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Offer

APO — Advanced Process Optimizer

Version of January 2018

This is the scope of work description for the software product Advanced Process Optimizer (APO) of algorithmica technologies Inc. Please refer to your personal offer letter for the prices of the items described herein. The commissioning of APO is usually done in four phases that are described in detail here.

1. Point of Departure and Goal

You operate a **process industry plant** in which many important quantities are continuously measured. This plant is to be optimized by maximizing a particular value, which is usually the financial profit of the plant.

An empirical data model constructed by an automatically learning system is to support the operators to achieve better operational conditions sooner and to maintain those conditions.

algorithmica offers a **process optimization software** that can determine the optimal point in real-time and derive concrete actionable suggestions to the operators. We call this the Advanced Process Optimizer (APO). Section 2 will provide more information about APO.

You wish to use APO to determine the **optimal point** at the present moment and then keep it there.

2. APO Product Description

APO consists of two mathematical modules.

The (1) **Machine Learning Module** obtains the differential equation that describes the dynamics of the process accurately. This module also keeps this model up to date as new data becomes available continuously. After an initial effort of parameterization, the model is maintained fully automatically.

The (2) **Optimization Module** uses this equation to determine the optimal point and the optimal path to get there. Optimal is defined as maximizing a particular key performance indicator. Any and all boundary conditions will of course be respected; those include for example variables that the operator has no control over, such as the weather. The difference of the current point to the optimal point is output as the suggestion for change.

In addition to the mathematics, APO offers an **interface** to periodically read the current data from some data source such as the control system. This interface uses the industry standard protocol OPC.

A browser-based user interface allows the users of APO to access the software from their desktop computers. They can then look at suggestions and make changes.

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3. Project Procedure

APO is a **standard software product** that can be installed just like any other software. In addition to the software, you require the dynamic model of your plant. This model is specific to your plant and must be made for you.

In order to produce this model, we need historical data as well as **some information** about the measurements of the process. These data will be gathered together with you in a workshop.

3.1 Phase 1: Preparation

First, we collect some **information about the process and the individual measurements**. We are preparing two files. One file will contain the historical values of all measurements for the last 1 - 3 years and the other will contain information about each measurement. Please see the precise requirements in section 5 of this document. We will also define the precise goal of the optimization at this point.

Typically this phase requires two days of effort and is usually done in the context of a two-day workshop conducted by algorithmica with you at your site. Optionally, you may choose to gather this data on your own according to the specifications given by algorithmica.

3.2 Phase 2: Modeling

As soon as the data of phase 1 is available, **modeling** can begin. This initial model creation cannot be done fully automatically as some restrictions must be programmed manually and the learning methods must be parameterized to your particular dataset. A few days of effort on the side of algorithmica are required to perform this work. Due to delays caused by communication and computation times, we estimate 4 - 6 weeks of duration for this phase.

You will obtain a **report** with sample suggestions and a quantified overview about what could have been achieved with APO in the past as the end product of this phase. This report can be used as the basis on which to decide to install APO.

3.3 Phase 3: Implementation

This phase will install APO in your plant for real-time use.

3.3.1 Phase 3.1: Installation

The APO software will be installed on a server of your choice. Please refer to section 5.4 for the technical requirement of the server. The installation is performed using a normal installation software and takes approximately 1 hour. The setting up of the connectivity to the data source and the network of users may require additional effort.

3.3.2 Phase 3.2: Fine-Tuning

The model is usually not yet ready to deliver fully correct and implementable suggestions because a few pieces of information from phase 1 (preparation) were forgotten. We thus draw a **random sample of 100 past suggestions** and check them manually. From this check, we will derive a number of model changes to be made. A modeling expert of algorithmica will go through this phase with you until at least 90% of the past suggestions are explicitly good. This usually requires 4 days.

The model can now be put into **live tuning** and the suggestions from the live feed are similarly examined to determine if they are good. If changes to

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the model are necessary, these are then made by algorithmica. We typically need 1 - 2 weeks of this procedure until nearly all suggestions are good.

3.3.3 Phase 3.3: Testing

The project can now progress to the **real live test** in which the suggestions are actually implemented in the process and the improvements are experienced. If additional changes are necessary, algorithmica will of course make them quickly. If not, APO will run as normal and suggestions will be put into practice. After a period of one month, the test results will be examined and the **success of the test determined**.

3.4 Phase 4: Usage

At this point, the project of introducing APO to your plant is over and the **normal usage** of the software can continue. This usage ends the license agreement for the testing phase and begins the license agreement for the normal usage phase for which a license fee must be paid.

