Software development and delivery performance measurement and management: Optimizing business value in software

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Introduction

Successful business executives and senior managers control their organization's performance by knowing their goals and measuring their business performance and results against them. They receive essential measurements soon enough to make any changes necessary for the desired results.

The same time-tested performance management practices can be and need to be applied to software development and delivery projects in order to optimize the business value in software. This becomes even more important in today's environment, where successful businesses use software to drive innovation and competitive differentiation. Apple's iPhone, for example, has captured and redefined the smart phone market by leveraging standard low-cost hardware components; at the same time, Apple is differentiating its products with great software and by building a platform that enables customers to run thousands of applications. Similarly, leading hybrid automobile manufacturers are using software in multiple operational modes for the vehicles to gain fuel efficiencies.

For years, software projects have charted a history of cost overruns, schedule slips, and quality issues. These challenges in effective software development and delivery have been well documented by the Standish Group and others. *

Add to these challenges today's current economic difficulties; business and technology executives are under increasing pressure to deliver innovative products and applications with fewer resources due to budget cuts. To address these challenges, business and technology leaders are reorienting their teams to focus on ROI and quantified business outcomes and to mitigate risk and reduce costs, according to a global survey of CIOs conducted by IBM in 2008. Other industry surveys find that aligning projects to achieve quantified ROI and mitigating risk is not a well-established discipline, with two-thirds of executives making more than half of their decisions based on "gut feel" rather than verifiable information, and 77 percent of all managers are aware that bad decisions have been made given lack of access to accurate information. These same managers report that poor decisions have resulted in a 75 percent loss of revenue against expectations.

** For example, only 34% of software projects are deemed successful, costing over $300B annually; 49% of budgets suffer overruns; and 62% fail to meet their schedules, according to "CHAOS Chronicles" v12.3.9, The Standish Group, June 30, 2008*

Highlights

Adding complexity to this, many executives find it difficult to measure the business outcomes associated with software, including things such as productivity and ROI. Many argue that the software industry lacks the ability to measure the effectiveness of software development and delivery, including any reasonable way to measure productivity or ROI. In order to measure productivity, one needs to monitor all the inputs into the business process of software delivery and at the same determine a way to measure outputs of this process.

Simply collecting measurements for their own sake will not result in business value. Instead, performance management must fit within the established team and tool constraints; any change to those constraints must be linked to the achievement of well-defined business goals.

It is misguided to assume that a team can make rapid, sweeping changes to its processes or scrap its tool suite and adopt a completely new one just to support performance management. Furthermore, simply collecting measurements for their own sake will not result in business value. Instead, performance management must fit within the established team and tool constraints; any change to those constraints must be linked to the achievement of well-defined business goals.

In this paper, we discuss the challenges in optimizing the business value in software, including the reasons current reporting and dashboard solutions have led to underused reports and dashboards, and we propose a new approach that addresses this challenge. Our performance measurement and management solution starts with identification of business outcomes and related measurements, and it provides senior decision makers with the information they need to leverage their software delivery process to drive innovation and achieve competitive differentiation.

Challenges in measuring the effectiveness of software projects

Some challenges in measuring and managing software projects arise due to separate teams focused on development, build, testing, and deployment each having stove-piped processes. This leads to lack of timely information and in-context, objective, and honest assessment and insight into the status of software delivery projects.

These challenges result even if all of the project members are co-located and working on a homogeneous environment. The picture gets more complicated when we add three additional dimensions commonly seen with many software delivery organizations:

Highlights

1. Geographical / regional distribution of team members adds:
- Poor communication
- Language, culture, time
- Process gaps resulting in rework

2. Crossing organizational boundaries leads to:
- Lack of effective collaboration
- Weak project governance
- Lack of domain expertise
- Poor LOB oversight
- Security of IP when outsourcing

3. Multiple team and heterogeneous infrastructure adds more challenges:
- Incompatible tools / repositories
- Unreliable access artifacts
- Lengthy on-boarding
- Inflexible tooling integration

The above barriers contribute to lack of timely and objective information and reports to allow business executives to manage the performance of their software projects against business outcomes they are striving for.

