A Metrics Analysis Framework for IT Service Management

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Abstract

There is an abundance of metrics for measuring various aspects IT Service Management both in research literature and practice. Also, there are numerous studies on the benefits of having an active performance monitoring and analysis embedded into the service delivery. However, frameworks that analyze metrics and provide actionable insights to address deviations for improved operational efficiency are non-existent. We propose a multi-method framework that integrates aspects of Qualitative System Dynamics with a statistical method known as factor analysis to bridge this gap. The framework has been illustrated with an 8 months metrics data stream from an actual ITSM engagement. This study alerts ITSM practitioners on the importance of fully understanding various influences in the system before taking corrective actions. By integrating multiple customer perspectives, such as business, technology, IT users and IT employees, to the framework, ITSM managers can holistically monitor the performance and achieve a balanced and an integrated view of the distribution of benefits across the organisation.

Keywords: Qualitative System Dynamics, Factor Analysis, IT Service Management, ITSM Metrics

1. Introduction

Imagine a scenario where New York stock exchange trading desk blacks out for an hour during peak trading period due to a system upgrade or a software update or a technical issue such as failure of some configuration item as given in Configuration Management Database. This could potentially create ripples across other financial markets and possibly be the news of the day across the world. Fortunately, the probability of such a thing is infinitesimally small because there is a system comprising of IT infrastructure management and IT service management (ITSM) that works tirelessly to provide essential IT support services to fulfil business needs of such enterprises. From business critical services to life critical services, IT service support is of paramount importance in the digital age. For this reason alone, organizations no longer view IT as a function, but as a set of services delivered to the users, regardless of whether IT is kept in-house or outsourced.

IT departments are now expected to adapt a service oriented approach to managing IT operations (Gacenga & Cater-Steel, 2011). Consequently, numerous frameworks for IT service management have been proposed with popular ones such as IT infrastructure library (ITIL), Microsoft Operations Framework (MOF) and IBM Service Management Reference Model being widely adopted. These best practice frameworks assist in visualizing the 'To-be' states for ITSM and in order to ensure that the path towards 'To-be' state is not disrupted multiple metrics have to be continuously monitored and analyzed. Even in the steady state continuous monitoring and control is required to keep the system up and running.

Due to the sheer size and complexity of IT Service Management engagements, the number of metrics needed to monitor is large. For instance, ITIL v3 (ITSMF, 2010) has proposed 147 metrics separated in 16 silos that cut across various functions and processes. To comprehend them and derive actionable insights is a challenging task. Customers view SLAs as instruments to establish measurable targets of performance with the objective of achieving required levels of service. They are also seen as handles to formalize their expectations and more importantly, steer the engagement by monitoring them from a distance. However, SLAs are generally the end point measures and they do not provide any assessment of the internal dynamics of the system. This study proposes a metrics analysis framework for ITSM managers to monitor, control and steer an ITSM engagement towards its objectives.

The rest of the paper is organized as follows: Section 2 contains survey of relevant literature, research gaps and the contribution of this study. Section 3 describes the methodologies used to build the framework and constructs the framework by combining various aspects of those methodologies. Section 4 links the domain specific attributes of ITSM with the framework described in Section 3. Section 4 also has an illustration of the metrics analysis framework. Section 5 concludes the paper.

2. Literature Review

Aspects of this study draw from the literature of Organization performance measurement, which branches into a more focused domain of IS performance measurement. Further, a subset of IS performance measurement is the literature on performance measurement of Services and IT Services in particular. Our study falls in the last layer of this hierarchy.

There have been many frameworks proposed by researchers over the years to measure the performance of an organization. Some popular ones are the balanced scorecard approach by Kaplan and Norton (1992), the Sink and Tuttle model (1989), performance pyramid proposed by Lynch and Cross (1992) and the SERVQUAL proposed by Parusuraman et al. (1985).

IS performance measurement has also generated equal amount of interest in the researcher community. All the studies under this category could be classified into two categories based on the way the researchers have approached the problem. First is a production economics based approach, where the performance is measured based on the functions that model the relationship between inputs such as capital (IT) and labor (resources). The second approach is process oriented, wherein each process is evaluated how its operational efficiency is translated into financial performance. Among many others, Chan (2000), Dewan and Min (1997), Brynjolfsson and Yang (1996), are some studies that have taken the production economics route to measure the performance. The process route studies measuring IS performance are by Marchand & Raymond (2008), Martinsons et al. (1999), Myers et al. (1997), Saunders & Jones (1992) and Van der Zee & de Jong (1999). Some of these studies were conducted due to the often quoted 'IT productivity paradox' in late 90s and early 2000s, which is the lack of evidence between IT investment and firm's overall productivity (Brynjolfsson & Hitt 1998). Mukhopadhyay et al. (1995) have assessed the business value of electronic data interchange (EDI) in a manufacturing setting by assessing the efficiency of various processes. In addition, adaptations of balanced scorecard are also be used to measure the performance of IS.

Further down the hierarchy, studies that deal with services or IT services, in particular are abundant. IT SERVQUAL (Hochstein 2004), an adaptation of SERVQUAL, is for measuring the performance of IT services. McNaughton et al. (2010) have proposed an evaluation framework for IT service management, which considers four different perspectives of IT users, IT employees, technology and management while measuring the performance. The framework proposes the use of SERVQUAL to measure the performance from each of these four perspectives.

Table 1. Related studies on ITSM Performance Measurement

Research Focus	Studies
IT Service Metrics Analysis	Barafort et al., 2005; Brooks, 2006; Steinberg, 2006; van Grembergen et al., 2003
IT Service Performance and Quality	Axel Hochstein, 2004; Praeg & Schnabel, 2006; Gacenga & Cater-Steel, 2011
Business value of IT Service	Moura et al. 2006; Šimková & Basl, 2006; Yixin & Bhattacharya, 2008
ITIL Process capability & maturity	Valdés et al., 2009; Lahtela et al., 2010; Tan et al., 2009
Evaluation framework	Hochstein et al., 2005; McNaughton et al., 2010

