World Quality Report
Contents

Introduction 04
Executive Summary 06
Current Trends in Quality Assurance & Testing 14
  Key trends in IT 16
  Artificial intelligence 22
  Test automation 26
  The quality assurance organization 31
  Test data and environments management 36
  Efficiency and cost containment in quality assurance 40
Sector Analysis 44
  Automotive 46
  Consumer Products, Retail, and Distribution 49
  Energy and Utilities 51
  Financial Services 53
  Healthcare and Life Sciences 56
  High-Tech 58
  Government and Public Sector 60
  Telecom, Media, and Entertainment 63
About the Study 66
About the Sponsors 70

Previous Editions
World Quality Report

2009 First Edition
2009–10 Second Edition
2009-11 Third Edition
2010-11 Fourth Edition
2011–12 Fifth Edition
2012-13 Sixth Edition
2013-14 Seventh Edition
2015-16 Eighth Edition
2016–17 Ninth Edition
Regional and country reports are available online from www.worldqualityreport.com or from Capgemini, Sogeti, and Micro Focus local offices covering: North America, United Kingdom, France, Germany, Benelux, Southern Europe (covering Italy, Spain, and Portugal), Eastern Europe (covering Poland, Hungary, and the Czech Republic), China, Australia and New Zealand, the Middle East, and the Nordic Region.

World Quality Report
2018–19
Tenth Edition
Welcome to the tenth edition of the World Quality Report (WQR) by Capgemini, Sogeti, and Micro Focus—a comprehensive and balanced overview of the key trends shaping quality assurance (QA) and testing today.

This year's WQR is based on a survey of 1700 executives from across 10 different sectors and 32 countries. If you are one of them, I thank you for your time and inputs. I would also like to thank our subject matter experts, lead authors for their invaluable insights and analysis, as well as the team that worked on this report.

At a very broad level, the report shows just how far QA and testing has come, from being seen mostly as a supporting function, to one that is critical to business outcomes and customer satisfaction. This has led to the increasing importance of the ‘quality at speed’ paradigm, and is a key factor driving many of the other trends we see in this report.

Trends in focus include the growth in adoption of agile and DevOps, the spread of digital transformation, the move away from Test Centers of Excellence (TCOEs) and the continuing low levels of basic automation that have become a critical bottleneck to the further evolution of QA and testing.

In addition, the report also points to regulatory and infrastructural challenges like handling test data, provisioning environments, and finding the right talent required for testing. We also see the criticality of adopting greater levels of automation to help solve some of these challenges.

Finally, we see emerging trends such as the Internet of Things (IoT), blockchain and the convergence of analytics, artificial intelligence (AI) and machine learning (ML) transforming the QA and testing function in the future.

The report contains an in-depth look into the above topics through six theme chapters. This is followed by eight sector chapters, which provide an additional analysis of the important QA and testing trends in these sectors. To understand the implications of these developments for your organization, I would encourage you to get in touch with Capgemini and Sogeti experts listed on the back-cover.

I hope you enjoy reading this report and that it gives you some serious food for thought. Happy reading!
In a digital economy, enterprises must compete through faster innovation and the delivery of high quality software that satisfies their end-user’s needs. At the same time, organizations must reconcile the competing concerns of enhanced quality and security, improved responsiveness to business demands, and optimizing budgets and resources.

Over the past decade or so, organizations have adopted agile and DevOps methodologies to achieve these goals, and are now scaling beyond just one or two teams to the entire enterprise. This is true of organizations worldwide, and across every vertical.

On the journey to scale, organizations face new challenges, such as end-to-end automation, and completing their testing quickly. This is due to a number of factors, such as not having enough time to test, or not having a secure, integrated, and automated build and test environment that supports open source and third-party tools.

The results from this tenth edition of the World Quality Report are conclusive: all but one percent of organizations are now using DevOps practices in their organization. Their focus is no longer on whether to move to DevOps; rather how to refine their DevOps approach and continuously improve. This may entail greater automation into continuous integration and deployment pipelines, accelerating collaboration and faster feedback, uncovering and eliminating bottlenecks, and ensuring uncompromising stability, reliability and security in production.

The World Quality Report is an in-depth analysis of responses from executives in medium to large organizations, and will help you to understand their challenges, how they are overcoming them, and current and upcoming trends in software quality. I recommend that you read the report and the analyses, and in particular, the recommendations and key takeaways which you can use to take your digital transformation to the next level.

With valuable lessons learned through our own DevOps transformation, we at Micro Focus are in a unique position to help our customers on their DevOps transformation, whether they are implementing solutions around cutting edge technologies such as the Internet of Things or blockchain; legacy technologies such as Cobol and mainframe computers; or both, a common scenario among our larger and more established customers.

Finally, I’d like to thank our friends and partners at Capgemini and Sogeti, and everyone who helped in the research by participating in this edition of the World Quality Report.
The role of quality assurance (QA) and testing has changed from mere defect finding to one of being an enabler of customer satisfaction and business outcomes. This is a fundamental change and its impact can be seen in almost every chapter of this year’s World Quality Report (WQR), which is based on a survey of 1,700 CIOs and other senior technology professionals from across 10 different sectors and 32 countries.

The most telling result which demonstrates this shift in outlook, is related to QA and testing objectives. According to our respondents, the top objective of their QA and testing strategy was “ensure end-user satisfaction,” (with a weighted average score of 5.85). The expectation that QA and testing should contribute to end-user satisfaction has grown over the years and would have been completely unthinkable ten years ago. Today, however, the increasing customer-centricity driving major IT trends such as digitalization of business and the adoption of agile, DevOps, and cloud, is also shifting the objectives and expectations for QA.

Important aspects of IT strategy, according to the WQR survey sample

<table>
<thead>
<tr>
<th>Objective</th>
<th>2018</th>
<th>2017</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhance security</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Enhance customer experience</td>
<td>35%</td>
<td>36%</td>
<td>36%</td>
</tr>
<tr>
<td>Higher quality of software solutions</td>
<td>42%</td>
<td>44%</td>
<td>41%</td>
</tr>
<tr>
<td>Higher responsiveness to business demands</td>
<td>31%</td>
<td>35%</td>
<td>33%</td>
</tr>
<tr>
<td>Cost optimization of IT</td>
<td>38%</td>
<td>42%</td>
<td>42%</td>
</tr>
<tr>
<td>Cloud transformation</td>
<td>35%</td>
<td>35%</td>
<td>33%</td>
</tr>
<tr>
<td>Faster time to market</td>
<td>34%</td>
<td>34%</td>
<td>33%</td>
</tr>
<tr>
<td>Increased output</td>
<td>39%</td>
<td>36%</td>
<td>36%</td>
</tr>
<tr>
<td>Implement third-party SaaS</td>
<td>35%</td>
<td>35%</td>
<td>35%</td>
</tr>
<tr>
<td>To implement agile or DevOps</td>
<td>36%</td>
<td>38%</td>
<td>38%</td>
</tr>
<tr>
<td>New statement</td>
<td>22%</td>
<td>37%</td>
<td>37%</td>
</tr>
<tr>
<td>Implement agile or DevOps</td>
<td>23%</td>
<td>36%</td>
<td>37%</td>
</tr>
</tbody>
</table>

*New statement*
Key trends driving IT today

The focus on customer-centricity drives digital transformation and requires IT systems which can deliver attributes such as speed, convenience and security all of which add up to a good customer experience. The importance of such attributes was clearly demonstrated in our survey results. When asked about the objectives of their IT strategy, respondents gave the highest weighting to objectives such as “enhancing security” (average weight of 5.97), followed by “enhancing customer experience” (average weight of 5.86), and ‘higher responsiveness to business demands’ (average weight of 5.73).

We also see encouraging signs of adoption for technologies such as IoT and blockchain. The number of organizations that work with IoT in some form has increased from 83% last year to 97% this year. There is also a lot of focus on blockchain, with 60% of our respondents saying that they are already using blockchain in their portfolio or planning to use it in the coming year.

According to our survey, 57% of respondents said they had projects involving the use of AI for QA and testing, already in place or planned for the next 12 months.

Today, an average 76% of applications across organizations are based in the cloud. The adoption of cloud and the growth in connectivity and open architectures have led to an increased focus on security. As mentioned above, the top objective for IT strategy today is “enhancing security.” Despite this, organizations still do not have a clear strategy for security validation, with concerns around security being driven more out of fear than the growth enabling abilities of well-thought out security strategy.

