

SPC AS PART OF AN OPERATIONS INTELLIGENCE SYSTEM COMBINING JMP® & SAS®

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Abstract

Statistical Process Control (SPC) systems are setup to provide warnings of unusual or unlikely conditions that might lead to problems. In a typical scenario, a specified rule violation occurs and then a user or set of users may need to act and start an investigation. In addition to Western Electric and Westgard rules, manufacturers are increasingly using multivariate-rules that look for combinations of factor levels that may lead to trouble. All if this is multiplied across the increasing amount of measurement and monitoring found in manufacturing, network monitoring and transactional operations.

A JMP® stand-alone or JMP® and SAS® combination solution in what we refer to as and Operations Intelligence System (OIS) allows technical staff to manage with the increasing volumes of analysis. In addition to higher yields and consistent quality, OIS systems deliver improve personnel utilization and quality of work-life.

Introduction

Developed by Dr. Walter Shewhart in the 1920s at the Western Electric Co., Statistical Process Control was introduced to monitor process behavior. Shewhart knew that only stable, on-target processes could produce consistent and conforming products.

Shewhart determined that there are two sources of variability: common cause variation and special cause variation. The latter is variability that is beyond the inherent variability found in all operations. Control charts detect them with Out of Control (OOC) signals on a control chart.

The original set of OOCs are known as the Western Electric Rules. Today, other sets of OOCs are found in Westgard Rules and multivariate control rules are increasingly being used.

With automated measurement and control, as well as increasingly sophisticated and demanding operations, it is virtually impossible for some operations to be monitored by people alone. Semiconductor fabs, for example, have literally tens of thousands of control charts to monitor. They are not alone. Life sciences, network operations, transactional operations and other diverse companies find themselves in need of help managing large numbers of processes and their control charts.

SPC systems are now part of larger Operations Intelligence Systems (OIS) that provide assistance with monitoring, intervening and management of demanding operations. The major hierarchical goals of an OIS are to:

respond to trouble quickly; as soon as it happens,
warn of trouble before it happens,
eliminate the need to respond to trouble.

In this paper, we detail the construction of an SPC system component of an OIS whose purpose is to push both data and analysis to the user. A JMP® based SPC system, with SAS® connectivity, automates the major tasks of warning setup, data collection, transformation and standard analysis.

Control Chart Capabilities of JMP®

Right out of the box, JMP® has some powerful Control Chart capabilities. It can produce a wide variety of control charts, including multi-variate charts. It can monitor charts according to Western Electric or Westgard Rules. Additionally, there are two ways to freeze and retrieve control limits: 1) as column properties and 2) in JMP® files.

All of these features, like all of JMP's capabilities, can be scripted via JMP® Scripting Language allowing users to create customized, automated applications.

OIS Topology

Consider two variants of an OIS topology as in figure 1. The first is JMP® only where the user pulls data out of ODBC-compliant databases and various analyses are conducted. This is appropriate with smaller operations without too many processes to monitor that do not have huge amounts of data to monitor. This "pull" approach means that analysis happens on demand so monitoring requires engineers and other technical staff to initiate the monitoring activity usually by running a JMP® script. This application collects the data, produces the charts and presents them in a user-friendly way. Frequently these monitoring systems will take advantage of JMP's Column Properties feature where estimates of sigma, spec limits and control limits can be recorded.

Larger operations that require constant supervision or have large volumes of data require a JMP® and SAS® solution. The tasks assigned to each of these products will depend on the situation but some general rules provide guidance. SAS® generally handles all of the server-type functions and large-data manipulations. SAS/QC monitors operations looking for violations of control chart rules as well multi-variate combinations in process conditions that have been found to be worrisome in the past. When these warnings arise, the SAS® side of the system warns the analysts responsible via email.

JMP® is then used to pull relevant data for the analysts to determine the source of the problems, rectify the situation and record a reset of the operation.

The partnership between JMP® and SAS® includes using JMP’s multivariate control chart capabilities, as well as other analysis platforms, to determine how SAS® scores combinations and sends warnings.