More specifically, our study focuses on using metrics for better service delivery. Spermic et al. (2008) have conducted a case study in the finance industry on similar lines. They have studied how an active performance measurement and analysis system could have positive implications on the quality of IT services provided to customers and daily work procedures. In addition, the system resulted in better employee satisfaction and an overall change in the organization culture over a medium term. Chan et al. (2008) have conducted a similar case study on multiple organizations that actively use metrics to improve the IT service delivery. There have seen empirical evidence of the cost reductions due to lower downtime and improved decision making ability due to real time metrics information throughout the organization. The study also emphasizes the marked improvement in IT service levels by the operational efficiencies. Another study (Hochstein et al., 2005) on the benefits of metrics and Critical Success Factors (CSFs) oriented approach finds evidence of improved client/service orientation, increased service quality, better transparency and comparability through process monitoring and enhanced operational efficiency due to standardisation. From the above studies, it is evident that considerable amount of research has been done on designing metrics/measures to evaluate the performance of IT Services and also on the benefits from implementing such performance evaluation metrics. To the best of our knowledge, none of the studies focus on how to analyse these metrics and convert them into actionable insights to accrue some of the above discussed benefits. There seems to be an implicit assumption that the path between monitoring performance indicators and transforming the service delivery is straightforward. In our view it does not appear to be the case. Over the course of this paper, we examine the need and also present a framework that bridges the gap by analysing the metrics for an efficient IT service delivery.

3. Metrics Analysis Framework

We propose a multi-method holistic analysis framework to analyze deviations in metrics. The framework determines the driving forces behind metric deviations and also, the possible implications due to those deviations by integrating statistical methods with Qualitative System Dynamics approach.

Although, most of the applications of System Dynamics (SD) approach have predominantly been based on quantitative models that could be simulated to generate insights into system behaviors, Qualitative System Dynamics methodology has seen a host of adaptations in the literature over the last 30 years (Coyle, 2000; Coyle & Alexander 1996; J Coyle et al. 1999; Coyle & Millar 1996; Pagani & Fine 2008). One of the earliest illustrations of qualitative System Dynamics can be seen in Roberts et al. (1983), where the dynamic behavior of complex systems is reasoned out by causal loop diagrams. Despite the often cited argument that the dynamic behavior of the system cannot be inferred simply by reasoning from a complex diagram, proponents of qualitative System Dynamics argue that if a close representation of the actual system cannot be reached, the analysis should be restricted to qualitative level (Coyle 2000). Wolstenholme (1985), in an effort to formalize the procedures for Qualitative System Dynamics, laid out a step wise framework for system enquiry without specific quantification of variables and simulation analysis. According to Wolstenholme (1985), the need for such a paradigm stems primarily from four reasons. Firstly, often quantification of all the variables is possible only for a small portion of the full spectrum of systemic problems. Secondly, most of the practitioners with an appreciation of systemic methods do not find quantitative approaches compatible with their approaches. Thirdly, Wolstenholme suggests a full-fledged System Dynamics study often is too slow a method for facilitating change in systems, given that it brings along many other supplementary techniques such as parameter estimation, calibration and sensitivity analysis. Finally, many system enquiries do not need simulation based analysis. Other arguments in favor of Qualitative System Dynamics are the ease to describe a problem situation and its possible causes and solutions, potential risks (Wolstenholme 1999, p424) and uncertainties, hypotheses and constraints, the ability to 'capture intricacies of circular causality in ways that aid understanding' (Richardson 1999, p441), more natural way to externalize and represent mental models and assumptions (Wolstenholme 1999, p424) and a more perceptive medium to share with people the dynamic system they are part of. In addition, many System Dynamicists view qualitative and quantitative approaches as complementary methods. Often, quantitative modelling exercises start with qualitative models such as influence diagrams and causal loop diagrams.

Coyle and Alexander (1998) modelled the dependence of drug trade on the changing military and political scene with Qualitative System Dynamics. Influence diagrams at different levels of aggregation are used as the basic tools of system enquiry in this study. Munro's (2011) report on child protection system used Qualitative SD for analysis. Causal loop diagrams were developed to review the child protection system in the UK. Another application of Qualitative SD was seen in the analysis of dynamic forces that influence the structure and development of 3G wireless networks by Pagani and Fine (2008). The study developed and tested various hypotheses to be included in causal loop diagrams. The hypotheses were tested by the inputs from 190 industry experts over 15 workshops conducted across Europe. Adams and Cavana (2009) have analyzed the Emission Trading Scheme (ETS) in New Zealand to reduce greenhouse gases using Qualitative SD. Causal loop variables were identified based on multiple interactions with stakeholders. The CLDs built from these variables were used to analyze the various dominant loops in the system.

In this study, we take a systemic view to analyze metrics by designing causal loop diagrams that represent the engagement and then map metrics to the CLD variables. The study uses the causal loop diagrams to define inter & intra relationships between the metrics that belongs to different silos (processes) of an ITSM engagement. As each CLD variable is defined by a set of metrics; a CLD variable – metrics mapping matrix is constructed. Deviant metric is then traced back to its CLD variable and two separate lists of metrics are compiled. First list, based on the inward links to the corresponding CLD variable, comprises of the metrics and CLD variables that have caused the deviation. Second list, based on the outward links from the CLD variable, contains the metrics and CLD variables that may soon be impacted due to the deviant metric. In the second stage of analysis, the metrics in the first list are arranged in a decreasing order of their explainability of deviant metric's variance using factor analysis.

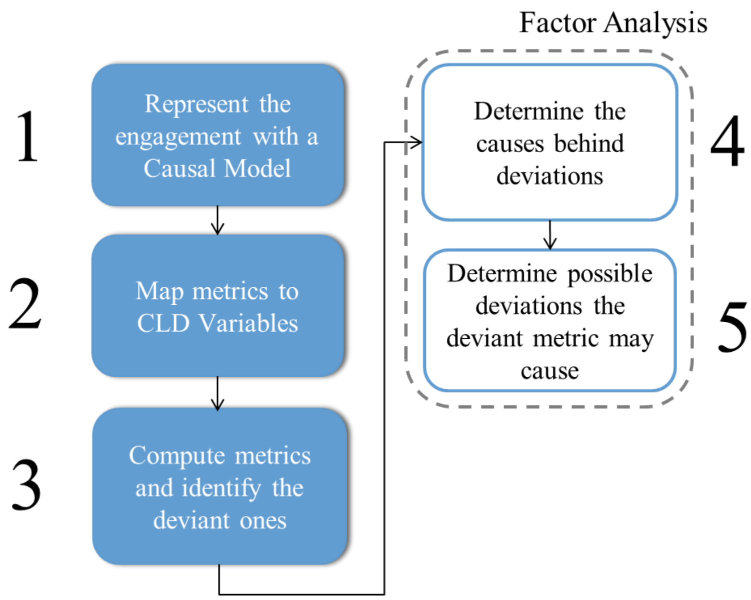

Figure 1: Metrics Analysis Framework

Originated in the field of psychometrics (Cattell 1952), Factor analysis is widely used in various domains such as operations, marketing, behavioral sciences and product management. Factor analysis searches for any probable joint variations in response to factors to condense the list of factors or unobserved variables (Fruchter 1954). The observed variables are further modelled as linear combinations of factors and error terms. More importantly, factor analysis quantifies the level of explainability of each factor on the observed variable, thereby enabling us to derive the relative dependencies.