Another key development is that while IT trends such as cloud, blockchain and IoT have not caused a major shift of testing approaches, they all require specific technical expertise. Working with cloud requires cloud and infrastructure expertise, blockchain calls for blockchain architecture knowledge and IoT requires engineering expertise in the QA and testing teams. The need for new skills as well as newer roles in QA and testing teams is a recurring theme which comes up in a number of different chapters in this report.

The role of artificial intelligence in QA and testing

The growth of artificial intelligence (AI) has two complementary influences on QA and testing. First of all, AI will enable enterprises to transform testing into a fully self-generating, self-running, and self-adapting activity. Secondly, AI developments require a new specific approach to validation and verification. The use of AI in testing is still in the initial stages, with organizations applying smart analytics to drive critical decisions that help optimize test activities and do early quality predictions. According to our survey, 57% of respondents said they had projects involving the use of AI for QA and testing, already in place or planned for the next 12 months. 45% of our respondents said they were using AI for intelligent automation in testing. In addition, 36% said they were using AI for predictive analytics in testing and 35% said they were using AI for descriptive analytics in testing.

The testing of AI products is still emerging as a requirement. At present, there is no coherent, widely accepted approach, guideline or solution for such testing and hence, organizations are experimenting with various approaches. This also came through in our survey, where 57% of respondents said that they were experimenting with new testing approaches for the testing of AI and ML elements.

There are still many challenges when it comes to AI in IT. For instance, a full 55% of our respondents said that the challenge they faced when setting up AI projects was in identifying where business might apply AI. The use of AI in testing is also likely to require newer skills and create newer roles such as AI QA strategists, data scientists, and AI test experts in QA and testing teams.

Irrespective of all these challenges, we believe that AI is going to be one of the biggest trends in QA and testing for the next two to three years and organizations will need to develop a strategy around it. They will first need to reach a certain level of maturity in automation, then go about implementing analytics and then work towards creating self-learning, self-aware systems that can be applied to testing.

Agile, DevOps and TCOEs

The adoption of agile and DevOps is driven by the dictum of “Quality at Speed” and has reached a critical mass today with 99% of our respondents reporting that they were using DevOps in at least some of their projects. Unfortunately, in some places this adoption of agile and DevOps has led to a focus on speed even at the cost of quality. Our survey also reveals that organizations are customizing Agile and combining it with waterfall to develop hybrid frameworks that are a best fit to their organizational, regulatory, cultural, and business requirements.

The transition to agile and DevOps has also led to a fragmentation of the QA and testing department. QA is now delegated to individual project teams and thus quality today is more dependent on the skills and preferences of the particular project or Scrum team members. This decentralization of QA makes it more difficult to leverage technologies, best practices, and test scenarios across teams.
According to this year’s WQR, the average spend on QA and testing is 26%, the same figure as last year. So, testing spends have come down and also seem to have stabilized.

Cost

We see two divergent trends when it comes to cost and efficiency of test activities. On the one hand, the waterfall-based test approaches of core IT and legacy systems have seen significant reductions in cost due to extensive automation and outsourcing. On the other hand, trends like digital transformation, the move to the cloud and the adoption of agile and DevOps, as well as the use of automation and analytics in QA and testing have all led to a wave of expenditures on new infrastructure, tooling and reorganization, and restructuring of workflows.

These led to a spike in QA and testing budgets that we saw in 2015 (when QA and testing accounted for 35% of the IT budget) and 2016 (QA and testing accounted for 31% of the IT budget). According to this year’s WQR, the average spend on QA and testing is 26%, the same figure as last year. So, testing spends have come down and also seem to have stabilized. However, with another wave of investments expected to take place in the virtualization of test environments, test data management, test automation, and the use of analytics across the testing lifecycle, this proportion might again increase to around 30% over the next two to three years, followed by another period of stabilization and increased efficiencies.

Environments and data

Over the last few years, there have been a host of developments in IT that have transformed the QA and testing function, but the changes in test data and test environment management required to enable this are falling behind. In test environments, we see a continued reliance on permanent environments, with 31% of testing occurring in such environments. Test data management and provisioning too are not maturing, as the number of enterprises that cite challenges in these areas is not dropping at all (50–60%). The number of organizations leveraging modern test data provisioning technologies is low, indicated by the fact that 58% of our respondents still rely on manually generated test data. According to our survey, 66% of our respondents said they use spreadsheets to manually generate new test data and 62% are using copies of production data to perform testing.
The first time ever that “end-user satisfaction” is the top objective of QA and testing strategy

Expecting QA and testing to directly contribute to “ensuring end-user satisfaction” is not an obvious or intuitive expectation. However, this year, it came out as the top objective of QA and testing strategy. Forty two percent of the respondents indicated that this was an important objective, up from 34% last year. In addition, “enhancing customer experience” emerged as the second most important aspect of IT strategy, with 42% of our respondents indicating it as such. It was only superseded by “enhancing security,” which had 47% of respondents indicating it as important.

Our survey reveals a lot of excitement and experimentation around the use of AI, ML, and analytics technologies. On average, organizations are devoting 22% of their IT budget to AI projects and 57% of our respondents said they had AI projects for quality assurance, already in place or planned for the next 12 months.

A new trend in evidence this year is the use of analytics to drive optimization prior to automating test sets. According to our survey, 54% respondents said they were using analytics from project data to optimize test sets, while 45% stated they were using data from operations for optimization, and another 34% said they were using code coverage analytics. In addition, as many as 45% of our respondents said that they were using analytics and AI for intelligent automation of QA processes, 36% for predictive analytics and 33% for creating self-learning, cognitive platforms.

Our survey also revealed the increasing use of bots for test activities. As many as 79% respondents said they were currently using or planning to use bots for the set-up of test environments, while another 78% were using or considering using bots for lifecycle test automation, and 77% were using or considering using bots for test data generation.

These trends are remarkable, for not only do they recognize the impact that QA and testing and IT can have on the end-customer’s experience, but they also give it the greatest importance. This means QA and testing processes, or IT systems that support speed, quality, and convenience (in other words, quality at speed). Over the next two to three years, we expect these objectives to become powerful drivers for digitalization and the greater adoption of cloud, agile and DevOps.

The convergence of AI, ML, and analytics and their use in carrying out smarter automation will be the biggest disruptive force which will transform QA and testing over the next two to three years.

Low levels of automation and challenges with test data and test environments holding back QA and testing efficiencies

Agile and DevOps adoption continues to grow driven by the “need for speed,” agility, and flexibility. According to our survey, 99% of respondents said they were using DevOps in at least some part of their business. Despite this growth in adoption, organizations are still not able to tap the full benefits promised by these approaches mainly due to low levels of automation and challenges with test data and test environments.
This came through clearly in our survey. When asked about the challenges in applying testing to agile development, the biggest challenge came out to be “lack of appropriate test environment and data,” followed by “inability to apply test automation at appropriate levels.” The number of respondents quoting these challenges have also risen from 46% last year to 53% today for “lack of appropriate test environment and data,” and from 41% last year to 50% this year for “inability to apply test automation at appropriate levels.” Additionally, when asked about the technical challenges in developing applications, respondents gave the highest weighting to “lack of end to end automation from build to deployment,” with 55% of them indicating this as a challenge.

Interestingly, automation too is held back by challenges related to test data and environments. So, when respondents were asked about the challenges in achieving their desired level of test automation, 48% of them reported challenges with test data availability and stability, making it the second-highest ranked objective. These issues around test data and environments are the result of several factors, including the greater frequency of releases, the increased complexity of test data and environments, newer types of data, challenges with integration and standardization of data coming from different sources, and the regulatory requirements relating to data brought about legislations such as the General Data Protection Regulation (GDPR) and the International Financial Reporting Standard 9 (IFRS 9).

These challenges around automation, test data, and environments, create a situation where organizations are unable to keep pace with the volume and frequency of testing required. Essentially, they slow down testing, thus defeating one of the main objectives of adopting frameworks such as agile and DevOps. This also came through in our survey results, when 43% of respondents said that “too slow testing process” was a challenge when it came to developing applications today.

The biggest factor that will help solve these challenges and allow organizations to derive the full benefits of Agile and DevOps is greater automation and the usage of smart elements such as AI and ML in QA and testing. Apart from this a few other things such as the adoption of containerized test environments, the rise of the API economy will also help.