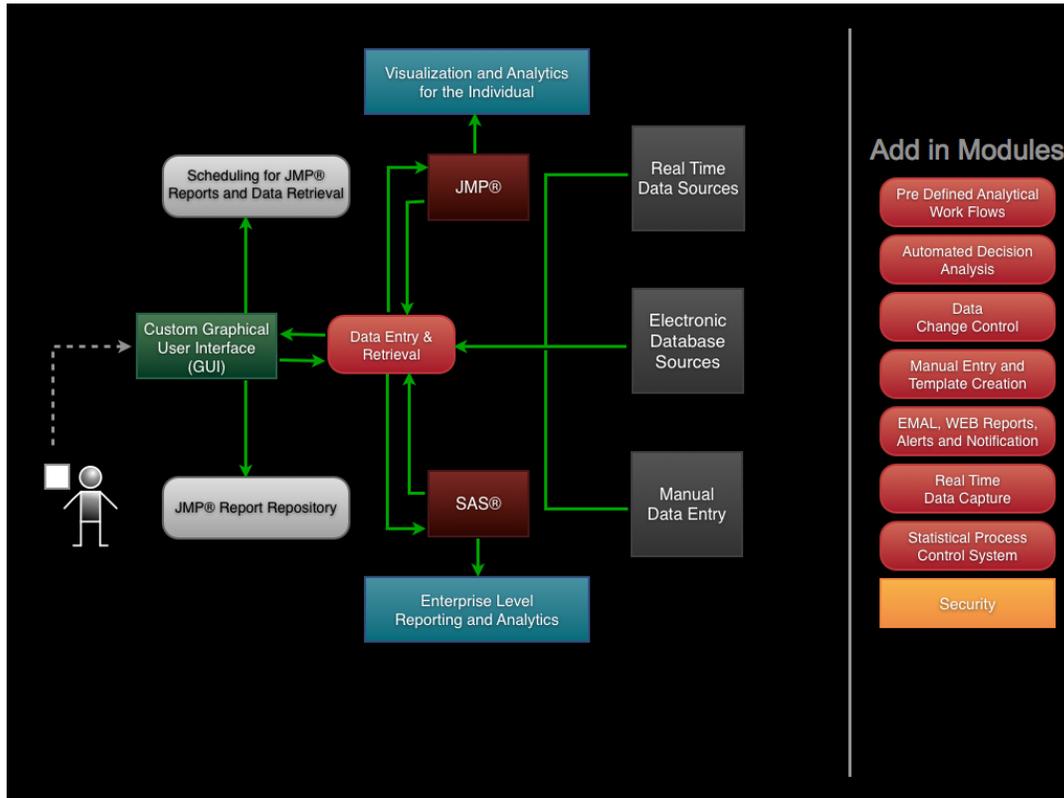


Figure 1: OIS Topology

Our goal here is to share JMP® capabilities to a primarily SAS® audience. As such, we will focus on how a non-server, pull-type of monitoring system would operate.

Elements of an SPC system

The basic element of an SPC system are shown in figure 2. Setup information details what data is collected and what types of charts are created. The SPC engine, created in JSL code, uses the setup information to process the data into an SPC chart. The engine determines rule violations, also according to the setup information. Output is then created so the end user can examine the violations.

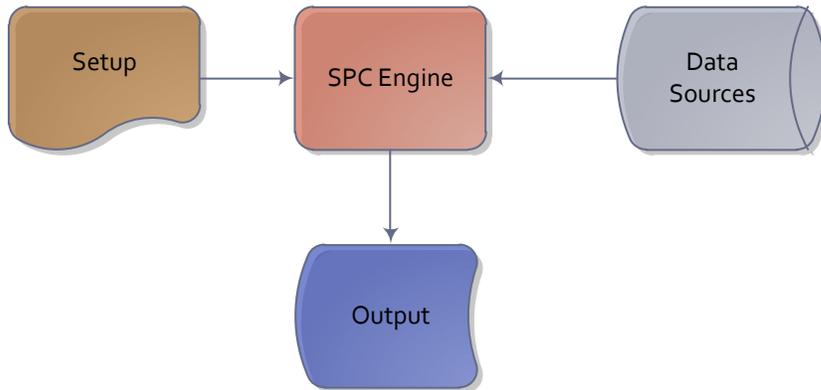


Figure 2: Basic Elements of an SPC System

An admin GUI is provided to allow the user to create or change setup information. Alternately, setup information may be edited from JMP® directly as it is contained in simple JMP® data tables. The system is executed and charts created when the scheduler runs the SPC engine. The schedule may be a simple windows scheduler or the schedule built into JMP® itself. Both of these methods are used.

