A Categorization Scheme for SLA Metrics

Adrian Paschke and Elisabeth Schnappinger-Gerull
Internet-based Information Systems, Technische Universität München, Germany
{Paschke, Schnappi}@in.tum.de.de
http://ibis.in.tum.de/staff/paschke/rbsla/index.htm

Abstract: Effective SLAs are extremely important to assure business continuity, customer satisfaction and trust. The metrics used to measure and manage performance compliance to SLA commitments are the heart of a successful agreement and are a critical long term success factor. Lack of experience in the use and automation of performance metrics causes problems for many organizations as they attempt to formulate their SLA strategies and set the metrics needed to support those strategies. This paper contributes to a systematic categorization of SLA contents with a particular focus on SLA metrics. The intended goal is to support the design and implementation of automatable SLAs based on efficient metrics for automated monitoring and reporting. The categorization facilitates design decisions, analysis of existing SLAs and helps to identify responsibilities for critical IT processes in disruption management during the execution of SLAs.

1 Introduction

Service Level Agreements (SLAs) defining the quality attributes (QoS - Quality of Service) and guarantees a service is required to process, are of growing commercial interest with a deep impact on the strategic and organisational processes, as many research studies and intensified interest in accepted management standards like ITIL[1] or the new BS15000[2] show. They are used in all areas of IT reaching from hosting or communication services to help desk or problem resolution. A well-defined and effective SLA correctly fulfils the expectations of all participants and provides metrics for accurately measuring performance to the guaranteed Service Level (SL) objectives. During the monitoring and enforcement phase the defined metrics will be used to detect violations to the promised SLs and to derive consequential activities in terms of rights and obligations. They play a key role in metering, accounting and reporting and provide data for further analysis and refinement of SLAs in the analysis phase.

SLA metrics are defined from a variety of disciplines, such as business process management, service and application management, or traditional systems and network management.

[1] IT Infrastructure Library (ITIL): www.itil.co.uk
[2] BS15000 IT Service Management Standard: www.bs15000.org.uk

Different organizations have different definitions for crucial IT parameters such as *Availability, Throughput, Downtime, Response Time*, etc, for example some focus on the infrastructure (TCP connections) to define service availability, while others refer to the service application (ability to access the service application). Ambiguity, unfulfilled expectations and problems during the accomplishment of SLAs are the result. A poor choice of metrics will result in SLAs that are difficult to enforce automatically and may motivate the wrong behaviour. Currently, practitioners have almost no support in selecting the appropriate metrics for the implementation of successful SLAs (in terms of automation and compliance with the service objects and IT management processes) in order to automatically gauge the service performance. The paper does not attempt to define an exhaustive list of metrics that should be included in a SLA - the topic is too large by the enormous number of potential metrics and it varies as seen before from organization to organization and service to service. We propose a general *categorisation scheme* for typical metrics for basic service objects and IT management processes and populate it with metrics which commonly appear in SLAs. The metrics are derived from industrial requirements, i.e. they are taken from SLAs currently in use in an effort to provide realistic terms that are both useful and usable in particular for the automation of SLAs. To our knowledge, this is a first-of-a-kind approach and a multi-dimensional categorization of SLA contents and metrics is missing in literature. The contribution of the categorization is manifold. It *supports SLA engineers in their design decision* in particular concerning the specification of SLAs which are intended to be *monitored and enforced automatically*. During execution time it might contribute in *root causes analysis* identifying problems such as infrastructure instability, low performance levels of service objects or poorly designed, critical IT processes for which responsible persons can be derived. Furthermore, it might be used to analyse existing SLAs indicating the extent to which an SLA is already oriented towards ITIL and if there is improvement potential.

The rest of the paper is structured as follows. Before we evolve our categorization scheme in section 3, we first give an insight into SLAs in section 2 and define used terms, the structure of SLAs as well as their different contractual appearances in order to reach a common understanding. In section 4 we demonstrates the application of the proposed categorization scheme by means of two use cases and finally conclude this paper in section 5 with some remarks on key findings, usability and future improvements of the categorization scheme.