Obtaining timely and objective information is further complicated by the highly distributed nature of the software supply chain involving software procured from multiple vendors, homegrown and custom applications developed in-house, packaged or purchased applications, by outsourcers, contractors, leading to a very complex technology and organizational landscape for software delivery.

Limitations of current performance measurement and management solutions

Currently, there are many solutions available to address these challenges and they help to provide partial solutions. But ultimately, they fall short given the manual effort required and lack of an objective way to manage performance.

Currently, there are many solutions available to address these challenges and they help to provide partial solutions. But ultimately, they fall short given the manual effort required and lack of an objective way to manage performance. As an example, typical project measurements include manually collecting information such as percentage of work complete from each employee working on a project, then calculating earned value of the project.

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This information can be very subjective: for example, a given software developer may think his work is 100 percent complete, sjnce there were no defects found in the code. However, if one looks at the code coverage or requirements coverage of this code, one may notice some portion of the code remains untested, leading to finding defects late in the project cycle. More of these challenges and their causes are described in Table 1.

Table 1: Challenges with current performance measurement and management solutions for software delivery

ROOT CAUSES...	LEAD TO...	RESULTING IN...
Disparate data, sources, formats, & definitions	*Lack of connectivity to live data; status data input manually to PPM tools*	*Disconnect between planning and execution*
Lack of relevant, timely, & actionable information	*Reporting limited to only part of the ALM cycle (e.g., test, requirements, etc.)*	*Blind spots with no way to objectively assess progress in a collaborative, globally distributed ALM environment*
Inability to baseline & benchmark status and progress	*Weak management of report changes*	*Information typically outdated & not linked to business outcomes*
Inability to measure & assess inobtrusively	*No framework or best practices for converting data into information*	*Inability to manage performance; no understanding of what to measure or benchmark*

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Introducing performance measurement and management for software delivery projects

- Performance measurement is the process whereby an organization establishes the parameters within which projects, investments, and acquisitions achieve the desired business outcomes.

- Performance management is the process of continuously assessing software delivery progress and taking actions toward achieving predetermined business goals and to align individual objectives with organizational objectives.

Highlights

In order for companies to effectively manage the performance of their software delivery projects and initiatives, they will need to have effective performance measurement programs in place. Table 2 shows results from a recent study by Capers Jones, illustrating that companies who measure their software projects produce much higher results than those who don't.

Table 2: Does it help to measure performance of software projects? A recent study by Capers Jones (www.spr.com) shows that companies who measure their software projects produce much higher results than those who don't

	COMPANIES THAT MEASURE	COMPANIES THAT DON'T
On-time projects	75%	45%
Late projects	20%	40%
Cancelled projects	5%	15%
Defect removal	>95%	Unknown
Cost estimates	Accurate	Optimistic
User Satisfaction	High	Low
Software Status	High	Low
Staff Morale	High	Low

Organizations exercising world-class performance management practices enjoy a 2.4 times market return compared with typical companies.
- Business Week

According to a *Business Week* study (May 2008), "The Payoff of Pervasive Performance Management," organizations exercising world-class performance management practices enjoy a 2.4 times market return compared with typical companies.

In summary, effective performance measurement and management solutions focus on achieving continuous improvement of software delivery by measuring things such as cost against business outcomes. Table 3 shows examples of business results that can be achieved with a performance measurement and management solution.

Highlights

Table 3: Performance measurement and management solution return on investment (ROI): Improving value and efficiency, manage risk

IMPROVE PRODUCTIVITY	*IMPROVE OUTCOMES*	*CONTROL RISK*
Automate reporting to improve productivity by 10%	*Increase project ROI 33% from faster time to market*	*Prevent rework that drives projects over budget by an average 30%*
Reduce analysis-paralysis that eats up 10% of team time	*Reduce portfolio spending by 10% by stopping troubled projects*	*Prevent released defects that cost 1000x expected in maintainance expenses*

Based on these percentage improvements, Table 4 describes sample ROI based on a $10 million annual portfolio with 50 resources over a 5-year period.

