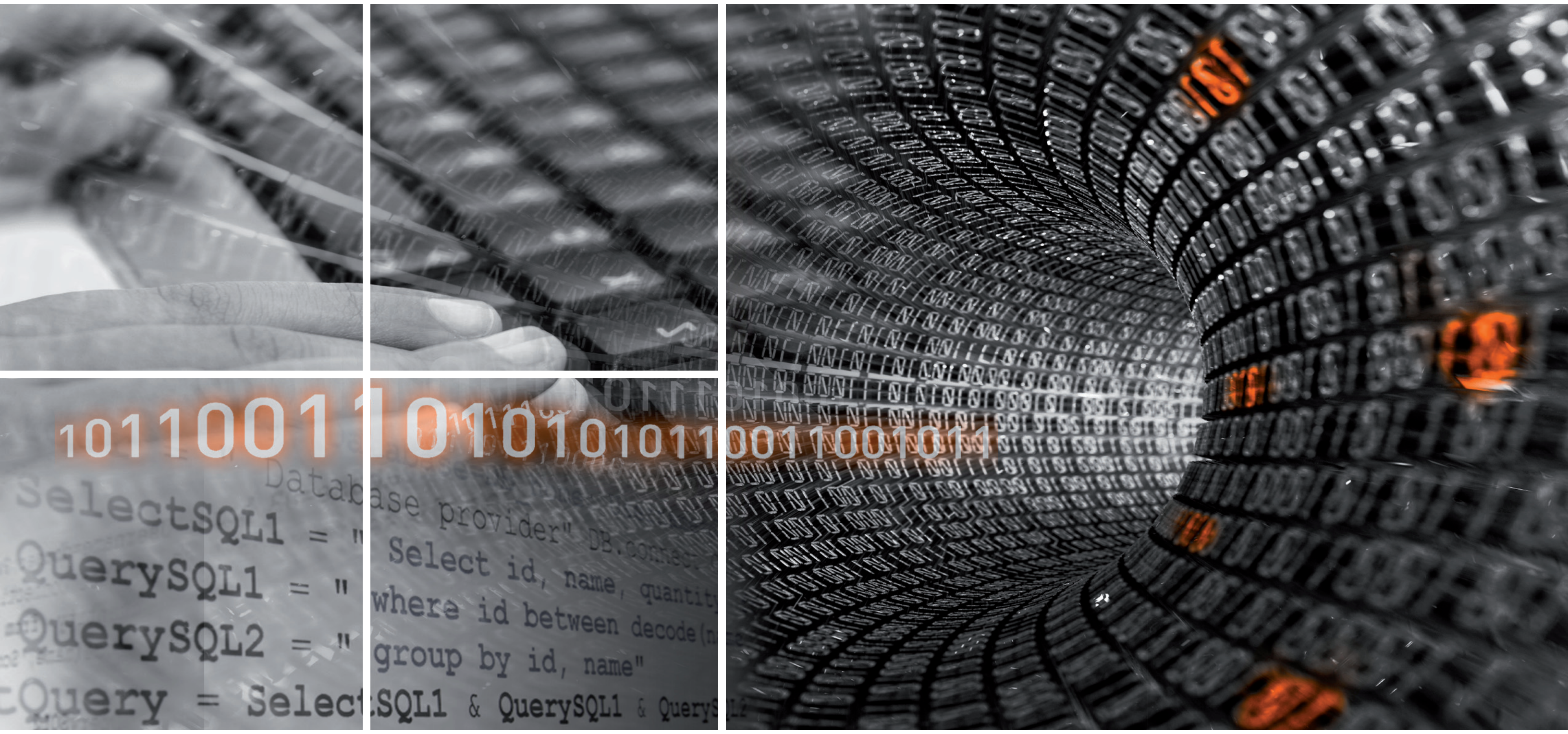


CAST Worldwide Application Software Quality Study – 2010

Summary of Key Findings

CAST
Achieve Insight. Deliver Excellence.

108 million lines of code

288 custom applications

75 organiza-tions

3 years of data collec-tion

Overview

This is the first in an annual series of reports highlighting trends in the structural quality of business applications regarding characteristics such as robustness, performance, security, and changeability.

Structural Quality - refers to the non-functional, internal properties of an application, that is, the engineering soundness of an application's architecture and coding rather than to the correctness with which the application implements functional requirements.

The purpose of these CAST reports is to provide an objective, empirical foundation for discussing structural software quality in both the public and the private sector. In this document we summarize some of the key findings extracted from the full report and will answer the following questions.

1. How much of an application's cost of ownership is caused by structural flaws hidden in its code?
2. Which technology and industry segement score high on application security?
3. Which technology scores lowest on structural problems that could degrade performance?
4. Which industry segment has applications that are the most difficult to enhance and maintain, and does outsourcing affect these results?
5. Does size affect the quality of an application?
6. What are the some of the most frequent violations of good architectural and coding practice?

Structural quality characteristics are critical because they are difficult to detect through standard testing, yet they are the most frequent causes of operational problems such as outages, performance degradation, breaches by unauthorized users, or data corruption. The full version of the report provides a deeper analysis of the structural quality characteristics and their trends across industry segments and technologies. In addition, the full version also presents the most frequent violations of good architectural and coding practice in each technology domain.

