ISSN: 3050-9696
E-ISSN: 3050-970X
EUROPEAN ADVANCED JOURNAL FOR SCIENCE & ENGINEERING
Volume: 03 Issue: 03
RECEIVED: JUNE 25 REVISED: JULY 09 ACCEPTED: JULY 23 PUBLISHED: AUGUST 13

The Rise of Self-Service Portals in Data Centers

Michael Anderson
Asst Professor

Abstract

Service Level Agreements (SLAs) are key contractual documents describing expected quality of service between a service provider and its customers. In the context of Data Center Provider Services, SLAs define electrical, mechanical, cooling, network, storage, security, and other attributes of the facilities. Both the provider and the customers share the responsibility for realizing the SLA objectives. Customers rely on their Data Center Providers to deliver the agreed-upon service quality and the Providers themselves utilize their own supporting suppliers and partners to ensure demand is met. A shortcoming of the prevailing SLA management paradigm is that it remains largely a suspenseful activity for customers. A complaint-handling, after-the-event exercise can have deep implications on their business. Allowing customers to self-service the entire life cycle and processes around their SLAs via an easy-to-use self-service portal enhances their experience and jointly drives quality with the Data Center Provider.

Visualizing and presenting SLAs in an engaging manner for customers is critical. Self-service SLAs enable customer-initiated workflows around creation, amendment, monitoring (via dashboards), ticket requests, and approvals. There are numerous operational support functions that can be formalized between the Data Center Provider and customers such as demand forecasts, spare part reservations, service requests, operational reports, etc. Enabling these requestfulfilling, change management, and knowledge-management processes through a self-service portal further drive quality during the day-to-day life cycle. There are several specific considerations that require attention in a Data Center context. Customers expect real-time position and health of Data Center Services to ensure quality. Any breach of physical or environmental parameters will have a cascading effect on one or more SLAs. Multi-tenancy and customer isolation further add complexity.

Keywords : Service level agreement; Self-service portal; SLA management; SLA monitoring; SLA creation; SLA changes; SLA requests; Service quality; Data center; Data-center; Infrastructure-as-a-Service; Operations support; Self-help; Capacity planning; Demand management; Knowledge management; Environmental monitoring; Multi-tenancy; Customer isolation; Customer experience; Risk; Compliance; Governance; Costs; Efficiency .

1. Introduction

An increasing number of service-level agreements (SLAs), covering a broad range of services and with various levels of complexity, are being deployed in contemporary data centers. Scale has introduced an unprecedented level of specialization and differentiation: co-location service providers operate data centers built to house, power, and cool thousands of servers for multiple customers; managed service providers can guarantee uninterrupted power thanks to battery farms and, in some cases, diesel generators able to take over in case of prolonged blackouts; public cloud providers and other mass-market service providers are able to offer services at unbeatable prices, thanks to a set of offerings that abstract and commoditize value from customers. It has become vital not only to keep track of all SLAs and ensure that all parties involved comply with their obligations, but also to go beyond the contractual promises to deliver an experience that is satisfactory for the customer. In response, many data centers are already adopting self-service portals.

ISSN: 3050-9696
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Self-service portals let customers submit reservations, and service requests, and monitor the status of all open tickets (e.g., incidents, service requests, changes, problems) in real time through dashboards that visualize key performance indicators and SLA compliance. Also, the information and knowledge accumulated in connection with these categories of tickets are made available for self-help purposes. These portals allow customers to report and track any incident directly, enabling a richer and more interactive exchange of information than classic notification channels. The decision to implement a portal for SLA management can be seen as an attempt to use technology to counterbalance the rising complexity that scale entails.

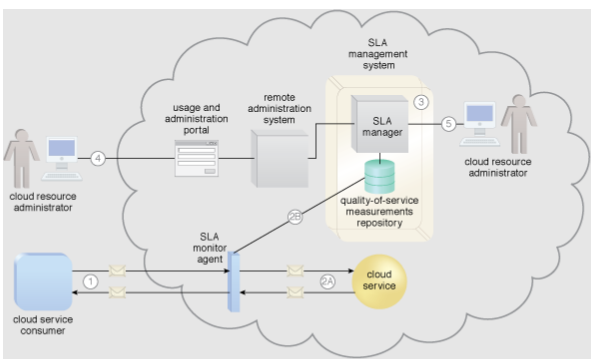

Fig 1: SLA Management System

1.1. Research design

Periodical research design outlining three aspects of service-level-agreement (SLA) management in data centers. First, a SLA is typically established between the provider and customer. Second, a self-service portal allows customers to visualize SLA performance metrics through a dashboard. These metrics act as input for approval or change requests by customers and propose management and operational processes associated with the SLA lifecycle.

A standard SLA in a data-center environment is mostly a document embedded in a contract that specifies mutually agreed expected service levels. SLA management relates to the associated processes that are normally based on Information Technology Infrastructure Library principles, such as incident, problem, and change management. However, service-level approaches such as ITIL and SLA management in a data center are often seen as "experts only" domains and require deep knowledge to create a request. A self-service portal is an online platform that facilitates service fulfillment for both service provider and customer. A self-service portal for textiles enables end-users to initiate service requests, monitor support incidents, or schedule service activities. Customers access their SLA via a self-service portal, which visualizes key performance indicators (KPIs) related to SLA delivery in real time and sends alerts and reminders about SLA breaches.