The skills required for QA and testing have changed

Today, the way QA and testing activities are executed has changed. On the one hand, the adoption of new frameworks and technologies has broadened the number of skills required for testing, while on the other, testing activities too have spilled over to other domains and functions such as Development and Business Analysis. Thus, today, everyone has a role to play when it comes to QA and testing. We need much more open, loosely formed teams with some people who can provide specialized, supporting expertise (for things like AI or analytics) and some people who possess the core testing skills and mentality and can lead the testing effort.

In the previous years WQR, we saw the need for Software Developer Engineer in Test (SDET) profiles in testing teams. This year, with greater experimentation around technologies such as AI, analytics and IoT, there is a further need for much more specialized skills in test teams. This also came through in our survey, where 42% of respondents said that the lack of proper skills for QA and testing was an important technical challenge they were experiencing in developing applications. Similarly, 36% of respondents said that with the advent of AI, they needed a greater understanding of AI’s implications on business processes among their QA and testing teams. Additionally, 30% of respondents stated that they need more functional automation expertise, 29% said they needed more of test environment; TDD (test-driven development) and BDD (behavior-driven development) expertise, and 28% have stated that they need predictive analytics skills.

With the new trends and adoption of technologies seen this year, it is clear that the skills challenge is not going to go away anytime soon. Unless organizations take active steps to retrain their employees and develop these skills, this could soon emerge as a critical bottleneck holding back the progress of the QA and testing function.
Key Recommendations

Increase the level of basic and smart test automation but do so in a smart, phased manner

We believe that automation is the biggest bottleneck holding back the evolution of QA and testing today. This is due, in part, to automation’s key role as an enabler of successful agile and DevOps transformation. With increasing agile and DevOps adoption (99% according to the 2018 survey), the importance of automation for delivering “Quality at Speed” has also risen. It is also a result of new technologies such as AI, ML, and analytics, all of which hold significant promise in terms of the benefits which automation can deliver. Finally, our survey also reveals that levels of basic automation are still quite low (between 14%–18%), thus indicating significant scope for growth.

For all these reasons, automation and especially smart test automation, is poised to bring about significant changes in the way QA and testing is done over the next two to three years and organizations need to have a strategy and roadmap in place if they want to reap its benefits. We recommend a phased approach in three stages, i.e. first, the optimization of testing, second, implementation of basic automation, and third, the adoption of intelligent and self-adaptive test automation solutions to make automation “smarter.”

Implement a non-siloed approach for test environment and data provisioning

Fifty-three percent of our respondents said they were facing challenges with test data and environments when applying testing to agile development. Such challenges negate all the efficiencies gained through the adoption of cloud, agile and DevOps by introducing delays in the provisioning of test data and environments. This is an area that needs urgent attention and we recommend taking a centralized approach to solving these issues. Organizations must start thinking in terms of lifecycle automation, i.e. automation of testing and the provisioning of test data and environments together, rather than in siloes.

A certain level of centralization will result in better leveraging of best practices, tools, and techniques, lead to better re-use of infrastructure, and in general, lead to greater efficiencies. Organizations must move towards “smart” test data and test environment management, i.e. the creation of self-provisioning, self-monitoring and self-healing environments and data based on specific requirements. Leveraging such technologies, together with a more centralized approach to test data and environment provisioning will help ensure the optimal level of risk coverage, speed up releases, cut infrastructure costs, and increase team productivity and throughput.

Build quality engineering skills beyond SDETs

In our last couple of reports, we have talked about the need for SDETs in testing. However, with trends like agile, DevOps, cloud, IoT, blockchain and AI on the one hand and the need for a more automated and integrated QA approach on the other, enterprises today need to focus on new quality engineering skills.

Given these challenges, we recommend that organizations take the following approach toward building up the required QA skills:

1. The first priority is to attract/reskill towards agile test specialists who have functional automation skills and domain testing skills. We would recommend that automation be a must-have skill for everyone in the QA function today.

2. The second priority is to attract/reskill Software Development Engineers for Test skills (SDET). The SDET must have advanced automation skills, white box testing capabilities, development skills, and the ability to build orchestration platforms. They may also be required to possess basic algorithmic application capabilities, and natural language processing skills in the event of it being an AI application.
Of course, getting the kind of resources listed above is a tough ask in today’s market, which is why we recommend a greater focus by organizations on building up these skills through workforce transformation programs comprising of internships, specialized trainings, and mandatory learning and development plans.

**Improve tracking to optimize spends**

The adoption of agile and DevOps in project teams has led to a situation where QA and testing activities are being done by many, including developers as well as specified testing professionals. This makes it tough to accurately track, understand, or optimize QA and testing spends. In addition, the last few years have seen increased investments in automation tools and cloud-based, virtualized, and containerized test environments, and there is a pressing need to track and understand these spends as well as the returns on these investments.

Thus, we would recommend that organizations take this issue of budgets and spends seriously and create a detailed and elaborate tracking mechanism to see how and where budgets are allocated and then track how and where they are spent. Such a mechanism would need to be quite granular, as project teams consisting of different skills sets and carrying out a variety of tasks make it difficult to understand whether a certain spend went into testing or development.

**Develop a testing approach for AI solutions now**

According to our respondents, in 2018, an average 22% of their IT budgets are being allocated to AI projects. In addition, 64% of our respondents said they had AI projects in place or planned for the next 12 months for customer processes, 62% said the same thing for internal processes, and 57% said so for QA purposes. Thus, the adoption of AI is clearly increasing.

However, when asked about the measures they were taking toward the testing of “intelligent applications” (including AI and ML elements), as many as 57% of the respondents said they were experimenting with new testing approach and 45% said they were investigating a suitable testing approach. Given the rate at which AI is coming up, every organization needs to start developing a QA and test strategy for their AI solutions now. Organizations must realize that the potential business and social impact of incorrect or faulty AI solutions can be huge. The validation and verification of AI solutions during development, as well as automated continuous quality monitoring must be part of this QA strategy for AI.

> We would like a system that could repair itself. It should be capable of automated code creation or code correction.

—Chief Product Officer, Technology, Germany
Current Trends in Quality Assurance & Testing
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key trends in IT</td>
<td>16</td>
</tr>
<tr>
<td>The brave new world of QA and testing</td>
<td></td>
</tr>
<tr>
<td>Artificial intelligence</td>
<td>22</td>
</tr>
<tr>
<td>A force multiplier for QA and testing</td>
<td></td>
</tr>
<tr>
<td>Test automation</td>
<td>26</td>
</tr>
<tr>
<td>The single-biggest enabler of maturity in QA and testing</td>
<td></td>
</tr>
<tr>
<td>The quality assurance organization</td>
<td>31</td>
</tr>
<tr>
<td>Greater adoption, newer challenges, and a move away from Test Centers of Excellence</td>
<td></td>
</tr>
<tr>
<td>Test data and environments management</td>
<td>36</td>
</tr>
<tr>
<td>The biggest obstacles to progress in QA and testing</td>
<td></td>
</tr>
<tr>
<td>Efficiency and cost containment in quality assurance</td>
<td>40</td>
</tr>
<tr>
<td>QA and testing costs showing signs of stabilization, though a wave of investments in new technologies is expected</td>
<td></td>
</tr>
</tbody>
</table>
The quality assurance (QA) and testing function has evolved considerably over the last few years. We see six key trends that will have an enormous impact on how QA and testing evolves over the next two to three years. These trends are: digital transformation and the API economy, the internet of things (IoT), artificial intelligence (AI), cloud, cybersecurity, and blockchain. In this chapter, we will be taking a more in-depth look into each of these trends, with the exception of AI, which has a separate chapter devoted to it.

To understand these trends, it is important to know what drives them. In this regard, the most important development is the increasing customer centricity and the consequent importance of end-user experience. IT today is not just about ensuring system availability, functionality, and cost reduction. It is also expected to contribute to business goals. For the third year in a row, our WQR survey confirms the importance of ensuring end-user satisfaction as a key objective of the QA and testing strategy. This year, it has come on top (cited by 42% of respondents and with the highest average rate of 5.85 out of 7). It has also consistently scored as one of the most important elements of IT strategy over the last three years. For instance, in 2018 it was cited as an important objective by 42% of respondents, surpassed only by the overarching concern to enhance security (cited by 47%).

This focus on customer experience also drives the primacy of objectives, such as time to market and is responsible for the increasing adoption of agile and DevOps across the world. It is also what drives firms’ attempts to capture, analyze, and utilize the masses of structured and unstructured data produced by consumers today. Together, these developments shape each of these trends in different ways.