2 Service Level Agreements

This section gives an insight into *Service Level Agreements* and in general IT service contracts. It categorizes different types of service contracts, presents the main component parts and defines the goals in order to reach a common understanding. We first start with the definition of some terms used throughout the paper:

- **SLA metrics** are used to measure the performance characteristics of the service objects. They are either retrieved directly from the managed resources such as servers, middleware or instrumented applications or are created by aggregating such *direct metrics* into higher level *composite metrics*. Typical examples of direct metrics are the MIB variables of the IETF Structure of Management Information (SMI) such as *number of invocations, system uptime, outage period* or technical network performance metrics such as *loss*, *delay*, *utilization* etc. which are collected via measurement directives such as management interfaces, protocol messages, URIs etc. Composite metrics use a specific function averaging one or more metrics over a specific amount of time, e.g. *average availability*, or breaking them down according to certain criteria, e.g. *maximum response time, minimum throughput, top 5%* etc.
- **Service Levels and Guarantees a.k.a. SLA rules** represent the promises and guarantees with respect to graduated high/low ranges, e.g., *average availability range [low: 95% , high: 99%, median: 97%],* so that it can be evaluated whether the measured metrics exceed, meet or fall below the defined service levels at a certain time point or in a certain validity period. They can be informally represented as ***if-then rules*** which might be chained in order to form graduations, complex policies and conditional guarantees, e.g., conditional rights and obligation with exceptions, violations and consequential actions: "*If the average service availability during on month is below 95% then the service provider is obliged to pay a penalty of 20%.*".
- **IT Management Processes / ITIL Processes** are IT management processes defining common practices in areas such as *Incident, Problem, Configuration, Change or Service Level Management.*
- **SLA** (Service Level Agreement): An SLA is a document that describes the *performance criteria* a provider promises to meet while delivering a service. It typically also sets out the *remedial actions and any penalties* that will take effect if performance falls below the promised standard. It is an essential component of the legal contract between a service consumer and the provider.

According to the Hurwitz Group the life cycle of an SLA is defined as follows:

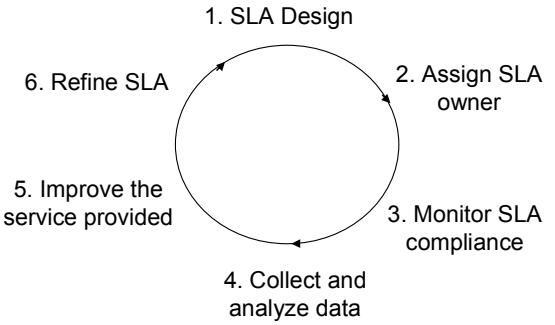

Fig. 1 SLA life cycle [St00]

The objectives of SLAs are manifold. In a nutshell the substantial goals are: [Pa04]

- Verifiable, objective agreements
- Know risk distribution
- Trust and reduction of opportunistic behaviour
- Fixed rights and obligations
- Support of short and long term planning and further SLM processes
- Decision Support: Quality signal (e.g. assessment of new market participants)

According to their *intended purpose*, *their scope of application* or their *versatility* SLAs can be grouped into different (contract) categories, e.g.

Table 1: SLA categorization

Intended Purpose	
Basic Agreement	Defines the general framework for the contractual relationship and is the basis for all subsequent SLAs inclusive the severability clause.
Service Agreement	Subsumes all components which apply to several subordinated SLAs.
Service Level Agreement	Normal Service Level Agreement
Operation Level Agreement (OLA)	A contract with internal operational partners, which are needed to fulfil a superior SLA.
Underpinning Contract (UC)	A contract with external operational partner, which are needed to fulfil a superior SLA.
Scope of Application	**(according to** [Bi01])
Internal Agreement	Rather an informal agreement than a legal contract
In-House Agreement	Between internal department or divisions
External Agreement	Between the service provider and an external service consumer
Multi-tiered Agreement	Including third parties up to a multitude of parties

Versatility	(according to [Bi01])
Standard Agreement	Standard contract without special agreements
Extensible Agreement	Standard contract with additional specific agreements
Individual Agreement	Customized, individual agreements
Flexible Agreement	Mixture of standard and individual contract

A particular service contract might belong to more than one category, e.g. an Operation Level Agreement (OLA) might also be an individual in-house agreement. Several service contracts can be organized in a unitized structure according to a taxonomical hierarchy:

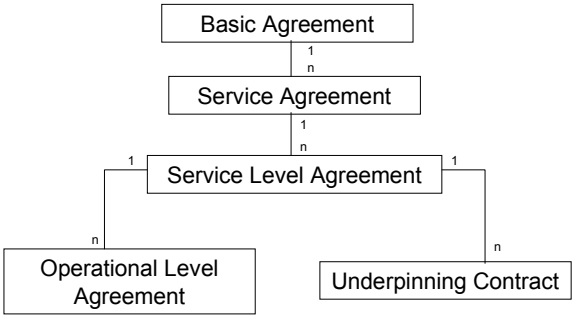

Fig. 2: Unitized, hierarchical Contract Model

Service Level Agreements come in several varieties and comprise different technical, organizational or legal components. Table 2 lists some typical contents.