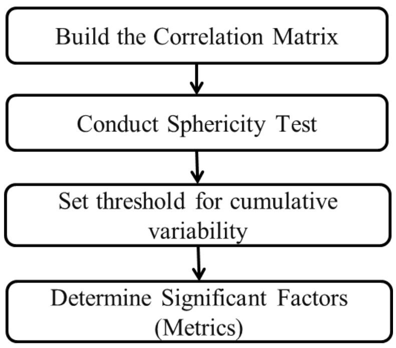

Figure 2: Factor Analysis

Explained variability of a variable being explained is taken as a function of loadings on various factors extracted (sum-square of loadings). In general, a factor is named after studying the nature of highly loaded variables on it. However, in this case, since metrics themselves are the loading variables on different factors, we can explain variability of a deviant metric in terms of other metrics (using their loading on factors). Other major steps involved in conducting factor analysis are.

1. Correlation Matrix: The data streams of various metrics are used to compute the cross correlations. Metrics with linear inter relation are pruned to avoid redundancies.
2. Sphericity Test: Bartlett's test (1950) is used to check if correlation matrix diverges significantly from the identity matrix, thereby, verifying the need for factor analysis.
3. Variability in Factors: To explain the deviant metric, factors needed to explain at least 80% variability are considered. Factor loadings are computed after pruning the list appropriately.
4. Significant Factors: For each deviant metric, highly loaded factors are determined. Further, these factors are used to determine highly loaded metrics.

The factor analysis combines with causal loop mapping to capture three key needs of an ITSM manager. Given a context, the framework provides insights into the propagation of deviations in key metrics, traces the root causes behind metric deviations and finally, quantifies the level of cause on the deviant metric or effect of the deviant metric on others.

4. Monitoring an ITSM Engagement

Amongst many other reasons, structural variations of ITSM engagements could stem from the scope. Some engagements may include all of the IT service management processes, while some include a small portion of them. Sometimes, organizations engage with multiple vendors to support a set of applications. Instances where problem management and change management are outsourced to one vendor and other service support processes such as incident management and event management outsourced to another are commonly found. Moreover, within a process, lower levels of support can be outsourced, while higher levels of support are kept in house. A snapshot of some key service delivery and support processes as per ITIL (ITSMF, 2010) is presented in Table 2. Service delivery processes view business as the customer of IT services whereas service support processes view IT users as the end customers. Naturally, service delivery processes are more strategic compared to the support processes which are operational in nature.

Table 2. Key Service Delivery and Support Processes (ITSMF, 2010)

Service Delivery	
Process	**Purpose**
Financial management	To budget, account and plan finances for various requirements
Availability management	To define, analyse, plan, measure and improve the services as a part of continual service improvement
Capacity management	To ensure that the capacity at various layers is adequate to deliver the service levels as per business requirements
IT Service continuity management	To manages risks that could seriously impact IT services
Service level management	To negotiate service level agreements with various departments and vendors and align them to the overall business objectives
Service Support	
Process	**Purpose**
Service desk (service function)	The single point of contact between the service provider and the user
Incident management.	To handle outages and quickly restore service
Event management	To monitor and foresee application outages with the view of taking preventive measures
Problem management	To conduct root-cause analyses to determine the errors behind outages

Change management	To develop solutions to errors that cause outages
Release management	To implement approved changes to IT services
Configuration management	To maintain information about various configuration items required to deliver services

To highlight the need for a holistic representation while evaluating the metrics in an ITSM setting, we refer to the presence of multiple feedback loops in the system and the constantly evolving relationships between variables. To illustrate, we consider three variables –Incident frequency, Known error database (KEDB) workarounds and the Average resolution time. Incident frequency, as the name suggests, is the rate at which service outages occur. KEDB, an acronym for Known error database, is a knowledge management tool to record the tacit knowledge gained by resources during incident resolution. Average resolution time is the time taken on an average to fix a service outage. As new incidents occur, they are resolved and sent to the problem management for root cause analysis. Once the root cause is identified and an error record is created, it is then sent to either change management or transformed into an update in the KEDB. Typically, a KEDB record/workaround contains pre-defined steps to handle the incident resolution process. Expectedly, every such KEDB update reduces the average time taken to resolve incidents. The metrics that are being influenced by this feedback loop belong to multiple process silos such as- Incident management, Problem management and possibly, Change management. Any deviations in these metrics should not be looked at in isolation. The impact of the deviations in these metrics can propagate further through the causal chains and impact other metrics. In addition, slight perturbations in metrics may amplify as they move across causal chains to throw metrics out of tolerance limits while they themselves stay compliant. To account for this the framework has a layer that represents the causal relationships in the system on top of statistical analysis layer to quantify the causes and effects.

The primary objectives of IT production service support are service availability and service quality. However, customer satisfaction often goes beyond service availability and quality, which anyway are strictly monitored through Service Level Agreements (SLAs). Customer satisfaction is a key variable for analysis but is difficult to be quantified by few metrics. Further, customers of IT services are a heterogeneous lot and each one of them may have different expectations. We adopt the performance measurement framework proposed by McNaughton et al. (2010) for IT service management. The study considers four different perspectives- IT users, IT employees, technology and management. The management perspective is from the top management that primarily evaluates the business impact of IT services. Financial implications of IT services are also considered in the management perspective. Technology perspective examines the efficiency of IT employees and technology. IT users directly use the system, hence would have to interact with IT department via helpdesk. Consequently, their perspective includes performance of service desk in addition to the performance of technology, equipment and products. Finally, IT employees are the actual network administrators, security personnel, database administrators and application owners. It is critical to consider the IT employees' perspective to validate IT users' perspective and vice versa. To measure these perspectives, a host of qualitative and quantitative measures are proposed. Business and Technology perspectives are measured by metrics whereas IT users and IT employee perspectives are measured by survey based questionnaires. Table 3 has metrics for Management and Technology perspectives divided into effectiveness, capability and efficiency metrics. Effectiveness is represented by the attributes that are measured relative to a target or a standard. Capability is seen as the shape distribution of an attribute's performance. Efficiency is described by measures of cost, utilization and throughput.

