be taken simultaneously. In the academic community, integrated vehicle routing problems is the expression frequently used to denote the class of problems where a Vehicle Routing Problem (VRP) arises in combination with other optimization problems within the broader context of logistics and transportation (e.g., cf. Bektaş et al., 2015). This class of problems is recently attracting an ever growing attention among academics and practitioners. Côté et al. (2017) state that this increasing body of literature is motivated by, on the one side, the desire of bridging the gap between academic problems and real-world applications, and, on the other side, the recent advances in optimization methods and computer capabilities that are making it possible to jointly solve strongly interdependent problems that have been, until recently, addressed independently.

Inspired by a real-world problem faced by a service company operating in the province of Québec, Canada, we study the Multi-Period Workforce Scheduling and Routing Problem (MPWSRP). This company installs, maintains, and repairs electrical infrastructures. Each job accepted by the company requires a given set of skills. Jobs can be simple and quick (e.g., installing a new power outlet), or very complex and long (e.g., wiring a new building). Jobs also have a priority, as some are more urgent than others. The company has hired a group of skilled workers to serve the jobs, and has a limited fleet of vehicles. The service time of each job depends on the number of workers assigned to it (e.g., three workers can finish a given job in a shorter time than two workers). At the beginning of the planning horizon, the company has to decide when each job will be served. Simultaneously, the company, has to decide how to group workers into teams, how to assign each team to a set of jobs, and to determine a routing plan for each team on each day.

The use of skilled workers is common in the literature. In what follows, we survey the most relevant contributions to our application, and refer the reader interested in workforce planning problems incorporating skills to the survey by Bruecker et al. (2015) and, and if routing aspects are to be considered, to the overview provided by Castillo-Salazar et al. (2016). Li et al. (2005) consider different skills for a set of workers and link them to a job by using constraints to assign a team to a job. Each job has a fixed service time, and the routing aspect considers time windows. The problem is defined on a single period, just like that of Xu and Chiu (2001), who considers also job priorities, imposing that some jobs must be performed prior to others. Kim et al. (2010) handle priorities as precedence constraints between jobs, proposing a mathematical formulation and solving the problem heuristically. Dohn et al. (2009) do not consider job priorities, but allow jobs to be left unassigned, and solve the problem via a branch-and-price algorithm. Kovacs et al. (2012) provide some flexibility by introducing the possibility of not serving some jobs, but rather outsourcing them. They propose a mathematical formulation and solve the problem using an Adaptive Large Neighborhood Search (ALNS) heuristic. Finally, Pillac et al. (2013) consider a problem in which the usage of tools and spare parts are also optimized, other than routing a set of skilled technicians, solving it via a hybrid of mathematical programming and ALNS.

To the best of our knowledge, the only multi-period problem similar to ours is that of Tang et al. (2007), but their version does not consider a skilled workforce neither job priorities. They solve the problem via a tabu search algorithm. Cortés et al. (2014) also do not consider the workforce in their problem, but jobs have priorities. Their branch-and-price algorithm allows jobs to be left unserved, and those serviced are considered with soft time windows. Goel and Meisel (2013) considers explicitly crews but not their skills, assuming the workforce to be homogeneous.

Other types of problems involving scheduling of heterogeneously skilled workers include call center scheduling, such as in Legros et al. (2015) who consider different workloads and requirements for the operators, and different service requirements on the demand side (unbalanced demand, for example). In the home healthcare service industry, one has to route workers to the patients houses, and each patient may require the visit of a different type of worker, configuring skills. Here, the service is

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