The Data Sample

The data in this report, collected over a period of 3 years, are drawn from 288 applications, representing 108 M lines of code (3.4 M Backfired Function Points), submitted by 75 organizations for static analysis of their structural quality characteristics. The results of these analyses are captured in Appmarq, a structural quality benchmarking repository maintained by CAST. These 75 organizations represent 8 industry segments: energy, finance, insurance, IT consulting, technology, telecommunications, manufacturing, and government. The organizations are located primarily in North America, Europe, and India. The applications range from 10,000 to 5 million lines of code, with 26% containing less than 50,000 lines of code and 32% falling between 50,000 and 150,000 thousand lines of code. Although these results may not characterize the entire global population of IT business applications, they do emerge from the largest sample of applications ever to be statically analyzed and measured against a full spectrum of structural quality characteristics across different technologies. Consequently, these results present a starting

Total cost of ownership estimates for projects need to add in $2.8 of technical debt per line of code

point for benchmarking the structural quality of IT business applications.

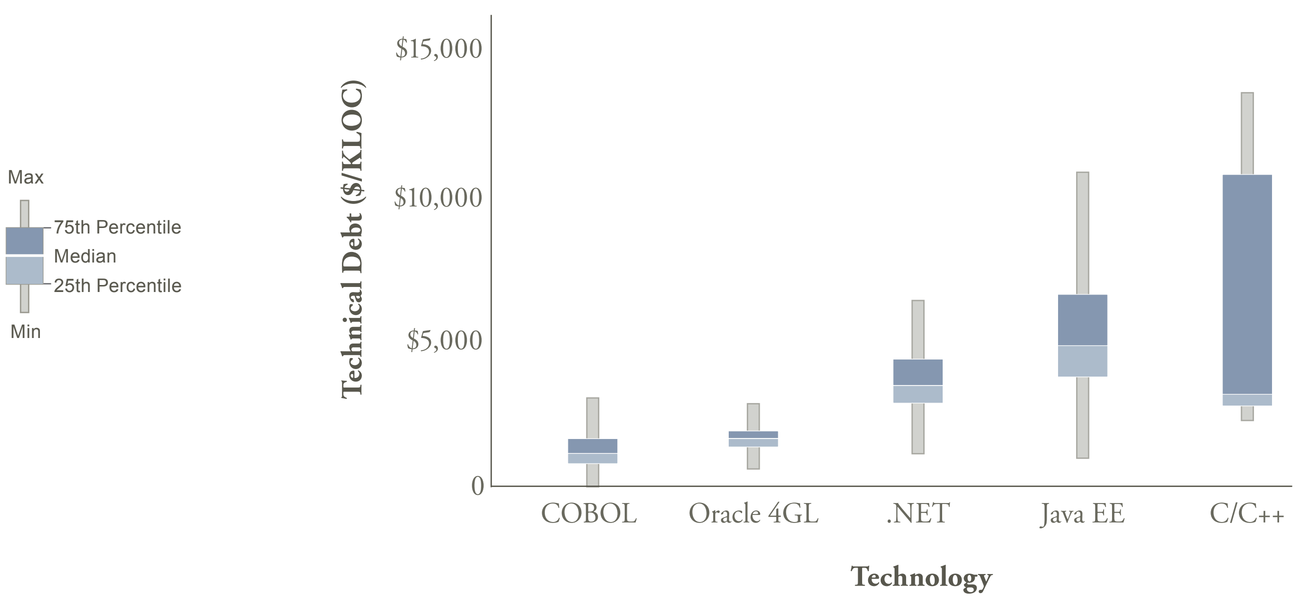
This summary will concentrate on four structural quality characteristics--robustness, performance, security, and changeability. These quality characteristics are computed by analyzing the source code to detect violations of good coding and architectural practice. Scores for each of the structural quality characteristics are aggregated from the component to the application level and computed on a scale of 1.0 (high risk) to 4.0 (low risk), using an algorithm that weights the severity of each violation and its relevance to each individual quality characteristic.

Finding 1—Over $1M of Technical Debt in Average Application

Since Technical Debt is a relatively new concept, there is little data on the Technical Debt of a typical application. CAST's Appmarq benchmarking database provided a unique opportunity to calculate an estimate of Technical Debt based on the number of structural quality flaws at the source code level. These data provide an objective, empirical frame of reference for the developer community. They also provide a platform for characterizing the management tradeoffs between expending resources on correcting

> **Technical Debt** - cost of the effort required to fix problems that remain in the code when an application is released to operation. Like financial debt, Technical Debt incurs interest in the form of the extra effort it takes to maintain and enhance an application due to the structural quality flaws left in the code.

Figure 1. Technical Debt by Technology



How We Calculate Technical Debt

1. The density of coding violations per thousand lines of code (KLOC) is derived from the source code analysis using the CAST Application Intelligence Platform. The coding violations highlight issues around Security, Performance, Robustness and Changeability of the code.
2. Coding violations are categorized into low, medium and high severity violations. In developing the estimate of Technical Debt, it is assumed that only 50% of high severity problems, 25% of moderate severity problems, and 10% of low severity problems would ultimately be corrected in the normal course of operating the application.
3. A conservative assumption is made that each problem would take only 1 hour to fix at a burdened cost of $75 per hour. Industry data suggest these numbers could be higher, especially when the fix is applied during operation.
4. Technical Debt = (10% of Low Severity Violations + 25% of Medium Severity Violations + 50% of High Severity Violations)*No. of Hours to Fix*Cost/Hr.

weaknesses in the source code versus risking the problems these flaws may cause such as outages or security breaches.

