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Final Prototype of Compliance Governance Dashboards

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	UNITN	Universita degli Studi di Trento (IT)
	TARC-PL	Telcordia Poland (PL)
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	PWC	Pricewaterhousecoopers Accountants N.V. (NL)

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Project no. 215175

COMPAS

Compliance-driven Models, Languages, and Architectures for Services

Specific Targeted Research Project

Information Society Technologies

Start date of project: 2008-02-01 Duration: 36 months

D5.5 Final Prototype of Compliance Governance Dashboards

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THALES – Thales Services SAS

TUV – Technische Universitaet Wien

UCBL – Université Claude Bernard Lyon 1

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Dissemination Level		
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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

History chart

Issue	Date	Changed page(s)	Cause of change	Implemented by
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0.2	2009-08-10	All sections	Updates	UNITN
0.3	2010-11-08	All sections	Create a concise version of the document	UNITN
0.4	2010-12-15	All sections	Reduce the size of the document and applying comments collected during our internal review	UNITN
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Abstract

Assessing whether a company's business processes conform to laws and regulations and follow standards and best practices, i.e., compliance governance, is a complex and costly task. Few software tools aiding compliance governance exist; however, they typically do not really address the needs of who is actually in charge of assessing and controlling compliance, that is, compliance experts and auditors.

In order to support compliance governance we advocate the use of *Compliance Governance Dashboards* (CGDs), whose design and implementation is however challenging for at least three reasons: (i) it is fundamental to identify the right level of abstraction of compliance performance to be shown; (ii) it is not trivial to visualize different analysis perspectives; and (iii) it is difficult to manage the large amount of involved concepts, instruments, and data.

All these issues are properly identified and documented in *On the Design of Compliance Governance Dashboards for Effective Compliance and Audit Management* accepted at the NFPSLAM-SOC'09 [SRC+09] and *Analyzing Compliance of Service-Based Business Processes for Root-Cause Analysis and Prediction* accepted at the 1st Workshop on Engineering SOA and the Web (ESW'10) in conjunction with ICWE'10 [RSD+10], as well as in the book chapter called *Aiding Compliance Governance in Service-Based Business Processes* published in the Handbook of Research on Non-Functional Properties for Service-Oriented Systems: Future Directions [SRA+10]. Together these references show which concepts and models underlie the problem, and, eventually, how IT can effectively support compliance monitoring and analysis in Service-Oriented Architectures (SOAs).

In this deliverable we simply present a user guide for CGDs and Root Cause Analysis prototypes, as well as their implementation details *CGDs* and how to install them.

1. Introduction

Compliance is a term generally used to refer to the conformance to a set of laws, regulations, internal policies, SLA, standards, or best practices (compliance sources according to COMPAS conceptual model [D7.1]). *Compliance governance* refers to the set of procedures, methodologies, and technologies put in place by a corporation to carry out, monitor, and manage compliance.

Compliance governance is an important, expensive, and complex problem to deal with as described in [SRC+09]. To address these and similar compliance problems, COMPAS proposes a conceptual model for compliance [D7.1] and for CGDs, along with a dashboard architecture and a prototype implementation. The aim of CGDs is to report on compliance, to create an awareness of possible problems or violations, and to facilitate the identification of root causes for non-compliant situations. In addition, COMPAS also proposes a root cause analysis solution, based on decision trees, in order to discover the causes of the violations and predict their future occurrences, when possible.

The dashboard addresses several classes of profiles: chief officers of a company, Business Line managers, internal auditors, and external auditors (certification agencies). These two latter typically focus on a fairly narrow set of processes and examine historical data to verify non-compliant situations and how they have been dealt with. Via the dashboard, they also have *access to key compliance indicators* (KCIs) [D5.4] defined for each process. Managers (especially high-level ones) are interested in a much broader set of compliance regulations and at *quasi-real* time compliance information that allows them to detect problems as they happen and identify the causes, so that they can correct them before they become (significant) violations. Compliance stakeholders have access and navigate through the entire set of compliance sources, business processes, and business units and also observe the overall compliance status (through aggregate KCIs). In addition, once problems are identified (unsatisfactory values for indicators) they drill-down to the low-level events (violation), as well as use the root cause analysis solution to indentify the problem or predict future non-compliance behaviors.

In that context, this deliverable describes how to use CGDs and Root Cause Analysis prototypes, as well as their implementation details and complementary information to download and install them.

1.1. Purpose and scope

To better understand the purpose and scope of this deliverable let us consider Figure 1, which shows a high-level view of the COMPAS compliance governance runtime architecture (part of the overall architecture described in [DA.1]) and helps us to point out the role of CGDs and root cause analysis and their interactions with other architecture components.

In such an architecture (Figure 1) we can see that all events from different fonts (i.e., Business process engine, Complex Event Processing, and Business protocol monitoring) are published in the ESB (Enterprise Service Bus), to afterwards be stored in the Event log. After that, an extraction, transformation and load (ETL) routine is executed to capture those raw data events and to store them into the Data warehouse (DW) [D5.3]. That done, the events conformed to a data model can be used as input for the Analysis/Business Intelligence component that shows their final results in the Compliance governance Web UI. Such component is in charge of computing KCIs, showing CGDs, and providing root cause analysis of violations using decision tree algorithms.

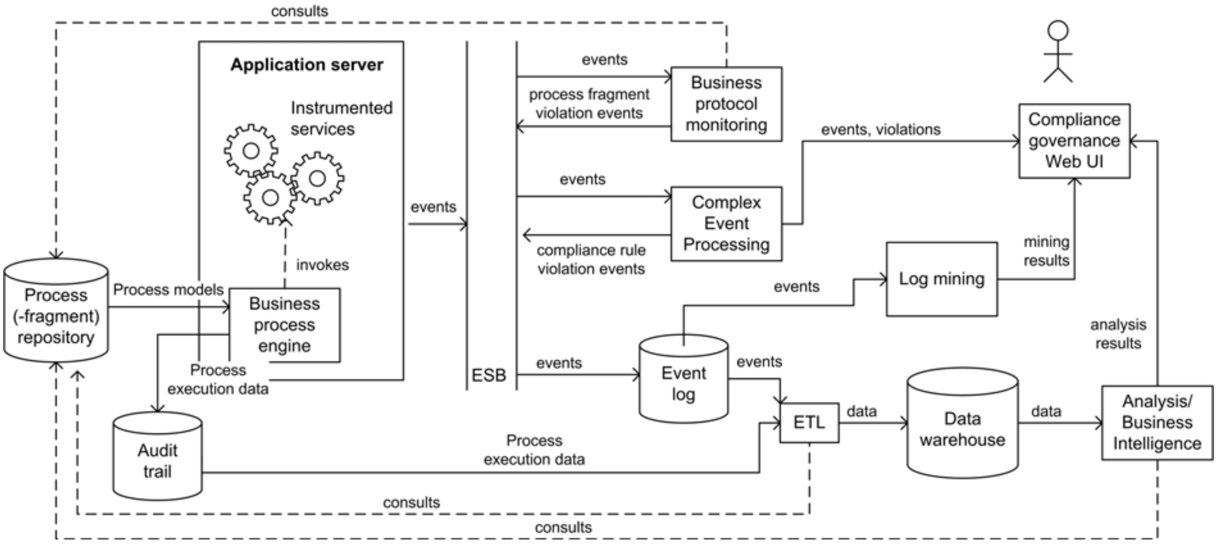


Figure 1 Compliance governance runtime architecture, an extension of [D5.3]

Given that, the CGDs and the Root Cause Analysis make part of the Compliance governance Web User Interface (UI). They are the presentation components used to do offline and on-line runtime compliance monitoring, showing violations, as well as KCIs. Both, KCIs and low-level violations take into account different summarization levels (granularity of business executions, i.e., process and activities) and analysis perspectives (i.e., business process or compliance). This allows different user profiles (internal and external auditors, compliance experts, CIO) to monitor the compliance status of an organization, starting from indicators (high-level) until violation instances. Yet, the users also can build decision trees in order to discover the causes of the non-compliant behaviors. More details about such compliance visualisation are provided in this deliverable (Section 2). The Complex event processing and Business protocol monitoring, which result in runtime monitoring, were respectively provided by UBCL and Telcordia in the [D5.4]. The Log mining component was developed by UCBL and its results are documented in the [D5.6].

