Designing and optimizing an LNG supply chain using LocalSolver

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This talk deals with the optimization of the sizing and configuration of a Liquefied Natural Gas (LNG) supply chain. This problem is encountered at ENGIE, a French multinational electric utility company which operates in the fields of electricity generation and distribution, natural gas and renewable energy. Having described the industrial problem and its stakes, we show how to model and solve it efficiently using set-based modeling features of *LocalSolver*, an innovative hybrid mathematical optimization solver combining both heuristic and exact search approaches. In the process, we combined ENGIE Lab CRIGEN business knowledge and mathematical modelling skills with LocalSolver agile design thinking and powerful solver components to tackle advanced routing & scheduling problems. The resulting software *OptiRetail* is now used by ENGIE to carry out design studies of LNG supply chains.

Several onshore customers need to be supplied with natural gas from LNG sources. The demand of each client is known for every time step. Different transportation means such as vessels or trucks are available to supply LNG from sources to customers, possibly using intermediate hubs. Each carrier is characterized by its storage capacity and its costs as well as the list of sites that it can visit. A tour is a distribution travel starting from a source with full capacity and visiting a certain number of sites, unloading a fraction of the capacity at each site, and finally getting back to the starting source. A planning is a set of tours over the horizon. The cost of the planning is composed of fixed costs and operating costs. The objective is to minimize this cost over a long-term horizon, typically 20 years.

Below is a sample of a LocalSolver model for the Capacited Vehicle Routing Problem (CVRP), written in LocalSolver Programming Language (LSP), which is the core of the LNG supply chain model discussed above. The reader shall notice that this set-oriented optimization model can be read and understood without any prior knowledge about LocalSolver. The simplicity and concision of this model is to be compared with classical mixed-integer or constraint programming modeling approaches. On the resolution side, LocalSolver relies on the declared high-level set-related structures to apply state-of-the-art heuristic search techniques, mainly based on fast local moves.

```
// Capacited Vehicle Routing Problem (CVRP)
function model() {
   // for each vehicle, the list of visited clients
   routes[1..nbTrucks] <- list(nbCustomers);
   constraint partition  [k in 1..nbTrucks](routes[k]);

   for[k in 1..nbTrucks] {
      route <- routes[k];
      c <- count(route);
      // truck capacity constraint
      constraint sum(0..n-1, i => demands[route[i]]) <= capacity;
        // sum of distances between each pair of clients and depot
      distances[k] <- sum(0..n-2, i => distance(route[i], route[i+1]))
          + distance(depot, route[0]) + distance(route[n-1], depot);
   }
   minimize sum[k in 1..nbTrucks](distance[k]);
}
```