Executive management objectives with QA and testing

The quality assurance (QA) and testing function has evolved considerably over the last few years. We see six key trends that will have an enormous impact on how QA and testing evolves over the next two to three years. These trends are: digital transformation and the API economy, the internet of things (IoT), artificial intelligence (AI), cloud, cybersecurity, and blockchain. In this chapter, we will be taking a more in-depth look into each of these trends, with the exception of AI, which has a separate chapter devoted to it.

To understand these trends, it is important to know what drives them. In this regard, the most important development is the increasing customer centricity and the consequent importance of end-user experience. IT today is not just about ensuring system availability, functionality, and cost reduction. It is also expected to contribute to business goals. For the third year in a row, our WQR survey confirms the importance of ensuring end-user satisfaction as a key objective of the QA and testing strategy. This year, it has come on top (cited by 42% of respondents and with the highest average rate of 5.85 out of 7). It has also consistently scored as one of the most important elements of IT strategy over the last three years. For instance, in 2018 it was cited as an important objective by 42% of respondents, surpassed only by the overarching concern to enhance security (cited by 47%).

This focus on customer experience also drives the primacy of objectives, such as time to market and is responsible for the increasing adoption of agile and DevOps across the world. It is also what drives firms’ attempts to capture, analyze, and utilize the masses of structured and unstructured data produced by consumers today. Together, these developments shape each of these trends in different ways.

Executive management objectives with QA and testing
Digital transformation and the API economy

Digital transformation refers to the use of digital technology to deliver services faster, cheaper, and better to consumers. This requires a change in almost every part of an organization’s ecosystem, including business models, organizational frameworks, technology, employee skill sets, and most importantly, its culture and mindset. All these elements need to add up to a cohesive whole that drives business value and ultimately serves customers better. Getting this mix right is what allowed smaller firms such as Uber, Airbnb, or Netflix to bring disruptive change in their industry.

Broadly, there are three key principles for achieving this successfully. The first is to re-think your business models and organizational frameworks. Usually, this means adopting business-aligned approaches such as agile and DevOps. The second principle is the use of data and its integrated approach to drive better customer service. In a world of ever-increasing data, this is the key to competitive advantage. Finally, the third principle is the appropriate leveraging of technology. This is where we see elements such as cloud, automation, IoT, microservices and analytics working together.

The WQR 2018 survey, reveals that digital transformation creates higher demands on QA and testing approaches and that a large proportion of enterprises have some serious challenges. For instance, when asked about their greatest challenges in testing mobile, web, and other types of front-office applications, 52% of our respondents pointed to “not enough time to test” as an issue, followed by 43% who said, “we don't have the right tools to test” and 34% who said, “we do not have the right testing process or method.” Such challenges could arise either due to organizations sticking to a traditional waterfall approach, an issue with skill sets, or a lack of the cultural transformation required by frameworks such as agile and DevOps.

Challenges with testing mobile and multi-channel (mobile, wearables, social and traditional) apps

![Figure 3](current_trends_in_quality_assurance_and_testing.png)
Despite these challenges, we see most organizations moving ahead on the path to digital transformation. Today, driven by the need to serve their customers, many companies have started using technologies like digital assistants, Bots, augmented reality, voice and face recognition, etc. The promise of these technologies also came through in our survey. For instance, 54% of our respondents said they foresaw themselves using robotics automation in the coming year. A key new development in this regard is the growth of microservices and the API economy. This refers to an approach where bigger applications are broken down into smaller, more manageable pieces called microservices. It simplifies development, testing, and release and allows for regular incremental improvements, lowered risk, greater flexibility, and improved time-to-market.

However, it is also important to remember that this approach has disadvantages. While splitting a bigger application into smaller containers might result in better time-to-market, it also creates the need for monitoring each of the individual components. While it simplifies the testing of individual components, it makes testing of the whole, integrated system tougher.

Internet of things

The internet of things (IoT) promises masses of richly detailed data on customer behavior and its adoption has been rising across industries. According to our survey, the percentage of respondents that do not have IoT products has decreased sharply from 17% in 2017 to 3% in 2018. The data also shows us that the adoption of IoT is increasing sharply in Energy and Utilities, High-tech, Public Sector, Transport, and Financial Services.

Of course, IoT also introduces new challenges around the effective usage of the vast amounts of user data it generates. One such challenge is related to the proper testing of IoT products. This came out in our survey as 34% of our respondents said, “our products have IoT functionality but do not have any specific test strategy, though we plan to include such strategy in the near future,” while 22% stated that “our products have IoT functionality but currently we do not have any specific test strategy.” Encouragingly, this year has seen an increase in the number of conversations taking place around end-to-end test strategies for IoT deployment. This implies greater awareness, if not actual implementation of proper testing strategies for IoT products.

Organizations with specific test strategies for testing products in an internet-of-things (IoT) environment

![Figure 4](image-url)
Cloud

Digital transformation, the adoption of agile and DevOps as well as the increased need for greater analytics capabilities have all been driving cloud adoption over the last few years. According to this year’s survey, as many as 73% of all applications are based in the cloud. Both private cloud and hybrid cloud are proving to be popular, with 22% of all applications running in a private cloud as opposed to 15% of all applications which run in a hybrid cloud.

Percentage of applications currently hosted in different types of cloud

In addition to our survey, we see two interesting, recent trends. The first is the rise of the multi-cloud. To prevent vendor lock-in, an increasing number of companies are hedging their bets and hosting different applications with different cloud service providers. This is a growing trend and we expect this will soon be the norm when it comes to the cloud. The second trend has to do with edge computing. This is a nascent trend, but as IoT and its associated technologies mature, more companies will be adopting a mixture of edge computing and cloud hosting in a manner that optimizes results.

This increase in cloud adoption comes with its own set of challenges. For instance, when asked about the testing of cloud-based or third-party SaaS services, as many as 60% of the respondents said they paid special attention to security requirements and risks, while 52% reported paying special attention to performance requirements and risks. Anecdotal evidence suggests that the integration of third-party services is another challenge faced by a growing number of organizations.

Every part of the production cycle will be affected by artificial intelligence and QA is not an exception.

— VP Applications, Logistics, Italy
Cybersecurity

This coming together of several trends, such as cloud, IoT, as well as digital transformation and customer-facing apps have all created the perfect storm for businesses. On the one hand, organizations now have both the motivation (given the increased focus on customer centricity), and the ability to track, store, and use customer data to serve their consumers better. On the other hand, there are increasing concerns over data privacy and security. This situation is compounded by a lack of clarity around standards and security protocols for emerging technologies such as IoT.

This concern around security can be seen from our survey results as well. For instance, when asked about the objectives of their IT strategy, respondents gave the highest weighting to enhancing security, with 47% of respondents naming it as an important aspect of their IT strategy. This concern regarding security seems to have risen since last year’s survey, in which only 35% of respondents saw security as an important objective.

Important aspects of IT strategy, according to the WQR survey sample

When it comes to protecting customers’ data, the European Union’s General Data Protection Regulation or GDPR, which came into effect on May 25 of this year, has been a milestone. The GDPR, which mostly consists of regulations concerning the storage, retrieval, and sharing of customer data, is applicable to every organization that operates in the European Union. Though it has already come into force, there is still a lot of confusion in the market about its impact on IT operations.
Blockchain

One of the hottest technology trends today is blockchain. While it was first put to use in the Financial Services industry for cryptocurrencies, more and more industries today are experimenting with use cases to leverage this technology.

The excitement around blockchain was also captured in our survey results. When asked about their plans for blockchain, 66% of respondents said they were already using it in their portfolio or planned to do so in the coming year. Anecdotal evidence suggests that this number might be slightly on the higher side but nonetheless, this statistic is indicative of the high level of awareness and excitement around this technology.

Of course, with blockchain being a new technology, it has also given rise to concerns. When asked about the major unknowns about blockchain in their portfolio, 52% of the respondents pointed to security-related risks, followed by 45% mentioning data-related risks, and 38% identifying risks of integration with the rest of the landscape.

Are you already using blockchain in your portfolio today or planning to use it in the coming year?