1.2. Document overview

This deliverable starts explaining briefly the complexities and challenges faced in order to provide CGDs, as well as, the role of dashboards in COMPAS. Then, the remaining sections are as follows: Section 2 describes how to use the CGDs and the Root Cause Analysis prototypes. Section 3 describes their implementation details. Section 4 introduces how to obtain and install such prototypes.

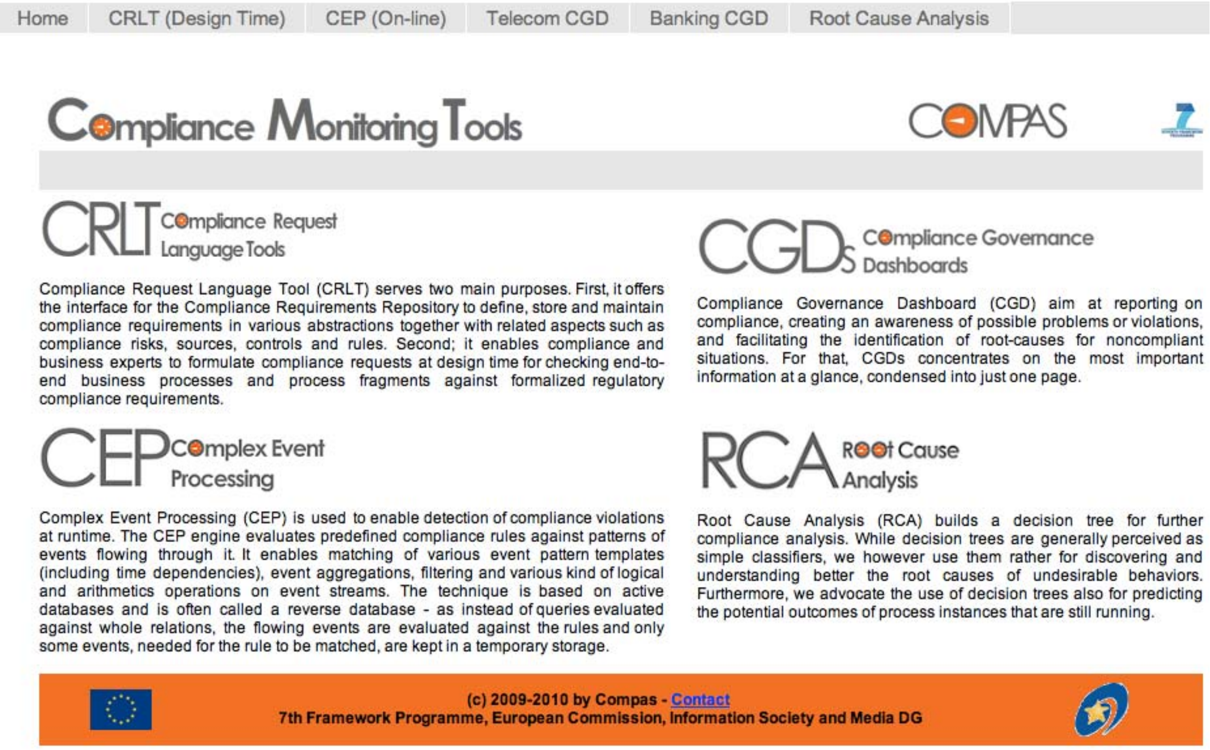
1.3. Abbreviations and acronyms

CGD	Compliance Governance Dashboard
CIO	Chief Information Officer
DoW	Description of Work
DW	Data Warehouse
IT	Information Technology
KCI	Key Compliance Indicator

MiFID	Markets in Financial Instruments Directive
QoS	Quality of Service
SOA	Service-Oriented Architecture
SOX	Sarbanes-Oxley Act
WebML	Web Modelling Language

2. User Guide for the CGDs and the Root Cause Analysis Prototypes

In this section we present and explain how to use the COMPAS' CGDs and the Root Cause Analysis prototypes. Both respectively are provided and accessed by the Telecom CGD, Banking CGD and Root Cause Analysis tabs in the COMPAS Compliance Monitoring Tools web portal (Figure 2) and available at *http://compas.disi.unitn.it:8080/CGDs/main.jsp*. This same portal also supports the Compliance Request Language Tools (CRLT) for design-time compliance monitoring and the Complex Event Processing (CEP) engine for runtime compliance monitoring. The CRLT does not make part of this deliverable, it was developed by the Tilburg University and is documented in D2.6. Regarding the CEP, it shows near to real time compliance violations to allow on-line runtime monitoring of business process and activities. Such visualization tool is an additional development effort, since it was not initially specified in the DoW, and its design and implementation descriptions are introduced D1.4 and D6.2.



CRLT Compliance Request Language Tools

Compliance Request Language Tool (CRLT) serves two main purposes. First, it offers the interface for the Compliance Requirements Repository to define, store and maintain compliance requirements in various abstractions together with related aspects such as compliance risks, sources, controls and rules. Second; it enables compliance and business experts to formulate compliance requests at design time for checking end-to-end business processes and process fragments against formalized regulatory compliance requirements.

CEP Complex Event Processing

Complex Event Processing (CEP) is used to enable detection of compliance violations at runtime. The CEP engine evaluates predefined compliance rules against patterns of events flowing through it. It enables matching of various event pattern templates (including time dependencies), event aggregations, filtering and various kind of logical and arithmetics operations on event streams. The technique is based on active databases and is often called a reverse database - as instead of queries evaluated against whole relations, the flowing events are evaluated against the rules and only some events, needed for the rule to be matched, are kept in a temporary storage.

CGDs Compliance Governance Dashboards

Compliance Governance Dashboard (CGD) aim at reporting on compliance, creating an awareness of possible problems or violations, and facilitating the identification of root-causes for noncompliant situations. For that, CGDs concentrates on the most important information at a glance, condensed into just one page.

RCA Root Cause Analysis

Root Cause Analysis (RCA) builds a decision tree for further compliance analysis. While decision trees are generally perceived as simple classifiers, we however use them rather for discovering and understanding better the root causes of undesirable behaviors. Furthermore, we advocate the use of decision trees also for predicting the potential outcomes of process instances that are still running.

