End-to-End Root Cause Analysis
Minimize the time to incident resolution

End-to-End Root Cause Analysis in SAP Solution Manager offers capabilities for cross system and technology root cause analysis. Especially in heterogeneous landscapes it is important to isolate a problem causing component as fast as possible and involve the right experts for problem resolution. With the toolset provided by Root Cause Analysis this is possible with the same tool regardless of the technology an application is based on and it allows a first in depth analysis by a generalist avoiding the ping-pong game during an analysis between different expert groups.

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INTRODUCTION
Customer’s heterogeneous IT landscapes running mission critical applications have become increasingly complex during the last decade. Finding the root cause of an incident in those environments can be challenging. This creates the need for a systematic top-down approach to isolate a component causing the problem. The approach must be supported by tools, helping customers to do this as efficiently as possible. End-to-End Root Cause Analysis provides tools that support customers and SAP in performing a root cause analysis across different support levels and different technologies. The basic idea behind Root Cause Analysis is to determine where and why a problem occurred.

A typical example (see Figure 1) is a problem where an end user experiences a problem while maintaining his bank account data in the corporate portal, the cause may be on the client PC (e.g. browser), in the network or somewhere in the server environment, which itself might comprise different instances of varying technologies. In this example the client request in question first hits a SAP NetWeaver Portal (based on SAP AS Java), then reaches a SAP ERP System (based on SAP AS ABAP) via a RFC call and finally results in a SQL statement which retrieves information from the ERP database.

Figure 1: A typical scenario for Root Cause Analysis

The performance problem or functional defect might have occurred in any of those systems. SAP’s root cause analysis tools help to identify the specific system part, which has caused the error. When such an issue occurs that affects the customers productive solution the central goal of the customer’s IT team is to provide an immediate corrective action (workaround), which restores service operations as quickly as possible and which affects end users minimally, a complete
solution to the issue at hand by isolating the area of concern. Additionally, with respect to operation, SAP’s root cause analysis tools are designed to reduce the number of resources in each step of the resolution process. An IT generalist with core competence in root cause analysis, who involves a Component Expert, are mostly enough to investigate an issue and nail it down. Therefore Root Cause Analysis offers tools for each task in cross-component (end-to-end analysis) and component-specific analysis. Per definition, a cross-component analysis involves several systems or technology stacks, whereas component-specific analysis deals with one system or technology stack.

Overall, Root Cause Analysis works towards simplifying the problem resolution process within an IT environment and reducing the total cost of ownership. Benefits SAP’s tools for Root Cause Analysis are:

- **Ensured continuous business availability** – Root Cause Analysis helps to accelerate the problem resolution process.
- **Reduced costs for support experts** - The targeted top-down approach of RCA supports a one step dispatching of issues from an IT Generalist to a Component Expert.
- **Reduced license costs** - Supporting RCA Tools offered by SAP are part of the standard maintenance contract and come at no additional fee.
- **One safe access channel to all systems** – Root Cause Analysis provides one safe and central access channel to the customer’s landscape. If required, an investigation is continued on the system in concern using a predefined support user (SAPSUPPORT), who is only assigned read-only rights.
- **Collected data is displayed in unified views**, thereby abstracting data from the underlying technology stack. This approach supports the structured top down analysis approach, as generalists and experts start investigating at one common point.
- **Empowers the customer to solve problems himself** - Nobody knows the customer’s landscape as well as the customer himself. E2E Root Cause Analysis provides expert tools which enable a customer to quickly solve problems, thereby reducing overall resolution time.

All tools and applications are available in the Root Cause Analysis Workcenter (see Figure 2) in SAP Solution Manager.

The tools are grouped in different categories along the usage in the analysis process, but all tools share a common navigation paradigm. Before you start one of the available tools, a detailed selection allows you to define queries which group systems. So each user can define queries containing the systems, hosts or databases depending on his work focus (e.g. one query for all production systems, one query containing all CRM systems and so on). Based on these queries, you select one or multiple entries that you want to analyze and then start one tool in this context.