Table 4: Sample Return On Investment (ROI)

GOAL	*ISSUE*	*INTENDED BENEFIT*	*BENEFIT/(COST)*
Improve productivity	*Waiting for decisions and manually collecting and reporting information can eat up to 20% of a resource's time*	*Improve productivity 20% through more directed and decisive activity across the team*	*$2,000,000*
Improve Outcomes	*Troubled and zombie projects continue to consume resources from valuable projects which can drive revenue as soon as they get to market*	*Stop troubled projects, reallocating to enhance the winners with faster time to market for more ROI*	*$1,000,000 (est)*
Control Risk	*Time-consuming and error-prone reporting fails to identify risks that cost 1000x per incident to fix, and drive project costs up an average of 30% in rework*	*Alerts and analytics prevents issues, reduces rework and maintenance costs, saving up to 20% on project costs*	*$2,000,000*
POTENTIAL BENEFITS			*$4,000,000*

Highlights

IBM believes that Web architecture and business intelligence systems can be married to produce a powerful performance management solution for software development.

An approach that addresses the customer pain points

Our approach to solving the performance management problem for software development organizations is based on two observations. First, many business units face similar performance management challenges due to the complexity and proliferation of operational systems used to implement typical business processes. Business Intelligence systems have been used in this context to collect, integrate, report, and analyze data to support effective performance management. Second, the World Wide Web is one example of a highly successful and scalable architecture that combines technologically diverse, geographically distributed applications. IBM believes that Web architecture and business intelligence systems can be married to produce a powerful performance management solution for software development; IBM has recently released the IBM Rational Insight product, designed in support of these ideas.

Figure 1 illustrates the high-level architecture of IBM Rational Insight, which is based on the standard architecture for business-oriented data warehousing applications.