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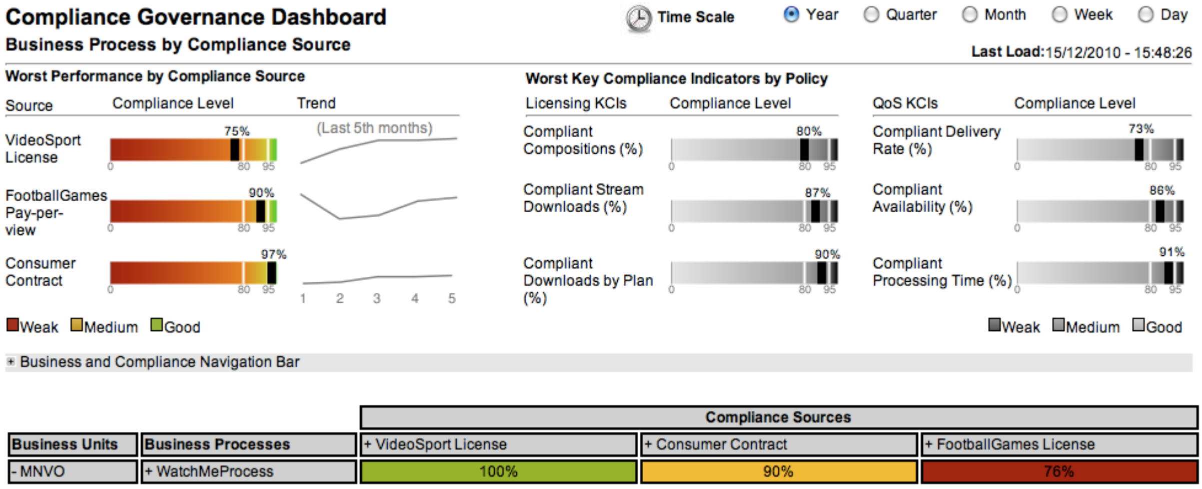
Figure 2 Compliance Monitoring Tools Web Portal of the COMPAS Project

2.1. Compliance Governance Dashboards

To provide the look-and-feel idea of what we has been implemented, the sequence of figures presented below illustrates screenshots from our CGD prototype (Figures 3 to 7). Such sequence is disposed according to the navigation model proposed in [SRC+09], starting from the highest-level information (Compliance Home page) until the lowest-level (Compliance Rules Violations page). It is important to highlight that here we just show screenshots from the WatchMe scenario (Telecom CGD) in order to avoid replications since the same structure presented here is applied to the THALES scenario (Banking CGD). To visualize the CGD of the THALES scenario please visit the COMPAS Monitoring web portal.

The CGD web pages are composed of three colored indicators (top left), in which the highest level of compliance performance status of each perspective is highlighted. Near to the colored indicators are located the trend line charts, where are shown the compliance performance during the last period (e.g., the last five months). Hence, for example, the project manager can see if his past actions impact beneficially or harmfully the general compliance performance (e.g., the enrolment of new employees decreased the performance in the first month, than after the compliance introductory courses such problem was solved). The gray indicators (top right) also report on the compliance, but taking into account the two main policies present in the WatchMe scenario (i.e., Licensing and Qos policies). It is worth to mention that all the indicators are organized in a descended compliance performance order, thus the worst and most risky performances are always located at the top. At the bottom of the page, there is the interactive compliance drill-down table containing the compliance performance according two main perspectives: compliance (columns) and business (rows). The content of such table, as well as the indicators, change every time the users navigate on the different perspectives as will be presented along this section. The *Time Scale* (top left) also updates the content of the CGDs, using it the users can navigate thought the time searching for past performances, or grouping the information according to their needs (e.g., monthly results, year results). The examples listed here consider the complete data set corresponding to the 2010th year.



Compliance Governance Dashboard

Business Process by Compliance Source

Time Scale ● Year ○ Quarter ○ Month ○ Week ○ Day

Last Load:15/12/2010 - 15:48:26

Worst Performance by Compliance Source

Source	Compliance Level	Trend
VideoSport License	75%	
FootballGames Pay-per-view	90%	
Consumer Contract	97%	

🟥Weak 🟨Medium 🟩Good

Worst Key Compliance Indicators by Policy

Licensing KCIs	Compliance Level	QoS KCIs	Compliance Level
Compliant Compositions (%)	80%	Compliant Delivery Rate (%)	73%
Compliant Stream Downloads (%)	87%	Compliant Availability (%)	86%
Compliant Downloads by Plan (%)	90%	Compliant Processing Time (%)	91%

⬛Weak ▨Medium □Good

+ Business and Compliance Navigation Bar

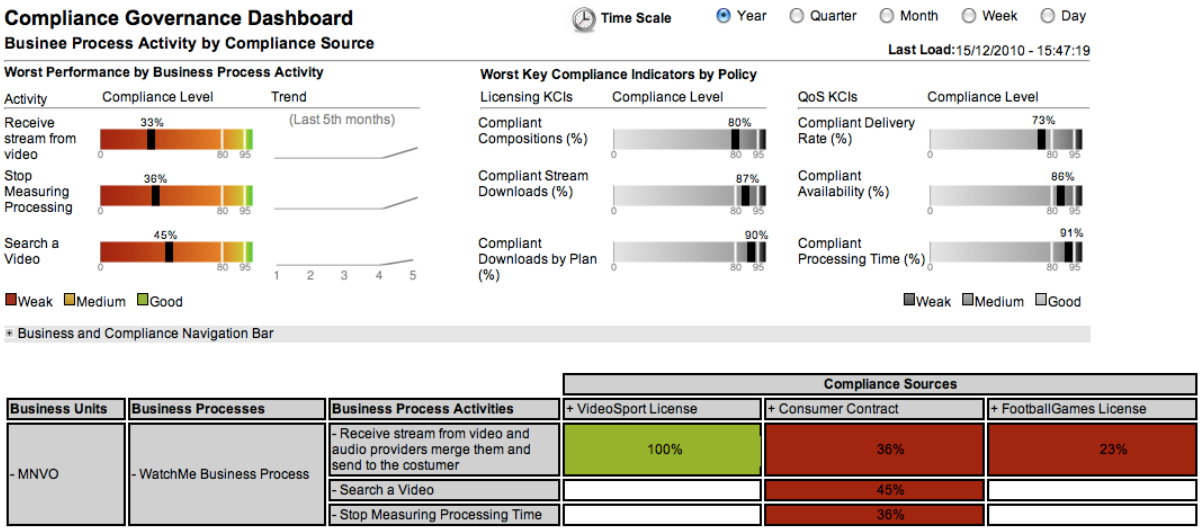
		Compliance Sources		
Business Units	**Business Processes**	+ VideoSport License	+ Consumer Contract	+ FootballGames License
- MNVO	+ WatchMeProcess	100%	90%	76%

Figure 3 Compliance Home page of the CGD with graphical widgets for the visualization of indicators and the compliance drill-down table

In each page of the CGD, the amount and the position of the graphical widgets for the indicators, the tables, the summaries, and so on are carefully chosen in accordance with our short-term memory and the convention of most western languages that are read from left to right and from top to bottom [Few06].

Now that we are aware of the main components of the CGDs, let's start with the navigation details. In order to navigate through the difference analysis perspectives and granularity levels the users may use the interactive table simply clicking on its cells. In that way, it is possible to do drill-down (clicking the + symbol in the table) or roll-up (clicking the – symbol). When the lowest level of perspectives is reached (i.e., compliance requirement X business process activity) the click in the cells conduces to the violation web page that is further presented. The colours of the table cells follow the same taxonomy adopted to build the indicators. Red and yellow cells always lead to violations (low-level events listed in the violations page), and green and white cells just show details about the compliance requirement and business activity. It happens, because green and white cells do not have violations associated to them. The white cell means that none compliance requirement is associated to the process or activity. It is worth to notice that the compliance perspective follows the compliance conceptual model of the project, in which a compliance source is composed by requirements that could be groups in one or more compliance policies. The sequence of pages presented in the next paragraphs is a navigation example and is consistent with the WebML model introduced in [SRC+09].