- **End-to-End Workload Analysis**: If a customer faces a performance problem, E2E Workload Analysis might be the tool to start with. Solution Manager regularly collects performance information of each system and makes this data centrally available in the Solution Manager Work Center RCA. The Workload Analysis allows to identify general performance bottlenecks such as sizing problems, or problems which affect all users who are using a particular system.
- **End-to-End Trace Analysis**: End-to-End Trace is a tool for isolating a single user interaction through a complete landscape and providing trace information on each of the involved components for one interaction only, starting with the user interaction in the browser and ending with data being committed to the database. Identifying long running user requests within a complex system landscape is the most common use case of E2E Trace Analysis, but you can also identify which functional errors have occurred during the execution of one request. These exceptions (like a dump) are then attached to the trace. So the trace can also be used to do functional testing and ensuring that an activity executed in one system does not lead to functional errors in connected systems during the request execution.
- **End-to-End Change Analysis** If a system behaves differently after a certain date or change, E2E Change Analysis is the first tool...
to use. It displays changes (e.g. transports and support package updates, profile parameter changes,…) that have been applied to a system within a certain timeframe. The Change Analysis application is based on a central Configuration & Change Database (CCDB). The CCDB provides the foundation for change analysis and change reporting based on daily configuration of system, host and database related configuration data. A Change Analysis can then be performed on all information stored in the CCDB. Furthermore it is possible to compare different systems and generate a report which contains the results. This approach identifies the problem by comparison rather than by drilling down, which is faster and easier in most cases.

- **End-to-End Exception Analysis**
  E2E Exception Analysis provides unified access to exceptions reflecting in high severity log entries and dumps. Exception Analysis provides the basis for statistical analysis on exception in the landscape, but also allow to access component specific log and dump viewers directly with a jump-in to the appropriate tool on the managed system.

- **System Analysis**
  In case of Java based system the Wily transaction trace can be used to identify which part of a request in a Java environment caused the problem. Wily Introscope is shipped by SAP with preconfigured dash boards, offering dedicated views for the SAP Application Server Java. A deep analysis of Java problems is possible in the investigator mode, which displays detailed performance metrics. Several other system analysis tools as Thread Dump Analysis, Change Reporting and Central LogViewer are provided.

- **Host Analysis**
  With the Host Analysis section of the RCA Work Center it is possible to analyze the most important OS metrics like CPU, memory, paging, network and disk/file system. In addition the filesystem browser allows a central read-only access to predefined directories on the managed system without having to logon to the console of the managed system. In the same manner it is also possible with the OS Command Console, to execute predefined, non destructible commands (like a ping, netstat, iostat and so on). Both tools work ensure that even whilst access to the managed system is granted, no change can be made, no business data can be accessed and not harmful commands can be executed.

- **Database Analysis**
  The DB Analysis summarizes DB Performance Warehouse specific metrics across all supported DB types. This also includes standalone DB’s that are connected to the DBA Cockpit within Solution Manager

- **Client side Analysis**
  If the outcome of an analysis is that the problem is located on the client side, SAP offers the tool BMC AppSight to analyze the problem further. At least one resource should exist in the customers IT department who received a special training for this tool. BMC AppSight is free of charge if only used in combination with SAP systems and with recording profiles offered by SAP.

**END-TO-END TOOLS IN ROOT CAUSE ANALYSIS**

All the End-To-End tools available in SAP Solution Manager are built on the same infrastructure and follow a common navigation approach. First, the infrastructure: Data is collected from the managed system using multiple channels. For ABAP based systems a direct communication channel from the SAP Solution Manager system towards the managed system exist with the RFC connections. For all other system types data is collected via CA Wily Introscope. Introscope is an essential part and available free of charge in the so called Right To View (RTV) license. This allows customers to use the SAP delivered instrumentation and dashboards without having to buy a separate license. In addition, the Diagnostics Agent is used to collect additional data, like files from the file system, for all system types. Second, the navigation: All the tools share a common principle. You start with an overview which shows you the most important information in a condensed format. Which data finally gets displayed is defined by a timeframe selection. More detailed information is always available with a drill down. Most of the data presented in the tools is stored in the BW system which is integrated in SAP Solution Manager. The whole data extraction, aggregation and deletion process is managed by the so called Extractor Framework (EFWK) and no manual interaction is needed. The EFWK also has an integrated resource control to ensure that neither the Solution Manager nor the managed system are overloaded with the data extraction. Also the housekeeping is managed by the EFWK, so that the data growth keeps at a passable level.

Now to the tools in detail…

**End-to-End Workload Analysis**

The End-to-End Workload Analysis helps you to get workload information of your complete system landscape in order to analyze overall performance bottlenecks in your solution. There are different monitors and analysis tools that provide you with key performance indicators for the different
components. Most commonly, an initial check of overall workload is done to check the overall workload. Therefore the workload overview screen summarizes the most important performance KPIs independent of the technology the system is based on (see Figure 3).