Equation 1: SLA Availability Equation

Step 1: Define total observed time

Let

- T= total service observation time
- D= downtime during that period

Then the **uptime** is:

$$\text{Uptime} = T - D$$

Step 2: Define availability ratio

Availability is uptime divided by total time:

$$A = \frac{T - D}{T}$$

Step 3: Simplify

Split the fraction:

$$A = \frac{T}{T} - \frac{D}{T}$$
$$A = 1 - \frac{D}{T}$$

Final Equation 1

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$$\boxed{A = 1 - \frac{D}{T}}$$

1.2. Scope and Objective

A self-service portal allows designated users to control and access services without intermediate support staff. These portals facilitate standard procedures but may not provide in-depth process alternatives or knowledge-base information. Streamlining common activities eases operations across service delivery teams and enhances the customer experience. The objective is to investigate the role of customer self-service portals for SLA management in data centers to balance customer decision-making and lowering operational costs.

Customer self-service portals provide information tailored to a group of users. Comfort level and trust in the system affect usability, and these portals do not permit all functions for all users. They focus on allowing customers to enter requests, assess service standards, and explore system conditions that might impact delivered services. Self-service portals are generally less complex than full-fledged service management interfaces since they abstract sub-processes.

2. Background and Key Concepts

SLA Management in Data Centers

A Data Center is a reserved and secure information-processing environment defined by a set of documents describing the operation, architecture, and services offered in a predetermined way. A SLAs are contracts between a provider and its customers that define the related risks and obligations. In standard services levels agreements processes, customers must wait for some SLA-related actions to occur, e.g., amendments path or monitoring information collection. Add value for both parties by improving the SLA management reducing clients' expectations, expectations fulfillment time, and allocation of providers' technical resources.

A. Self-Service Portals are a dedicated application and services offered to external clients with controlled access. Most common types and objectives for Self-Service Portals are: IT services offered to external clients and/or public services offered by companies or governmental organizations; and access control for portals related to sensitive information or applications (BASS et al., 2009; BOTHA et al., 2008; DINDO, 2011). For IT providers, it is a way to offer non-standard services with no intervention or support from their technicians.

Stage	**Description**
Creation	Define SLA terms between provider and customer
Monitoring	Real-time tracking via dashboards
Amendment	Modify SLA based on needs/capacity
Request Handling	Customer-initiated workflows
Approval	SLA changes validated by stakeholders

Table 1: SLA Lifecycle Functions

2.1. Service Level Agreements in Data Centers

A service level agreement (SLA) is a contractual agreement between a service provider and a customer, which defines the quality, scope, and context of the service(s), specifies penalties or remedial actions in case of failure to meet service commitments, and serves as a basis for performance evaluation and continual service improvement. In the context of data centers serving multiple customers (tenants), SLAs normally delineate technical requirements such as service availability percentages, expected response times to incidents, and the extent of notification periods for planned downtime.

In data center environments such as IaaS or PaaS models, the service provider is usually integral to the management, support, maintenance, and enhancement of the offering.

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Thus, the execution of SLAs is not only a key area of negotiation but also infrastructure monitoring, internal reporting, incident management, and real-time communication with customers. Despite the enormous operational complexity associated with internal SLAs in such environments, external SLAs typically remain poorly supported. Most data centers rely on informal means (e.g., e-mail) to handle customer requests. As a consequence, external SLAs are often not tracked or actively managed, diluting accountability and improving customer experience.

The service consumer community is often diverse and may include application developers, sales organizations, customers, and others. In addition to making a variety of service management processes visible, the portal enables member organizations (tenants) to view service-quality statistics, query the availability of service resources, and even conduct reviews. The portal also serves as a front end for systems that provide monitoring and reporting for specific services.

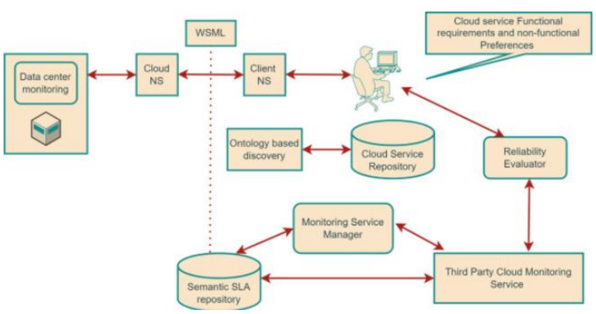

Fig 2: Service Level Agreement

2.2. Self-Service Portals: Definitions and Scope

An Internet-based self-service portal provides access to information and services via a graphical interface tailored for specific stakeholders. Information published in the portal can be made available to all users or restricted to specific groups. The range of services provided by such portals is broad and includes requests for new services (e.g. new servers, new security rules, new firewalls, new domain addresses), information on incident status, monitoring alerts and reports, and other information. A self-service portal is a channel that consolidates the service-level management process and its key workflows (involving services, configuration items, incidents, problems, changes, known errors, capacity planning and management, and knowledge management) into a single interface.