The main and initial page of the CGD is the Compliance Home page, which concentrates on the most important information at a glance, condensed into just one page (see Figure 3). It represents the highest granularity of information, in which the users can see the compliance of the sources and business processes combinations. For example, the WatchMe processes are 76% compliant regarding the *VideoSport License*, which is considered a weak performance and is highlighted in red. Hence, in order to see more details about this non-compliant behavior the users can navigate to a page with lower level information, using the table (more specifically clicking in the *WatchMe Business Process* cell), and see which activities of the WathMe process have the worst performance.



Compliance Governance Dashboard

Businee Process Activity by Compliance Source

Time Scale ● Year ○ Quarter ○ Month ○ Week ○ Day

Last Load:15/12/2010 - 15:47:19

Worst Performance by Business Process Activity

Worst Key Compliance Indicators by Policy

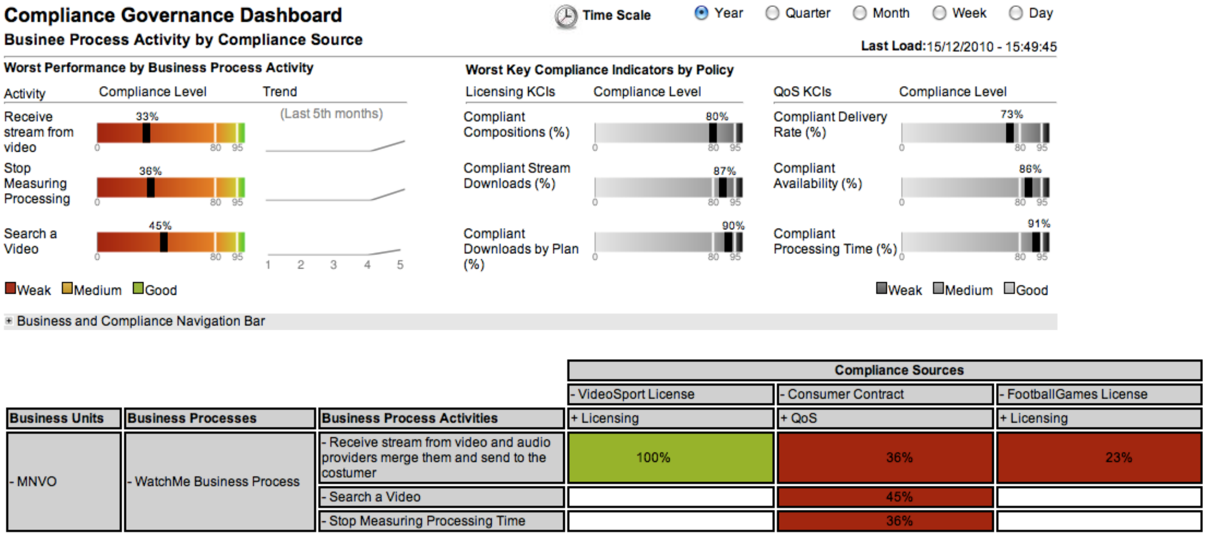
Activity
Compliance Level
Trend
(Last 5th months)
Receive stream from video
33%
Stop Measuring Processing
36%
Search a Video
45%
0
80
95
1
2
3
4
5
🟥Weak
🟨Medium
🟩Good
Licensing KCIs
Compliance Level
Compliant Compositions (%)
80%
Compliant Stream Downloads (%)
87%
Compliant Downloads by Plan (%)
90%
QoS KCIs
Compliance Level
Compliant Delivery Rate (%)
73%
Compliant Availability (%)
86%
Compliant Processing Time (%)
91%
■Weak
▨Medium
□Good

+ Business and Compliance Navigation Bar

			Compliance Sources		
Business Units	Business Processes	Business Process Activities	+ VideoSport License	+ Consumer Contract	+ FootballGames License
- MNVO	- WatchMe Business Process	- Receive stream from video and audio providers merge them and send to the costumer	100%	36%	23%
		- Search a Video		45%	
		- Stop Measuring Processing Time		36%	

Figure 4 Compliance Sources by Activity page with activity specific indicators and activity-level compliance info

The action described above lead the users to the ComplianceSouce by Activity page (Figure 4). Such page condenses lower level information concerning a combination of all the activities of the WatchMe Business Process (*Business Process Activities* in the third column) and the all the Compliance Sources. At this level the colour indicators show the compliance status of the activities with the worst compliance performance level. The gray indicators continue showing the compliance status of the Licensing and QoS policies, but taking into account the activity level to compute them. In the example illustrated here we cannot see this difference of values because the WatchMe scenario just has one process, for that reason the values are still the same in both levels. At that level we can see that *Receive stream from audio and video provider* activity is the only activity evaluate by the three compliance sources *SportVideoSport License, FootbalGames License,* and *Consumer Contract*. Hence, in order to investigate more details about the weak performance of this activity, users can click in the cells containing compliance sources. As a result they will see the Compliance Policy by Activity page (Figure 5), where the compliance status of the activities are grouped by policies. In the WatchMe scenario we just deal with two policies *QoS* and *Licensing*, however the table was developed to support bigger numbers. It is important to mention that the compliance policy view is also reached from the Compliance Home page (Figure 3), just clicking the compliance perspective.



Compliance Governance Dashboard

Businee Process Activity by Compliance Source

Time Scale ● Year ○ Quarter ○ Month ○ Week ○ Day

Last Load:15/12/2010 - 15:49:45

Worst Performance by Business Process Activity

Activity	Compliance Level	Trend
Receive stream from video	33%	(Last 5th months)
Stop Measuring Processing	36%	
Search a Video	45%	

🟥Weak 🟨Medium 🟩Good

Worst Key Compliance Indicators by Policy

Licensing KCIs	Compliance Level	QoS KCIs	Compliance Level
Compliant Compositions (%)	80%	Compliant Delivery Rate (%)	73%
Compliant Stream Downloads (%)	87%	Compliant Availability (%)	86%
Compliant Downloads by Plan (%)	90%	Compliant Processing Time (%)	91%

