RED HAT®
DECISION
MANAGER

BUSINESS OPTIMIZATION WITH RED HAT DECISION MANAGER

TECHNOLOGY OVERVIEW

RED HAT DECISION MANAGER BENEFITS:

- A lightweight, embeddable planning engine
- Solves constraint satisfaction problems efficiently
- Combines optimization heuristics and metaheuristics with very efficient score calculation
- Easily adjustable optimization algorithm

INTRODUCTION

Red Hat® Decision Manager 7 offers Java™ developers a unique toolkit for the construction of applications that solve complex scheduling and resource optimization problems. Its business optimizer can quickly find good solutions to problems that are otherwise extremely difficult, time-consuming, and expensive to solve. No specific knowledge of optimization techniques is required in order to use business optimizer, making it easy for IT organizations to deliver optimized business solutions without the need for specialized expertise and tools.

Business optimizer is based on the OptaPlanner JBoss® community project, and it is included with a Red Hat Decision Manager 7 subscription at no additional cost. Business optimizer benefits from the underlying capabilities of the business rules engine, which conveys scalability benefits compared to traditional planning solutions that do not use rules-based technology.

MANY DEMANDS, LIMITED RESOURCES

Every organization faces planning problems and must provide products or services with a limited set of constrained resources, such as employees, assets, time, and money. Business optimizer optimizes planning so you can do more business with fewer resources. This is known as constraint satisfaction programming.

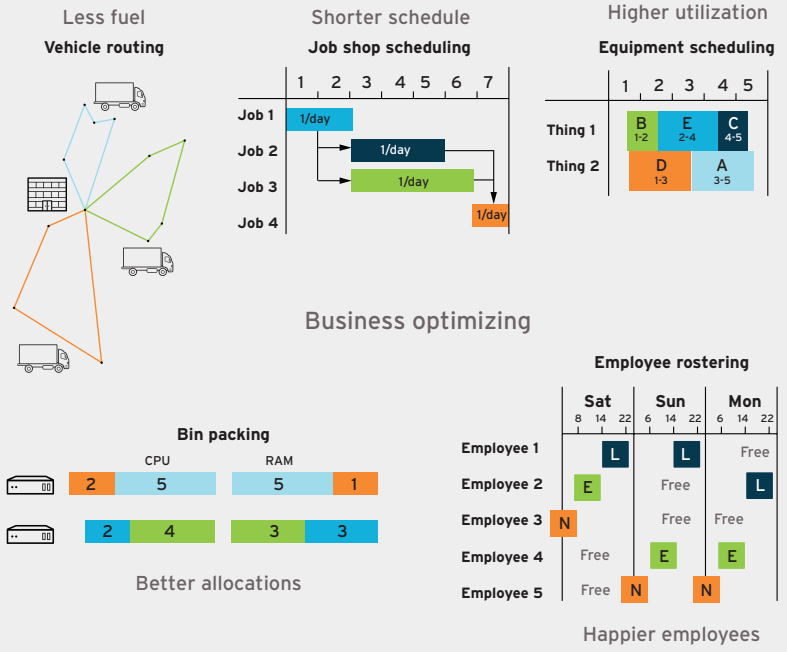

Figure 1. Business resource planning.

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None of the smartest computer scientists in the world have found a means to solve NP-complete (nondeterministic polynomial time) problems yet. In fact, there's a $1 million prize for the first correct solution.

Examples of the types of challenges that business optimizing can address include:

- **Employee rostering**—scheduling personnel, such as nurses or service personnel, with the appropriate availability and skills for 24-hour coverage
- **Agenda scheduling**—scheduling meetings, appointments, maintenance jobs, advertisements, and more
- **Educational scheduling**—scheduling lessons, courses, exams, or conference presentations
- **Vehicle routing**—planning vehicles, such as trucks, trains, boats, or airplanes with freight or people
- **Bin packing**—filling containers, trucks, ships, and storage warehouses, but also cloud compute nodes
- **Job shop scheduling**—planning car assembly lines, machine queue planning, or workforce task planning
- **Cutting stock**—minimizing waste while cutting paper, steel, or carpet
- **Sports scheduling**—planning football or baseball leagues
- **Financial optimization**—optimizing investment portfolios or spreading risk

These types of problems are very common across many industries, and they are difficult and expensive to solve. In mathematical terms, these problems are probably NP-complete. This means that there is no known way to find an optimal solution in a reasonable time.

PLANNING PROBLEMS

HARD AND SOFT CONSTRAINTS

A planning problem has a number of solutions. There are several categories of solution:

A constraint is a restriction that any solution to a planning problem should satisfy. Planning problems have at least two types of constraints:

- A (negative) hard constraint must not be broken. For example: one teacher cannot teach two different lessons at the same time.
- A (negative) soft constraint should not be broken if it can be avoided. For example: Teacher A does not like to teach on Friday afternoon.