Equation 2: SLA Compliance/Breach Indicator Equation

Step 1: Define actual performance and required threshold

Let

- M= measured service metric
- S= SLA target or minimum acceptable level

For example:

- measured availability vs required availability
- measured response time vs allowed response time

Step 2: Define compliance condition

For "higher is better" metrics like availability, compliance occurs when:

$$M \geq S$$

Step 3: Define breach amount

The shortfall is:

$$B = S - M$$

Step 4: Interpret breach

- If $B \leq 0$, no breach
- If $B > 0$, breach exists

Final Equation 2

$$\boxed{B = S - M}$$

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2.3. Stakeholders and Governance

Considering the complex interdependencies between a data center and its customers, it is important for the self-service portal to reflect this external view. Therefore, the principal user group for the Self-Service Portal is external: customers of the data center service. These customers when signing a contract with the data center agree on service levels, response times, reporting and monitoring, and consequently also bear some of the responsibility for service quality. For this purpose, service level agreements (SLAs) are normally defined. An SLA is a written agreement and is therefore a contract in the broader sense; an extension to a legally standing contract externalizes the customer responsibilities and clarifies rights and obligations for both parties, thus avoiding legal breaches caused by misunderstanding.

In addition to the customers, other stakeholders also need to be considered when implementing the self-service portal. An SLA is not only an agreement between customers and service providers; it is also a governance mechanism. The self-service portal should, therefore, enable the governance bodies to fulfill their monitoring responsibilities. Emerging service compliance monitoring tools satisfy this need, thereby ensuring that the deployed services follow the regulation. Similarly, corporate security policies need to be fulfilled to ensure company security also during service usage. Security issues need to be monitored and should, therefore, also be accessible through the portal, enabling customers to take remediation action when SLA metrics are not fulfilled.

3. Architectural Considerations for Self-Service Portals

A self-service portal is one of the primary touchpoints between customers and service delivery organizations. It enables customer representatives to autonomously execute certain service management processes with minimal or no involvement of service provider staff. The portal's continuity and uptime are therefore of paramount importance to ensure that critical business services remain available, without excessive delays in service request fulfilment that would otherwise impact the ability to leverage a self-service channel effectively.

Self-service portals typically enable direct customer interaction for a subset of service management processes. A detailed assessment of demand volume across all service management functions is necessary to identify processes that can be efficiently automated to allow portal-driven execution. Tracking and monitoring of these processes should enable the presentation of a "self-service operation dashboard" for customer representatives. The exact dashboard implementation can vary greatly, depending on the maturity, scale, and objectives of the service provider. Portals are also repositories of information to support the customer's own incident resolution. Maintenance and growth of a knowledge base, usually managed by the service provider, help reduce operational disruptions for all parties involved.

Equation 3: Capacity Utilization Equation

Step 1: Define demand and capacity

Let

- d= actual demand or resource consumption
- c= available capacity

Step 2: Define utilization

Utilization is the proportion of available capacity being consumed:

$$U = \frac{d}{c}$$

Step 3: Interpret the ratio

- If $U < 1$, capacity is sufficient
- If $U = 1$, system is fully utilized
- If $U > 1$, demand exceeds capacity and SLA risk increases

Final Equation 3

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$$\boxed{U = \frac{d}{c}}$$

3.1. System Landscape and Interoperability

The SLA management self-service portal should be designed as part of a broader ecosystem of tools involving many other stakeholders such as customers, service providers, natural language processing systems such as chatbots, incident tracking systems, business intelligence and reporting systems, and so on. These systems need to communicate with each other for relevant information flows, which may necessitate the use of a service-oriented approach based on suitable data formats, protocols, and data access methods. A central Enterprise Service Bus (ESB) can serve as an integration hub that connects various services for easy interoperability, routing, aggregating, and more.

In the context of SLA management, the self-service portal for a specific service may need to interact with other enterprise systems, such as: An Operations Support System (OSS) for real-time service assurance; A (sub)ordering system to formalize requests such as order status tracking or service change requests; and A Business Intelligence Tool to provide dashboards showing service key performance indicators – such dashboards can be realized either via direct connections between the OSS and the visualization tool, or through the ESB using data aggregation service calls. For each integration point, the data model between the two systems should be defined. In some cases, the control and data models of the self-service portal can also match with those of a process-driven tool, in which case it can automatically publish fulfillment/fulfillment-update requests to control point operations.

3.2. Data Models and Metadata

Well-defined and interoperable data models and metadata are critical for successful self-service portals. The information to be captured and exchanged, and its respective format, must be established prior to the implementation of (inter-)operable systems. Key source and target fields should be integrated in a single definition within a semantically rich model and persistent storage location.

A data model consists of structured information, including the definitions of entities, attributes, relationships, and classes. It forms the basis for data exchange between systems and also stipulates the information captured by the various systems. In a self-service portal context, it also details how the captured information is used for decision-making, and operational and performance-tracking purposes. These systems use the information to provide useful operational-level dashboards and reports for customers and for their operational, service-delivery, and decision-making processes.

Metadata provides information about the actual data captured and exchanged. It describes the characteristics of the data, including its source and format, as well as its semantic meaning and context of use. Each service-level metric should have appropriate metadata to enable reliable, effective, and useful self-service.