Table 3: Management and Technology Perspectives

Management			Technology		
Effectiveness	*Capability*	*Efficiency*	*Effectiveness*	*Capability*	*Efficiency*
Unresolved calls at week end	User response Time	User Support Cost	Classifying/Categorising Incidents	Calls received vs. Calls Logged.	IT labour cost per incident Resolved
1st Level Support Resolution Rate	Incident Resolution Time	Labour Cost of user downtime for incidents	Documenting Known errors	Service Desk usage	Man hours spent per change
Change Request Completion	Users disrupted by change	Change Request Cycle Time	Change Request Approval	Rework per change	Release Costs
Problem free Releases	Help desk calls per release	Business disruption due to new release	Problem free releases	Release Employee Resource usage	Cost of maintaining the CMDB
Documenting configuration items	Configuration Management Database (CMDB) Errors	Cost of supporting configuration items	Homogeneity of Configuration Items	Usefulness of the CMDB	SLM Man hours
SLA Breaches	SLA Variation	SLA Penalty Costs	Service Catalogue	SLA's with external IT based service providers	IT Budget Breakdown
IT Budgets Comparison	Budget Accuracy	Comparison to external service providers	Cost recovery	Cost of Service support and Service delivery per User	Capacity TCO
User calls related to capacity	Capacity per user	Cost of capacity	Excess Capacity	Proactive Capacity Planning	Cost of recovery
Rehearsals & Drills	Recovery Time	Insurance Premiums	Vulnerabilities and counter measures	Failure Variability	Unscheduled Outages
Hours of unplanned outages or failures	Critical Systems Availability	Cost of Failures	Number of Failures	Calls logged per help desk operator per hour	

The framework discussed in section 3 is deployed on an actual ITSM engagement with 4 process modules. Event Management, Incident Management, Problem Management and Change Management are part of this engagement. In addition, the engagement is under an ongoing drive towards automation of the service desk function. We identify causal structures based on the boundaries of the engagement in the form of above mentioned processes. The unit of analysis is a single argument made about the system's structure or a system behavior that originates from the modeler's mental model (Kim & Andersen 2012). These arguments are based on the supporting rationales. ITSM managers attempt to structure their mental models in the form of these supporting rationales which in turn are converted to system variables, direction and strength of causal relationships and expected behavior of system variables. Owing to the interpretive nature of this process, the same system can be represented by modelers in multiple ways. Hence, the representation through Causal Loop Diagrams requires communication and collaboration amongst different individuals involved

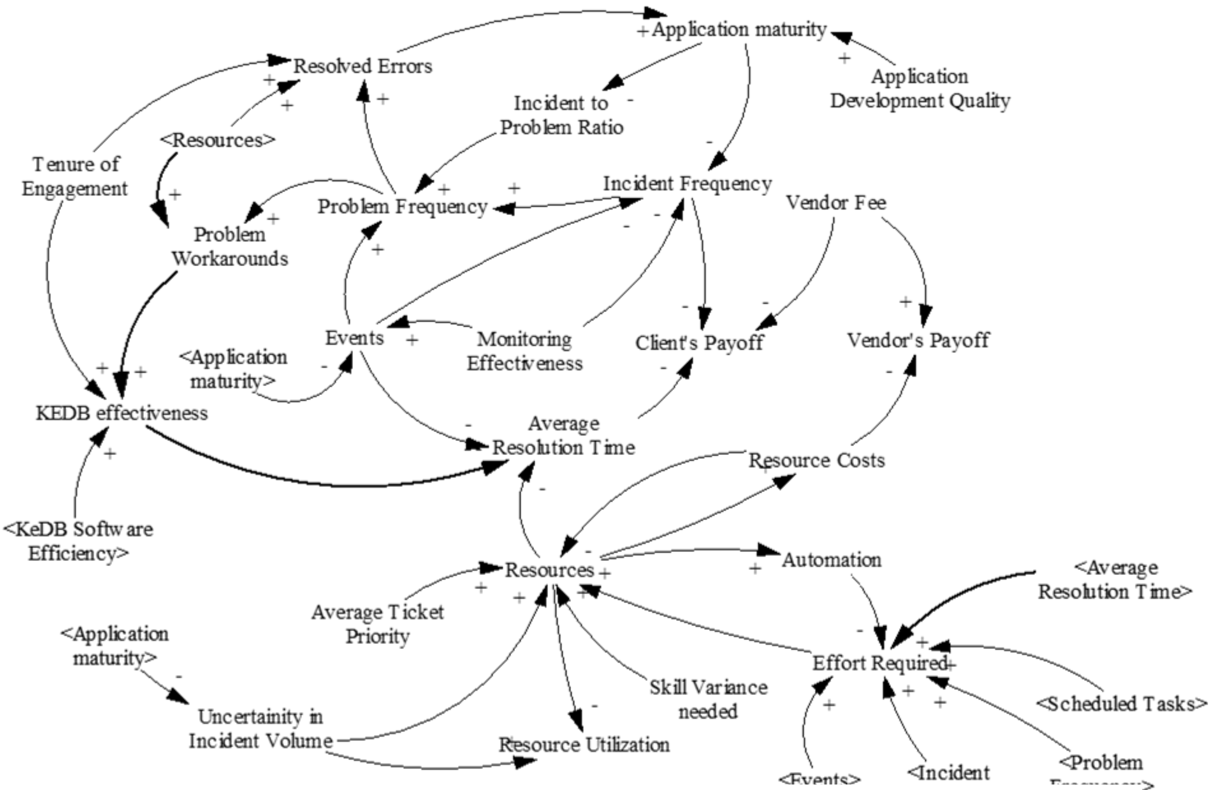

Figure 3: Causal Loop Diagram

in the service delivery. In addition, the depth of representation also is a key aspect. The level of granularity to which the system is represented in the CLD is also a modeler's prerogative. As a general guideline, level of granularity that enables seamless metrics mapping with CLD variables is preferable. To summarize, the entire exercise comprises of three major steps (Pruyt 2013).