Output from the SPC engine consists of several items. An EMAIL repository with one EMAIL per chart is created. WEB output is created for each chart. System level reports are created which detail statistics on number of charts processed and which chars are in violation. There are a large number of parameters than can be included in system reports.

Setup Information

Setup information is contained in simple JMP® data tables as shown in figure 3. These files may be edited with JMP® directly or with an Administrative Graphical User Interface (GUI) that is provided (not shown).

System level setup information specifies global values such as whether log files are written and if EMAILs are sent. Values in this category are usually changed by system administrators only. There are 41 system setup parameters. Additional setup information details what types of charts are created and where the data to be monitored is located.

	Parameter Name	
1	Reset Comment required	Y
2	Allow History Changes	N
3	Ignore Violations Older than N Points	360
4	Write Completion Stats to Log File	Y
5	Create System Reports	Y
6	File Path Type	Relative
7	EMAIL Completion Stats	Y
8	EMAIL Error Status	Y
9	EMAIL System Reports	Y
10	Archive System Reports	Y

Figure 3: System parameter setup - example

Output to the User

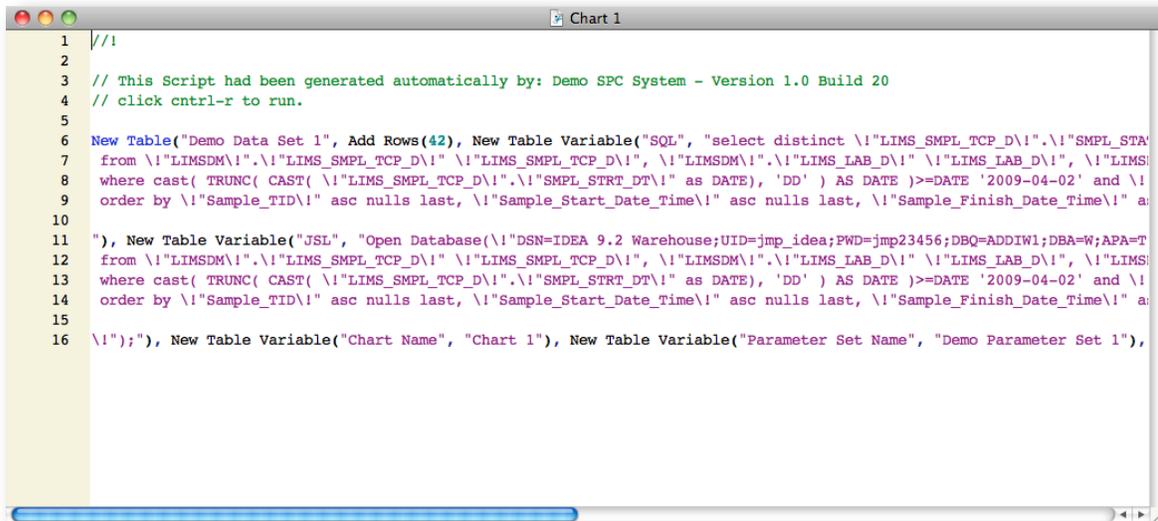
For this illustration, we have constructed a system that is JMP-based that is self-contained for convenience but with some features found using a SAS-based system.

The system generates various reports and log files as it runs. An example of a simple report is shown in figure 4. System level reports tell the user that the system has run successfully and then lists various stats on each chart. An EMAIL repository is then created. These EMAILS consist of JMP® scripts that, when opened, fully create the chart and its relevant data sets.

Chart Name	Status	Owner	Chart Type	Data Treatment	New Violation Counter	EMAIL On	EMAIL Type	Control Plan	EMAIL List
Chart 1	In Violation	Predictum I		Raw	0	Y	New Violation Plan 1		test@predictum.com
Chart 2	In Violation	Predictum I		Raw	0	Y	New Violation Plan 1		test@predictum.com
Chart 3	Normal	Predictum I		Raw	0	Y	New Violation Plan 1		test@predictum.com

Figure 4: General System Report.