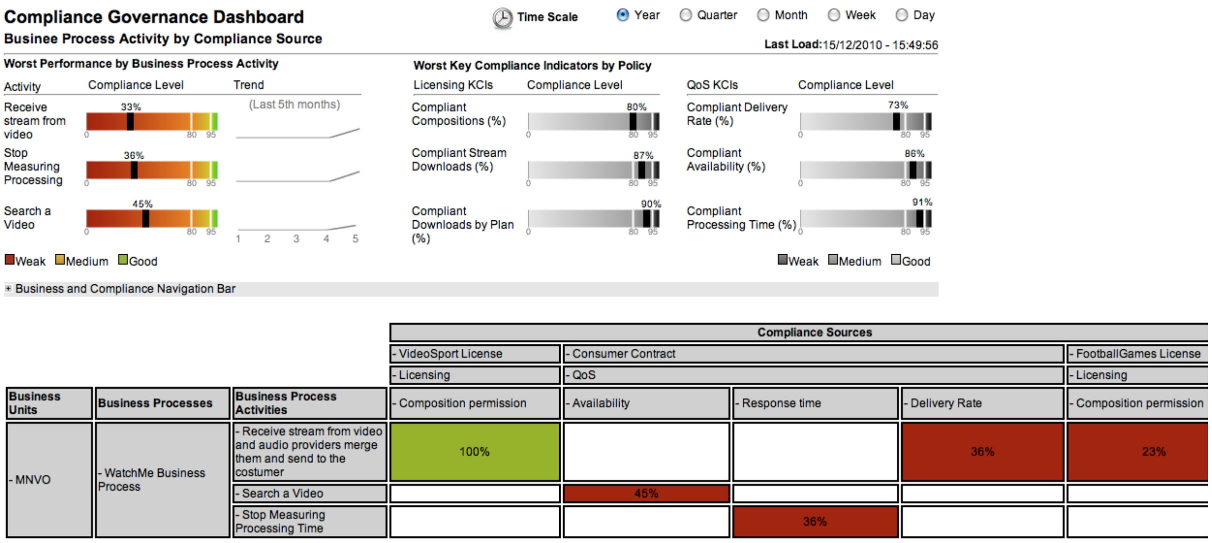
■Weak ▨Medium □Good

+ Business and Compliance Navigation Bar

			Compliance Sources		
			- VideoSport License	- Consumer Contract	- FootballGames License
Business Units	Business Processes	Business Process Activities	+ Licensing	+ QoS	+ Licensing
- MNVO	- WatchMe Business Process	- Receive stream from video and audio providers merge them and send to the costumer	100%	36%	23%
		- Search a Video		45%	
		- Stop Measuring Processing Time		36%	

Figure 5 Compliance Policy by Activity page with activity specific indicators and activity-level compliance info

By clicking in the policy cells (Figure 5) the users will see the compliance requirements that are grouped in each policy at the Compliance Source by Activity page (Figure 6). In the WatchMe scenario the licensing policies contain just one requirement named *Composition permission*. On the other hand, the QoS policy is composed of the *Availability*, *Response Time* and *Delivery rate* requirements. Due to size limitations we cannot show the complete view of the table here, for more details you can visit the COMPAS web portal. When the table shows compliance requirements as columns and activities as rows, it reached its lowest level of information. From here users can select a combination of a requirement and activity, intersection cell of a compliance requirement and a business process activity, in order to explore all the violations associated to it. For example, clicking the in 23% value, which means the intersection between *Composition Permission* and *Receive stream video and audio* the users can discover all the low-level events (violations) associated to this weak performance.



Compliance Governance Dashboard

Businee Process Activity by Compliance Source

Time Scale ● Year ○ Quarter ○ Month ○ Week ○ Day

Last Load:15/12/2010 - 15:49:56

Worst Performance by Business Process Activity

Worst Key Compliance Indicators by Policy

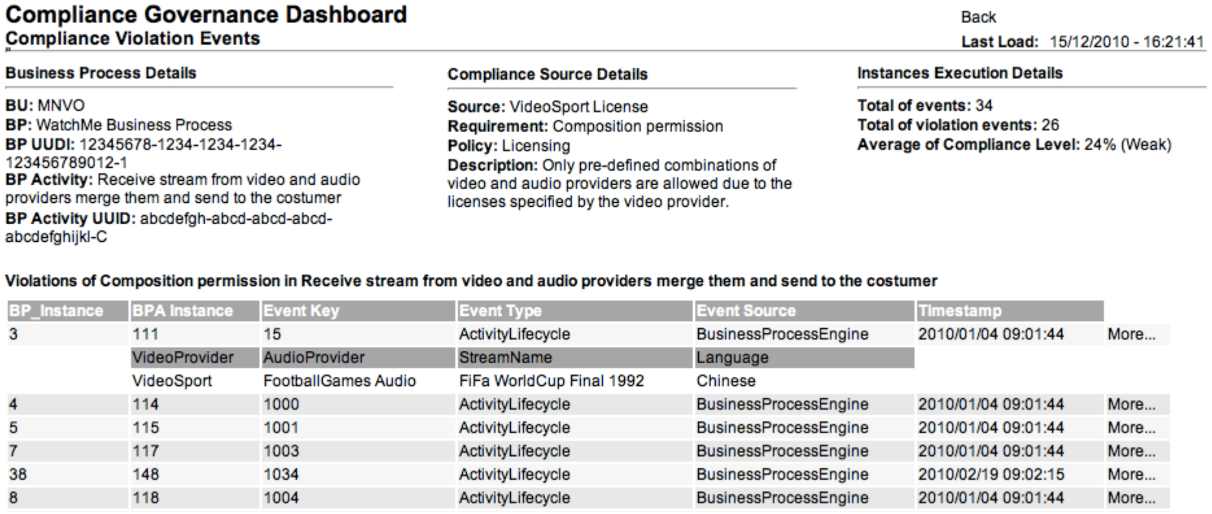
Activity
Compliance Level
Trend
(Last 5th months)
Receive stream from video
33%
Stop Measuring Processing
36%
Search a Video
45%
0
80
95
1
2
3
4
5
🟥Weak 🟨Medium 🟩Good
Licensing KCIs
Compliance Level
Compliant Compositions (%)
80%
Compliant Stream Downloads (%)
87%
Compliant Downloads by Plan (%)
90%
QoS KCIs
Compliance Level
Compliant Delivery Rate (%)
73%
Compliant Availability (%)
86%
Compliant Processing Time (%)
91%
■Weak ■Medium □Good

+ Business and Compliance Navigation Bar

			Compliance Sources				
			- VideoSport License	- Consumer Contract			- FootballGames License
			- Licensing	- QoS			- Licensing
Business Units	Business Processes	Business Process Activities	- Composition permission	- Availability	- Response time	- Delivery Rate	- Composition permission
- MNVO	- WatchMe Business Process	- Receive stream from video and audio providers merge them and send to the costumer	100%			36%	23%
		- Search a Video		45%			
		- Stop Measuring Processing Time			36%		

Figure 6 Compliance Requirement by Activity page with activity specific indicators and activity-level compliance info

Figure 7 presents the all the event violations associated to the compliance requirement and business activity previously selected in the interactive table. The top of the page contains details about the business process (i.e., unit, name, UUID, activity, and activity UUID of the process), the compliance requirement (i.e., source, name, policy, and description of the compliance requirement) and the execution (i.e., total of events, total of violations and average of the compliance level). UUID is a Universally Unique Identifier, which uniquely identifies a model or a model element (see [HZD09]).



Compliance Governance Dashboard

Compliance Violation Events

Back

Last Load: 15/12/2010 - 16:21:41

Business Process Details

BU: MNVO
BP: WatchMe Business Process
BP UUDI: 12345678-1234-1234-1234-123456789012-1
BP Activity: Receive stream from video and audio providers merge them and send to the costumer
BP Activity UUID: abcdefgh-abcd-abcd-abcd-abcdefghijkl-C

Compliance Source Details

Source: VideoSport License
Requirement: Composition permission
Policy: Licensing
Description: Only pre-defined combinations of video and audio providers are allowed due to the licenses specified by the video provider.

Instances Execution Details

Total of events: 34
Total of violation events: 26
Average of Compliance Level: 24% (Weak)

Violations of Composition permission in Receive stream from video and audio providers merge them and send to the costumer

BP_Instance	BPA Instance	Event Key	Event Type	Event Source	Timestamp	
3	111	15	ActivityLifecycle	BusinessProcessEngine	2010/01/04 09:01:44	More...
	VideoProvider	AudioProvider	StreamName	Language		
	VideoSport	FootballGames Audio	FiFa WorldCup Final 1992	Chinese		
4	114	1000	ActivityLifecycle	BusinessProcessEngine	2010/01/04 09:01:44	More...
5	115	1001	ActivityLifecycle	BusinessProcessEngine	2010/01/04 09:01:44	More...
7	117	1003	ActivityLifecycle	BusinessProcessEngine	2010/01/04 09:01:44	More...
38	148	1034	ActivityLifecycle	BusinessProcessEngine	2010/02/19 09:02:15	More...
8	118	1004	ActivityLifecycle	BusinessProcessEngine	2010/01/04 09:01:44	More...