1. Identify and define the model boundaries and important variables
2. Based on the mental models of modelers, construct a conceptual model with important mechanisms and feedbacks in the system
3. Formulate a causal theory that comprises of multiple dynamic hypotheses. A dynamic hypothesis is how behavior is generated by the model structure

Figure 3 has the causal loop diagram of the above discussed engagement. Needless to say, the CLD presented is one of the many possible interpretations of the engagement. ,. Appendix 1 has the list of relevant metrics, their respective periodicities and the tolerance limits used for analysis.

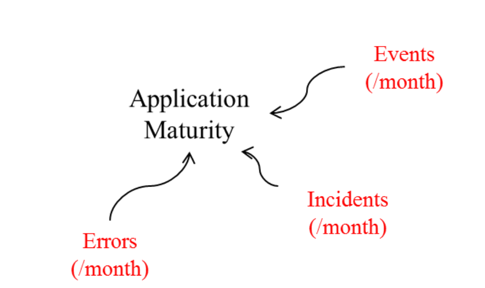

Figure 4a: Application Maturity

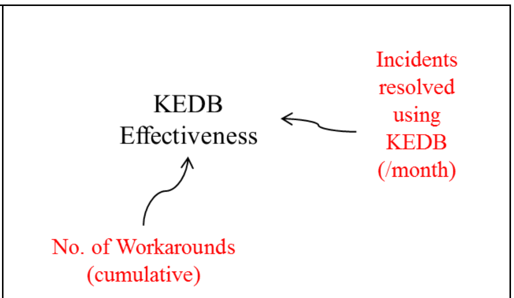

Figure 4b: KEDB Effectiveness

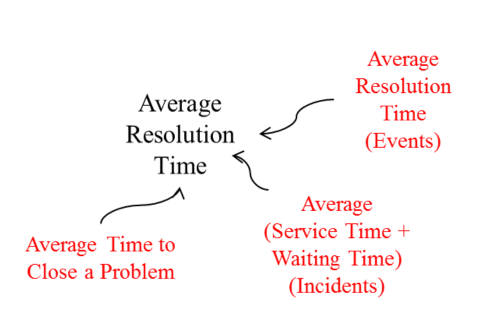

Figure 4c: Average Resolution Time

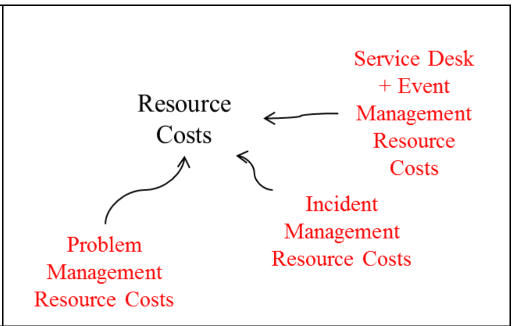

Figure 4d: Resource Costs

Figures 4(a-d): Metrics- CLD Variable Mapping

Figure 4a and 4b show sample metrics (in red) that were mapped to variables in the CLD shown in Figure 3. Figure 4a shows the metrics mapped to the CLD variable 'Application Maturity'. Application maturity, in the causal model, can be seen as the measure of how bug free an application is. A more detailed explanation of application maturity is the time between faults, which are incidents, events and errors. The metrics that measure faults are Event, Incident and Error frequencies. As discussed previously, events are typically notifications generated by the monitoring system, when not handled can cause service outages, which are incidents. Incidents are sent for root cause analyses and errors behind these incidents are determined.

Table 3. Deviant Metrics

Metric	Tolerance Limit	Monitored Value
Average Resource Utilization (%)	60	55
Average cost to solve a Problem ($)	500	540

Similarly, Figure 4b shows the metric mapping of 'KEDB Effectiveness'. Effectiveness of KEDB is dependent on the number of workarounds available and also the type of incidents that occur has a bearing on the overall effectiveness. When patches are deployed on the application or the application is completely overhauled with a newer version, the nature of incidents may change. As a result, the old KEDB records, meant to aid incident resolution, may no longer be appropriate.

Figure 4c shows the mapping between the variable -'Average Resolution Time' and its related metrics. 'Average Resolution Time' is an alibi to the effort spent on resolving events, incidents and problems. We pick related metrics from the list in Appendix I, which are the time taken to close a problem, resolve an event and incident. For incidents, metrics to measure service time and waiting times are generally measured separately. By exercising this additional level of granularity, we can differentiate between the average time taken by resources to resolve and the average time taken by incidents to be picked up from the queue. In the first case, a richer KEDB or by deploying skillful resources can help reduce the resolution time. Whereas in the second case, onboarding more resources can reduce resolution time.

Similarly, Figure 4d links the CLD variable 'Resource Costs' with relevant metrics. Due to its human centric nature, major chunk of ITSM costs come from resources employed across various levels and processes. ITIL defines metrics needed to capture resource costs in the

‘Financial Management’ process. Based on how the resources are structured in an engagement, the usage of these metrics varies. Some engagements have a separate service desk, while some club it with support level 1(L1). Similarly, Problem management can be a separate team or be a part of support level 3(L3). Here, metrics are considered based on the process/function with the notable exception of Event management resources that are clubbed with the service desk resources as dictated by the team structure of engagement under analysis.

Values of selected metrics have been computed from the data stream of 8 months (Figures 5a and 5b, Appendix II). Deviant metrics were identified by comparing with tolerance levels (indicated in figures by red lines). Table 3 has the two deviations in the metrics. As seen in Table 3 the first deviation is about the metric ‘Average Resource Utilization’. Most IT engagements maintain a healthy amount of surplus resources, termed as ‘bench’, to account for sudden requirements. After taking the bench strength into consideration, Average resource utilization is expected to be more than 60% (Brooks, 2006). Similarly, the metric ‘Average cost to solve a problem’ has shot up beyond the permissible limit. Although the metrics’ tolerance limits vary based on the support engagement, Brooks (2006) proposed benchmark figures based on his analysis of multiple ITSM engagements. Due to the higher resource costs and lengthier resolution times, cost to resolve problems is high.