<table>
<thead>
<tr>
<th>Portfolio Status</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>66%</td>
</tr>
<tr>
<td>No</td>
<td>34%</td>
</tr>
</tbody>
</table>

Major unknowns with blockchain in the portfolio

<table>
<thead>
<tr>
<th>Unknown Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security-related risks</td>
<td>52%</td>
</tr>
<tr>
<td>Data-related risks</td>
<td>45%</td>
</tr>
<tr>
<td>Risks of integration with rest of the landscape</td>
<td>38%</td>
</tr>
<tr>
<td>Business risks</td>
<td>35%</td>
</tr>
<tr>
<td>Other technology risk (block-size, performance)</td>
<td>27%</td>
</tr>
</tbody>
</table>

Summary

The IT industry is going through a period of rapid change, driven by increasing competition, newly emerging technologies, and new frameworks and modes of operation. Although these trends have enabled newer capabilities, they have also increased the complexity and challenge with regard to IT operations. Together, these changes have several implications for QA and testing.

Firstly, they have sped up the entire IT development, testing, and release process due to which testing speed and collaboration have both become critical. This has led to a lot of focus on “QA at speed” as well as on decentralizing testing to make testing operations faster and more collaborative.

Secondly, all these changes revolve around the need for greater customer centricity and business alignment. This means that testing too must support business goals and start thinking beyond simple identification of defects or delivery of services. Instead, testing has a positive contribution to make in terms of delivering a superior quality product on budget and ahead of schedule.

Finally, it’s also important to remember that the new IT model is not just about the latest technologies or improved processes. Above all, it is a change in culture, attitude, and mindset, which will also require a change in the traditional ways of working or delivering services. This means that people, processes, and technology will all have to go through a period of change and improvement before we can fully realize the benefits promised by the new technologies and frameworks.
When it comes to artificial intelligence (AI), one must keep two things in mind when interpreting this year’s WQR survey results. The first is that AI in testing refers both to the application of AI to quality assurance (QA) and testing, as well as to the testing of AI products. The second thing to be kept in mind, is that AI is an emerging technology and the knowledge, expertise, and maturity required to apply it to QA is still lacking in many organizations. Clearly, there is enthusiasm for and excitement about AI technologies and solutions, but their actual application in testing is still emerging.

Our survey results unambiguously reflect this excitement. They also reveal that there is a lot of experimentation going on with AI technologies. The purpose of applying AI to QA and testing is simple: to create a smarter and faster testing architecture that runs and adapts itself automatically to application changes. A first essential step in this process is applying smart analytics to critical decisions in the testing process, such as which tests to run, how many tests to run, etc. Today, smart analytical solutions can automatically select and prioritize test cases, assist in the creation of test-case design, identify risk factors, and automatically assign QA tasks to the most productive professionals in a team in order to reduce cost and time to market. However, the ability to quickly make progress in this area seems to hinge on an organization’s maturity in mining data. For AI-driven QA, this typically means data from application lifecycle management (ALM) tools, such as test case coverage, execution and defect data, and production data as well as code coverage and operational logs.

Data is, thus, one of the biggest challenges when it comes to the adoption of AI in testing; not just the ability to work with it but also the quality and quantity of the data available. The other big challenge lies in identifying possible use cases for AI in testing. In addition, the use of AI in testing creates roles that are very different from the typical tester profiles. These roles require a different mix of skills comprising testing, development, natural language processing, data science, mathematics, algorithmic knowledge, and machine learning. This is an aspect that we expect will become critical in the future.

Despite such challenges, AI is here to stay and its importance will only grow in the coming years.

Artificial intelligence: The oft-repeated (but often misunderstood) mantra

Our survey results indicate that, across sectors, organizations are devoting an average of 22% of their IT budgets to AI projects. Interestingly, this percentage is highest for the High-Tech sector (25%), followed by organizations in the Financial Services (23%), and Energy and Utilities sectors (23%). As mentioned earlier, this probably reflects the development of better AI use cases in these sectors.

In addition, when respondents were asked about AI projects or plans they had in place for the next twelve months, a full 64% said they had AI projects in place or planned for customer processes, followed by 62% for internal processes, and 57% for quality assurance purposes. While expert opinion holds that these numbers reflect plans and aspirations rather than implemented projects, the fact that a majority of organizations are at least talking about it, reflects the potential that businesses see in this technology.
Artificial intelligence projects or plans for the next 12 months

Figure 9

However, translating that potential into reality is not always easy. In their engagement with AI, most organizations are still stuck at the level of data analytics rather than using AI technologies such as machine learning, neural networks, fuzzy logic, robotics, or deep learning. They are also struggling with how to impact business outcomes using AI technologies. This came through clearly in our survey results. For instance, when asked about the challenges they faced or expected to face in implementing AI projects, a full 55% of respondents reported that they had “difficulties with identifying where business might actually apply AI.” Some of this also has to do with how companies approach new technologies, such as AI. Many of them first build up their knowledge and expertise in the technology and then try to build a business case for it.

Apart from the above challenges, the survey results also pointed to “difficulty integrating AI with the existing applications” (51% of respondents) and “(lack of) available AI knowledge in development” as two big issues. In addition, expert opinion also points to problems with the quantity and quality of data as one of the biggest obstacles holding back the greater adoption of AI for QA and testing.

Challenges encountered or expected when setting up an artificial intelligence project

Figure 10
AI: What’s it good for?

So how are organizations using AI in QA and testing today? The 2018 WQR survey results give us a few indications.

Our survey results confirm that speed-to-test using intelligent automation and optimization is where AI is playing a key role in QA, with 45% of respondents stating that they use AI for intelligent automation, 36% for predictive analytics, and 35% for descriptive analytics and self-learning cognitive platforms. These trends are directly related to some of the trends, such as predictive analytics, robotics automation, cognitive automation, and machine learning that were identified as emerging trends in this year’s survey.

The use of analytics and artificial intelligence for optimizing quality assurance

The complexity of AI, together with its growing popularity across all business areas, leads us to the question of how enterprises are dealing with the testing and validation of AI solutions. When respondents were asked how they tested such intelligent applications, 57% said that they were experimenting with a new testing approach, 45% said that they were investigating a new testing approach, and 35% said that they were using a new testing approach. From the results, it is clear that no standard processes have yet been developed and that different organizations are experimenting in different ways.

Changing roles in AI

Our survey yielded some interesting results when it came to the skills required for both applying AI in the test process as well as for the testing of AI products. For instance, when asked about the challenges they faced or expected to face when setting up an AI project, only 38% of the respondents reported “the lack of available AI knowledge in testing” as an issue, thus ranking this statement second last among all options given. Interestingly, the sectors that displayed greater maturity in the usage of AI technologies tended to see this as more of a challenge. Thus, 43% of respondents from the High-Tech sector and 42% from Energy and Utilities, and Financial Services reported this as a challenge.

This complacency regarding the skills required for working with AI was also seen when respondents were asked about the extent to which AI changed the skills they needed from their QA and testing professionals. As many as 51% of respondents said that AI did not change the skills required for test data set-up expertise, 50% said there were no changes required in test strategy, and test design skills, and 49% said there were no changes required in data science skills.
The extent to which AI changes the skills expected of QA and testing professionals

Figure 12

Experience however, suggests that AI changes the skills required from QA professionals. The traditional tester is no longer adequate, as working with AI requires professionals with a diverse range of competencies such as testing, mathematical optimization, neuro-linguistic programming, AI, business intelligence skills, and algorithmic knowledge. At present, finding this combination of skills is difficult and experts suggest that challenges regarding the availability of qualified professionals will increase in the future as more organizations start experimenting with AI.

Moving forward, as the practice of AI matures, we see three new roles emerging in QA and testing:

**AI QA strategists:** These professionals will need to understand the implications of AI for business processes.

**Data scientists:** In the future, data scientists will also need to be a part of QA teams. These professionals will need to sift through data and use predictive analytics, mathematics, and statistics to build models.

**AI test experts:** They will need to have the traditional testing skills as well as the ability to build machine learning algorithms, mathematical models, and natural language processing models.

**Summary**

AI is an exciting new technology, with many possible business applications and considerable scope to evolve in the future. Our survey results clearly demonstrate the excitement around it as well as its challenges. As an emerging technology, there is still some lack of clarity around what business applications it can be used for as well as on how to use it. Such questions are likely to become clearer as time goes by.

To do this, they will need to have business knowledge as well as a broad understanding of data and techniques such as mathematical optimization, natural language processing, and robotics.

**Data scientists:** In the future, data scientists will also need to be a part of QA teams. These professionals will need to sift through data and use predictive analytics, mathematics, and statistics to build models.

**AI test experts:** They will need to have the traditional testing skills as well as the ability to build machine learning algorithms, mathematical models, and natural language processing models.