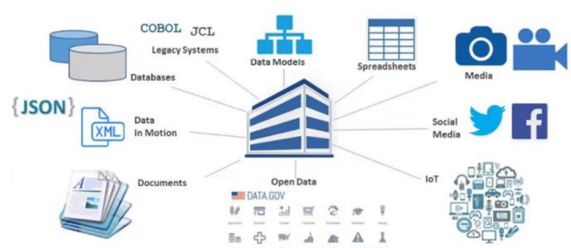

Fig 3: Data Models and Metadata

3.3. Security, Compliance, and Access Control

Self-service portals enable customers and other external partners to interact with service providers without the need for direct assistance from internal support teams. Because many of the requests originate from external users with different operational procedures, security and compliance management are critical. Appropriate method for managing user credentials is one area where careful consideration is needed. Allowing unlimited access to all portal functions through a single credential set can result in significant security exposures. Role-based access control provides a reasonable solution by segmenting user groups and assigning each group a clearly defined set of authorized functions

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within the portal. At the same time, role-based access control brings with it its own problems: it increases administrative overhead in maintaining the role definitions and assigning users to roles.

External customers and partners typically require only a limited number of functionality areas, and these functions can be further restricted to discrete configuration settings or data queries. This suggests that it may be possible to create a large number of user roles covering increasingly granular functionality areas and providing access to only those functions needed at the time.

4. Functional Requirements for SLA Management

The functional requirements for a customer self-service portal supporting SLA management are organized according to a typical service lifecycle. They encompass the creation, tracking, and amendment of SLAs; real-time monitors and dashboards; request fulfillment; and change management.

SLA Creation, Tracking, and Amendments

A fundamental consideration in any SLA management solution is whether to support customizable SLAs that can be created for individual customers and environments or to configure a smaller set of standard SLAs automatically linked to corresponding request profiles. Complexity is added by the need to expand or amend SLAs based on capacity and compliance reporting but must be kept within reasonable bounds to avoid impacting the quality of the SLA process.

Real-Time Monitoring and Dashboards

SLA monitoring should be performed in real time, with violations, breaches, and foreseen violations highlighted for the customer, a process that is especially crucial in a multi-tenant environment where compliance with customers, legislators, and corporate governance can be at stake. Monitoring dashboard views should be tailored for various stakeholders, including customers, the service desk, engineering groups, and management. Monitors should be grouped as required to reflect common interests across different service lines and include correlation capabilities with other operational monitoring data.

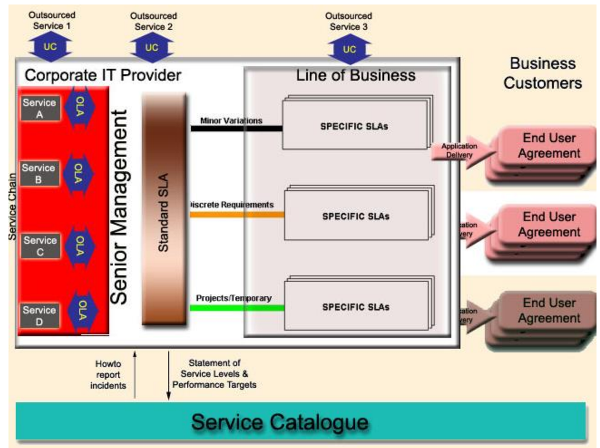

Fig 4: Functional Requirements for SLA Management

4.1. SLA Creation, Tracking, and Amendments

A self-service portal supports different stages of the service life cycle, which is summarized in a service life cycle model. The service life cycle starts with Service Strategy, which enables the organization to design, develop, and implement service management as a strategic asset. During the Service Design phase, every service should have a Service Level Agreement (SLA) and the provision for monitoring services against the SLA must be established. Proper planning, implementation, and operation will result in services that can be managed in an affordable and effective manner, complying with policies and procedures. To ensure effective services, Service Operations should monitor service performance against SLAs and take action to resolve incidents, fulfill requests, and manage problems and changes. Service Transition enables the organization to build and deploy IT services and will also perform the required complete testing of new services.

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Portals play an important role in providing information and providing customer interaction to external, corporate, or business-feeding users. Customers use these portals for a variety of functions, with two of the most frequently requested being the submission of incidents and requests, and real-time monitoring of the progress of those incidents or requests. Real-time interaction is furthermore supported in the incident management process with live chat capabilities. Additionally, performance metrics and key performance indicators (KPIs) designed to provide management with a clear understanding of service performance, status, and issues in an efficient manner for them and the customer are available from those same portals.

Equation 4: Multi-metric SLA Score Equation

Step 1: Define normalized metrics

Suppose we track nSLA metrics:

$$m_1, m_2, m_3, \dots, m_n$$

where each metric is normalized between 0 and 1.

Step 2: Assign importance weights

Let corresponding weights be:

$$w_1, w_2, w_3, \dots, w_n$$

with

$$w_1 + w_2 + \cdots + w_n = 1$$

Step 3: Compute weighted aggregate

The overall SLA score is the weighted sum:

$$Q = w_1 m_1 + w_2 m_2 + \cdots + w_n m_n$$

Final Equation 4

$$\boxed{Q = \sum_{i=1}^{n} w_i\, m_i}$$

4.2. Real-Time Monitoring and Dashboards

Service level agreement monitoring must provide a near-real-time view of compliance status for the key stakeholders involved in the processes defined in a data center service management system. Monitoring dashboards with configurable content, detail, and alerting capabilities are established. A unified communications service can send alerts via e-mail or mobile device, allowing customers to react more quickly in the event of non-compliance.