Using a conservative estimation model, described above, the average Technical Debt for applications in our sample is $2.82 per line of code. For the average-sized application of 374,000 lines of code in our sample, this translates into approximately $1,055,000 of Technical Debt. The cost of fixing Technical Debt is a primary contributor to an application's cost of ownership, and one driver of the high cost of IT.

Preliminary analyses displayed in Figure 1 show that C/C++ applications tend to have a wider distribution of Technical Debt results than applications built in other technologies, although a larger sample of C/C++ applications is needed to characterize this distribution reliably. Looking at the trend in Technical Debt across different technologies, it appears that the higher the level of abstraction in the technology, the lower the Technical Debt. Thus, the higher the level of abstraction, the fewer chances for developer to make mistakes because the platform/framework takes care of more low-level tasks.

Finding 2—COBOL Achieves the Highest Security Scores

The distribution of Security scores across the sample is presented in Figure 2. The bi-modal distribution of Security scores indicates that applications are grouped into two distinct types: one group that has very high scores on Security and a second group with modest scores and a long tail toward poor Security scores. The distribution of scores on Security is wider than for any of the other quality characteristics, suggesting strong differences in attention to Security among different types of applications or industry segments.

Security - Attributes that limit the risk of unauthorized intrusion into the data being managed by the application.

Further analysis presented in Figure 3 reveals that applications with higher Security scores are predominantly large mainframe and COBOL applications in the financial services sector where high security for confidential financial information is mandated.

COBOL applications in Financial Services score the highest in terms of Security

Mainframe-based applications are also less exposed to the security challenges posed to Web-facing applications. Nevertheless, the lower Security scores for other types of applications is surprising. In particular, .NET applications received some of the lowest Se-

Figure 2. Distribution of Security Scores

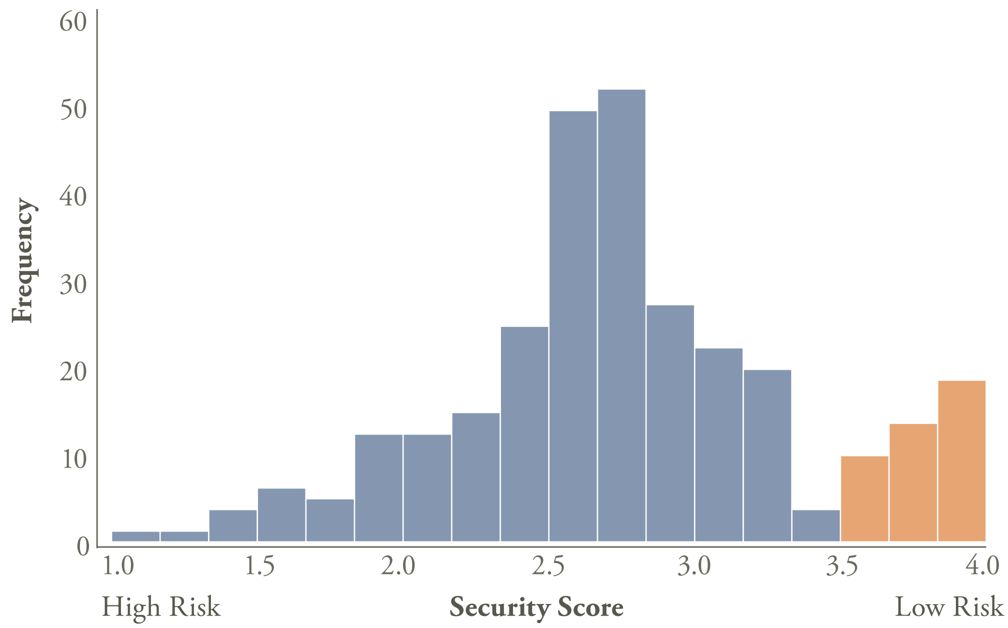
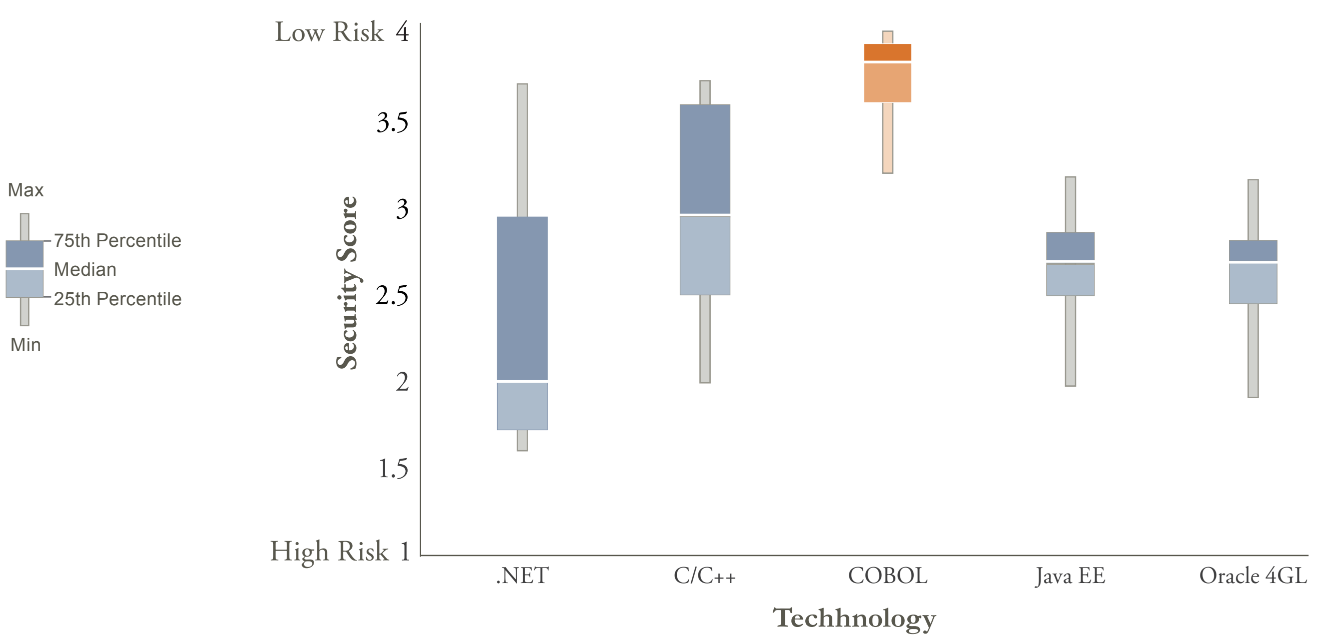