Over the next two to three years, we will see an increase in the use of data and test automation to become more predictive when it comes to QA and testing. We are also likely to see an adoption of AI across the entire lifecycle, extending from the requirements side, through operations, to customer experience. All in all, the testing profession can look forward to some exciting developments ahead.
Test automation
The single-biggest enabler of maturity in QA and testing

Sridhar Throvagunta
Senior Director, Financial Services, Capgemini

Brian Olsen
Senior Consultant, Sogeti Denmark

Antoine Aymer
Global Director, Sogeti

Nothing can stop an idea whose time has come, and test automation today, is just such an idea. The time is exactly right, because nearly every major IT trend we see simply reinforces the need for greater automation. Take, for instance, the focus on time to market, the rising adoption of agile and devOps, the convergence of technologies, such as machine learning (ML), artificial intelligence (AI), and analytics and in strategic terms, the increasing alignment between IT and business. All these trends contribute to the ever-increasing importance of automation; either because automation is a critical ingredient for these trends to succeed, or, because they have a multiplier effect on the benefits that automation can offer.

Our 2018 WQR survey, unambiguously demonstrates these trends. When respondents were asked about the objectives of their QA and testing, 42% (28% in 2017) picked “ensure end-user satisfaction,” another 42% (34% in 2017) pointed to “detect software defects before go-live,” and 41% (29% in 2017) mentioned “contribute to business growth and business outcomes” as important objectives.

Additionally, 29% of the respondents said that “reducing overall application cycle times” was an important objective for QA and testing. All of these are business goals and they reiterate a theme we have been seeing for several years now – the tighter coupling of IT with business. For QA, this means an increased focus on the concept of “Quality at Speed” and its associated promises of avoiding human intervention wherever possible, reducing costs, increasing quality, and achieving better time to market. And the way to achieve each of these goals? Automation.

Executive management objectives with QA & testing

<table>
<thead>
<tr>
<th>Objective</th>
<th>2018</th>
<th>2017</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detect software defects before go-live</td>
<td>42%</td>
<td>42%</td>
<td>41%</td>
</tr>
<tr>
<td>Ensure end-user satisfaction</td>
<td>28%</td>
<td>34%</td>
<td>25%</td>
</tr>
<tr>
<td>Contribute to business growth and business outcomes</td>
<td>25%</td>
<td>38%</td>
<td>39%</td>
</tr>
<tr>
<td>Increase the quality of software or product</td>
<td>27%</td>
<td>38%</td>
<td>39%</td>
</tr>
<tr>
<td>Protect the corporate image and branding</td>
<td>26%</td>
<td>36%</td>
<td>35%</td>
</tr>
<tr>
<td>Increase quality awareness among all disciplines</td>
<td>30%</td>
<td>35%</td>
<td>29%</td>
</tr>
<tr>
<td>Implement quality checks early in the lifecycle</td>
<td>25%</td>
<td>38%</td>
<td>37%</td>
</tr>
<tr>
<td>Reduce the overall application cycle times by reducing waste</td>
<td>21%</td>
<td>35%</td>
<td>30%</td>
</tr>
</tbody>
</table>
There are two additional factors driving the adoption of automation. First is the adoption of agile and DevOps, which seems to have reached a tipping point today, with 99% of our respondents saying they use DevOps for at least some part of their business. This also increases the importance of automation, since one cannot derive the full benefits of agile and DevOps without automation.

Finally, we are also seeing the adoption of analytics, AI, and ML in testing, a trend that started in earnest recently and is only likely to gain momentum in the coming years. In our survey, as many as 45% of respondents said they used analytics and AI for intelligent automation of QA processes. This is an important development, one which holds promise in terms of the benefits that automation will deliver in the future.

Automation today and tomorrow

For many years, the focus of test automation was on test execution and functional testing, and automation used to happen in silos. So, we had point solutions for automating individual processes, such as test execution. Today however, more and more components of the lifecycle are being automated and there is a focus on automating the entire lifecycle. Take, for instance the increasing importance of robotic process automation (RPA), which seeks to automate manual business processes, thereby reducing costs and improving speed and quality. Similarly, today’s ever-changing applications and the increased complexity and number of new releases, have also led to a rise in the importance of both model-based testing (for automated test cases and automated script generation based on requirements) and eco-system automation (for test data and test environment provisioning) along with traditional end-to-end automation. Another emerging trend is that of automating API testing and we are likely to see increased activity around this over the next couple of years.

So, what does automation look like today? According to our respondents, automation continued to be the most popular for generating and executing functional test cases. On average, 18% of functional test cases were generated using test generation tools, and 16% were executed using test automation tools. Similarly, 16% of all security tests were executed using automation tools, and automation was also applied to the execution of 16% of all performance test cases. Quite encouragingly, 15% of all end-to-end business scenarios were also being executed using test automation tools.

To understand future trends, we asked respondents about new automation techniques they could foresee, using in the coming year and 61% percent said “model-based testing.” A further 59% said predictive analytics, 54% said robotic automation, and 49% said cognitive automation. We have already touched upon model-based testing, a trend facilitated by the increased availability of both commercial and custom-made, model-based tools and accelerators today.

<table>
<thead>
<tr>
<th>Activity</th>
<th>2018</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of functional test cases that are generated with test generation tools</td>
<td>18%</td>
<td>16%</td>
</tr>
<tr>
<td>% of functional test cases that are executed with test automation tools</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>% of security tests that are executed with test automation tools</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td>% of performance test cases that are executed with test automation tools</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>% of end-to-end business scenarios that are executed with test automation tools</td>
<td>15%</td>
<td>16%</td>
</tr>
<tr>
<td>% of test data that is generated by test data tools</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>% of API test-cases that are automated</td>
<td>14%</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Organizations today, are trending towards lifecycle test automation, which means achieving an assembly-line-like test lifecycle. This is achieved by orchestrating automation in an ecosystem comprising proprietary, open-source, and commercial tools. The next step is smart test automation, which is achieved by bringing together solutions, such as model-based testing, optimization solutions, scriptless test automation, test data and environments management, service virtualization, nonfunctional engineering, etc., and orchestrating them to achieve lifecycle automation besides infusing intelligence through analytics and dashboards, RPA, and other non-intrusive proactive techniques to course-correct development. This trend will develop fully over the next two to three years and our survey confirms that organizations are already experimenting with and adopting many of the technologies discussed.

This means we are very close to a future in which it will be possible to start analyzing log files (using predictive/model building capabilities) and gaining a perspective on a piece of code even before it is ready to be tested (i.e., while the developer is still working on it). Such automation will help identify issues in the way the code is being developed and would even suggest course corrections to the developer, so they can avoid potential pitfalls that might arise. In other words, it would build quality into the product itself so that less time and effort are spent on testing. By allowing testers to work in parallel with the development process and make suggestions in a non-intrusive way that does not hold up development, this would also facilitate a greater adoption of agile and DevOps.

However, before we reach this golden age, there are significant challenges that need to be overcome.

### The many obstacles to success

When asked about the main challenges in achieving their desired level of automation, 61% of respondents said they had difficulties automating as their applications changed with every release. This could be a direct result of the flexibility provided by frameworks like agile and DevOps, which allow organizations to change their requirements or stories frequently. This often leads to too many changes with every release and puts additional pressure on testers as test cases generated earlier or previous automation work no longer remains relevant.