The report in figure 4 shows that two of the charts are in violation and an email has been sent to the engineer responsible. An example of the script sent as an EMAIL attachment is shown in figure 5.



```
1 //!
2
3 // This Script had been generated automatically by: Demo SPC System - Version 1.0 Build 20
4 // click cntrl-r to run.
5
6 New Table("Demo Data Set 1", Add Rows(42), New Table Variable("SQL", "select distinct \!\"LIMS_SMP_L_TCP_D\!\".\!\"SMP_L_STA
7 from \!\"LIMS_DM\!\".\!\"LIMS_SMP_L_TCP_D\!\" \!\"LIMS_SMP_L_TCP_D\!\", \!\"LIMS_DM\!\".\!\"LIMS_LAB_D\!\" \!\"LIMS_LAB_D\!\", \!\"LIMS
8 where cast( TRUNC( CAST( \!\"LIMS_SMP_L_TCP_D\!\".\!\"SMP_L_STA_DT\!\" as DATE), 'DD' ) AS DATE )>=DATE '2009-04-02' and \!
9 order by \!\"Sample_TID\!\" asc nulls last, \!\"Sample_Start_Date_Time\!\" asc nulls last, \!\"Sample_Finish_Date_Time\!\" a
10
11 ), New Table Variable("JSL", "Open Database(\!\"DSN=IDEA 9.2 Warehouse;UID=jmp_idea;PWD=jmp23456;DBQ=ADDIW1;DBA=W;APA=T
12 from \!\"LIMS_DM\!\".\!\"LIMS_SMP_L_TCP_D\!\" \!\"LIMS_SMP_L_TCP_D\!\", \!\"LIMS_DM\!\".\!\"LIMS_LAB_D\!\" \!\"LIMS_LAB_D\!\", \!\"LIMS
13 where cast( TRUNC( CAST( \!\"LIMS_SMP_L_TCP_D\!\".\!\"SMP_L_STA_DT\!\" as DATE), 'DD' ) AS DATE )>=DATE '2009-04-02' and \!
14 order by \!\"Sample_TID\!\" asc nulls last, \!\"Sample_Start_Date_Time\!\" asc nulls last, \!\"Sample_Finish_Date_Time\!\" a
15
16 \!\";\"), New Table Variable("Chart Name", "Chart 1"), New Table Variable("Parameter Set Name", "Demo Parameter Set 1"),
```

Figure 5: JMP® Script emailed to Analyst

The script provides functionality which gives those responsible for the operation access to everything they need to understand the situation. This includes the original data, charts and any related data that may be needed for further investigation. When problems arise a good deal of time is lost pulling data to give the current situation context. While the analyst is figuring things out, operations may be stopped or outputs help to be contained for possible intervention.