Figure 7 Low-level events (violations) with details associated to the Composition Permission Compliance Requirement

At the bottom, the page lists the most relevant content of the events. Each row of the table represents a distinct violation and the columns contain the typical information required by auditors, e.g., process instance, activity instance, key of the event, type of the event, source of the event, and timestamp. When available additional information is also presented (e.g., video and audio providers, stream name and language of the stream downloaded in the WatchMe scenario). In order to visualize such information the users need to click the *More…* link at the end of the rows. In our example, the table shows all the violations associated to the *Composition Permission* and *Receive stream from video and audio providers* activity. Such requirement states: “**Football Games** can only have audios streams from **AudioSport** or **SportingAudio**. **VideoSport** can only have audio streams from **AudioSport”**. The violation in the first line occurred due to the non-compliant integration of the *FiFa WorldCup Final 1992* video stream, provided by the VideoSport provider, with an audio stream distributed by the FootballGames Audio provider. This same behavior was detected in 24% of the cases, 26 events, from the 34 executed in the total.

2.2. Root Cause Analysis

The root cause analysis in the COMPAS project is implemented as decision trees. In this subsection we show how to build such a tree and how it correlates business and compliance data of executions of the WatchMe business process. Hence, based on that it will be possible to understand how business parameters are associated with the fulfillment (or not) of the company's compliance requirements.

As in any decision tree, internal nodes represent the attributes on which split points are defined to draw the various branches from the root node to the leaf nodes of the tree. On the other hand, leaf nodes represent the class attribute and it tells us to which class the object in study should be classified. In our case, the objects of study are tuples that contain data corresponding to instantiations of business process executions.

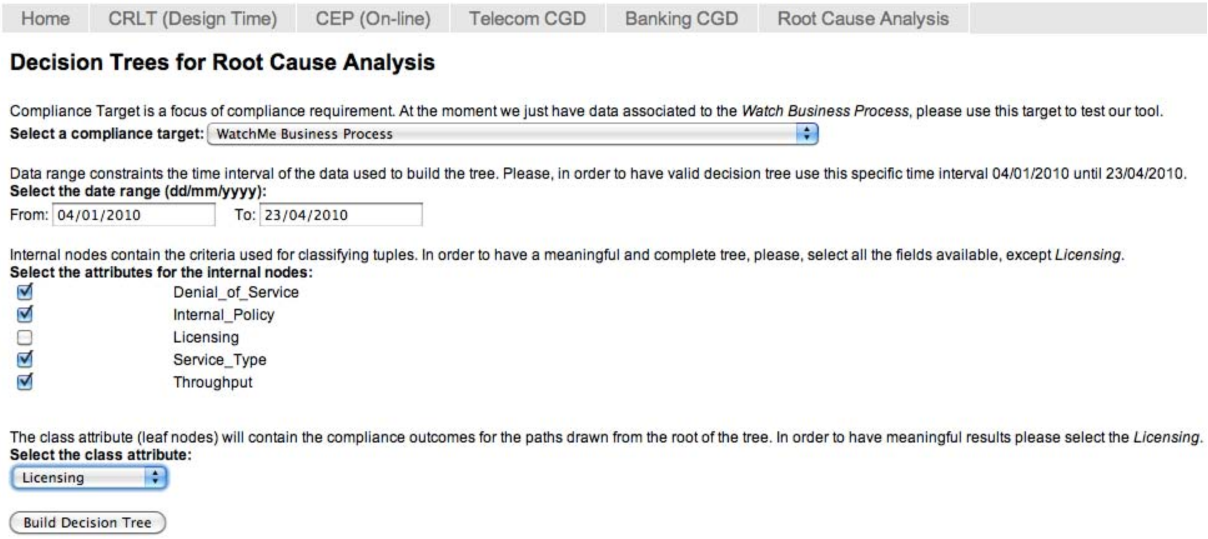
To build the tree users need to select some parameters, as depicted in Figure 8. First of all, it is required to choose the compliance target to be analyzed (e.g., a business process or an activity). Then, users need to define a data time interval in which we want to analyze the data. After that, the business data used to build the tree need to the selected, which will constitute the internal nodes of the tree. The predefined attributes listed by the tool are the parameters (columns) retrieved from the F_BPInstance table stored in the DW (Figure 5 in [SRA+10]). In our example, *business data* are represented by the following attributes:

- *Denial_of_Service*: counts the number of requests that were not fulfilled because of performance issues or any other factor that avoids the fulfillment of clients' requests.
- *Service_Type*: indicates the type of service that is being requested.
- *Throughput*: is the average number of requests that were fulfilled with success according to the establish compliance requirement.

Finally, the user needs to select a class attribute, which we expect to be one of the compliance data (note, however, that our tool does not restrict the user to select only compliance data as class attributes). In our example, the compliance data are represented by the following attributes:

- *Licensing*: corresponds to policies related to license issue. Whenever an instance of the process violates one of the terms of the license, this policy is violated and thus Compliance(Licensing) = False (otherwise, Compliance(Licensing)=True).
- *Internal_Policy*: this refers to a set of policies that needs to be checked and, when violated, affects negatively the revenue of the company. In our example, part of the internal policy consists in checking "access by unauthorized users". Whenever an unauthorized user accesses the service, the evaluation is *True*, otherwise, it is evaluated as *False*.

By selecting the parameters as illustrated in Figure 8, we obtain the decision tree depicted in Figure 9. In this tree, the internal nodes are composed by the attributes *Denial_of_Service*, *Internal_Policy*, *Service_Type*, and *Throughput*. *Licensing*, instead, is the class attribute for the decision tree. This is, we would like to understand how the former attributes are related to or might affect *Licensing*.



