COORDINATION IN VEHICLE ROUTING

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ABSTRACT

Coordination involves the re-deployment of payload between depot and customer, and includes split deliveries, load transfers and load swapping, facilitated by the establishment of coordination sites at strategic locations. Real-world coordination includes mid-air refuelling, the use of temporary replenishment sites, trailers left for later uplift by their towing vehicles, bulk re-suppliers travelling to field operatives, fleet re-supply, and couriers swapping loads on the side of the road.

This thesis models the coordination process and investigates the basic types of coordination in single depot, pure delivery systems in both the Euclidean plane and the rectilinear grid network. Strategies are developed for dealing with dynamic situations in the rectilinear grid, which are based on the pre-processing of scenarios in order that dispatchers may select a suitable response from an existing selection at the time that dynamic values are revealed.

In addition, a procedure is suggested that reduces the number of edges and vertices of a rectilinear grid to those that may be useful within a coordination hull.

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GLOSSARY

Centroid	Geographical centre, weighted by population.
Close list	List of vehicles that approach within the near radius of each other, and the time step at which this happens.
Commodity class	Type of payload.
Coordinated system	A routing and sheduling system to which coordination has been applied.
Coordination	A relaxation of the standard VRP in which the load for a customer is allowed to vary its integrity or carriage before arrival at that customer.
Coordination hull	Area of a graph within which lie all nodes and depots and the region in which coordination can occur.
Coordination point	Location at which coordination may occur.
Coordination site	Location at which coordination does occur.
Cul de sac	A section of path that has an intersection at only one end.
Delivery time	The time required to deliver a customer's demand - a linear function of the demand and the distance travelled to reach the customer's node.
Demand	The requirement by a node of goods.

Edge	A link between two vertices in a graph.
Essential point	Node or depot. Such a point must not be eliminated from a graph.
Existing route	A route that has been identified without recourse to a change mechanism, e.g. load swapping, that may be applied.
Goods	Items that are delivered to customers. May be divided into different types.
Graph	A combination of nodes, vertices and edges representing a system of customers, depots and vehicle routes.
Grid reduction	Removal of non-essential edges and vertices from a rectilinear grid.
Horizon	Temporal limitation.
Load plan	Result of routing and scheduling. The final assignment of nodes to routes and to vehicles.
Made edge	An edge that has been created, i.e. incorporated into a tour, usually after other edges.
maxVehCap	Variable representing maximum vehicle capacity.
maxVehDist	Variable representing maximum vehicle distance.
Maximum vehicle capacity	The maximum amount of payload that can be carried at any one time by a vehicle.
Maximum vehicle distance	The maximum distance permissible by law (or by other means) that any one vehicle may travel during one work cycle.

Metastable state	A transition state between two stable states.
Multi-routed vehicle	A vehicle that services more than one route.
Node	Customer, represented as a location on a two-dimensional graph.
Orientation	An indication of the direction of travel of a vehicle around a route.
Path	The actual locus of a vehicle, including nodes visited and all intervening points.
Phase space	The phase space of a system is the space of all possible states or behaviours.
Pre-determined	Decided in advance.
Near radius	Distance from node or path that is investigated for coordination possibilities. [§4.8]
No Choice String	A section of a path the has no intersections except at the ends.
Nodal zone of influence	The area defined by a minimum distance from a node within which coordination has no significant effect.
Non-coordinated	Something to which coordination has not been applied.
Payload	A generic term for anything carried by a vehicle that can be collected and/or delivered.
Rectilinear grid	A mesh that consists only of straight lines intersecting at right angles.
Routing scheme	Result of routing and scheduling for a system of nodes, depots, demands and vehicles.

Route structure	The actual nodes attended (even if not serviced) by each vehicle, in the order in which they are visited.
Service	To satisfy the demand (of a node).
Spatial	Concerned with distance and physical location.
Split delivery	The demand of a node is delivered in batches, possibly by more than one vehicle (at the same or different times) or by the same vehicle at different times. Where split deliveries are permitted, the demand for a particular node could even be split en route, carried by different vehicles, re-combined and delivered intact to the node.
Surplus table	Table indicating the differences between actual payloads and/or distances and potential (capacity) values.
Temporal	Concerned with time.
Threshold	Spatial limitation.
Transfer	The movement of goods from one location to another.
Uplift	Collection by a vehicle, e.g. of goods.
Vehicle	Any object capable of carrying payload, e.g. truck, plane, bus, van.
Work cycle	The length of time in which vehicles may be away from the depot. At the beginning of the work cycle, vehicles leave the depot to service nodes; at the end of the work cycle, all vehicles must have been returned to the depot. Normally has the value of one working day.