The data center is a multi-tenant environment, and customers need to be isolated from one another in terms of service quality. If the quality of service declines for a specific period (e.g., the number of service interruptions in the last month exceeds three), this can severely affect the confidence that potential customers have in the service provider's ability to deliver services without interruptions. An SLA metric can therefore be defined for each customer to verify this aspect as part of the SLA monitoring. An SLA dashboard can therefore be established, which indicates whether the number of service interruptions for the last month has been more than three.

Stakeholder	Role
Customers	Monitor SLA, raise requests
Service Providers	Deliver and manage services
Security/Compliance Teams	Ensure policy adherence
Operations Teams	Handle incidents and changes

Table 2: Stakeholders in SLA Management

4.3. Request Fulfillment and Change Management

Enabling users to initiate fulfilment, change, or enhancement requests, with supporting workflows, is central to most SLAs. Requests may involve anything from time-bound access to restricted areas (or permissions) to requests for additional CPU power during peak seasons, reinforced by requirements to provide business justification as a deterrent to abuse. Just as large and complex organizations tend to

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forgo formal SLAs because these often wind up being empty shells, so too do infrastructures with many virtualized components often resist establishing SLAs for self-service and system-native requests based on the belief that services can be created or removed in near-real time. Even the mainframes of the past usually required the locking and unlocking of physical tape drives to make such requests meaningful, and real-time security levels still typically required access requests to be embedded or at least regulated via an SLA-style contract.

Request fulfilment workflows need to call on multiple teams as necessary and route requests for approvals based on either the type of request (e.g., data center access, new user access set-up) or rules in a data access-custodian knowledge base. Hot-wash checklists can act as both step-by-step work instructions and integration points for a service desk or management layer that needs to oversee submission (or dialog) with the customer. Management tickets automatically produced by technical processes often disappoint stakeholders because of poorly communicated statuses, but simply incorporating acknowledgements into underlying operations remains a low-cost, low-complexity way of alleviating customer frustration.

5. Operational Processes and Workflows

It is quite common knowledge that SLA infringements or violations strongly influence customer satisfaction and agreement renewal rates. Although standard SLA definition processes with standardized templates, monitoring by automated systems and alerting of responsible parties can help alleviate these risks, resolution of incidents remains highly sensitive to time and quality. Self-service portals for SLA management can expedite the repair or recovery process by making organizations aware of incidents, problems and outages more quickly through the news or status pages. In addition, allowing customers to request updates and follow the ongoing work improves the overall customer experience. And finally, providing automated mechanisms for straightforward service updates — such as weekend maintenance operations or support services during public holidays — can reduce organizational effort while improving customer experience.

Service Quality Management (SQM) encompasses processes required for the management of quality and continuity of delivered services such as incidents, problems, changes, developments or investments by providing with a framework for planning, operational control and reporting of services quality. Service Quality Management is enabled through the integration of Service Demand processes, which focus on understanding, forecasting and influencing customer demand, with Service Level Management, which focuses on defining service levels, with the aim of fulfilling business objectives while maintaining risk within acceptable limits. On a lower level, SQM processes focus on operational responsiveness, assuring fulfilment of established service levels and providing mechanisms to identify potential impacts on service quality before levels are infringed.

Control loops, or primary processes, devote effort and cost monitoring services delivered to customers, detecting deviations from quality requirements, and implementing actions to return the status to normal operational conditions. Examples of control loops related to SLA management are the lifecycles of incidents, problems and changes. The self-service portal can contribute to increasing the quality of the process notified stakeholders expect, increasing the accuracy, reducing the time to supply information and updates, or even permitting the automation of low-complexity requests.

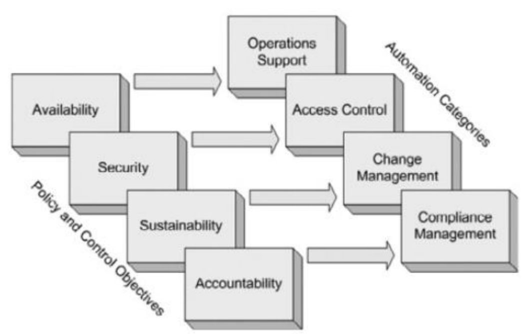

Fig 5: Operational Workflow - an overview

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5.1. Incident, Problem, and Change Lifecycle

The principal operational process for customer support in IT and data center environments is the "service request" or "incident" lifecycle. While the categorization of service requests clearly distinguishes incidents from other requests for service, it is of a functional nature, and an operational centre may in fact handle all requests congruently. Service requests are items in the service management process model that describe progress, status, reasons and effort for undertaking anything other than a normal, operational task for the service provider.

Following a risk assessment, it is recommended that the user self-service portal should support the creation and fulfilment of service requests for trivial issues impacting the customer or for common requests such as configuration changes or other routine tasks. Such relationships can deliver significant improvements in service operations—reducing effort and costs across the service provider as well as improving perceived turnaround time—but deliberate business processes, stakeholder involvement, education, training, community content and triage are key.

The lifecycle process also handles problems, later stages of major incidents, and changes. The provision of services that depend upon the fulfilment of change requests (whether minor adjustments or major projects) is in many respects the primary life-blood of service management. Changes in installed IT components normally require development, testing and implementation effort that impact both the service provider and the user.