Table 2: Categorization of SLA contents

Technical Components	Organizational Components	Legal Components
- Service Description - Service Objects - SLA/QoS Parameter - Metrics - Actions …	- Liability and liability limitations - Level of escalation - Maintenance / Service periods - Monitoring and Reporting - Change Management …	- Obligations to co-operate - Legal responsibilities - Proprietary rights - Modes of invoicing and payment …

Although the characteristics and clauses may differ considerably among different contracts, they nevertheless share some general constituent parts such as the *involved parties*, the *contract validity period*, the *service definitions*, the *QoS definitions* stated as *SLA rules* specifying *service level guarantees* and appropriated *actions* to be taken if a contract violation has been detected according to measured performance values via *SLA metrics*, etc. Whilst these components and rules can be automated in many instances, legal components are hard to enforce in an automated system. There are some works on automated *legal* and *deontic contract norms with exceptions and violations* [PBD05]. Nevertheless, in the majority of cases legal terms can not be automated and enforced by a management system, which might be a serious restriction that should be considered in the design of SLAs. A part from that, a key factor in the automation of SLAs is whether performance values can be automatically measured or not. In the following section we propose a categorization scheme which picks up this question and categorizes typical metrics found in real-world SLAs in relation to their applicability in *automated* monitoring of *service objects* and *IT management processes*.

3 SLA Metrics

In order to develop a useful categorization scheme for IT metrics, we have spoken to close to three dozen IT service providers from small-and medium-sized enterprises to big companies and we have analyzed nearly fifty state-of-the-art SLAs currently used throughout the industry in the areas of IT outsourcing, Application Service Provisioning (ASP), Hardware Hosting, Service Suppliers and many other. One of the biggest problems we identified is the lack of rapport between metrics and service objects/IT processes as well as the lack of automation in SLA management and monitoring which is directly influenced by the underlying metrics and their ability to be automated. According to this observation we use three major categories to structure the field of SLA metrics: The *service objects* under consideration, *ITIL processes* and *automation grade*. The first category distinguishes basic service objects such as hardware, software, network etc. Composite metrics such as end-to-end availabilities can be broken down in smaller direct metrics which are assigned to one of these basic object types. The second category is organized around the eleven ITIL management processes. This leads to clear responsibilities and procedures and the metrics might reveal potential for process optimization. The last category deals with the question of measurability and therefore implicitly with the automation of metrics. It helps to find “easy-to-collect” metrics and to identify problematic SLA rules in existing SLAs, i.e. rules with metrics which can be measured manually only or which can not be measured at all.

In a nutshell, each category gives answers to different questions relating to design, implementation and analysis of SLAs, such as "*Which metrics can be used for a particular service object?*", "*Can the metric be automatically measured and what are the possible units?*" or "*Does a particular SLA sufficiently support the ITIL processes or is there improvement potential in terms of missing metrics?*" etc. Furthermore, the combination of the categories helps to identify dependencies between used SLA resources and the performance of management processes and management tools.

3.1 Categorization according to Service Objects

Although the particular end-to-end service objects may differ considerably among SLAs, they can mostly be reduced to five basic IT object classes, namely: *Hardware, Software, Network, Storage and Help Desk (a.k.a. Service Desk)*. The respective instances can be combined in every combination in order to form complex and compound services such as e.g. ASP solutions including servers (hardware), applications such as SAP (software), databases or data warehouse (storage) and support (help desk). Each object class has its own set of typical quality metrics. In the following we present useful metrics in each class and give examples for their units.

Hardware

The class "*Hardware*" subsumes different physical resources e.g., servers or workstations, processors or simply computing power. The most important metric is *instructions per second*. Table 3 shows useful metrics together with their possible units.