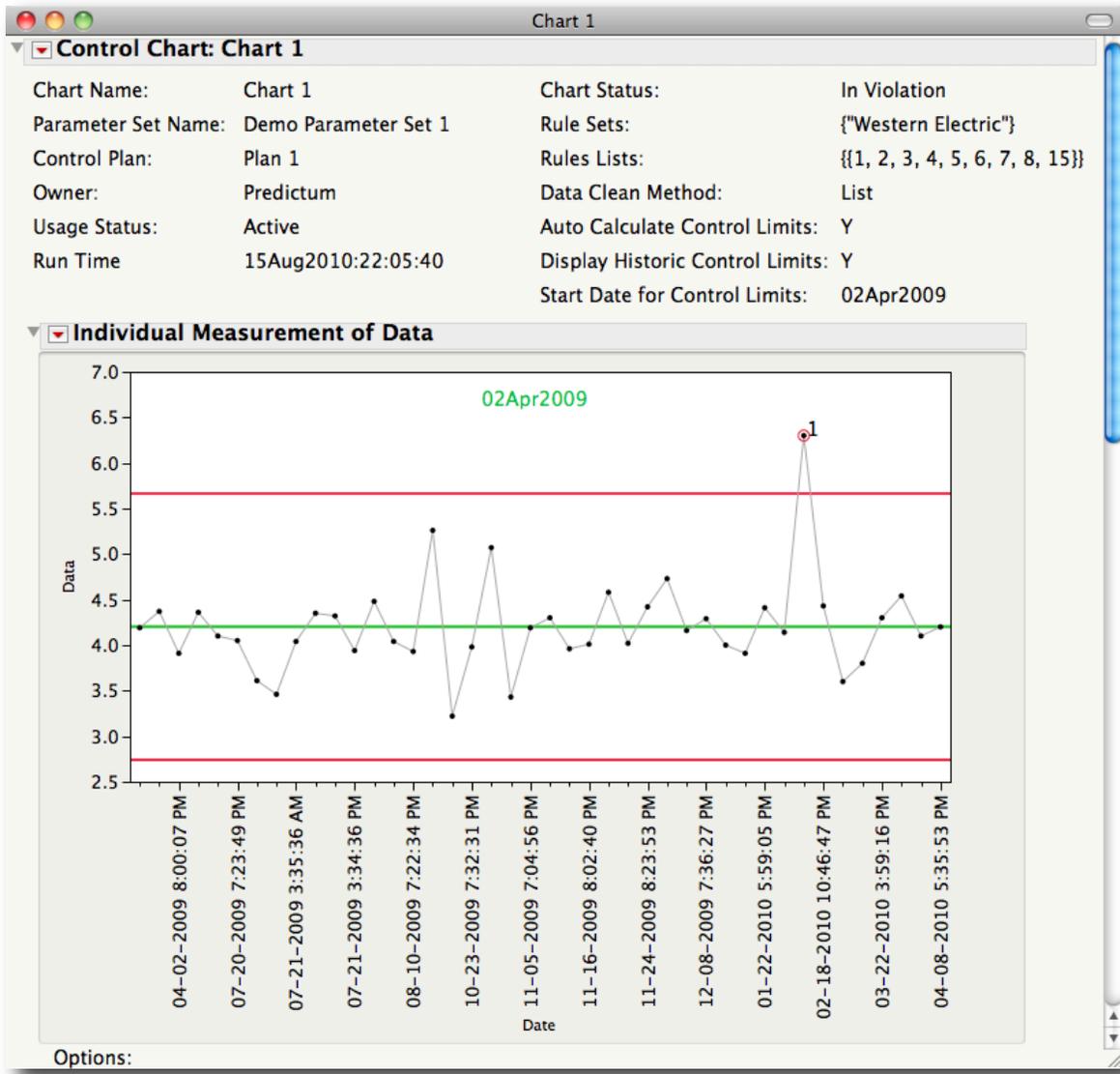


Figure 6: Control chart generated from the script

The initial view seen when opening a chart EMAIL attachment is shown in Figure 6. The chart itself contains setup information as well as the normal JMP® visual representation of the data and any violations. This chart is part of an individual and moving range chart part, one of the JMP® standard charts.