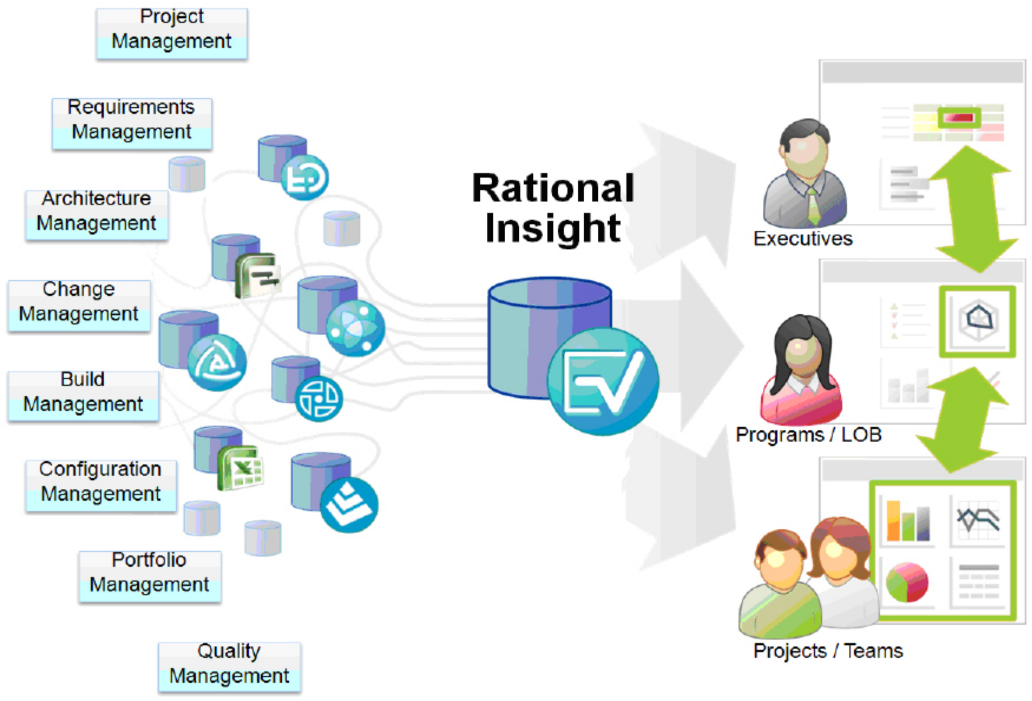

Figure 1: Rational Insight architecture

Highlights

At the left of Figure 1, we have the operational databases. These are the software development tool repositories for each domain such as project management, requirements management, architecture management, etc. Each of these repositories manages information about some portion of the overall development lifecycle. There may be multiple, geographically distributed instances of each type of repository from one or more vendors. The information in one repository is related to information stored in others, and only by integrating all of this information does a holistic picture of the development organization emerge. At the center is IBM Rational Insight, which is built on IBM Cognos Business Intelligence. Insight collects the information from the operational databases using Web protocols and stores it in a data warehouse which links all the information together and organizes it for efficient reporting and analysis. On the right we have the people who use the information, each accessing it with a tool appropriate to their role. For example, project team members may use Web browsers, program managers may use office products such as Microsoft Excel, and executives may use handheld devices such as BlackBerry. The information may be presented as tables, charts, pivots, dashboards, or scorecards, and users may set up notifications to alert them when significant events occur.

Web architecture

As noted above, software development organizations use a large variety of tools, often from multiple vendors, and some possibly developed in-house. Furthermore, the tools may be geographically distributed and used across organizational boundaries. The challenge is to access the data managed by these tools so that conclusions about development projects can be based on fact instead of "gut feel." These tools represent a significant investment. A performance management system must therefore work with the existing tool infrastructure. Web architecture offers a promising solution to this problem.

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The Web provides a highly scalable architecture for integrating multiple, heterogeneous, distributed, independently developed applications. The Web achieves this by using a small set of relatively simple standards, protocols, and formats such as HTTP and XML. These concepts can be applied directly to software development tools. IBM Rational has adopted these concepts in the Jazz Integration Architecture (JIA) which is both the foundation for a new generation of tools and an infrastructure for integrating legacy tools. The result is an architecture that supports performance management for large, globally distributed software development organizations.

Highlights

Web standards give us a way to access the data locked in proprietary repositories, but in order to flexibly query, analyze, and integrate it, we turn to another standard IT technology: business intelligence.

Business Intelligence

Software development activities generate a lot of data. However, this data is typically siloed in proprietary tool repositories where it cannot in general be flexibly queried, analyzed, or integrated with other data. Furthermore, a typical software tool repository may only store the current state of artifacts, making trend analysis impossible. Web standards give us a way to access the data locked in proprietary repositories, but in order to flexibly query, analyze, and integrate it, we turn to another standard IT technology: business intelligence.

As observed above, the problem of gaining insight into a holistic process based on data spread across multiple data sources is not unique to software development. Businesses regularly face this problem when attempting to understand core processes such as sales, inventory, or distribution. Over the years, business intelligence has emerged as the standard architecture to solve this problem. IBM Cognos 8 BI is an example of a market-leading business intelligence product, and we have integrated it into our performance management solution.

The central concept in business intelligence is the data warehouse, which is a special purpose database designed specifically for reporting and analysis. The databases used by the applications that support business processes are referred to as operational databases. They are typically designed for high transaction rates to support online transaction processing (OLTP). In contrast, the data warehouse is designed for reporting and analysis and supports online analytical processing (OLAP). The data warehouse may include a copy of the operational data which is referred to as the operational data store (ODS). More commonly, the data warehouse includes aggregated data, such as daily sales totals. This aggregated data is organized in a dimensional model that supports analysis of measurements (e.g., sales) along various attributes or dimensions such as time, geographic location, and product type. In the context of software development, a typical measurement would be the defect discovery rate, which would be analyzed along the dimensions of time, component, and severity.

Highlights

A project manager might schedule a defect analysis report to run nightly and be ready for review first thing in the morning. Report data items can be automatically monitored and alerts triggered when data values fall into a predefined range.