Table 3: Hardware Performance Metrics

No	Description	Object	Unit
1	Availability	Hardware	Time hour, percent
2	Maximum down-time	Hardware	Hours or percent
3	Failure frequency	Hardware	Number
4	Response time	Hardware	Duration in minutes/seconds
5	Periods of operation	Hardware	Time
6	Service times	Hardware	Time
7	Accessibility in case of problems	Hardware	Yes/no
8	Backup	Hardware	Time
9	Processor time	Hardware	Seconds
10	Instructions per second	Hardware	Number per second
11	Number of workstations	Hardware	Number

Software

"*Software*" comprises applications such as ERP solutions, but also includes application management services. Typical SLA metrics are:

Table 4: Software Performance Metrics

No	Description	Object	Unit
1	Service times	Software	Time
2	Response times	Software	Minutes
3	Availability	Software	Time
4	Solution times	Software	Minutes
5	Number of licences	Software	Number

Network

"Network" services provide the technical infrastructure to communicate and work in a distributed environment. The most important metrics are *availability* and *throughput*.

Table 5: Network Performance Metrics

No	Description	Object	Unit
1	WAN period of operation	Network	Time
2	WAN Service times	Network	Time
3	LAN period of operation	Network	Time
4	LAN Service times	Network	Time
5	Solution times	Network	Minutes
6	Availability WAN	Network	Percent
7	Availability LAN	Network	Percent
8	Access Internet across Firewall	Network	Yes/no
9	Access RAS	Network	Yes/no
10	Latency times	Network	Ms

Storage

"Storage" services are used to make data or information persistent. The main SLA parameters are storage *volume* and *bytes per second* which states how fast data is transferred from or to the storage.

Table 6: Storage Performance Metrics

No	Description	Object	Unit
1	Availability	Storage	Time hour, percent
2	Maximum down-time	Storage	Hours or percent

3	Failure frequency	Storage	Number
4	Response time	Storage	Duration in minutes/seconds
5	Periods of operation	Storage	Time
6	Service times	Storage	Time
7	Accessibility in the case of problem	Storage	Yes/no
8	Backup	Storage	Time
9	Bytes per second	Storage	Number per second
10	Memory size	Storage	Number in bytes

Service Desk

The interface to the service customer is referred to as "*service desk*" (according to ITIL) or "*help desk*". *Service times* and the *self solution rate* are most important for this object type.

Table 7: Help Desk Performance Metrics

No	Description	Object	Unit
1	Self solution rate (not with 2nd level support)	User Help Desk	Percent
2	Service times	User Help Desk	Time
3	Availability	User Help Desk	Time
4	Failure forwarding degree	User Help Desk	Percent
5	Failure categorization degree	User Help Desk	Percent
6	Availability with phone	User Help Desk	Hours
7	Availability with Email	User Help Desk	Hours
8	Response time	User Help Desk	Hours, minutes
9	Language variety	User Help Desk	Number of languages

3.2 Categorization according to ITIL process elements

The second categorization dimension we use the eleven ITIL components [OGC03] and their respective tasks. Table 8 gives a short summary of the ITIL categorization.

Table 8: Categorization of ITIL processes

Description	Position	Task
Service Desk	Function	Group of specialists, inquiry -, treatment of disturbances
Incident Management	Process	Support user, problem acceptance, assistance, monitoring service level
Problem Management	Process	Treatment of losses, cause identifying, recommendations at Change Mgmt., improvement of productive resources use
Configuration	Process	Process control of the inventory (components hard -,

Management		software....)
Change Management	Process	Change process
SLM	Process	Formulate SLA
Release Management	Process	Storage of authorized software, release in productive environment, distribution to remote bases, implementation to start-up
Capacity Management	Process	Correct and cost-related-justifiable IT capacity provision analysis, prognosis; Capacity plans
Availability Management	Process	Optimization IT resources use, foreseeing and calculation of losses, safety guidelines monitoring SLAs, Security, Serviceability, Reliability, Maintainability, Resilience
Service-Continuity-Management	Process	Re-establishment of services, replacement in case of failure
Financial Management	Process	Process investment strategy, definition that-achievement-aims, those-brought achievement to measurement

In this dimension the metrics of the prior service object categorization can be assigned to respective ITIL processes. This relates them to process performance and helps to identify problematic processes and responsible persons. Furthermore, it might indicate the extent to which a SLA is already oriented towards ITIL and if there is improvement potential. Table 9 exemplarily shows the allocation to ITIL processes:

Table 9: ITIL Process Metrics

ITIL Process	Service Metrics
Service Desk	Customer satisfaction with the Help Desk
Incident Management	Time between loss and replacement
Problem Management	Number of repeated disturbances
Configuration Management	Time between adding configuration items to Configuration Management Data Base (CMDB)
Change Management	Number of untreated changes
Service-Level Management	Number of SLAs
Release Management	Time between releases
Capacity Management	Completion of the capacity plan at a fixed time
Availability Management	Completion of the availability plan at a fixed time
IT-Service-Continuity-Management	Completion of the contingency plan at a fixed time
Financial Management	Cost overview to the deadline

3.3 Categorization according to measurability

The last and most important differentiation in the context of SLA automation depends on the measurability[3]. Three categories are introduced.

