A multi-objective distribution problem for parcel delivery at TNT

With almost 160,000 employees worldwide and a 2006 turnover of over 10 billion US$, TNT is one of the largest courier services companies in the world. Its main operations consist of collecting parcels from customers, and redistributing these parcels to a destination indicated by the customer. In this talk, we discuss several opportunities for operations research, and especially vehicle routing, to assist in these complex operations. We also discuss a heuristic approach that we developed for a multi-objective routing problem at TNT.

The way in which TNT works is as follows. Customers call to demand the pickup of a parcel. The parcel is picked up later that day (or the following day, if pickup that day is not possible), and brought to the distribution center. There, it is sorted and loaded into bins (containers). These containers usually contain the orders to be delivered to a geographically restricted region. If possible, these regions are defined by postal code, for easy sorting. When orders have been loaded into containers, the assignment of containers to trucks is determined. Each truck may contain a fixed number of containers. Pre-sorting the items in containers has the additional advantage that late-arriving parcels can be added to the correct container at the last minute. Of course, care is taken that containers on a specific truck correspond to geographical regions that are in close proximity, to minimize unproductive travel of the trucks. When all containers have been loaded, the trucks leave the depot and visit each geographical region corresponding to a container. In each geographical region, all delivery points are visited in milk-runs.

If we focus on the distribution side of the operations, i.e. after the parcel has been dropped off at the hub, several potential optimization problems arise:

1. Determining the regions for delivery (containers).
2. Determining the assignment of regions (containers) to trucks.
3. Determining the order in which regions should be visited.
4. Determining the milk-runs per region.

In this talk, we focus on problems 2 and 3, as this was seen by TNT to be the most urgent. Problem 1 is a so-called districting problem, in which the aim is to partition the set of customers into subsets so that certain criteria are satisfied. This problem is a tactical, rather than an operational problem, because TNT does not want these zones to change from day to day. The main reasons for this are that it should be easy to sort the packages into containers corresponding to a region (which is why postal codes are mostly used), and that drivers should be able to become acquainted with the geographical layout of a certain zone. Determining the zones on a day-to-day basis, i.e. as an operational problem, is not an option.
Problem 4, determining the milk runs in each region, is done by the driver, who is mostly familiar with the characteristics of a certain region, and with the peculiarities of different customers (e.g. opening hours, ...). Although decision support systems integrated in the trucks are envisaged to help solve this problem, drivers should still be given some discretion in determining their own delivery pattern.

In this talk, we discuss how problems 2 and 3 can be solved in an integrated way. For each region, TNT calculates an average (expected) amount of work. The real time needed to completely finish all deliveries in a region may deviate from this due to a multitude of factors (e.g. traffic conditions, customer unavailability, ...). A driving time between each pair of regions, corresponding to the time needed to drive from the boundary of a region to another one, is also calculated. Total travel time for a given truck is equal to the travel time within each region plus the travel times between regions. It is not difficult to see that the problem to minimize total travel time is simply a capacitated vehicle routing problem (CVRP).

From discussions with TNT, three different objectives were identified:

1. The total travel cost (distance or time) of all trucks should be minimized.
2. The routes should be balanced, i.e. the difference in route cost between the shortest and the longest routes should be minimized.
3. The routes should not change too much over time.

Objective 3 was considered to be very important by TNT, because the familiarity of a driver with a certain region has many advantages. Moreover, some companies require TNT to visit them with the same driver each day, e.g. because they want to entrust the driver with a key to their company.

In this talk, we discuss a tool that we developed to support these operational decisions at TNT. The outcome of the tool is a limited set of alternative solutions, each with a high performance on each of the three criteria. The tool uses specifically developed neighborhood structures, combined with update rules for each of the three criteria, in a metaheuristic framework. Results of the tool will be discussed.