Figure 3. Security Scores by Technology



Overall IT maintenance costs are driven by changeability of the applications

curity scores. These data suggest that the IT community's attention to security may be primarily driven by compliance regulations within industry segments.

Finding 3—Government Systems Least Maintainable

Changeability scores presented in Figure 4 exhibit a bi-modal distribution indicating important differences in the maintainability of applications across our sample. Since the Changeability of an application is a critical driver of its cost of ownership, this distribution suggests large differences in the costs of ownership between applications with high and low Changeability scores.

Changeability - Attributes that make an application easier and quicker to modify.

We compared Changeability scores by industry segment. The results presented in Figure 5 reveal that scores for applications in the public sector are significantly lower than those in other segments. Our sample included applications from national governments in both the US and EU. Although we do not have application cost data, these results suggest that government agencies are spending significantly more of their IT budgets on maintaining existing applications than on creating new functionality. Not surprisingly, in their 2010 IT Staffing & Spending Report Gartner reported that the government sector spends about 73% of its budget on maintenance, higher than almost any other segment.

Poor changeability scores in the government sector may be partially explained by the high percentage of outsourced applications in the government as compared to the private sector. Figure 6 reveals that 75% percent of the government applications in this sample were outsourced compared to 51% for the private sector. When government applications were removed from the sample, there was little

Figure 4. Distribution of Changeability Scores

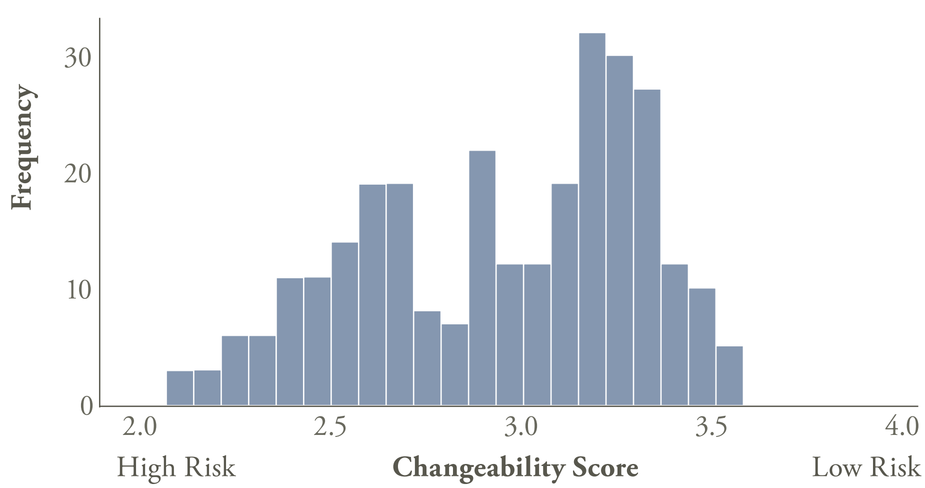
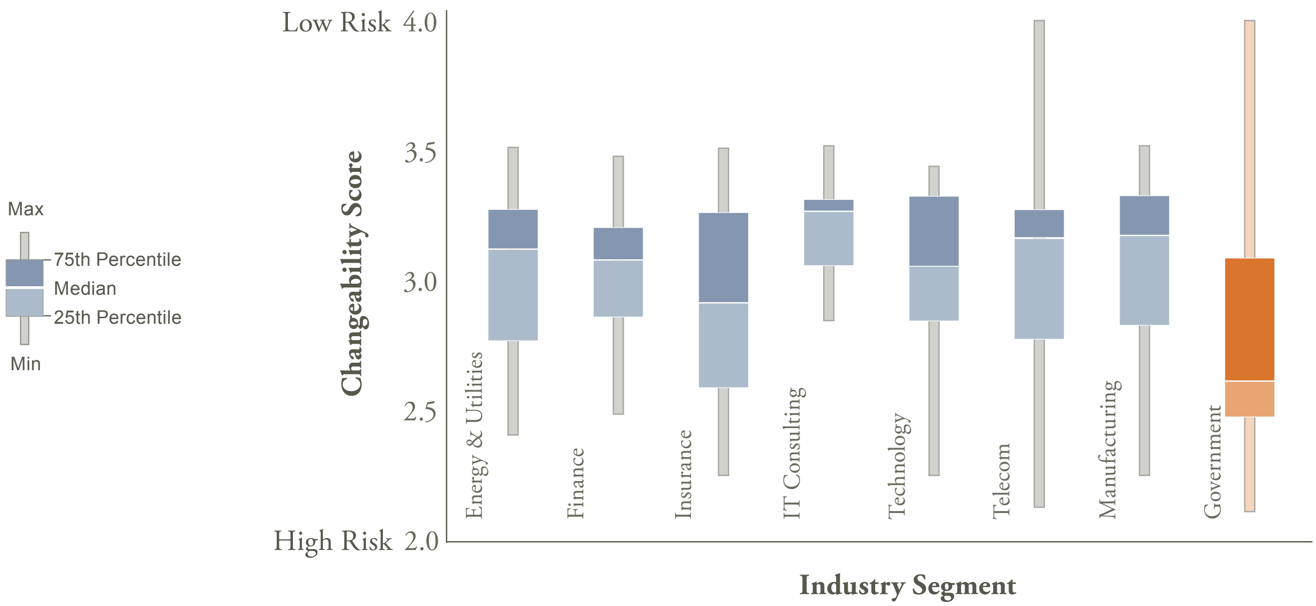