[3] measurability means automatically measurable

Table 10: Categorization according to Measurability

Description	Examples
Measurable	Availabilities, Response Times
Limited Measurability	Customer Satisfaction
Not Measurable	Qualification of employees

Data, which cannot be determined automatically (e.g. customer satisfaction) and which are determined only by questionnaires, are defined as conditionally measurable. Not measurable performance values such as the qualification of co-workers cannot be determined objectively by questionnaires.

3.4 Mapping of categorization levels

Based on these three categories we implement a multi-dimensional categorization scheme which reveals connections and dependencies between these three levels. We first merge the ITIL components with the service objects. Table 11 shows the result: *O* stands for optional management processes and *X* for necessary.

Table 11: Mapping of process dimension and object dimension

ITIL Components / Objects	Storage	Network	User Service	Hardware	Software
Service Desk	O	O	X	O	O
Incident Management	X	X	O	X	X
Problem Management	X	X	O	X	X
Configuration Management	X	O		O	X
Change Management	X	X		X	X
Service-Level Management	X	X	X	X	X
Release Management	O	O		O	X
Capacity Management	X	X		O	X
Availability Management	X	X	X	X	X
IT-Service-Continuity-Management	X	O		O	O
Financial Management	X	X	X	X	X

In the next step the criteria of the measurability is added in a third dimension.

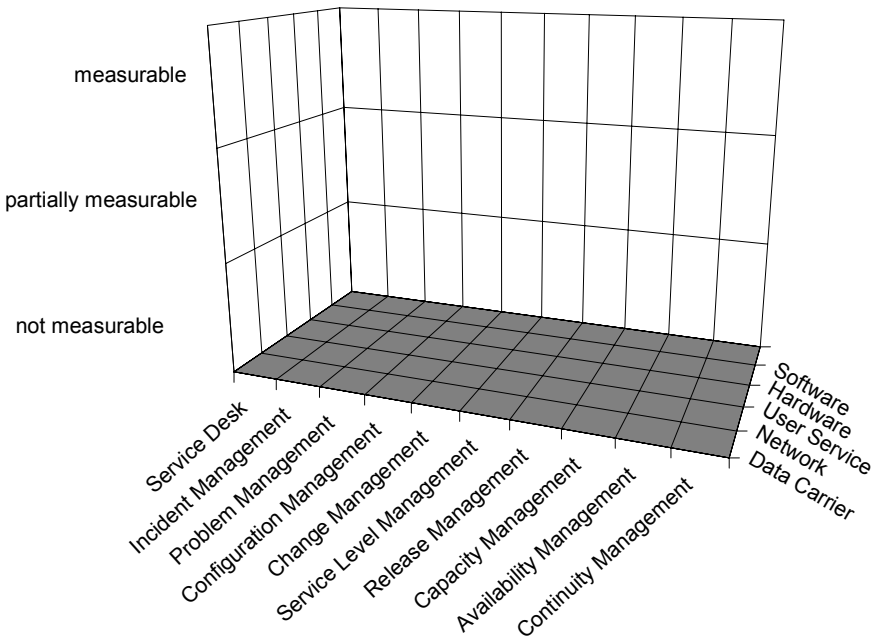

Fig. 3: Three-dimensional categorization scheme for SLA metrics

Table 12 exemplarily illustrates the multi-dimensional categorization of metrics.

Table 12: Multi-dimensional categorization

Metric	Service Object	ITIL Process	Automation Grade
Maximum down-time	Hardware Storage	Incident Mgt. Problem Mgt. Availability Mgt.	Measurable
Customer satisfaction	User Help Desk	Service Desk	Limited Measurability
Number of repreated disturbances	All	Problem Mgt.	Measurable
Response times	Hardware Software Storage User Help Desk	Service Desk Incident Mgt. Problem Mgt. Availability Mgt.	Measurable
…	…	…	…

4 Use Cases

This section demonstrates possible applications of the proposed categorization scheme by means of two use cases, namely *disruption management* and *decision support in SLA design*.