Business intelligence solutions provide easy-to-use report authoring tools. Ad hoc queries can be quickly created as required to answer questions on demand. More complex reports can be defined to satisfy recurring needs. Reports can be interlinked to provide drill down, drill up, and drill through capabilities to support data analysis and problem diagnosis. Reports can be run on demand or scheduled to run at set times. For example, a project manager might schedule a defect analysis report to run nightly and be ready for review first thing in the morning. Report data items can be automatically monitored and alerts triggered when data values fall into a predefined range. For example, a project manager might be emailed when defect arrival rates fall outside the predicted range.

The use of business intelligence has many advantages for software development organizations. It allows data to be collected and integrated across all aspects of the software development lifecycle. This gives managers a holistic view of their projects and enables them to explore the data so they can identify and resolve problems. The data warehouse maintains the history of data values across time. This timeline of data enables managers to objectively assess the benefit of process improvements, the effect of system age on maintenance costs, and other important trends. The value of the collected data increases over time since it provides a factual description of the organization's performance that can be used for planning future projects. Accurate estimation of project costs, schedules, productivity, and quality is a key strategy for reducing development risk.

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Clearly, we are only at the initial stage of applying business intelligence to software development. In the future, we can expect to see the emergence of a new discipline we might refer to as development intelligence. The following scenario illustrates how development intelligence can be used in performance management for software development organizations.

A performance management scenario

Imagine a software development organization in which all the tools across the entire development lifecycle provides secure, scalable, Web access to their data, and that this data is collected by a business intelligence system and stored in a data warehouse for reporting and analysis. Let's explore how you, as a project manager, would use such a system to monitor and control a development project to create the next release of a product.

Highlights

In the following scenario, the business goal is to grow market share. Customer satisfaction has been identified as a main contributor to growth, and quality has been linked to customer satisfaction. The team selects defect arrival rate as the relevant process metric to measure quality improvement. The team decides to improve quality by reducing the defect injection rate and plans to achieve this by adopting a development best practice such as code inspections or test-driven development.

- Your organization has prioritized quality improvement as a business goal in order to increase customer satisfaction and grow market share. In your planning for this project, you access the data warehouse and analyze the defect discovery rates on past similar projects. You use this objective data to estimate the baseline defect discovery rate for the current project. You work with your development team to identify a process improvement to reduce the defect injection rate and set correspondingly lower defect arrival rate targets for the current project. You also set targets for other project metrics such as productivity and test coverage. These are also based on the measured values from past similar projects. Your targets are not single numbers, but instead define a range of values (e.g., high-medium-low) to express your level of uncertainty or risk. You now have estimated lifecycle curves for a number of key software metrics and will use these to track progress.

Tracking your current project manually would be labor-intensive and error-prone. Instead, you rely on your business intelligence system to automatically collect measurements from your operational software development tool repositories and store these measurements in the data warehouse.

- The data warehouse provides past project measurements, which helps you define realistic targets for your current project. But tracking your current project manually would be labor-intensive and error-prone. Instead, you rely on your business intelligence system to automatically collect measurements from your operational software development tool repositories and store these measurements in the data warehouse. Defect metrics are collected from your change management system. Software growth metrics are collected from your configuration management system. Test activity metrics are collected from your quality management system. You define a set of dashboards and scorecards that compare the measurements to the estimates. You also set up alerts that inform you when a measurement differs significantly from the estimate.

Highlights

Is the process improvement working even better than expected, or is some other factor at play? Is the software being developed on track? Is the test coverage adequate?

- The project starts and proceeds as planned. You review the reports on a regular basis and all looks well. After one month, the defect discovery rate is tracking under the estimate and you feel that the new process improvement must be working. However, the next morning on your way to the office, you receive an email alert on your BlackBerry. The defect discovery rate has dipped below the lower limit of the estimate. Now you are concerned. On the one hand, an absence of defects might mean the team is producing much higher quality software. But on the other hand, the project is performing outside the expected parameters, so you need to understand why. Is the process improvement working even better than expected, or is some other factor at play? Is the software being developed on track? Is the test coverage adequate? Or did you simply over-estimate the defect discovery rate? You need more information.