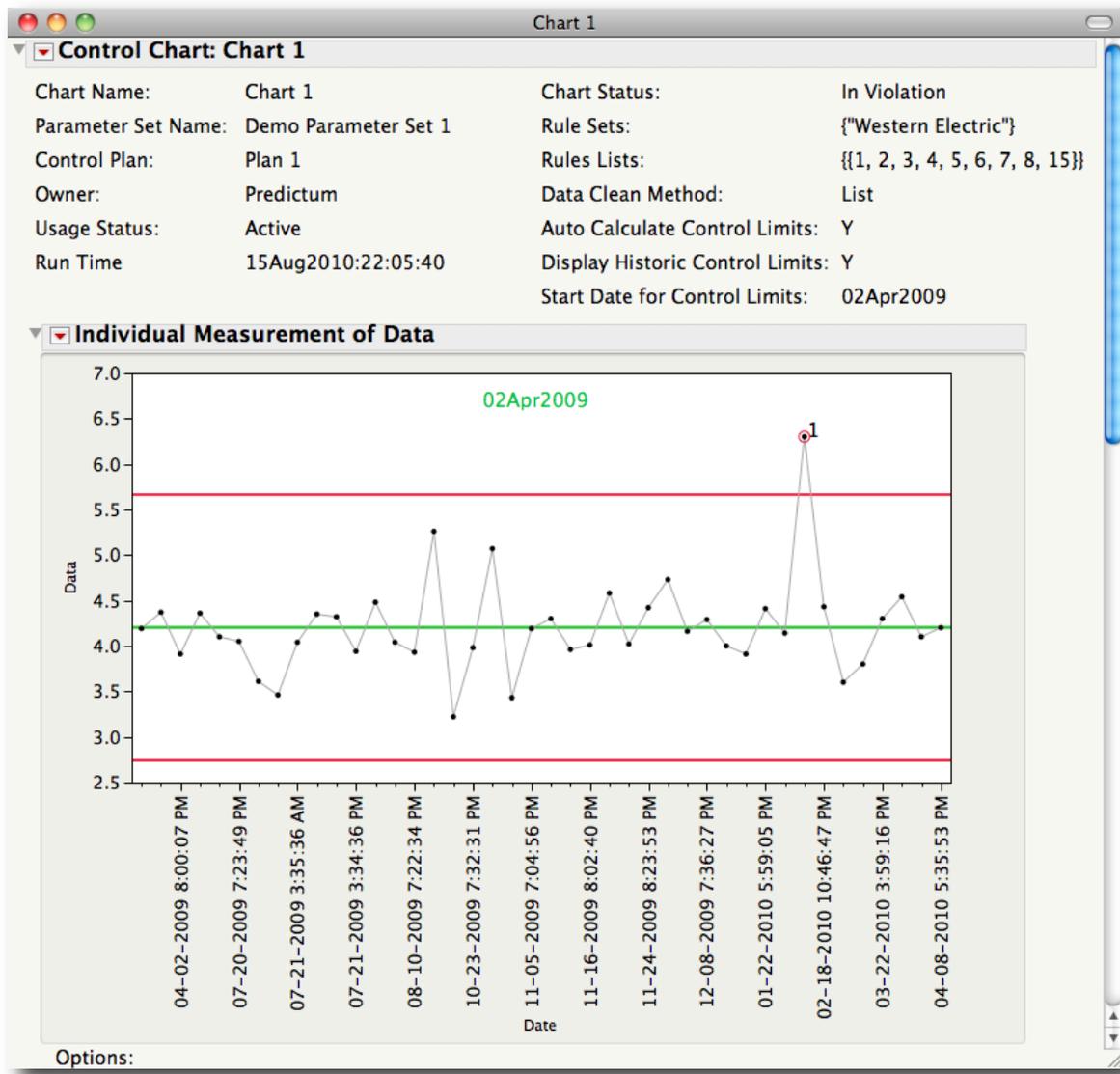


Figure 6: Control chart generated from the script

Figure 7 shows the moving range part of the chart pair. These are contained in the same output window that was generated by the script. Included at the bottom are sections that show active violations as well as recent history of the chart. Buttons are included to reset the violations by activating a reset process.

The JMP® Script can additionally provide access to all sorts of information and functionality. Some examples are overlaying timelines onto the chart or providing regression analysis to a pre-selected set of inputs. The possibilities are endless.

Applications that think for themselves

One of the great powers of JMP® Scripting Language is its ability to be written at higher levels of abstraction. This means that as new steps in the operation are added or new responses or new components as the result of engineering change orders appear, the OIS automatically incorporates them in the analysis without any changes to the coding. Applications developed in this manner are highly adaptive and scalable. This keeps maintenance costs low and it also helps in validation.

This also facilitates development especially for those who are concerned about control of their data. As contract developers, we do not require any of the client's specific data. All we need is the structure of the data. From that we can concoct our own set of data for development and testing purposes.

Summary

A fully automated SPC system has been constructed using the JMP® scripting language. This system can be set to run automatically using the scheduler built into JMP® or using a native operating system scheduler. At its core, the system creates charts and data tables that are stored as JMP® scripts. These scripts can then be sent by EMAIL. The user of the system can immediately begin an analysis after simply opening the JSL file. This results in faster analysis and higher productivity for analysis personnel.

Contact Information

This is a work in progress. Your comments and questions are valued and appreciated. Please contact the authors at:

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