5.2. Capacity Planning and Demand Management

Effective capacity planning enables proactive resource allocation that minimizes oversizing, undersizing, and profit loss. A self-service portal helps monitor demand fluctuations across all resources in a data center by providing up-to-date visualizations. Historical demand data guides the projection of customer service usage trends. Automated alerts notify customers of exceptional demand increases and identify unusual usage patterns for in-depth analysis.

Demand forecasting is crucial for optimizing resource availability while minimizing waste. Traditionally, capacity data for internal services were not exposed to customers; the self-service portal now bridges supply and demand signaling. Build-and-grow approaches have often resulted in capacity oversizing. On-demand service delivery is gaining appeal, but past elasticity challenges in complex services hinder widespread adoption. Using the self-service portal to display near-real-time demand and historical usage patterns builds customer confidence in forecasting demand and thereby minimizes reliance on elasticity.

Equation 5: Operational Cost Saving Equation from Self-Service

Step 1: Define old and new cost

Let

- C_m= manual handling cost without portal
- C_s= support cost after self-service portal

Step 2: Define cost saving

Savings are simply the difference:

$$E = C_m - C_s$$

Step 3: Interpret

- If $E > 0$, the portal saves money
- If $E = 0$, no financial effect
- If $E < 0$, the portal costs more than manual handling

Final Equation 5

$$\boxed{E = C_m - C_s}$$

5.3. Knowledge Management and Self-Help

For service providers, crafting and maintaining a knowledge base for problem resolution typically requires dedicated effort and resources—not to mention specialized skills in content authoring and curation. For these reasons, fully-fledged self-help features in customer self-service portals

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may not be both practical and cost-effective in all data center contexts. Nevertheless, enabling customers to record and share solutions to repeat incidents or problems can prove beneficial, especially in multi-tenancy environments. This knowledge can also usefully complement active incident and problem management processes; by providing simple solutions for frequently experienced issues, demand on these processes may be curtailed, resulting in faster service restoration times for others.

For such records to be included in a knowledge base, organizations should adopt and maintain suitable quality assurance processes. A curated knowledge base allows organizations to capture lessons learnt during post-incident reviews and post-mortem reviews of major incidents or service outages. It should also document known errors and workarounds for existing problems, ensuring that customers have a self-help option when service impacts are likely to be short-lived or trivial. Organizations should consider providing visibility of a curated knowledge base within their customer self-service portal, even if the underlying processes and supporting functionality lie outside it.

6. Data Center Context and Specific Considerations

The above considerations apply to the SLA management of any service or service provider delivering a portfolio of services to its customers, but the specific environment is a data center maintained for one or multiple customers that receive and share the services. Hence these additional items should be considered:

* Preparation of an SLA management solution for a data center means both the ability to gather physical and environmental data from the large variety of sensors in the data center and the ability to configure these sensors in a location-aware manner allowing the collection and presentation of location-aware metrics. Supporting the monitoring of humidity, temperature, free space in racks, smoke detection, and so on is a requirement. The SLA metrics page should include the warning and critical ranges for relevant metrics so service customers or service management can spot and follow up abnormalities.

* Data centers are usually multi-tenancy environments where resources are shared among multiple customers (but with the possibility to completely isolate customers as well). Therefore, the SLAs need to be constructed in order to reflect this environment. For example, should customer A's SLA state that the total CPU utilization can't be higher than 90% and at the same time customer B's SLA states that it can't be higher than 85%? More interestingly, if the total CPU utilization for the data center exceeds 90% and then customer C's SLA has been breached, how to reflect that in the SLA of customer A and/or B? When customer C's SLA is breached, should A/B be warned? These type of questions should be handled by the SLA management solution.

* Finally, data centers are complex environments where it's not always intuitively obvious what metrics should go in the SLAs and how often they should be checked. Therefore, location-aware SLAs can be useful in data centers. Instead of adding 10 sensors to the SLA of customer A, the SLA management solution can prepare a page with all relevant sensors in one place, which should be considered by customer A before the signing of the SLA.

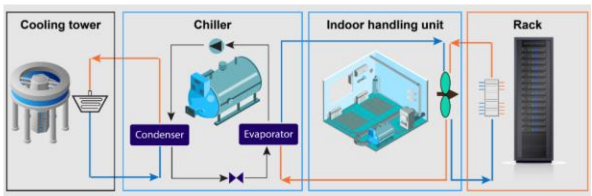

Fig 6: Data Center Context and Specific Considerations

6.1. Physical and Environmental Monitoring

Recognizing that customers naturally focus on service quality as perceived from their environments, data centers need to monitor customers' physical environments within the data centers themselves and outside. Real-time metrics relevant to customer-defined SLAs such as cable duct or Network Operation Center (NOC) temperature or smoke

ISSN: 3050-9696
E-ISSN: 3050-970X
EUROPEAN ADVANCED JOURNAL FOR SCIENCE & ENGINEERING
Volume: 03 Issue: 03
RECEIVED: JUNE 25 REVISED: JULY 09 ACCEPTED: JULY 23 PUBLISHED: AUGUST 13

detection must be visible in the customers' self-service portals. Customers with their own NOC often demand 24 hours a day, 7 days a week monitoring of data center conditions from their own services perspective. In such instances, the data center might offer customers a real-time view of the relevant environmental attributes that go beyond the SLA requirements in return for a NOC monitoring fee.