Table 4a. Factor Analysis Results – Average Resource Utilization

Deviant Metric	**Responsible Metrics**	**Variance Explained**
Average Resource Utilization	Average Service time (Incidents)	44.46%
	Average Inter Arrival Time between Incidents	32.34%
	Number of Incidents Resolved (/resource)	12.45%

Table 4b. Factor Analysis Results – Average Cost to Solve a Problem

Deviant Metric	**Responsible Metrics**	**Variance Explained**
Average Cost to Solve a Problem	Average Problem Closure Time	39.58%
	Number of RFCs Raised	37.42%
	Resolved Problems	18.34%

By traversing the inward causal chain linkages of ‘Average Resource Utilization’ and ‘Average Cost to Solve a Problem’, we draw a list of metrics that could account for the variance in the metric. The data streams of various metrics during the period are used to conduct factor analysis. Section 3 has the details on how metrics are converted to principal components for conducting factor analysis and how they are transformed back into metrics to derive insights. As mentioned before, the metrics listed in the second column of tables 4a and 4b, while they explain the variance in deviant metric, need not be deviant themselves. Nonconformity in a metric could be due to tiny disturbances from multiple paths combined together. After pruning the metrics based on individual variance thresholds, ‘Resolution Time’, ‘Inter Arrival Time between Incidents’ and ‘Resolved Incidents per Resource’ explain over 80% of the variance in Average Resource Utilization. Similarly, ‘Average Cost to Solve a Problem’ is explained by the metrics – ‘Problem Closure Time’, ‘RFCs Raised’ and ‘Problems Resolved’. These inputs could prove crucial while designing policy interventions to arrest deviations. For instance, if variance in problem management costs is explained by the average time to close a problem (Table 4b), a deeper investigation into the efficiency with which problem management resources operate or an analysis to understand the nature of problems resolved during that period may provide insights needed to determine appropriate corrective actions.

4. Conclusion

In order to provide an efficient and effective IT service delivery, engagements have to be constantly assessed for their performance. Metrics play a critical role in providing a scientific basis to compare and correct the system. Improvement strategies often start with setting the target levels to a chosen set of metrics. The size and complexity of a typical IT service engagement compels us to observe a large number of metrics to monitor every aspect. In this study, we propose a framework to monitor and analyze the metrics with a view of controlling deviations. The framework includes representation of the system with a causal model, followed by a layer where statistical analysis is used to identify and quantify the causes and possible implications due to these deviations in metrics. The framework recognizes and acknowledges the need to have a holistic view of the system while addressing the metric deviations. More often than not, deviations occur due to slight disturbances in other metrics which are propagated through the causal chains of the system. These disturbances may not be significant enough to cause deviations alone but cumulatively can cause serious implications. The statistical layer in the proposed framework has the capability to quantify every possible cause behind a deviation with a view of eliminating the non-significant ones and ordering the rest based on their impact. Also, by integrating customer perspectives, the framework's horizon moves beyond operational improvements to a more strategic, integrated view of the engagement. These perspectives help monitor the performance to ensure an even distribution of benefits across various stakeholders in the organisation. The study adds to the applications of Qualitative System Dynamics and the broad topic of performance measurement and analysis frameworks in the domain of IT Service Management. By applying the framework onto an actual engagement, we have demonstrated its practical use. The framework can help IT service managers to better understand the performance of various ITSM processes and initiate improvement actions.

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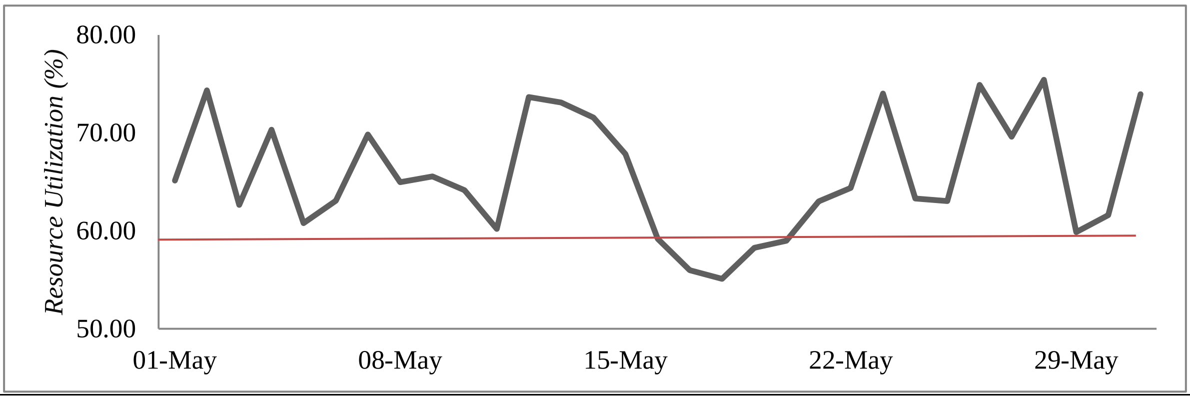
6. Appendix I

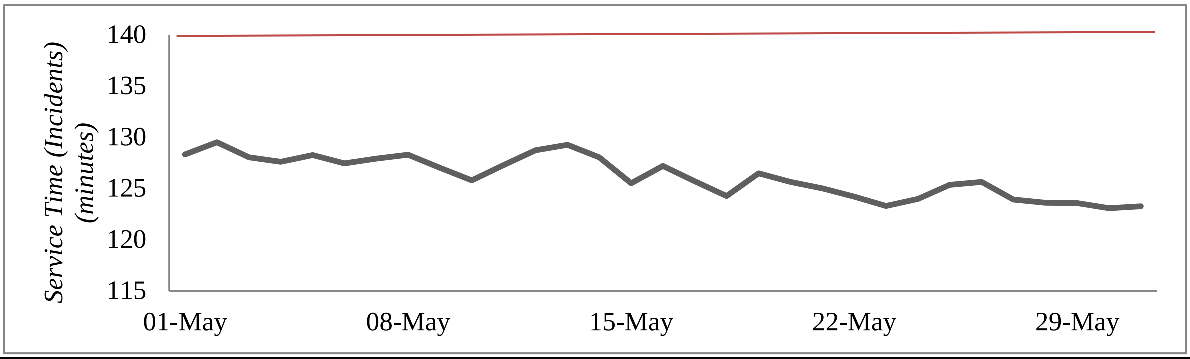
Metric Name	Definition	Periodicity
Event Management		
Number of Informational events	Number of events that do not require any action and does not represent and exception.	Daily
Number of Auto Response events		Daily
Number of Alert events	Alert will contain all the information necessary for that person to determine the appropriate action – including reference to any documentation required (e.g. User manuals)	Daily
Number of Incident events	Some events will represent a situation where the appropriate response will need to be handled through the Incident Management process	Daily
Number of Problem events	Some events will represent a situation where the appropriate response will need to be handled through the Problem Management process	Daily
Number of Change events	Some events will represent a situation where the appropriate response will need to be handled through the Change Management process	Daily
Number of warnings	A warning is an event that is generated when a service or device is approaching a threshold	Daily
Number of exceptions	Exception event means that a service or device is currently operating abnormally	Daily
Number of Human intervention events	Total number of events - total number of events handled automatically	Daily
Number of events caused by existing errors	Total number of Events whose relevance is found in KEDB	Daily
Number of repeated events	Number of events that are not unique. Repeat events are clubbed together while raising a Problem.	Daily
Number of duplicate events	Since monitoring and control system has multiple sensors at different layers, it is possible that multiple alerts may be generated for the same event such events are indicated through this metric	Daily
Number of events indicating performance issues	Total number of events indicating performance issues and divided by total number of events	Daily
Number of events indicating potential availability issues	Total number of events indicating excessive workload or failovers	Daily
Number of events compared with number of incidents resulted by events	(Total number of events/total number of incidents)	Daily
Number of events caused by each CI	Configuration Item can be a single module, which is a part of the infrastructure, such as a monitor or tape drive, or more complex items. Events originating from every CI in the Configuration Management	Daily