In addition to the above challenge, 48% of our respondents, pointed to issues with test data and test environment availability and stability, while 46% said they lacked skilled and experienced test automation resources. These are issues that have existed for some time now and are likely to become even more problematic as an increasing number of organizations adopt automation. Fortunately, there is a plethora of tools and solutions which could help ease both of these challenges.
Main challenges in achieving desired level of test automation

**Figure 16**

<table>
<thead>
<tr>
<th><strong>Challenges</strong></th>
<th><strong>2018</strong></th>
<th><strong>2017</strong></th>
<th><strong>2016</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>We find it difficult to automate because our applications change too much with every release</td>
<td>61%</td>
<td>48%</td>
<td>42%</td>
</tr>
<tr>
<td>Challenges with the test data and environment availability</td>
<td>42%</td>
<td>40%</td>
<td>34%</td>
</tr>
<tr>
<td>Lack of skilled and experienced test automation resources</td>
<td>46%</td>
<td>36%</td>
<td>41%</td>
</tr>
<tr>
<td>We don’t have the right automation tools</td>
<td>29%</td>
<td>25%</td>
<td>24%</td>
</tr>
<tr>
<td>We have too many different automation tools</td>
<td>24%</td>
<td>18%</td>
<td>22%</td>
</tr>
<tr>
<td>We have poorly defined project requirements prohibiting us from deciding on the right test scenarios</td>
<td>42%</td>
<td>41%</td>
<td>35%</td>
</tr>
<tr>
<td>We started too late with testing and test automation</td>
<td>41%</td>
<td>32%</td>
<td>32%</td>
</tr>
<tr>
<td>Current automation solution does not support mobile testing</td>
<td>40%</td>
<td>39%</td>
<td>38%</td>
</tr>
<tr>
<td>We don’t have the right automation testing process/method</td>
<td>39%</td>
<td>37%</td>
<td>38%</td>
</tr>
<tr>
<td>We find it difficult in automating because we use multiple development lifecycles</td>
<td>38%</td>
<td>37%</td>
<td>38%</td>
</tr>
<tr>
<td>We find it difficult to integrating the different automation tools</td>
<td>38%</td>
<td>37%</td>
<td>38%</td>
</tr>
<tr>
<td>find it difficult to integrate test automation into a DevOps process</td>
<td>38%</td>
<td>37%</td>
<td>38%</td>
</tr>
<tr>
<td>Challenges with service virtualization</td>
<td>38%</td>
<td>37%</td>
<td>38%</td>
</tr>
</tbody>
</table>

Notwithstanding all these challenges however, our WQR 2018 survey also reveals that there is a significant percentage of organizations that have started reaping the benefits of automation.

**Delivering on its promises**

As organizations gain maturity in the way they handle the new IT paradigms, the benefits they gain from automation also increase. This is corroborated by our survey data. For instance, when asked about the benefits they had derived from test automation, 2018 respondents gave the highest weighting to “better test coverage” (68% in 2018, up from 51% in 2017 and 40% in 2016), followed by “better control and transparency of test activities,” (66% in 2018, 43% in 2017 and 38% in 2016) and “better reuse of test cases” (65% in 2018, 57% in 2017, and 40% in 2016). One can see an almost linear increase in the numbers for every benefit mentioned in the survey. In other words, automation reduced costs and time to market, allowed for better detection of defects, and allowed for a better risk coverage. This maps perfectly to the top objectives of QA and testing, namely “to reduce software defects before go-live” and “to contribute to business growth and business outcomes.”
The highest-rated benefit of “better test coverage” also enables optimization of testing as organizations can control the amount of coverage and risk they are comfortable with. All the benefits quoted are also quality-related and consistent with the dictum of “quality at speed.” Despite these benefits, we should note that a significant proportion of organizations still struggle to see the benefits of automation. According to our survey, the sectors that are leading in terms of accessing these benefits are Telecommunications, Automotive, High-Tech, and Transportation.

When asked about the (expected) benefits they had failed to realize from automation, 39% of respondents pointed to a “reduction in test costs,” 36% indicated “better detection of defects,” and another 36% said they had not been able to achieve a “reduction of test cycle time.” This failure to reap the benefits promised by automation could be due to a number of reasons. For instance, the top benefit that organizations were unable to realize with automation was the “reduction in test costs.” This could be due to the initial up-front investments that are required when setting up automation or it might be due to the costs of retraining or upskilling resources.

While one can give multiple reasons for companies not being able to convert automations promises into reality, most of these reasons could possibly be grouped under the single heading of a lack of maturity in handling agile and DevOps and integrating them with automation. Given this fact, we believe that as organizations gain in expertise and maturity, they will be able to leverage automation much more successfully in the years to come.

**Summary**

Automation is set to grow smarter and become much more effective over the next two to three years, especially as the convergence of technologies such as analytics, AI, and ML bring about a paradigm shift in the benefits that it can deliver. However, getting to that stage requires a lot of up-front investment that organizations must be willing to make over the next few years. To be successful, organizations must understand that automation is not only about replacing manual testing and chasing some incremental cost savings. Instead, a focus on delivering quality at speed and supporting frameworks such as agile and DevOps to deliver much greater results and take QA and testing to the next level.
The quality assurance organization

Greater adoption, newer challenges and a move away from test centers of excellence

Driven by digitalization, increased competitive pressures, and the primacy of objectives such as time to market, the adoption of both agile and DevOps has been growing over the past few years. As an increasing number of organizations adopt these frameworks, newer challenges, which were perhaps not so apparent earlier, have come into focus. At the same time, these frameworks have also led to a move away from Test Centers of Excellence (TCoEs), with most companies decentralizing testing to the project level.

These trends are not uniform and there is wide variation in terms of both adoption and maturity across geographies and sectors. Our survey reveals that organizations across the world are customizing agile in different ways and combining it with waterfall, to find an approach that best fits their needs and capabilities. This kind of a hybrid approach often develops naturally as a pure play agile framework does not work in many scenarios due to its organizational, regulatory, cultural, and business requirements. For this reason, we see many organizations adopting agile and DevOps for a few processes (typically the customer-facing, front-end applications) while still sticking to waterfall for other processes (typically back-end processes based on older, legacy systems).

The increasing engagement with agile and DevOps has also led to a better and more wide-spread appreciation of the challenges associated with adopting these frameworks. One of the biggest emerging challenges is related to the skill sets these new frameworks require. There are also significant challenges involving test environments, data and tooling.

Agile and DevOps: Continuing adoption and varying levels of maturity

Thirty percent of our respondents said that implementing agile and DevOps was an important aspect of their overall IT strategy. Survey results also reveal that the adoption of DevOps has increased over the last few years. In 2015, 82% of our respondents said that they were using DevOps principles in their organization. By 2017, this figure had grown to 88% and, according to this year’s survey, a full 99% of respondents said that they were using DevOps principles in their organization.

Proportion of projects using DevOps principles

---

**Figure 18**

Not applicable as we do not use DevOps principles

- 2018: 1%
- 2017: 12%
- 2016: 12%
- 2015: 18%

Fewer than 20% of our projects use DevOps principles

- 2018: 16%
- 2017: 42%
- 2016: 47%

20–50% of our projects use DevOps principles

- 2018: 30%
- 2017: 30%
- 2016: 32%

50–70% of our projects use DevOps principles

- 2018: 15%
- 2017: 11%
- 2016: 21%

70–90% of our projects use DevOps principles

- 2018: 9%
- 2017: 8%
- 2016: 26%

90–95% of our projects use DevOps principles

- 2018: 3%
- 2017: 11%

---

Mandar Salunkhe  
Senior Director, Financial Services, Capgemini

Gitte Ottosen  
Principal Consultant, Digital Assurance and Testing, Capgemini Sogeti Denmark

Andrew Fullen  
Solutions Director, Sogeti UK

Deepika Mamnani  
Senior Director, Financial Services, Capgemini

Frederik Scheja  
Test Architect, Sogeti Sweden
What many organizations call agile is, in fact, a combination of these frameworks and waterfall. This also came through in this year’s survey. For instance, when asked about how test activities were performed in their organization, 45% of respondents said that “test activities were performed by all team members, supported by a test professional,” while 43% said that “test activities were performed by all team members, without a test professional.” At the same time, 39% also reported that “test activities were performed in a distributed team” and another 33% said that “test activities are mostly performed by test professionals.” This almost bi-modal distribution (between agile and non-agile ways of organizing testing responsibilities), shows that most organizations are opting for the hybrid model mentioned earlier.

This type of hybrid model is mostly adopted by companies that have a significant legacy component in their IT systems and it ends up complicating operations and raising the effort and time spent on testing. According to the WQR survey, respondents spent an average 25% of their overall project effort on testing in an agile project.

It’s important to keep in mind, that there is considerable variation across regions when it comes to these trends. We see more of these hybrid models and waterfall methods persisting in regions that are further behind on the maturity curve. In these regions, the rise of DevOps and the importance of business goals such as time-to-market has also led a marginalization of testing and operations, with most project teams being dominated by developers. This often results in greater emphasis on speed over accuracy, which can defeat the very purpose of testing. Such firms will need to strike a balance between these two often competing objectives, in order to derive the full benefits of these approaches.

On the other hand, in the more mature regions, we see an increasing number of companies shifting from waterfall to agile and DevOps. These regions are marked by a greater adoption of continuous testing and integration testing and a lot of excitement and some early adoption of artificial intelligence (AI) and machine learning (ML) technologies.