Disruption Management

The basic idea of disruption management is to support decision-makers with measurement values to react to or even prevent possible exceptions in service processes. Unfortunately, the term *disruption* is ambiguous. It may refer to either the deviation of a value from its target or whatever causes this deviation. Therefore, we will use *symptom* for any measured deviation and *root cause* to refer to the source of the symptom (i.e. the causing service object(s)), whereas the term *disruption* encompasses both. *Root cause analysis* describes the process of identifying root causes of occurring symptoms during service execution. The categorization scheme supports this analysis. For example assume the overall end-to-end *maximum response time* (MRT) is missed. Via a table look-up in our categorization scheme we identify several possible service objects such as the applied *software* or the *network* which might cause this disruption.
We therefore take a closer look at smaller subordinated metrics in each possible category and see that the *latency of the network* is high while the *processing time of the software* is quite fast, i.e. the network is identified as root cause and specialized network performance metrics such as the network *delay* (e.g. *one way delay, round-trip delay, delay variance*) can be analyzed in the next step. However, our studies have revealed that often poor service delivery has little to do with technologies (i.e. used service objects) which are or are not used, than it does with missing critical IT processes. For example assume our service has a low *average availability*. In a first guess the outages of a faulty service object might be a possible root cause. But, missed change management metrics such as a *high number of changes* with long outage times due to false starts, multiple reworks, duplicate efforts, periodic work stoppages point to a problematic change management process. As a result the responsible process manager can be informed and corrective actions can be taken.

Decision Support in SLA Design

When setting up a SLA there are many possible metrics from which to choose in order to design the respective SLA parameters and service levels. One way to approach these metrics is to group them into categories, decide which ones in a given category work best for the intended purpose, and then construct the desired SLA parameters and rules from it. But, due to the complicated selection process, which must be tempered by different implicit, explicit, endogenous and exogenous considerations such as the service objects under consideration, the intended behaviour and goals, the organizational experience with metrics or the cost and effort of collecting measurement data etc., design variations are to large. Therefore, in this paper this topic is necessarily presented in an introductory manner and has a particular focus on the selection of metrics which are usable in automated solutions. In the following we propose a general approach to systematically determine the requirements and constraints in a specific SLA design situation which can be applied on the selection of appropriate metrics using the categorization scheme.
The process of design is composed of a *requirement analysis phase* and a *synthesis phase*. In the analysis phase the needs and desires for a given design situation are investigated and transformed into a more or less formal set of requirements and constraints. The extracted requirements are then used in the synthesis phase for the selection and precise specification of the metrics and particular SLA rules. In order to systematically analyse the needs and derive the respective requirements and constraints we follow an approach used to categorize negotiation protocols [SW03] and adapt it to the field of SLA design. We distinguish two orthogonal dimensions: *exogenous / endogenous* and *explicit / implicit decision criteria*. While exogenous criteria are determined by the business context in which the SLA is supposed to be situated and can not be influenced by the designer, endogenous criteria represent the choices and parameters which can be directly selected within the design of a SLA. Explicit criteria can be directly specified and quantified. Implicit criteria assess the consequences of explicit criteria. They are not written down but determined during the execution of a particular SLA. Endogenous criteria depend to some extent on the exogenous criteria and have to be analysed and mapped into corresponding endogenous explicit criteria which are then applied in the synthesis phase for the selection and implementation of the appropriate metrics. The observation and results of the execution can then be evaluated with endogenous implicit criteria at run-time or proactively on the basis of a theoretical run-time approximation such as a simulation or experiment. Formal, logic-based representation approaches for SLAs facilitate this kind of "testing" toward intended goals and explanatory reasoning chains provide means for explanation and analysis [DP05]. Table 13 shows some typical questions in each category from which to derive the requirements.