Some problems have positive constraints too:

- A positive soft constraint (or reward) should be fulfilled if possible. For example: Teacher B likes to teach on Monday morning.

The quality of a solution to a planning problem can be measured by the extent to which it complies with the problem's hard and soft constraints. A score calculation (or fitness function) is used to produce a numerical score for each solution, and to compare solutions in order to determine which out of a set of possible solutions is the best.

Red Hat's optimizer repeatedly demonstrates outstanding performance in competitions such as the ICON Challenge.

A HUGE SEARCH SPACE

A planning problem has a number of solutions. There are several categories of solutions:

- A *possible solution* is any solution whether or not it breaks any number of constraints. Planning problems tend to have an incredibly large number of possible solutions. Many of those solutions are worthless.
- A *feasible solution* is a solution that does not break any (negative) hard constraints. The number of feasible solutions tends to be relative to the number of possible solutions. Sometimes there are no feasible solutions. Every feasible solution is a possible solution.
- An *optimal solution* is a solution with the highest score. Planning problems tend to have one (or a few) optimal solutions. There is always at least one optimal solution, even in the case that there are no feasible solutions and the optimal solution isn't feasible.
- The *best solution* found is the solution with the highest score found by an implementation in a given amount of time. The best solution found is likely to be feasible, and given enough time, it's an optimal solution.

The number of possible solutions is typically huge, even with a small dataset. Most problems have a lot more possible solutions than the minimal number of atoms in the known universe (10^80). Because there is no fast, easy way to find the optimal solution, any implementation is forced to evaluate at least a subset of all those possible solutions.

RED HAT APPROACH

The business optimizer, part of Red Hat Decision Manager 7, is a lightweight, embeddable planning engine. Business optimizer helps Java programmers solve these types of constraint satisfaction problems efficiently. Business optimizer combines optimization heuristics and metaheuristics with very efficient score calculation. Depending on the use case, some optimization algorithms perform better than others, but it's impossible to tell in advance.

With business optimizer, it is easy to switch the optimization algorithm by changing the solver configuration in a few lines of XML or code. The included benchmarker toolkit allows you to easily determine the best configuration for your business.

USING THE BUSINESS OPTIMIZER

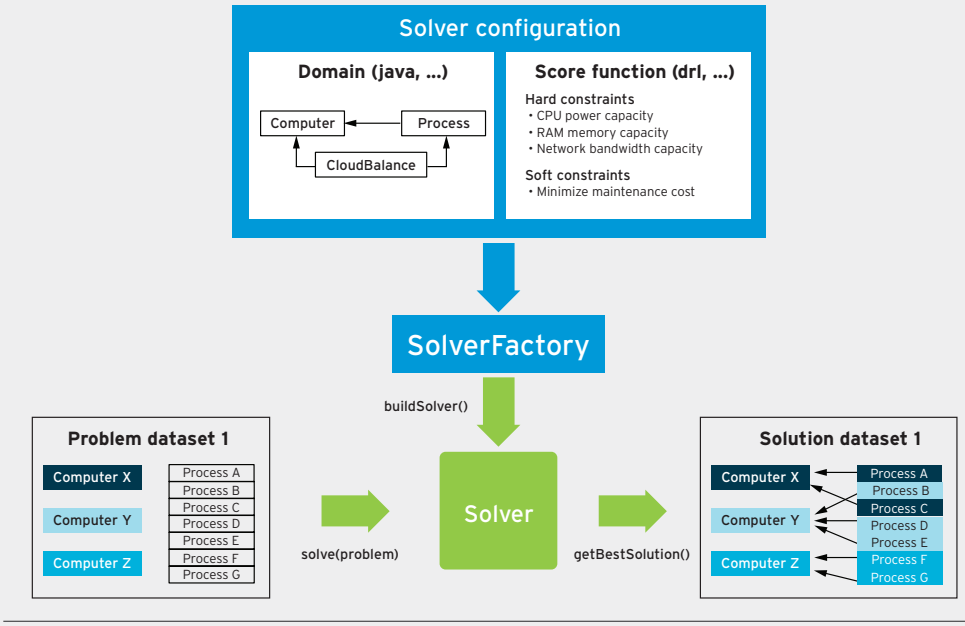


Figure 2. Using the business resource planner.