Figure 5. Changeability Scores by Industry Segment



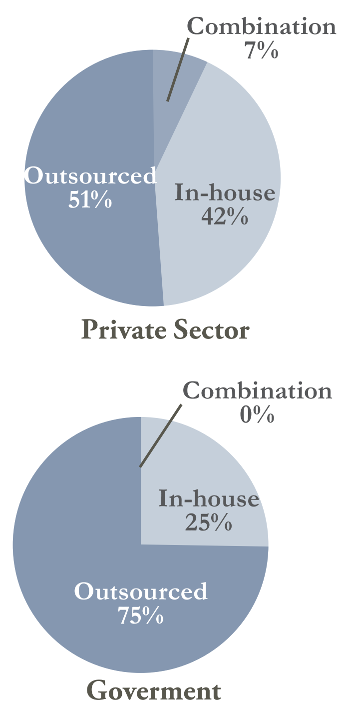
Less changeable code partially explains Government's higher maintenance costs

difference between the Changeability scores for insourced and outsourced applications. The lower Changeability scores for government agencies may partially result from conditions unique to their acquisition. Multiple contractors working on an application over time, disincentives in contracts for building easily maintained code, and challenging acquisition practices are potential explanations for the Changeability scores for government applications. In contrast, IT Consulting had the highest median and smallest range for the applications they build for their own internal use.

Finding 4—Newer Languages Score Lower in Performance and Robustness

Scores for Performance were widely distributed as displayed in Figure 7a, and in general are skewed towards better performance.

Figure 6. % of Outsourced Applications in the Public and Private Sectors



In contrast, scores for Robustness were the most tightly clustered of all the quality characteristics, with a slight negative skew.

The trend observed in Performance scores might be explained by hypotheses that involve both technology and people factors. First, the availability and use of automated

Performance - Attributes that affect the responsiveness and efficiency of applications.
Robustness - Attributes that affect the stability of an application and the likelihood of introducing new defects when modifying it.