Figure 3: Workload Analysis Overview

In addition to the overview, there are different view types available which display the data in different ways. For example the Scatter view (see Figure 4) displays the data with the Average Response Time on the x-axis and the Accumulated Response Time on the y-axis. Similar to the Time Profile, data points will be displayed as hourly average values for the chosen timeframe.

Figure 4: Scatter Chart

In interpreting the diagram, one can structure the displayed area roughly in four quadrants, distinguishing between low and high Average Response Times on the x-axis and low and high Accumulated Response Times. Then, the top right quadrant with both high Average Response Time and high Accumulated Response Time can be regarded as a Critical Quadrant. Values in here have the strongest impact on the system they were measured on.

From here you can do the drill down to product specific KPI’s. In the following diagram, you see an example of the structuring for an ABAP based system:

Figure 5: ABAP Workload Summary

By utilizing this drilldown you can find what is causing the general performance bottleneck and start follow up activities. It is also possible with standard BW functionality to further drill down in the detailed metric views by right clicking on a column and choosing from the list of available drill-down options (like in Figure 6).

Figure 6: Drill-down options

End-to-End Change Analysis
Changes are a common starting point for problems in your landscape. Imagine that something worked yesterday, but it is not working anymore today. The first question would be what changed in between? E2E Change Analysis is the tool to analyze problems like this. Again, the tool starts with an overview on the overall changes which have been applied to the landscape (see Figure 7). You can use the timeframe mechanism, to limit the timeframe to the point when the problem occurred first.

Figure 7: Change Analysis Overview

From here, the Change Analysis application allows you again to drill down to the type of changes and from there to the actual changes itself. The available changes are categorized (again depending on the system type) and then displayed like in Figure 8 (example for an ABAP
system). Here you can easily identify that on a certain date a lot of notes have been implemented in a system, or that on another day parameter changes have been applied to the system.

Based on the available statistical information on exceptions, the main use cases is that you want to perform an exception trend analysis to find out if after implementing a special path or update more or less exceptions are occurring. Another use case is to ensure that with a specific patch or a SAP note a problem is fixed and the exception does not occur anymore.

**Figure 8: Change Analysis Categories**

With a further drill down it's then possible to identify the changes in detail and also get a history on the single change in the change reporting application.

**Figure 9: Change Reporting with history**

In addition to the time based analysis, it is possible to compare the configuration of two systems against another one. By this it is possible for example if you have a problem in your production system which cannot be reproduced in the quality assurance system, what the configuration differences between the two systems are.

**End-to-End Exception Analysis**

The E2E Exception Analysis follows the same approach than the other two previously described tools but displays all kinds of exception in managed systems. This starts with dumps in an ABAP system but also includes for example Out of memory situations in a J2EE engine. As the information about the exceptions is persisted on the Solution Manager, it is prevented that the exceptions are overwritten by a round robin log mechanism or cleanup procedures in the managed system. Of course not all information is persisted on the Solution Manager system (only relevant header data which is needed for error statistics as type of the exception, description, severity, time and date, user that caused the exception,…)

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**Figure 10: Overview of exceptions**

In the overview (see Figure 10) you can identify in the time profile on which time of the day which exceptions occur, or use the history diagram to see the distribution of exceptions over the selected timeframe (see Figure 11).

**Figure 11: History of exceptions**

The drill down allows you to identify the exact exception which is only summarized in this diagram. Depending on the exception type more data is stored in BW to allow an efficient first analysis, but the complete exception data is always available in the managed system itself and can be reached with a jump-in from the Solution Manager system. In the following example you can see that 90 dumps have been triggered in the selected timeframe by a syntax error in a test program. Using the green jump-on, you could now navigate to the managed system and analyze the dump in transaction ST22.
Similar possibilities exist for all kind of supported exception, like system and application errors in a J2EE engine with a jump-in to the NetWeaver Administrator.

End-to-End Trace Analysis
The main purpose of E2E Trace Analysis is investigating problems related to a single user activity caused by one or more user clicks in the front end. Single user click in a Web UI or Portal front end can trigger one or more requests to the web server. While the web application running on the web server processes a request, it can trigger several requests to other components (systems) in the solution landscape. These components on their side can trigger additional requests to their components and so on.

The analysis of performance and functional problems in such a complex landscape is time consuming and requires expert knowledge. The end-to-end cross component tracing aims to decrease the time for gathering the relevant trace data related to a single user activity and simplifies the analysis by guiding the user through the analysis steps and identifying the component which consumes the biggest amount of the total execution time. In addition it is possible to find exceptions which were triggered by the request in one of the involved components.