Table 13: Categorization of SLA design criteria

	Exogenous	Endogenous
Explicit	*What are the service objects and service processes under consideration?*	*Level of automation?* *High/medium/low values of metrics?*
Implicit	*Level of trust?* *Reduced opportunism?* *Level of reputation?*	*Cost and effort of collecting measurement data (cost/effort efficiency)?* *Reduce defects?* *Increase performance?* *Increase reliability?*

We now want to illustrate this process with an example. We assume a service offer which is composed of three heterogeneous service objects: *storage*, *hardware* and *software* (explicit exogenous criteria). Our intended goal is a *high cost/effort efficiency for collecting measurement data* (implicit endogenous) as well as an *increase in trust* (implicit exogenous). From these constraints we can identify the categories "*service objects→hardware|software|storage"* and "*automation grade → automatically"* (because of high cost/effort efficiency). By a table look up in our categorization scheme we can identify a set of possible "simple-to-collect" metrics such as *availability*, *mean time between failures*, *mean time to repair* etc., from which to choose the final metrics for the implementation of SLA parameters and SLA rules. The intended goal "*increase in trust*" might be implied by promising high performance values or hard penalties in the SLA rules based on the chosen metrics.

As the presented uses cases show, the categorization scheme supports different phases in the SLA life cycle (see fig. 1). Other application areas are the analysis of existing SLAs in terms of compliance with ITIL or the analysis of existing "natural-language-defined" SLAs in view of their intended automation in management and monitoring solutions, i.e. "*Does the SLAs include all needed metrics to automatically and effectively measure and report process performances or are there any metrics which can not measured properly?*"

5 Conclusion and Outlook

Our studies of a vast number of SLAs currently used throughout the industry have revealed that today's prevailing contracts are plain natural language documents and most contracts primarily focus on a small set of QoS metric, namely *Availability* and *Response Time*. Other important metrics are almost never mentioned.

We believe this reflects the fact that the current literature primarily focuses on a few examples of well-known SLA metrics (mostly Availability) or directly on higher-level business metrics [Kü04] e.g., metrics used in balanced scorecard approaches and gives only some high-level guidelines such as "*choose metrics which are easy to collect*" [Ha04].

But, there is no real benefit without saying which metrics are easy to automate and which metrics are commonly used in different IT processes and service. Based on this research gap, we have specified a multi-dimensional categorization scheme for SLA metrics and collected typical metrics from a variety of real world SLAs. We used three top level categories with a primary focus on the automation of metrics and their possible implementation in an SLA monitoring and enforcement system. As a kind of usability analysis we have applied the categorization scheme in a research project which deals with a declarative and automated rule-based representation approach of SLAs. [PBD05] [DP05] In summary, the proposed categories are useful in finding an initial set of possible metrics which can be automated and used to measure performance compliance of (basic to end-to-end) service objects and IT management processes and they can be used to analyze and refine existing human-oriented SLAs in order to implement them in automated representation approaches. In our view, this provides a useful contribution to the field of SLAs and there is enough evidence to warrant further research. For example our categorization requires further specification and refinement such as additional categories which reflect different endogenous and exogenous criteria and a more fine grained and deeper taxonomical structure consisting of top level categories and more specialized subcategories. Furthermore, the categorization scheme must be populated with more metrics, which should be done internally in an enterprise in order to build up catalogs of specialized metrics which reflect the current state of an enterprise, e.g., with respect to the automation grade of applied SLAs.

References

[Bi01] Binder, U: "Ehevertrag für IT Dienstleistungen." Infoweek 34(4), 2001.

[DP05] Dietrich, J., Paschke, A.: On the Test-Driven Development and Validation of Business Rules. 4th Int. Con. on Information Systems Technology and its Applications (ISTA05), 2005

[Ha04] Hayes, I.:. Five Principles for Selecting SLA Metrics, http://www.clarity-consulting.com/five_principles.htm, Clarity Consulting, 2004.

[Kü04] Kütz, M.: Kennzahlen in der IT, Dpunkt, 2004.

[OGC03] OGC :. ITIL – The key of Managing IT Services, Service Delivery, Stationery Office for OGC, 2003.

[Pa04] Paschke, A.: Rule Based SLA Management - A rule based approach on automated IT service management (in german language), IBIS, TUM, Technical Report 6/2004.

[PBD05] Paschke, A., M. Bichler, Jens Dietrich ContractLog: An Approach to Rule Based Monitoring and Execution of Service Level Agreements. Int. Con. on Rules and Rule Markup Languages for the Semantic Web (RuleML 2005), Galway, Ireland, 2005.

[SW03] Ströbel, M, Weinhardt, C. :"The Montreal Taxonomy for Electronic Negotiations." Group Decisions and Negotiation Kluwer Academic Press(12): 143-164, 2003.

[St00] Sturm, R., et al.: Foundations of Service Level Management. Indianapolis, SAMS, 2000.