Figure 7a. Distribution of Performance Scores

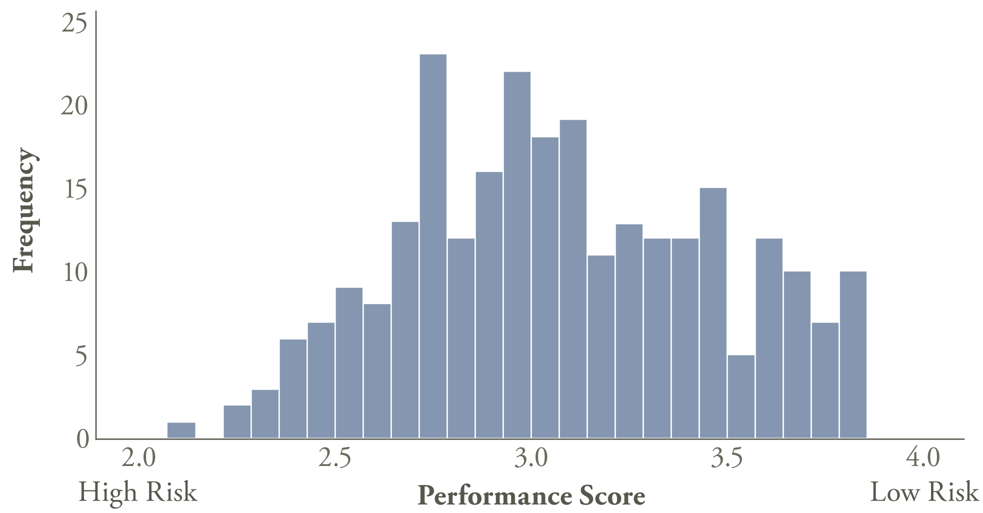


Figure 7b. Distribution of Robustness Scores

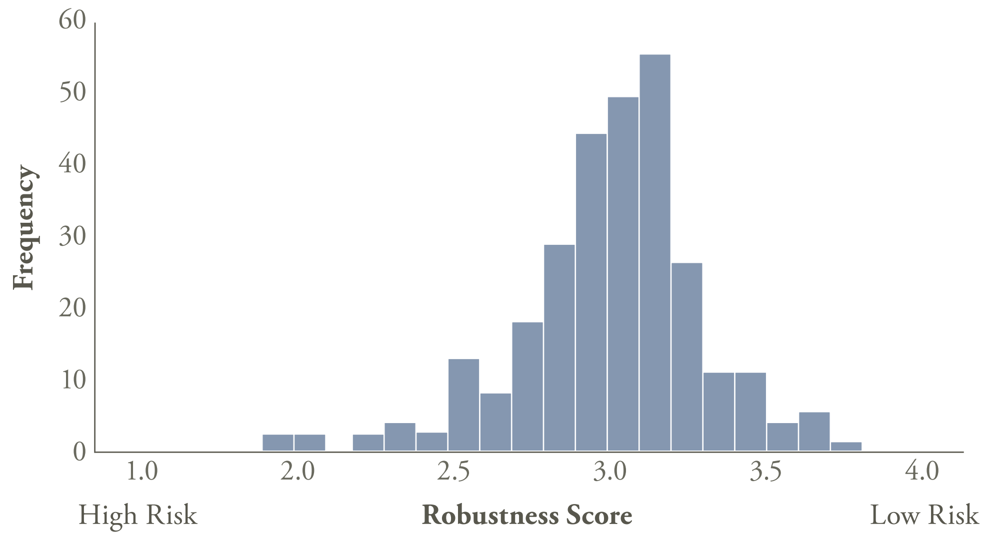
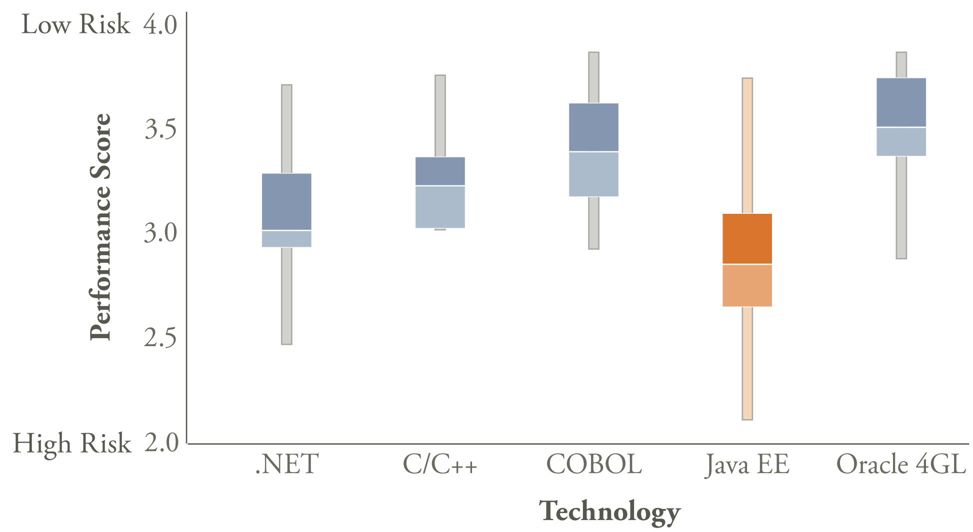


Figure 8a. Performance Scores by Technology



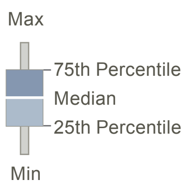
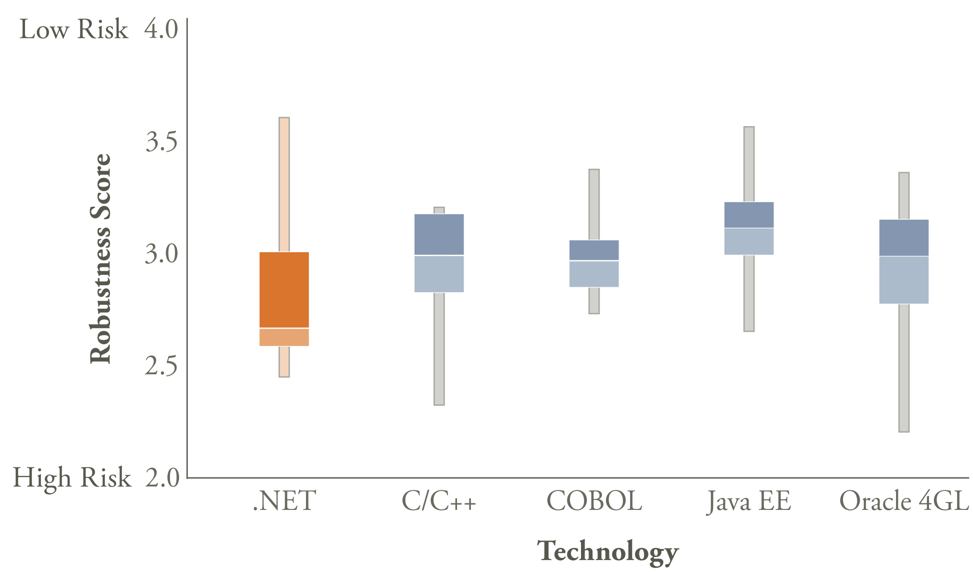