This all is achieved with the help of the SAP Passport. The passport is a simple extension of the communication protocols used in SAP landscape (such as HTTP or RFC) and consists of two parts. The first one is a GUID which identifies the requests uniquely, the second one are trace flags which indicate which trace should be turned on in one of the involved components.

The passport is injected on client side into the communication and then later on passed over from system to system. Each system that receives a request which contains a passport turns its trace on dynamically for the processing of this request (based on the trace flags). When the trace is written to the disk or the database the GUID of the passport is included to be able to identify the request later on. The passport is also injected into follow up requests when another call to an external system is made, which then turns on the trace dynamically, write it to the disk and so on and so on.

This means actually, that all traces throughout a landscape can be collected for a single click of an end-user because they are identified by the GUID which was generated at client side. Based on the trace information which is collected it is very easy to identify which component took which time to process the request (e.g. processing in java in an Enterprise Portal, processing in a connected ABAP system, processing on the DB, in the network, on the client side,…) and isolate problem causing components.

But back to the start, the E2E trace is triggered with the HTTP client plugin for web based scenarios or directly from the SAPGUI with the transaction /SDF/E2E_TRACE (starting with SAP Basis 7.20 SP6 it is also possible to start tracing during the execution of a dialog transaction using the function code/ $gui_e2e_trace as in Figure 13). Then the end user performs the activities which are causing the problem and the whole tracing process is started in the connected backend systems.

After the trace has been created, SAP Solution Manager collects all the trace data from all systems and displays the results broken down per step in an overview screen (see Figure 14). The trace overview allows to identify on which part of the request execution, the most time has been spent (e.g. client, network, server,….).
In the given example it can be easily seen, that most of the time is spent on server side, so the next natural step is to look deeper in the server execution and which server instances have been involved.

As you can see in Figure 15 the execution of a single request can spawn multiple systems. Nevertheless it is also obvious that in the scenario the most time is spent on the ABAP system PR2 (namely nearly 30 seconds).

Figure 15: Server summary

Following the drill down we can see that out of this 30 seconds, 26 are spent on the database, which hints to a problem with a bad performing DB or a not tuned SQL statement or the sheer amount of data which is transferred.

Figure 16: Trace time distribution

Now it is possible to analyze on a request level which traces have been triggered by the request and by this identify the function module or the SQL statement which causes this problem.

E2E Trace is a very powerful tool which is integrated in all SAP infrastructures and also reused in monitoring & alerting by the End User Experience Monitoring. This deep insight into a SAP system gets more and more useful in today's highly integrated and heterogeneous landscapes.

**AVAILABILITY**

End-to-End Root Cause Analysis is available since SAP Solution Manager 7.0 SP 12 up to the latest release SAP Solution Manager 7.1. The main differences between the releases are.

- **Release prior to SAP Solution Manager 7.0 EhP1 (SPS18)**
  - Own application in SAP Solution Manager Java WebDynpro
  - Based on solutions to perform analysis
  - Focused on ABAP & Java analysis
- **SAP Solution Manager 7.0 EhP1 (SPS18) and later**
  - Integrated in SAP Solution Manager Workcenters
  - Based on technical systems (no solution required anymore)
  - Flexible query based approach (each user can define his own queries for grouping systems)
  - Focuses on all technologies used by SAP & Partners
- **SAP Solution Manager 7.1**
  - Focused on SAP & non-SAP
  - Integration of further system & technology types
  - Personalization options for each user
  - New applications for Host and Database analysis added

In addition to these major feature deliveries, in each SP new supported products are added. This starts with the delivery of new instrumentation and dashboards for CA Wily Introscope but also includes functional enhancements in the E2E applications to support further SAP & non-SAP products. For a detailed description of the added products please refer to the later mentioned SAP Notes.
WHERE TO FIND MORE INFORMATION

If you want to know more, please consider the following resources:

**Root Cause Analysis Home in SDN:**
http://wiki.sdn.sap.com/wiki/display/TechOps/RCA_Home

**Technical Operations in SDN**
http://wiki.sdn.sap.com/wiki/display/TechOps

**Application Lifecycle Management in general**
http://service.sap.com/alm

**Relevant SAP Notes:**
- [1010428](http://service.sap.com/alm) – Supported Products with SAP Solution Manager 7.0 (and EhP1)
- [1293438](http://service.sap.com/alm) – Supported Partner Products
- [1478974](http://service.sap.com/alm) – Supported Products with SAP Solution Manager 7.1