Decision Trees for Root Cause Analysis

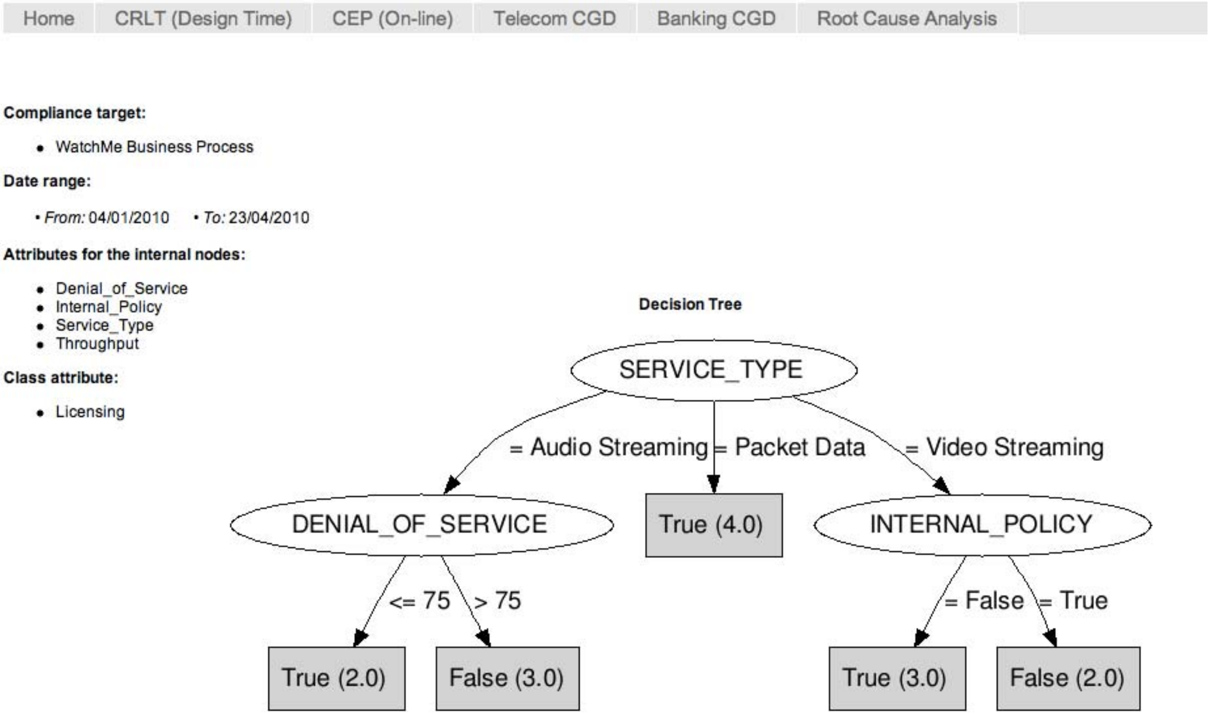
Compliance Target is a focus of compliance requirement. At the moment we just have data associated to the *Watch Business Process*, please use this target to test our tool.
Select a compliance target: WatchMe Business Process

Data range constraints the time interval of the data used to build the tree. Please, in order to have valid decision tree use this specific time interval 04/01/2010 until 23/04/2010.
Select the date range (dd/mm/yyyy):
From: 04/01/2010 To: 23/04/2010

Internal nodes contain the criteria used for classifying tuples. In order to have a meaningful and complete tree, please, select all the fields available, except *Licensing*.
Select the attributes for the internal nodes:
☑ Denial_of_Service
☑ Internal_Policy
☐ Licensing
☑ Service_Type
☑ Throughput

The class attribute (leaf nodes) will contain the compliance outcomes for the paths drawn from the root of the tree. In order to have meaningful results please select the *Licensing*.
Select the class attribute:
Licensing

Figure 8 Feature Selection Page of the Decision Tree Solution for Root Cause Analysis



Compliance target:

- WatchMe Business Process

Date range:

• *From:* 04/01/2010 • *To:* 23/04/2010

Attributes for the internal nodes:

- Denial_of_Service
- Internal_Policy
- Service_Type
- Throughput

Class attribute:

- Licensing

Figure 9 Decision tree computed over instances of the WatchMe business process

From the resulting decision tree (Figure 9), we can see that we have three types of services, namely, audio streaming, packet data and video streaming all defined by an IT expert. For packet data, we can see that Licensing policies were always (or "most of the time") fulfilled, thus, regardless of the rest of the attributes, Packet data is licensing-compliant for the set of process instances in study. Audio streaming, however, is somehow related to *Denial_of_Service* and the estimated threshold for being compliant or not is 75. Finally, video streaming licensing-compliance is related to the *Internal_Policy* attribute, and we can see that when this attribute is False ("Access by unauthorized users") we are licensing-compliant, otherwise, we are not (and this makes sense as, typically, a user cannot access the service if he/she does not have a valid license).

Finally, it is worth to mention that the tree we presented in this section has been built on synthetic data, which we have generated manually for the purpose of presenting the approach in this deliverable with an example that can be easily understood. However, the results that we have shown here are real, in the sense that they have been computed on our synthetic data using the running version of our prototype and data warehouse that are already deployed in COMPAS's test bed.

3. Implementation Details

The CGD is set on the top of a data DW (optimized for reporting purposes) that implements the conceptual model described in D5.3. It is however important to recognize that this does not affect the logic behind the designed navigation structure [SRC+09], which represents a best practice for the rendering of compliance information to auditors, according to the experience by the industrial partners involved in the project.

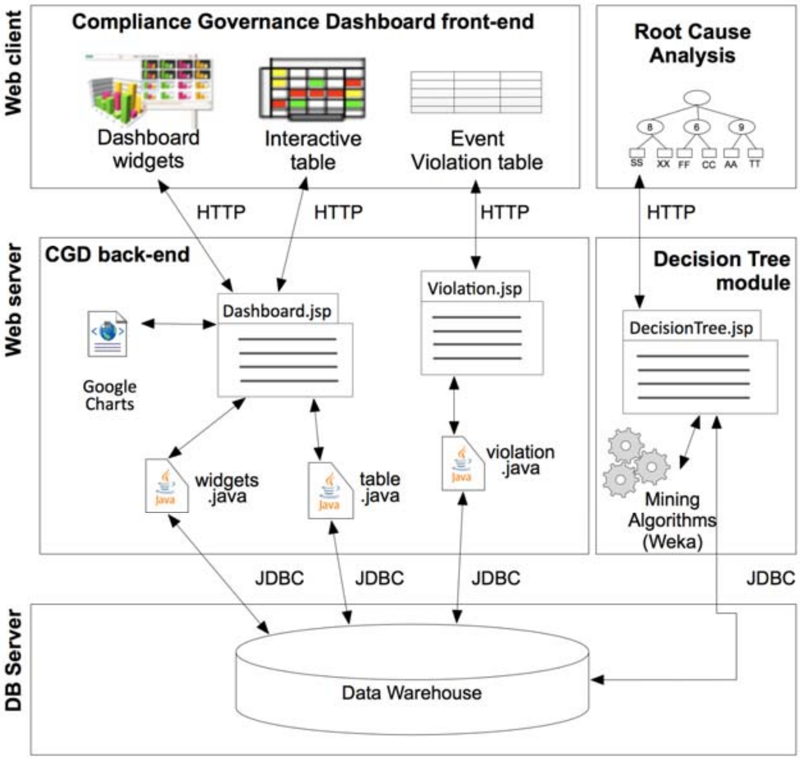


Figure 10 Web application involving the implementation of the CGD and the Root Cause Analysis

The front-end of the CGD is an interactive web application implemented according to Figure 10 and composed of JSP pages. *Dashboard.jsp* is responsible for loading the dashboard widgets and the interactive table as illustrated in the previous section in Figure 3 to 6. Each time this page is loaded, i.e., at the first access or when a new time scale is selected, it invokes the *widgets.java* class, which runs a set of pre-defined, parameterized SQL queries over the DW, filled with variable input parameters (e.g., time scale and business level) representing user selections. Listing 1, for example, shows a typical query used to retrieve the necessary data to render indicators in their colorful or gray UI widgets. These graphical representations of indicators are implemented using Google Charts (http://code.google.com/apis/chart/), which require a predefined invocation URL as listed in Listing 2.

```
SELECT Req.Source_Name AS Name,
       ROUND(100*(Count(*)-Sum(Proc_Inst.CausedViolation))/Count(*)) AS
Value
FROM F_BPInstance Proc_Inst JOIN F_ComplianceEvaluation Evaluation
      ON Proc_Inst.BPInstance_Key = Evaluation.BPExecutionKey
                            JOIN D_ComplianceRequirement Req
      ON Req.ComplianceRequirement_Key =
         Evaluation.ComplianceRequirement_Key
                             JOIN D_Calendar_Date dc
      ON dc. Calendar_Date_Key = Evaluation.Calendar_Date_Key
WHERE
D_Calendar_Date.System_Date >= ?('startDate', 'DD/MM/YYYY') AND
D_Calendar_Date.System_Date < DATE_ADD(?, INTERVAL 1 DAY)
GROUP BY Req.Source_Name ORDER BY Value ASC;
```