- You arrive at your office and open your Web browser to your project dashboard page. This page shows gauges for several key metrics, including defect arrival rate. All of the gauges look OK except for the defect arrival rate as shown in Figure 2. The average defect arrival rate appears to be within the estimated limits, but the minimum rate is in the red zone indicating that at least one component is not on track. You click on the gauge and are taken to the defect scorecard, which shows the breakdown of defect arrival rates by component. Sure enough, one component is under the estimate and is trending down. You have isolated the component and now need to diagnose the cause.

- You now explore the data. Your first thought is that perhaps the development team has not been delivering the new features. You drill through from the defect arrival rate for the component to its source code growth chart. The code is under active development. You then drill into the data and determine which features the code changes apply to. You check the build history and see that the code was built successfully and the automatic unit tests were run. You check the test coverage and see that the test cases had adequate coverage for the new features.

Highlights

- The objective data is telling you that development is proceeding as planned and the quality of the new code is higher than you expected. You phone the quality assurance manager and ask him to assess the code quality. He confirms that the code appears to have high quality. Next, you phone the component lead and she tells you that the process improvement is having a very positive impact. The team was being conservative about its benefits since this was the first time they had used it. However, based on the experience to date, you should revise the estimates.

- At the end of the current iteration, you meet with the development team and review the impact of the process improvement. The team reports that the new process is working very well and agrees to further reduce their estimate for the defect arrival rate. This new estimate becomes part of the updated project baseline and will be used to track the next iteration. The team is on track to meet its business goal of improved customer satisfaction.

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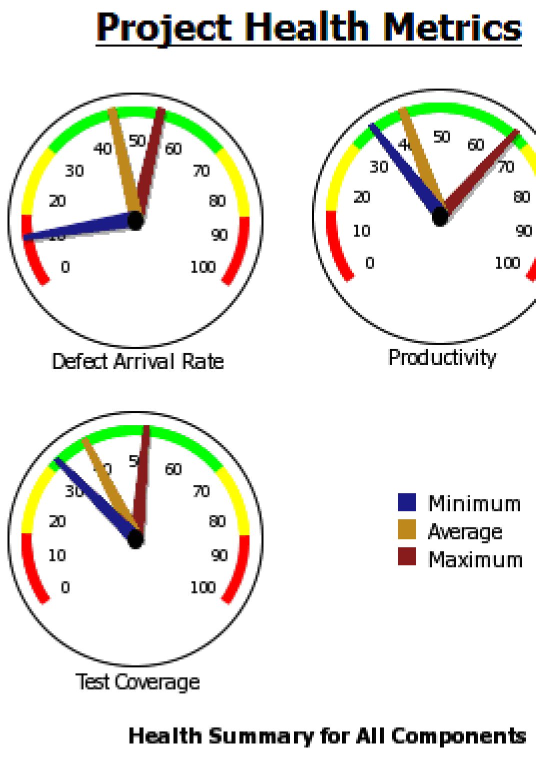

Figure 2: Project health dashboard

Highlights

In this scenario, the performance management system has provided the project manager with objective evidence that the quality of the current release will be better than previous one, and that this should improve customer satisfaction and drive revenue growth. This insight into the quality of the current release can also be used to derive additional immediate business value. For example, the lower defect injection rate should result in less testing effort. Some testing resources can therefore be released and made available to other projects. This translates into reduced cost for the project and increased capability for the development organization. More importantly, greater confidence in the quality may translate into reducing the length of the testing phase and accelerating the release of the product, thereby driving more revenue. Furthermore, by having objective evidence of the benefits of the process improvement, it can be rolled out across the development organization more rapidly, resulting in cost savings across the board.

Linking performance management to business value

Implementing a performance management program in a software development organization must be done in a focused and incremental manner if it is to succeed. The first step in performance management is therefore to identify the business goals and link those back to process metrics that will be monitored. These metrics become the key performance indicators (KPIs) for the development team. Once the process metrics are identified, the development team can explore ways to improve them.