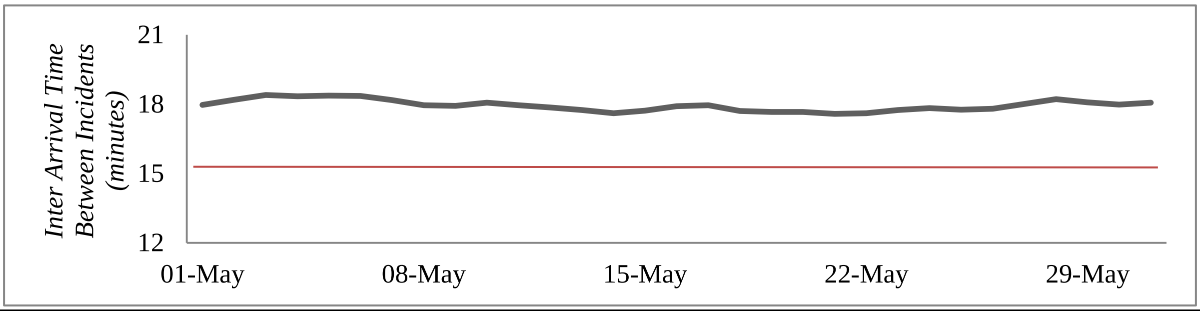
	System(CMS) are recorded.	
Incident Management		
Number of Incidents	Total number of incidents arrived	Daily
Incidents (logged, WIP, closed)	Logged: Incidents which have been identified and logged in the system ; Work in progress: Incidents which are being solved ; Closed: Solved incidents which have been reviewed and closed by proper authority	Daily
Backlog incidents	Current number of waiting incidents	Daily
Incidents breakdown by shifts	Number of incidents per shift	Daily
Incidents breakdown by priority	Priority can be high, critical, medium and low. Incidents are separated in each of these categories.	Daily
Average service time	Total service time of incidents divided by total number of incidents	Fortnightly
Average service time (per support level)	Total service time of incidents at each support level divided by total number of incidents at each support level	Fortnightly
Average waiting time (per support level)	Total waiting time of incidents at each support level divided by total number of incidents at each support level	Fortnightly
Average resolution time	Total resolution time of incidents divided by total number of incidents	Fortnightly
Average resolution time (per priority)	Total resolution time of incidents of particular divided by total number of incidents of that priority	Fortnightly
Reopen percentage	Total number of reopened incident divided by total number of incident	Fortnightly
SLA compliance(Percent)	(total number of incidents that are meets SLA divided by total number of incidents) * 100	Monthly
Average cost per incident	Total cost incurred divided by total number of incidents	Monthly
Resolved incidents per resource	Number of incidents resolved by each resource	Monthly
Incidents resolved remotely (percent of total incidents)	Total number of incidents solved remotely and divided by total number of incidents	Monthly
Incidents resolved using KEDB	Number of incidents that have KEDB entry	Monthly
Resolution rate (per hour)	Number of incidents resolved per hour	Monthly
Average resource utilization(Percent)	Is a ratio of the amount of time resource is engaged to the total time	Monthly
Reopen rate (per hour)	Number of incidents reopened per hour	Monthly
Problem Management		
Problems resolved	Number of problems resolved	Monthly
RFCs raised	Number of requests for change raised	Monthly
Average time to close a problem	Total time required to close problems divided by total number of problems	Monthly

SLA missed	Total number of problems that missed SLA	Monthly
Average cost to solve a problem	Total cost incurred divided by total number of problem	Monthly
Number of workarounds	Total number of workarounds proposed per month	Monthly
Total problem arrived	Total number of problems per month	Monthly
Percentage SLA met	(number of problems solved within SLA)/(total number of problems)	Monthly