4. Pre-Requisites for APO

APO assumes that...

- Your plant is sufficiently instrumented that all important physical quantities that determine performance are available.
- All data is available from one data source, typically the control system.
- All data has been archived for a long period of time, usually at least one year, in some data historian.
- The current data can be accessed via the OPC protocol.
- The operators are capable of making direct pro-active changes to important parameters that can influence plant performance.

5. Technical Specifications

5.1 Table of Metadata

In phase 1.2 you will collect a **list of all measurements** that are important for the process and its optimization. We suggest that you begin with an empty list and add one-by-one those tags that are important for the process. Having obtained a list of all necessary tags, you will then need to collect certain information about each of them. This is specified in a separate document.

5.2 Historical Data

To learn the dynamics of your plant, APO need historical data. Typically **1 - 3 years** are a good amount. Less than one year is usually not good as the weather tends to play an important role and so we will want to model at least one full cycle of the weather. Generally, more data is better for model quality and optimization potential. The file format for this data is specified in a separate document.

5.3 Optimization Goal

The goal function defines the key performance indicator that should be maximized using APO. This is usually the financial profit of the plant. The goal function is the sum of terms. Each term is the multiplication of a factor with two tags. One of the tags could be the physical value of an item and the other the financial price per unit of this item. The factor can be used to perform unit conversions or to define if that term is a cost or a revenue. For example,

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$$\text{Profit (\$/h)} = +0,001 (\text{kW/MW}) * \text{Price (\$/kWh)} * \text{Production (MW)} \\ - 1 * \text{Coal price (\$/t)} * \text{Coal amount (t)}$$

5.4 Computer Hardware

APO will run on a computer of your choice in your plant. Your data will thus be held locally without any direct connection to the internet. The computer can be a hardware or virtual computer. The system administration will be provided by your IT department. The computer must fulfill these criteria:

1. Microsoft Windows 64-bit operating system
2. Account for algorithmica with administrator privileges
3. Hard disk capacity at least 1 TB
4. Memory at least 8 GB
5. Processor at least Intel i7 920
6. We suggest a RAID system against hard disk failure
7. We suggest a regular data backup strategy
8. Access to the OPC server; may require fire walls to be configured
9. Access to the office network; may require fire walls to be configured. APO provides its browser-based user interface on port 3000 of the server.
10. Remote access for algorithmica when needed for help

6. Project Management

Section 3 describes the principal project process. algorithmica will guide you through all aspects of this process that have to do with data, mathematics and IT.

In addition to the technical steps described here, such a project contains operative changes in the organization of the users to be discussed, planned, documented, implemented and maintained. This **project and change management** component is not covered in this document. It is assumed that you will provide this work in house. If not, algorithmica is happy to connect you to several consulting companies that provide this service in cooperation with algorithmica.

7. Commercial Terms

The client organization will name a **project manager**. The project manager will have the authority to make decisions regarding budget.

Until the decision has been made to use APO for normal operations and the license fee has been paid, the APO software and model remains the property of algorithmica. The project itself will be billed and paid for according to the number of effort days used by algorithmica. algorithmica will bill the number of days used up at the end of each calendar month.

All work will be billed on basis of a daily rate where one day consists of eight hours. The work will generally take place in the offices of algorithmica. When algorithmica works on-site with the client, algorithmica will bill a travel flat rate per day of travel. This includes all costs of transportation, accommodation, food, insurances and so on.

Optional items are not contained in any estimated project efforts and may be billed separately. Our payment terms are 30 days. All prices are net

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prices without any sales or value-added taxes that may or may not be applicable depending on the location of the client's organization.

8. Legal Terms

algorithmica retains the right to cite this project and the client as a **reference** in the future. It is furthermore our goal to publish the results of projects in the **scientific literature** together with our clients. Of course, any non-disclosure rules and regulations will be obeyed.

It is expected that both parties sign a **non-disclosure agreement** prior to starting work on this project.

Before APO can be used in your plant, a **license agreement** must be signed. During the trial phase, this license will be supplied free of charge.

algorithmica accepts **no liability** whatsoever for any damages that results from the use of its products. All software of algorithmica supplies information only and can therefore cause no direct damage of any type. The decision to engage in some action on the basis of this information is in the responsibility of the persons making this decision. Any claims of production loss, product damage, machine damage, collateral damage or any form of physical or non-physical damage are excluded.

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