Furthermore, because of sheer volume of data, new ETA's are not all communicated to drivers. And because of the "permanence" of hard-copy paper manifests and limitations of voice-based radio communications (clarity, completeness, and bandwidth), manifest changes are limited to a handful of changes per vehicle, negatively impacting the efficiency and cost for delivering para-transit service.

AVLM IMPLEMENTATION STATUS

The Automatic Vehicle Location and Monitoring (AVLM) project to install 1,329 AVL/MDC (Mobile Data Computer) units onboard para-transit vehicles belonging to 8 Carriers by December 31, 2008 was awarded to Init in December, 2005. The staged installation process was kicked off on July 29, 2007 with a "mini-fleet" installation of 12 units onto vehicles belonging to Star Cruiser, one of the NYCT Carriers. For the next 2 weeks, 4 vehicles were selectively monitored to validate infrastructure at the Carrier site, Verizon cellular communication service, servers and the computer network, AVL/MDC units, and the bi-directional data exchange through the Adept-AVLM interface, throughout all phases of the live para-transit process. Each driver was given the usual paper manifest as precaution so they could fall back to the usual execution process seamlessly if necessary.

"Mini-fleet" was a success, and by first quarter, 2008, some 500 units representing the complete fleet of 3 Carriers had been installed and put into operation, side by side with the remaining 5 carriers using the old methodology of paper manifests. As of July, 2008, 875 units have been installed and put into operation.

Load and performance were carefully monitored throughout. The Performance Monitor shows that with some 66% of the units online, CPU utilization is well under 10% at peak information transmission periods of the day.

In January, 2005, the NYCT trip demand peaked at 13,000 trips per day on weekdays (1). In July, 2008, the NYCT trip demand peaked at 22,500 trips per day on weekdays. As a consequence of such strong growth in service demand, a contract modification to acquire an additional 493 AVL/MDC units has been awarded to Init, and the Carrier pool of 8 has been expanded to 21. The acquisition of additional vehicles and units to support service growth is an ongoing requirement, in lock step with the double-digit service growth.

DISPATCHING WITH AVLM – ITS WITH AVL/MDC

AVLM is by design focused on providing core functionality – providing a real-time data feed of vehicle location and schedule execution status from vehicle to Adept, automatically, and providing a real-time data feed of manifest modifications to reflect the new reality as needed from Adept to vehicle, automatically.

With its emphasis on customer service, NYCT is taking full advantage of the real-time refresh of the execution world state to enable quicker and more accurate answers to the standard question Clients invariably call in to ask – "where's my ride."

At the beginning of the day, the driver logs in on the AVL/MDC unit. The manifest of work, a timed sequence of Pick stops and Drop stops, is downloaded via a WIFI network. When ready to depart, the driver pushes a button (an icon on the MDC screen) to record a "pull-out" event of the vehicle from the garage to start the shift. When the vehicle is within 150 feet of the next scheduled stop address, the unit automatically records an "auto-arrive" event. After the actions at the stop are completed, and the driver is ready to depart, he/she pushes a button to record a "performed" event for that manifest stop. Other buttons are available to the driver to report "no show" events, "cancel at door" events, etc. When the shift is complete, as the driver arrives back at the garage, he/she pushes a button to record a concluding "pull-in" event. Prior to logging out on the AVL/MDC unit, log files documenting manifest execution, and serving as an audit trail, are uploaded from the unit via the WIFI network.

On an event, the vehicle location (stop address geocodes), event type, and event time are communicated to Adept through a cellular data network and update Adept's schedule representation in real time. Dispatchers are freed from tediously entering the status and time manually. On a "performed" event, Adept re-ETA's the remaining un-executed stops on the manifest. On a "no show" or "cancel at door" event, Adept removes the now-unnecessary Drop from the manifest before it re-ETA's the manifest. In all cases, the new stop times are communicated to the AVL/MDC unit through the same cellular data network to update the new reality – in real-time, automatically, clearly, and completely. Drivers are freed from recording changes to paper manifests manually.