The approach to solving a planning problem with business optimizer can be broadly divided into these steps:

1. **Model the planning entities.** A set of Java classes are created to describe the problem in terms of the key entities and their relationships. For example, for a vehicle routing problem, Java classes are required that represent the types of vehicles, types of drivers, delivery locations, etc.
2. **Define constraints.** Hard and soft constraints on planning entities, such as maximum loads and driver availability, are defined by scoring functions that calculate a score representing the extent to which a specific constraint is met by a given solution. Scoring functions may be written in Java, or for complex planning problems, in Drools DRL, which lets business optimizer take advantage of the speed and scalability of the Red Hat Decision Manager 7 rules engine.
3. **Load a problem dataset.** Provide business optimizer with data representing a specific instance of the problem to solve—for example, a set of vehicles and delivery locations.
4. **Start solving.** Use the business optimizer API to start solving the problem. Business optimizer will work continuously to find solutions and will keep the best one found so far.
5. **Obtain a solution.** Use the business optimizer API to retrieve the current best solution. Typically it will converge on a solution within a few minutes, depending on the size and complexity of the problem.

Business optimizer offers users considerable control over the solving process at runtime. The relative importance of each constraint can be modified, and one or more components of a solution can be locked to specific values and made immovable. In this way, users can exercise more control over generated solutions; they can limit automatic solving to specific aspects of a problem and incorporate their own preferred answers into the overall solution.

CONTINUOUS AND REAL-TIME PLANNING

In most scenarios, planning solutions need to be revisited constantly as the goals, resources, and constraints change over time. Unexpected events such as equipment breakdowns, severe weather, and absent staff mean that a solution may no longer be effective and new solutions are needed quickly. Or solutions such as a staff roster may need to be generated on a regular basis, perhaps weekly, with each week's roster dependent on assignments completed in the prior week.

For these scenarios, the business optimizer offers both real-time and continuous planning capabilities. In real-time mode, business optimizer can continually adjust solutions as the problem data changes, allowing a rapid response to unplanned events. In continuous mode, business optimizer produces incremental solutions for an advancing window of time that takes prior results into account.

INTEGRATION WITH BUSINESS APPLICATIONS AND DATA

Business optimizer offers many flexible options for developers to integrate with their IT infrastructure. Input and output data (the planning problem and the solution) are plain old Java objects (POJOs), so integration with other Java and Java EE (JEE) technologies is straightforward.

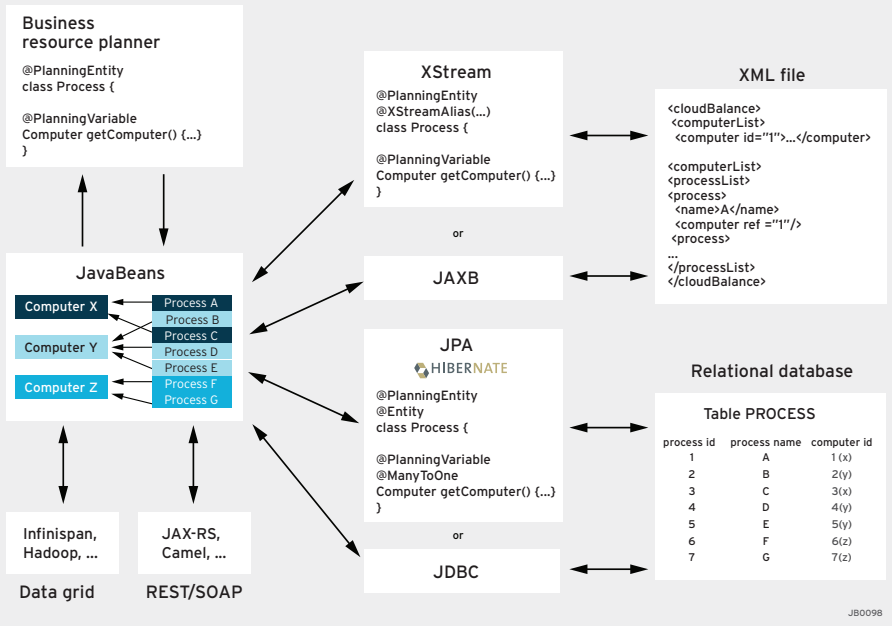


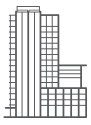
Figure 3. Integration overview—business optimizer combines easily with other Java and JEE technologies

In addition, business optimizer is fully compatible with JEE and Open Service Gateway Initiative (OSGi) environments and can easily be exposed as a service on an enterprise service bus (ESB), such as Apache Camel.

MORE INFORMATION

Many organizations are using business optimizer to solve a wide range of problems, from scheduling sporting events to optimizing the use of shift workers to scheduling package deliveries. Red Hat now offers worldwide support and consulting services to help you create timely and successful optimizer implementations.

For more information on how Red Hat Decision Manager 7 with its business optimizer can help optimize business operations, visit redhat.com/Decision-Manager.



ABOUT RED HAT

Red Hat is the world's leading provider of open source solutions, using a community-powered approach to provide reliable and high-performing cloud, virtualization, storage, Linux, and middleware technologies. Red Hat also offers award-winning support, training, and consulting services. Red Hat is an S&P company with more than 80 offices spanning the globe, empowering its customers' businesses.

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