Self-help knowledge management portals also need to be complemented with customer service-focused knowledge bases. Description and procedures of common incidents and problems affecting multiple customers, which customer service representatives often respond to, would lessen the load on these representatives and improve customers' satisfaction levels by reducing their waiting times for responses. Information regarding upcoming change requests involving customers' services, service impacts, and preventive actions undertaken by the data center also need to be available to customers proactively. Periodic SLA and trend dashboard distribution could be automated to reduce administrative overheads.

Benefits	**Risks**
Improved customer experience	Security exposure
Real-time visibility	Complexity
Reduced operational cost	Governance challenges
Faster incident handling	Misuse of access

Table 3: Benefits vs Risks

6.2. Multi-Tenancy and Customer Isolation

Data centers are typically operated as shared service environments supporting multiple organizations, with the resources of all customers pooled and dynamically allocated according to demand. While this fosters greater efficiency in the provision of IT infrastructure, these environments also introduce challenges for the management of service quality and any associated service levels. The SLA metrics typically used to measure and report service delivery related to the availability and performance of the services consumed are very much influenced by the shared, multi-tenancy nature of the environment. In most cases SLA breaches are rare, but when they do occur it is usually difficult to determine the root cause of the breach and which organization or organizations involved should be held accountable.

To mitigate these challenges a self-service portal could be developed that provides for segregation of the data center SLA metrics, delivering clear isolation from a customer perspective. For example, availability reporting of the virtualized compute environment could be isolated at the cluster level where the hypervisors are hosting virtual machines for a single customer organization. Such reporting segregation could also assist data center service providers in their own internal SLA reporting by enabling them to allocate service quality to a specific infrastructure zone and group of customers more definitively.

6.3. Location-Aware SLA Metrics

Through customer self-service portals, service-level agreements (SLAs) can be monitored in real time, amended directly through a workflow, and requested, with planned changes to the service catalog. Involving customers in these processes promotes higher satisfaction and a sense of control. Portals also help operational teams by enabling dynamic communication based on change, problem, and incident lifecycles. Consequently, a dashboard with SLA compliance deadlines and recent changes fosters awareness of potential service degradations. Other processes can benefit from introduction of a customer self-service channel. Enabling business units or external customers to manage planned service requests helps consolidate demand, making it easier to track growth and shrinkage in capacity. Self-help for frequently asked questions increases the efficiency of support staff. Monitoring the physical environment and its associated service quality indicators can help pinpoint underlying issues.

Most data centers cater to multiple business units, each typically requiring a steady supply of energy-hungry computing devices. Recent years have witnessed a hyper-scale shift in cloud/data-center service providers, and the ability to provide low-cost, scalable databases has ensured

ISSN: 3050-9696
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EUROPEAN ADVANCED JOURNAL FOR SCIENCE & ENGINEERING
Volume: 03 Issue: 03
RECEIVED: JUNE 25 REVISED: JULY 09 ACCEPTED: JULY 23 PUBLISHED: AUGUST 13

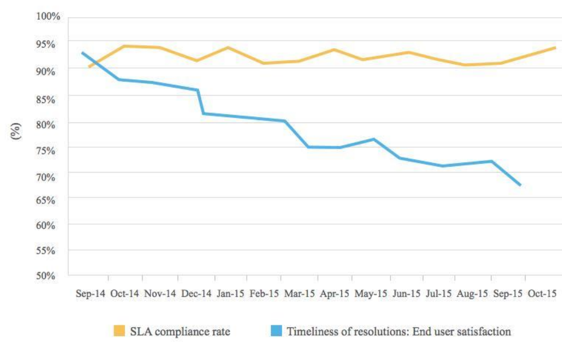
customer demand remains robust. Hosted data gorges are growing, and colocation data centers are experiencing a renaissance. Nevertheless, even non-hyper-scale data centers, catering to internal business units or external customers in a colocation model, have to price using marginal economics: users will shift capacity to the cloud or scale down equipment to cut costs during business slowdowns. SLAs need to scale down if business units or external customers are not using the data center infrastructure, and scaling up should not be a painful exercise. Therefore, SLAs need to use metrics that are location aware. If all IT services are using the services of the underlying data center that is providing services for a business unit or an external customer, then, ideally, the SLAs should show green.

7. Evaluation of Benefits and Risks

The early empirical efforts characterize the operational environment for Data Centers that provide IT services to multiple organizations or business units, with the goal of establishing a Customer Self-Service Web Portal that simplifies Service Level Agreement (SLA) management from the point of view of both the customers and the operators.

Self-service experience modeling usually emphasizes expected customers' behavior when using a portal. However, in Data Center environments, the customers are not acting for themselves but on behalf of a business unit or organization, thus accountability for SLA management activities is a complex consideration. Moreover, a Data Center provides many services that are not easily connected into a coherent business deal. A more elaborate consideration of these factors, redesigned according to the specific implications in a Data Center context, should favor the analysis and evaluation of customer self-service portals.

The presence of a self-service web portal would improve the perceived quality of service and the overall customer satisfaction, while easing operations management. However, it should be noted that merely implementing a web-based portal for SLA management, and exposing it to the customers, would not suffice. The operational processes associated with incident, problem, demand request and change fulfillment, as well as capacity and knowledge management, must be adequately modeled and governed to fully leverage a self-service portal. These are not trivial concerns, particularly for incident and demand management. If after an incident a customer feels forced to notify the operator every time an SLA is violated, the perceived quality and ease of use of the self-service portal will certainly decrease.