Appendix II







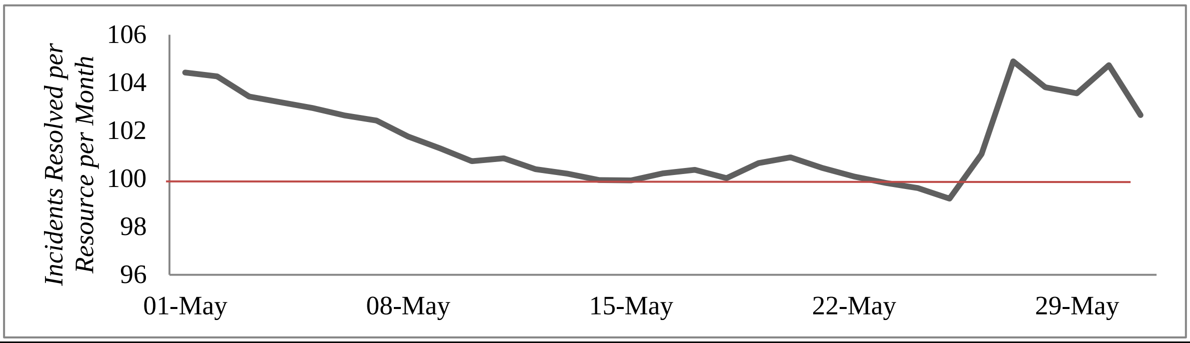
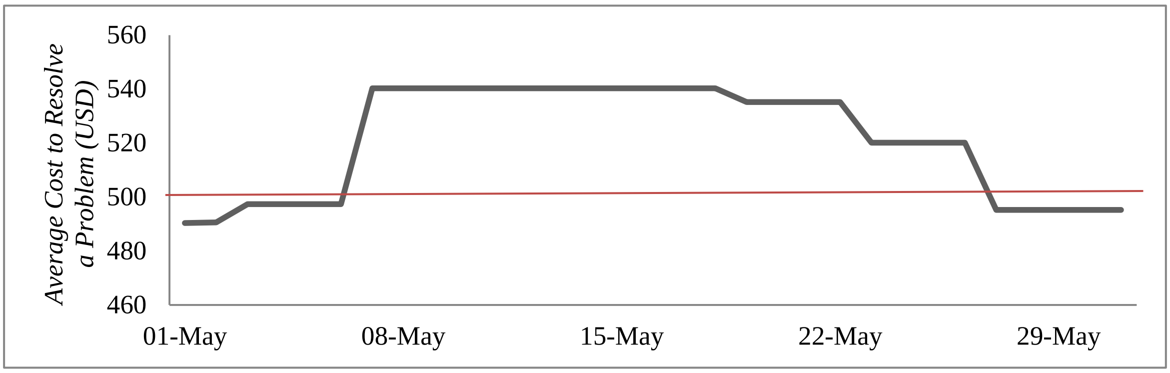
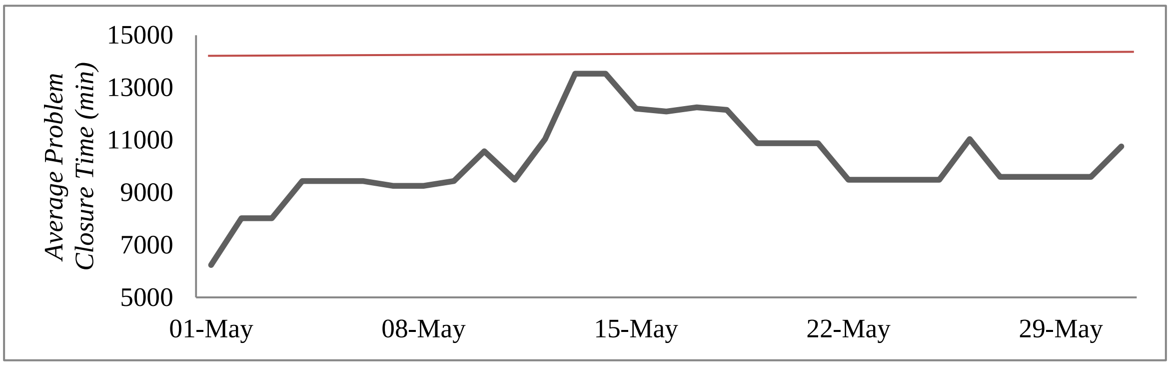
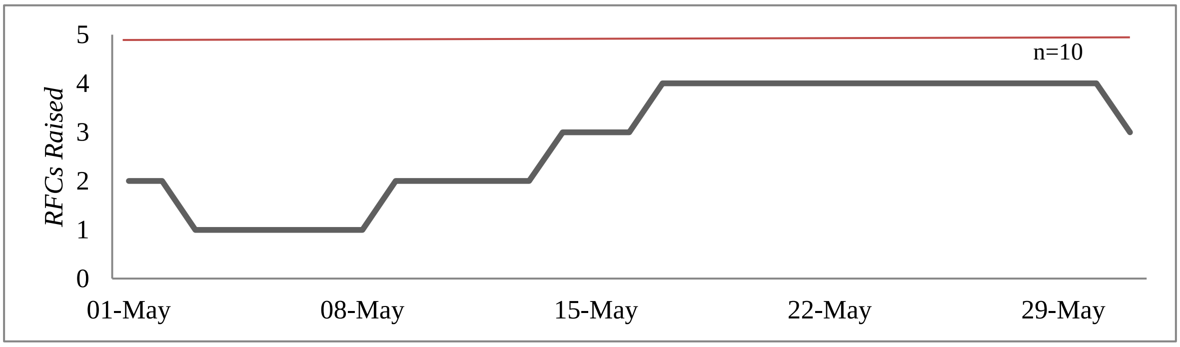


Figure5a: Input Data Stream of Metrics –Resource Utilization, Incident Service Time, Inter Arrival Time between Incidents and Incidents Resolved per Resource (Red line - Tolerance Level)







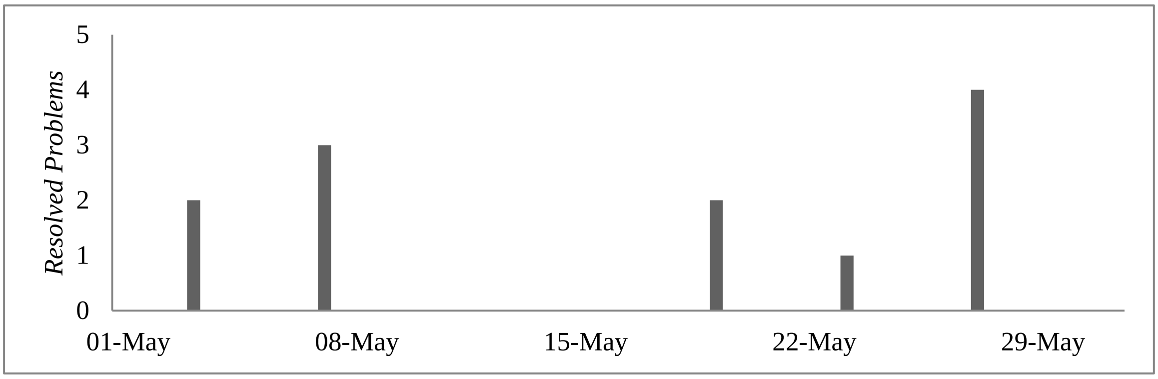


Figure5b: Input Data Stream of Metrics –Cost to Resolve a Problem, Problem Closure Time, RFCs Raised and Resolved Problems (Red line - Tolerance Level)