Because the MDC displays only the next several manifest stops, potentially massive changes to the manifest downstream of the current time can be made as needed because such change are now transparent to the driver, and the update requires no effort on the driver's part to receive. Because the manifest data is online in the MDC, the scope of changes is no longer limited by the rigidity and permanence of paper manifests. ITS thereby frees drivers and dispatchers from the mundane chores, enabling them to apply their unique skills. Dispatchers do not need to make assumptions about vehicle status or location. They take corrective actions with confidence through Adept based on the up-to-the-minute state.

Eliminating paper manifests also introduces significant new options for improving responsiveness. For example, after a large number of trip cancellations, having Adept re-optimize during the day of service to consolidate remaining trips onto fewer vehicles becomes a real cost-cutting possibility. The precondition for this ITS-enabled next step forward is for automatic scheduling & dispatching systems, such as Adept, to schedule at high speed and produce efficient results that dispatchers understand and agree with, therefore requiring little or no re-work on their part (2).

ENHANCING ADEPT TO SUPPORT & LEVERAGE AVLM CAPABILITY

Scheduling is intrinsically a sequential process. Each event (such as inserting a new trip, canceling an existing trip, moving a trip from a late-running vehicle, logging a "performed", and so on) changes the world state for the next event.

The Adept system is built on a Strategy Engine that serves as the automatic scheduling & dispatching component (3). Originally, requests were sent singly to the Engine. On receiving a request, Adept checks that the Engine is available, and when it is, locks it up to handle the request sequentially. The Engine:

1. Wakes up and notes the starting system time,
2. Re-creates the world state,
3. Processes the request,
4. Stores the new world state in its own representation,
5. Notes the ending system time,
6. Logs the status of the request & runtime, and goes to sleep.

By necessity, the Adept system has been enhanced to handle the increase in trip volume and information volume presented by NYCT's phenomenal service growth. For 22,500 trips, there are 45,000 stops and therefore 45,000 associated "performed" events alone. For a weekday, from scheduling the first trip request, to pulling out the first vehicle to start service, to pulling in the last vehicle to end service, Engine requests can approach 100,000. Handling these events singly is untenable.

We added "Queue mode" to collect requests while the Engine is locked up, and when it becomes available, sending the accumulated requests in a block to the Engine as a single call. The number of accumulated requests is dependent on the wait for the Engine to become available. On a "queue mode" call, the Engine:

1. Wakes up and notes the starting system time,
2. Re-creates the world state,
3. Processes all of the requests in the block sequentially, noting the system time after each request is processed,
4. Stores the new world state in its own representation,
5. Notes the ending system time,
6. Logs the status of the request block & runtime, and goes to sleep.

The overhead of steps 2 & 4 are performed once for the block, and it should be noted that these two steps take up the majority of the runtime for the Engine call. Consider production log entries from the 7-22-08 service day. In Figure 1, the request block contains a single "performed" request, request 54501 submitted at 14:08 by user at workstation "AS5294-7273" when the world state contains 20,166 scheduled trips. The Engine runtime is 0.3 seconds.

```
--------
54501 07-22 14:08 AS5294-7273         : PERFORM        0.3s RC=   1 (20166 Ts)
--------
```

Figure 1. A block of 1 request in 1 Engine call (from NYCT production logs)