Listing 1 Percentage of non-compliance for a given sources in a pre-defined time interval

```
http://chart.apis.google.com/chart?cht=lc&chs=140x30&chbh=0,0,0&chd=t:100|0
,100&chds=0,100,0,100&chco=00000000&chxt=x&chxs=0,000000,0,0,t&chxtc=0,0&ch
f=c,lg,0,e6e6e6,0,a4a4a4,0.80,6e6e6e,0.95,000000,1&chxs=0,,9,0,t,000000|1,,
9,0,t,000000&chxp=0,0,80,95&chm=V,FFFFFF,1,0.8,2|V,FFFFFF,1,0.95,2|V,000000
,1,0.73,7,1">
```

Listing 2 Line of code to create and invoke a Google chart

When loading the dashboard into the client browser, also the content of the interactive table is updated according to the same parameters and the functions contained in *table.java*. In addition, the rows of the interactive table are also refreshed when a new business or compliance perspective is selected, e.g., via a mouse click. This table is fed with the DW data based on two SQL queries, one that brings all the data associated with business process and the other with business process activities. In both cases, the results of the query are locally stored on the client side as hash table objects, which allow the CGDs to dynamically show or hide their content in an HTML table according to the selected business and compliance perspectives.

The *Violation.jsp* page shows the lowest level information (events) and can be accessed through the interactive table, more specifically via a mouse click on one of the coloured cells of the interactive table rendering the intersection of a business process activity and a compliance requirement. White cells correspond to activity-requirements combinations that do not have compliance requirements to be checked, thus no events associated to them are stored in the DW. The business process activity and the compliance requirement of the clicked cell are passed as parameters to the classes of the *violation.java* class that connects to the DW and retrieves the respective events. Similar to the previous approach, the *Violation.jsp* file also adopts an SQL query as depicted in Listing 3.

```
SELECT
      Sum(IsViolation) AS Violations,
      Count(*) AS Total,
      ROUND(100*(Count(*)-Sum(IsViolation))/Count(*)) AS KCI
FROM
      F_BPInstance Proc_Inst JOIN F_ComplianceEvaluation Evaluation
      ON Proc_Inst.BPInstance_Key = Evaluation.BPExecutionKey
      JOIN D_ComplianceRequirement Req
      ON Req.ComplianceRequirement_Key =
Evaluation.ComplianceRequirement_KeY
      JOIN D_Calendar_Date
      ON Evaluation.Calendar_Date_Key = D_Calendar_Date.Calendar_Date_Key
WHERE Evaluation.Service_Key is null AND
      Evaluation.BP_Key = ? AND
      Evaluation.BPActivity_Key = ? AND
      Evaluation.ComplianceRequirement_Key = ? AND
      System_Date >= ? AND
      System_Date < DATE_ADD(?, INTERVAL 1 DAY);
```

Listing 3 SQL query used to retrieve all the low-level events associated to a specific compliance requirement and business process activity

The *decision tree* page guides the user in the process of decision tree mining for root cause analysis and prediction. In this process, the page helps users in choosing the parameters of interest for building the decision tree. More precisely, it helps users in selecting the attributes for the internal nodes, the class attributes to which tuples will be classified, the time range used for filtering process instances, among other parameters of the algorithm used for the mining task. Once these parameters have been selected, *DecTree.jsp* processes the instances from the process instance table (stored in the DW) in order to prepare the training tuples that will be used to feed the mining algorithm. The concrete algorithm used for building the decision tree is J48 and we rely on Weka [HFH+09] as the supporting library for the whole mining process as it is a well-known and mature data mining library. Note, however, that we can choose any other decision tree mining algorithm among the ones available in Weka. We choose J48, which is an open source implementation of the C4.5 algorithm, due to its popularity and the fact that this is a well-understood algorithm for building decision trees. In addition, it is equipped with features such as continuous number categorization and missing value handling, which are key features when doing classification on data coming from realistic settings.

All pages of the CGD were developed using Eclipse Java EE IDE for Web Developers, and the DW runs on Oracle 11g (first version) and MySQL 5.1 (second version). An example of the CGD web portal as used in the Compas project is available at *http://compas.disi.unitn.it:8080/CGDs/main.jsp* selecting the CGD tab. From the same start page it is also possible to access the decision tree component by selecting the Root Cause Analysis tab.

4. Source Code and Additional information

The CGDs code is released as an open source project under the GNU Affero General Public License (AGPLv3) 2. In order to actually reach the open source community, we made the application available at the well-known open source community, Source Forge [SF10]. More specifically, the source is available at https://cgd.svn.sourceforge.net/svnroot/cgd/ using the following credentials login: guest and password: compas. The code is organized in two separate folders:

- *CGDs* folder contains the whole dashboards code
- *DB* stores the data warehouse data model schema that is used as input for the dashboards.

In each folder there are text files containing additional details in order to install and configure both prototypes.

The CGDs prototype is deployed at http://compas.disi.unitn.it:8080/CGDs/main.jsp together with other compliance governance monitoring tools (e.g., Complex Event Processing, CTRL and Root Cause Analysis). At the moment the dashboards provide detailed compliance information about the two case study scenarios explored by the COMPAS project, named Loan Approval (Banking CGD) and WatchMe (Telecom CGD).

Videos about the CGDs and the date warehousing environment, as well as additional documentation, are available at http://compas.disi.unitn.it/CGD/home.html.

5. Conclusion

In this deliverable we have presented the CGDs and the Root Cause Analysis prototypes, both relevant for to support compliance governance. Increasingly, industry and academia are investing money and efforts into the development of compliance governance solutions. Yet, we believe compliance governance dashboards in particular, probably the most effective means for visualizing and reporting on compliance, have mostly been neglected so far. It is important to implement sophisticated solutions to check compliance, but it is at least as important (if not even more) to effectively convey the results of the compliance checks to a variety of different actors, ranging from IT specialists to senior managers.

6. Reference documents

6.1. Internal documents

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[D5.4] "Reasoning mechanisms to support the identification and the analysis of problems associated with user requests", ver. 1.0 of 2009-12-15.

[D5.6] "Compliance mining tool", ver. 1.0 of XXX.

[D7.1] "Public Web-Site", http://www.compas-ict.eu

[DoW] "Description of Work", ver. 15 of 2007-09-25.

6.2. External documents

[HZD09] T. Holmes, U. Zdun, S. Dustdar. MORSE: A Model-Aware Service Environment 4th IEEE Asia-Pacific Services Computing Conference, pp. *470-477*, IEEE Computer Society Press, IEEE Conference Proceeding, 2009.

[RSD+10] C. Rodríguez, P. Silveira, F. Daniel, F. Casati. Analyzing Compliance of Service-Based Business Processes for Root-Cause Analysis and Prediction. In Proceedings of the 1st Workshop on Engineering SOA and the Web (ESW'10) in conjunction with ICWE'10, Springer, 2010.

[SRC+09] P. Silveira, C. Rodríguez, F. Casati, F. Daniel, V. D'Andrea, C. Worledge, Z. Taheri. On the Design of Compliance Governance Dashboards for Effective Compliance and Audit Management. Proceedings of NFPSLAM-SOC'09, November 2009, Springer, Stockholm, Sweden.

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[SF10] Source Forge. Available at http://sourceforge.net/