7.1. Service Quality and Customer Experience

A self-service customer portal should aim to improve service and customer experience. The success factors and key performance indicators that matter to the data center business are usually expressed in the contract made with customers and in service level agreements (SLAs). One important aspect of the use case is that customers have an excellent impression of the service quality provided and of the responsiveness of the service organization. This positive impression is not a guarantee that the IT services actually meet the contractual obligations; however, it does drive demand and sustain revenue. Effective use of the self-service portal appears to automate the activities engaged by customers in these non-IT support components of the overall IT landscape, thus ensuring a smooth experience for customers. Designing such components requires careful attention, both in terms of capturing infrastructure and service landscapes, and in making those available to customers.

ISSN: 3050-9696
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Volume: 03 Issue: 03
RECEIVED: JUNE 25 REVISED: JULY 09 ACCEPTED: JULY 23 PUBLISHED: AUGUST 13

Although many components of the self-service portal serve different business roles (including the roles of the service desk agent), some components are especially important for ensuring that customers have a good experience when they have a problem with an IT service. Monitoring and alerting customers when incidents occur is part of a good operational monitoring practice that aims to provide courteous service by proactively informing users. A simple dashboard to show the overall service status also helps in this responsibility. Customers expect any disruption of their services to be acknowledged, and the self-service portal enables time-consuming communication to be automated.

7.2. Operational Efficiency and Cost Implications

Creating a self-service portal for SLA management should increase operational efficiency by removing SLA-related tasks from the workload of operations personnel and transferring them to a system that automates function fulfillment. Potential efficiency gains can be inferred from the increased scale and lower perceived costs associated with public cloud services. Hosting data across multiple data centers with different SLAs and Service Catalog profiles should yield lower operational costs and faster times to fulfill customer service requests, provided that a suitable set of controls can be implemented.

The self-service portal should enable a closer alignment between the demand and supply of data center capacity through effective monitoring of actual usage against the appropriate SLA-defined target levels. Accurate predictions of upcoming demand should also be possible, as customers can request additional provisioned capacity days or other resources and associated performance levels before the existing allocations are exhausted. Handling of Change Requests, particularly those that incur additional costs, should be allocated to the appropriate data center(s) to enable localized analysis and decision making. Resource usage – such as the utilization of capacity allocated to the customers – should also be explicitly addressed by the portal, and suitable levels set in the SLA.

7.3. Risk, Compliance, and Governance

A customer self-service SLA portal can help mitigate compliance, governance, and risk issues. Providing real-time status metrics of the data center environment and infrastructure can reduce operational risk. If scheduled maintenance is properly publicized, stakeholders can plan accordingly. The data center operator can closely manage personnel access and use a knowledge management base to minimize errors, and the risk associated with inappropriate service requests can be reduced. From a governance perspective, the SLA provides a contractual framework against which violations can be tracked and subsequently addressed.

However, customers and data center operators must still mitigate significant exposure. Customer segregation and isolation must be enforced based on the application demand in the infrastructure. The physical components and locations that each customer can access should be strictly managed; if any policies are violated, the portal needs to generate alerts. Similarly, the physical and environmental monitoring of a data center can allow the operator to enforce alerts on SLA metrics that are corrupted by system faults or abnormal events.

8. Conclusion

Customer self-service portals for service-level agreement (SLA) management represent an adaptation of an established IT service management capability for use in controlled data center environments. A comprehensive review of SLA management functions indicates compliance with business commitments, a critical component of service quality, can be improved through the adoption of self-service capabilities.

Self-service SLA management combined with real-time status visibility enhances the operation of the incident, problem, change, and capacity management processes while also supporting demand management activities. Integrating self-service capabilities into data center operations increases the productivity of internal IT service management teams while optimizing the user experience for business customers. The cumulative impact of these benefits is a more efficient, effective service that is less costly to operate and meets customer demands for accountability, quality, and reliability.

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Nonetheless, organizations must remain cognizant of the additional risk profile introduced into cloud environments with shared service delivery models.

8.1. Emerging Trends

A growing number of enterprise IT departments are establishing internal cloud service-delivery capabilities. As infrastructure-as-a-service solutions—most notably Amazon EC2 and Amazon S3—demonstrate their suitability for production workloads, organizations are considering whether to extend their such-and-such or internal cloud environments to business partners such as suppliers and customers. To date, such-and-such has assisted in the security design of several of these cloud implementations. Security requires more than just certification and policy. Security also requires procedures and processes that are adapted to the cloud paradigm. Like its name-sake, the cloud, Security becomes nebulous and hard to visualize when external parties gain shared access. Specialized management systems to handle the specifics of cloud security are required.

Additionally, self-service cloud portals are maturing into a rich and fully featured user experience. The best systems not only allow provisioning of cloud infrastructure services but also provide context-aware information on service availability, service monitoring dashboards, chargeback detail, service requests, service-level agreements and, in a coming trend, information on compliance. Providing users of cloud services with a single interface to access all these features not only offers users a more seamless experience but it also significantly lowers administrative workload.

These systems are complex by nature, with many moving parts, and supporting them doesn't come without its challenges. Self-service management isn't only business-as-usual operations; a few key areas within infrastructure and operations also require special focus and attention to keep an effective and efficient self-service cloud service running.

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