In Figure 2, the request block contains 27 requests (24 "performed"s, 2 "no show"s, and 1 "insert" of a new trip), submitted at 14:09 by various users when the world state contains 20,166 scheduled trips. The Engine runtime is 1.2 seconds.

```
--------
54534 07-22 14:09 AS5294-7273         : PERFORM        0.9s RC=   1 (    0 Ts)
54535 07-22 14:09 V:203781            : PERFORM        0.0s RC=   1 (    0 Ts)
54536 07-22 14:09 V:70121             : PERFORM        0.0s RC=   1 (    0 Ts)
54537 07-22 14:09 ADV-D2              : PERFORM        0.0s RC=   1 (    0 Ts)
54538 07-22 14:09 AMB-D13             : PERFORM        0.0s RC=   1 (    0 Ts)
54539 07-22 14:09 V:50139             : PERFORM        0.0s RC=   1 (    0 Ts)
54540 07-22 14:09 AMB-D99             : PERFORM        0.0s RC=   1 (    0 Ts)
54541 07-22 14:09 AV6197-7294         : PERFORM        0.0s RC=   1 (    0 Ts)
54542 07-22 14:09 TFM-D100            : PERFORM        0.0s RC=   1 (    0 Ts)
54543 07-22 14:09 RJR-D85             : PERFORM        0.0s RC=   1 (    0 Ts)
54544 07-22 14:09 GAR-TCP1            : PERFORM        0.0s RC=   1 (    0 Ts)
54545 07-22 14:09 MVT-D2              : NOSHOW         0.0s RC=   1 (    0 Ts)
54546 07-22 14:09 PRG-D2              : PERFORM        0.0s RC=   1 (    0 Ts)
54547 07-22 14:09 ATL-D53             : PERFORM        0.0s RC=   1 (    0 Ts)
54548 07-22 14:09 V:70785             : PERFORM        0.0s RC=   1 (    0 Ts)
54549 07-22 14:09 V:503045            : PERFORM        0.0s RC=   1 (    0 Ts)
54550 07-22 14:09 V:508047            : PERFORM        0.0s RC=   1 (    0 Ts)
54551 07-22 14:09 AV6181-7335         : INSERT         0.0s RC=   1 (    0 Ts)
```

```
54552 07-22 14:09 V:203454            : PERFORM        0.0s RC=   1 (    0 Ts)
54553 07-22 14:09 AV6306-7290         : PERFORM        0.0s RC=   1 (    0 Ts)
54554 07-22 14:09 V:803360            : PERFORM        0.0s RC=   1 (    0 Ts)
54555 07-22 14:09 V:804322            : PERFORM        0.0s RC=   1 (    0 Ts)
54556 07-22 14:09 V:503760            : PERFORM        0.0s RC=   1 (    0 Ts)
54557 07-22 14:09 AS5294-7273         : PERFORM        0.0s RC=   1 (    0 Ts)
54558 07-22 14:09 MVT-S4              : NOSHOW         0.0s RC=   1 (    0 Ts)
54559 07-22 14:09 V:203454            : PERFORM        0.0s RC=   1 (    0 Ts)
54560 07-22 14:09 V:803185            : PERFORM        0.3s RC=   1 (20166 Ts)
--------
```

Figure 2. A block of 27 requests in 1 Engine call (from NYCT production logs)

We installed a new Adept Mobile Data Computer (Adept-MDC) system on its own servers at NYCT to manage communication between Adept and the AVL/MDC vendor system, which stores and displays the GPS data. In anticipation of the completion of the AVLM project, eventually bringing some 2,000 units into production use, the Adept-MDC system was load tested for throughput under lab conditions with twice the current NYCT peak of 22,500 trips. The system met information capacity needs while maintaining its responsiveness.

SUMMARY

The ITS paradigm is providing automation and accuracy to save dispatchers and drivers time and effort in the fluid, dynamic application of para-transit dispatching for NYCT, the largest such operation in the world. To support the current service demand of up to 22,500 trips on weekdays (with continuing, annual double-digit growth), we have worked closely with NYCT staff to enhance Adept to handle the bi-directional ITS data streams and support new ITS-enabled capabilities, while maintaining system responsiveness.

REFERENCES

(1) Howard Ende and Chris Castle, “Right on Time: How IT Can Drive ROI in Paratransit Scheduling”, APTA TransITech 2005, February 23-25, 2005.

(2) William Ho, “Intelligent Scheduling and Dispatching in An ITS-enabled World”, 15th World Congress on Intelligent Transport Systems, November 16-20, 2008.

(3) William Ho, Kevin MacDonald, Tim Payne, “Strategy-based Scheduling”, APTA TransITech 2006, February 22-24, 2006.