Figure 8b. Robustness Scores by Technology



performance testing solutions has made performance problems easier to detect and address during development. Most modern testing platforms have embedded modules to test the performance of applications. Although they do not check the performance issues at the code level, they do highlight bottlenecks and attune developers to critical performance problems that could slow down an application or cause it to crash. Organizations using these tools would be expected to post high Performance scores. Second, performance is one of the most visceral quality characteristics, especially to end users whose

In newer technologies, quality does not decrease with size

productivity it impacts. It is not uncommon for end-users to complain vociferously to the development team about slow performance, prioritizing the remediation of performance problems over other quality problems such as poor maintainability.

Further analysis of these data presented in Figure 8a reveals that Java EE applications were found to have significantly lower Performance scores than other languages. .NET applications displayed the same trend, but not as strongly as Java EE. However, modularity might partially explain the lower Performance scores in .NET and Java EE, as discussed in Finding 4, since poor design or excessive modularity can adversely impact on the performance of applications.

Finding 5—Modularity Minimizes the Effect of Size on Quality

Appmarq data contradict the conventional wisdom that the quality of an application decreases as it grows larger. With one exception, the Total Quality Index (a composite of the four quality characteristic scores) failed to correlate significantly with the size of applications in this sample. However, the Total Quality Index did correlate negatively with the size of COBOL applications as is evident in Figure 9 where the data are plotted on a logarithmic scale to improve the visibility of the correlation.

One explanation for this negative correlation is that COBOL does not encourage modularity, resulting in applications possessing many large and complex components. The design of more recent languages encourages modularity and other techniques that mitigate the affect of complexity as applications grow larger. For instance, Figure 10 shows that the percentage of highly complex components (components whose Cyclomatic

Figure 9. Correlation of Total Quality Index With the Size of COBOL Applications

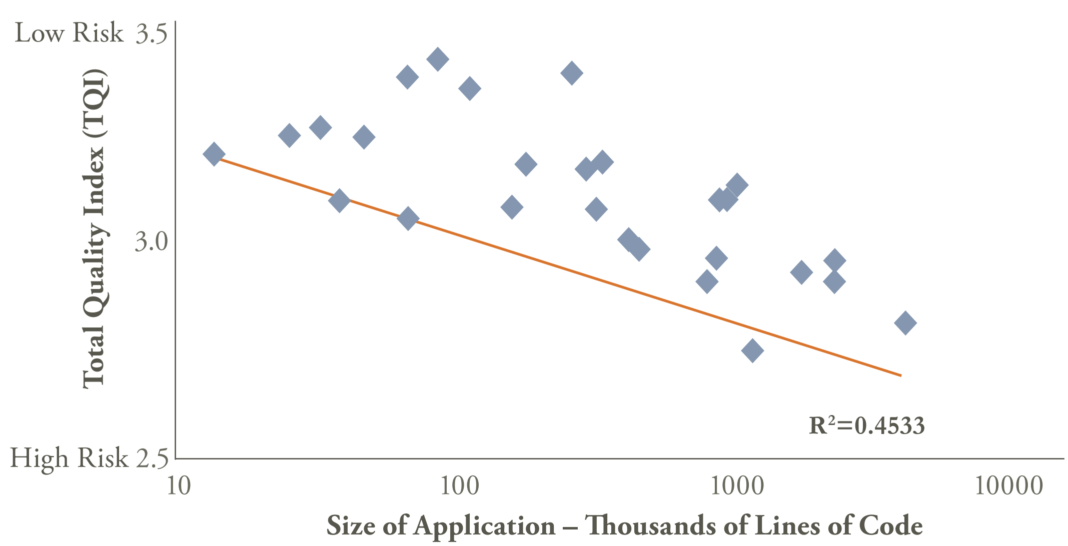
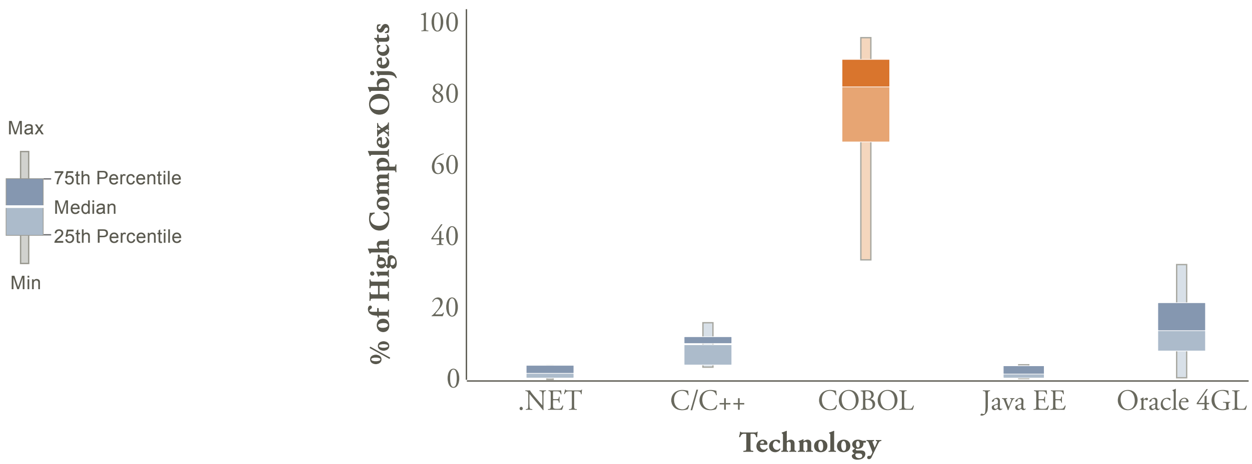