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A word of caution is in order at this point. A potential pitfall of performance management is to confuse metrics with business goals. For example, incenting developers to find more bugs in the testing phase may cause them to allow more bugs to escape from the coding phase. The error here is to confuse the operational metric of defect discovery rate with the business goal of improving customer satisfaction. Metrics are merely a tool to be used in the attainment of business goals. It is important that all managers and team members understand this distinction so they are not motivated to attain metric targets at the expense of the business goals.

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Highlights

A target is only a reflection of how well the team can predict the course of the project. If a target is not achieved, the team must diagnose the root cause and take appropriate corrective action, which may well be to revise the target.

In our example, when the development team is told that post-ship defects are a major cause of customer dissatisfaction, they may come to the conclusion that they need to improve the defect removal efficiency of their testing processes, and that they will track their progress by measuring the defect discovery rate. They will look at the defect discovery rate on their previous project and set a new higher target for their current project. A target is only a reflection of how well the team can predict the course of the project. If a target is not achieved, the team must diagnose the root cause and take appropriate corrective action, which may well be to revise the target. The ability to accurately predict the cost, schedule, and quality of a software project — and the capability delivered by it — enables businesses to make informed decisions about the project's business value.

Finishing our example, suppose the development team also adopted an improved requirements definition practice, which had the beneficial effect of reducing the defect injection rate and therefore of also reducing the defect discovery rate. The fact that the team will now fail to achieve their increased defect discovery rate target is irrelevant, since the business goal of improved customer satisfaction is being served. In this situation the team will understand that the improved requirements definition process should lead to a reduced defect discovery rate. The team would decrease their defect discovery rate targets and expect to find fewer defects in testing. This lower target acts as a check that the requirements definition practice is working as expected. If in fact the actual defect discovery rate exceeds the lower target, this could be an indicator that the requirements definition practice is not being executed correctly.

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How can organizations adopt the right practices and measure their benefit?***

The process of linking business goals to development process metrics and of selecting best practices to improve these metrics may be daunting to many organizations. The software industry is home to a plethora of ever-changing advice on how to work better, much of it exaggerated or unsubstantiated. How can organizations adopt the right practices and measure their benefit? Organizations seeking help in this area can obtain guidance from sources such as the Software Engineering Institute Capability Maturity Model Integration (CMMI) or the IBM Rational Measured Capability Improvement Framework (MCIF).

Highlights

The organization's business goals must be directly linked to project metrics, and these must be collected automatically from the software development tools to ensure timeliness and accuracy.

The IBM Rational Measured Capability Improvement Framework
MCIF offers software development organizations a phased approach that helps teams adopt an incremental, measured method to transforming their software delivery capabilities. Teams are guided to focus on the core practices that matter most within their own organizations, and they are allowed to articulate capability improvements in terms of their unique business value. The adoption of these best practices is accelerated through out-of-the-box assets such as self-assessments, practice guidance, and metrics.

Conclusion

The lack of timely, objective information about software development projects can lead to bad decisions and poor results. To overcome this problem, organizations should adopt performance management programs. The organization's business goals must be directly linked to project metrics, and these must be collected automatically from the software development tools to ensure timeliness and accuracy. These metrics must be frequently monitored and compared against established targets. When significant variances are detected, the root causes must be diagnosed and corrective action taken. Development teams must identify and adopt incremental process improvements that are aligned with the desired business goals.

In order to successfully implement a performance management program, development organizations should adopt a phased approach such as MCIF to ensure that change is directly linked to business goals and is introduced at a pace that allows the organization to absorb it. Furthermore, due to the complexity of software development data and the diversity of the tool infrastructure, an appropriate architecture must be adopted. The combination of Web architecture and business intelligence promises to provide a powerful solution to this problem.

By adopting a performance management program and a supporting metric collection, reporting, and analysis architecture, software development organizations will benefit from deeper insight about their projects and the ability to make better, fact-based decisions. This deeper insight will yield higher business value from IT investments and promote the achievement of business goals.

The application of business intelligence to software development is in its initial stages. As the industry gains experience in its use, a new discipline of development intelligence will emerge.

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