Figure 10. Percent of Components That are Highly Complex in Applications



Complexity is 30 or greater) in COBOL applications is much higher than in other languages, while for the newer Object Oriented Technologies like Java EE and .NET this percentage is lower, consistent with the objectives of object-oriented design. Modularity can also explain the poor Performance scores in .NET and Java EE, as discussed in Finding 4, since high levels of modularity can adversely impact the performance of applications.

Finding 6—The GOTO Is Eternal (and other top violations)!

The following two findings highlight common mistakes being made by developers. The full version of the report provides lists of the top violations by technology domain.

GOTO Considered Eternal: It has been more than 40 years since the eminent computer scientist, Prof. Edsger Dijkstra, assailed the GOTO statement as a construct that made programs needlessly complex and defect-prone. Dijkstra's letter to the editor of the Communications of the ACM in 1968 titled 'GOTO Considered Harmful' is often regarded as the beginning of the structured programming movement, a collection of practices now taught in every introductory programming course.

Although most modern programming languages have eliminated the GOTO statement, older languages such as COBOL still allow them. It is then shocking to observe that there were 334,249 GOTO statements detected in the 33.4 million lines of code contained in the 30 COBOL applications analyzed in this study -- roughly 1 GOTO statement in every 100 lines of code! Even after years of maintenance and refactoring, these damaging constructs still infest COBOL applications, suggesting that, like cockroaches, GOTOs are eternal.

Hidden Complexity: A common violation occurring frequently across most technolgies is high fan-out of connections to other components in the application. This violation oc-

IT executives are yet unable to master the tradeoff between immediate pain and long term cost

curred frequently in Java, .NET, COBOL, ABAP, and C/C++. The application-level complexity associated with high fan-out components dramatically increases the time required to make changes or enhancements to the application. The more complex the connections between components, the longer it takes to design, implement, and test a change, thus driving up the cost of ownership and increasing the time needed to deliver functionality to the business.

Observations such as these indicate that best design and coding practices are often slow to be adopted. In some cases organizations do not want to reduce the complexity of code that appears to be running correctly, even if cost of ownership and time to deliver enhancements could be reduced by refactoring the code. These observations may also identify the need for continued developer training in best design and coding practices.

Summary of Key Findings

Results reported in the previous sections revealed the following trends in the structural quality of business applications:

1. COBOL programs achieve the highest scores for security.
2. Newer technology platforms like Java EE and .NET showed poor Performance scores, relative to Mainframe or 3GL technologies.
3. Public Sector applications showed significantly lower Changeability scores, consistent with reports of higher maintenance spend in the public sector compared to the private sector.
4. The conventional wisdom that the quality of an application decreases as its size increases is not true so long as the application is properly modularized. Modularity helps reduce the complexity introduced by growing size of applications.
5. The average business application, about 374K lines of code, has over $1 Million in Technical Debt.
6. Even 40 years after the eminent computer scientist Edsger Dijkstra assailed the GOTO statement as a construct that made programs needlessly complex and defect-prone, there is, on average, 1 GOTO statement in every 100 lines of COBOL code! Coding best practices are slow to be adopted.

The observations from these data suggest that development organizations are focused most heavily on performance and security in certain critical applications. Less attention appears to be focused on removing the maintainability problems that increase the cost of ownership and reduce responsiveness to business needs. These results suggest that IT executives are still mostly in reaction mode to immediate business demands rather than being proactive in addressing the long-term causes of IT costs.

CAST Research Labs

CAST Research Labs (CRL) was established to further the empirical study of custom software implementation in business technology. Starting in 2007, CRL has been collecting metrics and structural characteristics from custom applications deployed by large, IT-intensive enterprises across North America, Europe and India. This unique dataset, currently standing at approximately 500 applications, forms a basis to analyze actual software implementation in industry. CRL focuses on the scientific analysis of large software applications to discover insights that can improve their structural quality. CRL provides practical advice and annual benchmarks to the global application development community, as well as interacting with the academic community and contributing to the scientific literature.

As a baseline, each year CRL will be publishing a detailed report of software trends found in the industry repository. The executive summary of the report can be downloaded free of charge by clicking on the link below. The full report can be purchased by contacting the CAST Information Center at +1 (877) 852 2278.

Authors

Jay Sappidi, Technical Director, CAST Research Labs

Dr. Bill Curtis, CAST Chief Scientist and Senior Vice President, CAST Research Labs

Dr. Jitendra Subramanyam, Director of Productivity Research, CAST Research Labs

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