**DevOps – driving change**

As already stated, only one percent of respondents indicated that they were not experimenting with or applying DevOps in any form. According to the survey, the top DevOps processes being followed were “breaking down large efforts into smaller batches of work” (44% of respondents currently using and 38% planning to use), “cloud-based development and test environments” (43% using and 40% planning to use), and the “continuous monitoring of apps in production” (41% using and 40% planning to use).
Enterprise-wide adoption of certain DevOps practices

The increased adoption of DevOps has led to a premium being put on the need for speed. Consequently, there is increased use of both automation and engineering platforms, as well as analytics. Over the past year, we have also seen an increase in the number of discussions around the usage of predictive analytics to drive optimization prior to automating test sets. For instance, when asked about the special approach they took to speed up and optimize testing in agile/DevOps environments, 54% of respondents said that they were using analytics on all available project data to optimize their test sets. Forty-five percent of the respondents also stated that they used analytics from operations to determine or optimize test coverage. Of course, this use of analytics is an emerging trend and we need to observe its impact on the overall testing approach, budget, and skillsets. Some of the new, emerging roles have been discussed in our AI chapter.

Another new trend driven by the same considerations is the usage of bots for automated testing. Our survey respondents stated that they were using or considering using bots for lifecycle test automation (49%), set-up of test environments (48%), test data generation (46%), and integration of test types as part of the DevOps pipeline (45%).

Interest in and likelihood of using bots for test activities

We are using or considering using bots to integrate automated test types as part of DevOps pipeline

- Currently using: 31%
- Not using today but planning to use: 45%
- No plans/don’t know: 24%

We are using or considering using bots to set up our test environments

- Currently using: 31%
- Not using today but planning to use: 48%
- No plans/don’t know: 21%

We are using or considering using bots for data generation

- Currently using: 31%
- Not using today but planning to use: 46%
- No plans/don’t know: 23%

We are using or considering using bots for lifecycle test automation

- Currently using: 29%
- Not using today but planning to use: 49%
- No plans/don’t know: 22%
Challenges – the dawn of realization

Testing continues to be a challenge, with only 6% of respondents stating that they had no difficulties in testing with agile. When asked about what difficulties they did face, 53% reported the lack of an appropriate test environment and data (versus 46% in 2017), 50% reported an inability to apply test automation at the appropriate levels (as opposed to 41% in 2017) and 48% pointed to difficulties in slicing test activities for more than one location for distributed Agile (as opposed to 42% in 2017). These results give us a sense that increased adoption has led to greater realization of how challenging these issues really are.

Forty-two percent of respondents also reported a lack of professional test expertise in agile teams. Agile, DevOps, automation and artificial intelligence not only require newer skill sets, but also make it necessary for QA professionals to have multiple technical competencies. This is a significant issue from a staffing perspective since this mix of technical testing skills is not readily available in the market. As the skillset is moving from functional to SDET (Software Development Engineer in Test), organizations are faced with challenges of reskilling the existing testing teams and attracting the right testing talent to build future-ready testing teams.

Challenges currently faced in applying testing to agile developments

In our survey, 30% of respondents stated that they needed more functional automation expertise, 29% said they lacked test environment, virtualization, test-driven development (TDD), and business-driven development (BDD) skills, while 28% said they needed more predictive analytics skills. To tackle this challenge, an increasing number of organizations are forced to adopt workforce transformation programs and aggressive hiring of these niche skills.
The extent to which agile and DevOps adoption changes the skills expected of QA and testing professionals

<table>
<thead>
<tr>
<th>Skill Type</th>
<th>2018</th>
<th>2017</th>
<th>Total 2018</th>
<th>Total 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional test automation expertise</td>
<td>18%</td>
<td>21%</td>
<td>52%</td>
<td>45%</td>
</tr>
<tr>
<td>Test environment and virtualization expertise</td>
<td>19%</td>
<td>25%</td>
<td>52%</td>
<td>45%</td>
</tr>
<tr>
<td>TDD (test-driven development) or BDD</td>
<td>19%</td>
<td>26%</td>
<td>52%</td>
<td>46%</td>
</tr>
<tr>
<td>Predictive analysis skills</td>
<td>20%</td>
<td>23%</td>
<td>52%</td>
<td>45%</td>
</tr>
<tr>
<td>Development and coding skills</td>
<td>22%</td>
<td>23%</td>
<td>51%</td>
<td>43%</td>
</tr>
<tr>
<td>Non-functional testing skills (performance, security)</td>
<td>20%</td>
<td>20%</td>
<td>53%</td>
<td>26%</td>
</tr>
<tr>
<td>Software development engineer testing skills (SDET)</td>
<td>22%</td>
<td>22%</td>
<td>52%</td>
<td>26%</td>
</tr>
<tr>
<td>Test strategy and test design skills</td>
<td>20%</td>
<td>20%</td>
<td>54%</td>
<td>24%</td>
</tr>
<tr>
<td>Test data set-up expertise</td>
<td>20%</td>
<td>20%</td>
<td>54%</td>
<td>24%</td>
</tr>
<tr>
<td>Understanding of business processes</td>
<td>22%</td>
<td>22%</td>
<td>53%</td>
<td>24%</td>
</tr>
<tr>
<td>Production quality monitoring skills</td>
<td>19%</td>
<td>19%</td>
<td>56%</td>
<td>24%</td>
</tr>
</tbody>
</table>

About four to five years ago, Test Centers of Excellence (TCoEs) were all the rage. They offered economies of scale and helped standardize tools, test environments, and processes. However, the excitement about TCoEs has ebbed considerably over the last two years. The rise of agile and DevOps and the importance paid to speed and flexibility, have led to most organizations placing testing responsibilities in individual projects.

While some organizations still retain a thin layer of centralization in the form of either a community of practice or a Test Excellence Center, most are moving away from it. According to our survey, when asked about the percentage of testing roles they had organized in a centralized QA organization, 21% of respondents indicated they had centralized test automation roles, 20% had centralized Software Development Engineer Tester roles, 19% had centralized non-functional testing roles, another 19% had centralized business domain-based tester roles, and 18% had centralized specialized technology tester roles.

Summary

In summary, we see a very mixed picture when it comes to agile, DevOps and TCoEs. On the one hand, there is an overall increase in adoption of agile and DevOps along with a growing realization of the kinds of challenges that need to be tackled to derive the full benefits of these frameworks. We also see variation in terms of maturity across regions as well as across sectors. When it comes to TCoEs, the trends are a continuation of those seen last year, with more organizations shifting away from such centralized organization of testing.

These trends are likely to continue with the increasing maturity of agile and DevOps practices and a greater focus on scaling these practices to the entire organization. We are also likely to see a greater adoption of cloud, automation, analytics and artificial intelligence all driven by the adoption of DevOps. The testing skillset has undergone radical change in the past years and will continue to morph to cater to the increased technical testing needs.
Test data and environments management

The biggest obstacles to progress in QA and testing

Eva Holmqvist
Senior Test Specialist, Sogeti Sverige

Shivakumar Balasubramaniyan
Vice President, Financial Services, Capgemini

Change is coming thick and fast in the IT industry. The coming together of frameworks such as agile and DevOps, with rapidly evolving technologies such as analytics, automation, cloud, the internet of things (IoT), and artificial intelligence (AI), has transformed the quality assurance (QA) and testing function. On top of that, new regulations, such as the GDPR and IFRS 9, add to the complexity and uncertainty of this period of rapid change. Nowhere is the impact of these changes felt more than in test data and test environment management.

Test data and environments today

The industry uses both permanent and virtual test environments, which can be either cloud or non-cloud based. According to our 2018 survey, an average 69% of all test environments used today are non-permanent test environments. This means that the reliance on traditional permanent test environments continues, with an average 31% of test environments being permanent. Respondents also indicated that, on average, 19% of their tests occurred in “cloud-based temporary test environments,” 17% occurred in “virtualized test environments,” 17% occurred in “non-cloud-based temporary test environments,” and 16% occurred in “containerized (docker or similar)” test environments.

It’s important to note the considerable variation that exists across different sectors when it comes to test environments. For instance, in the Public sector, a full 35% of all test environments are permanent, and in the Healthcare and Lifesciences industries the corresponding figure is similar, at 34%. On the other hand, a mere 26% of all test environments in the High-Tech sector and 28% in the transportation sector are permanent. The persistence of permanent test environments in the Public sector as well as the Healthcare, and Life Sciences sectors can be explained by the fact that these sectors have historically delivered services that were critical for the safety and well-being of the public and had therefore to deal with masses of data that needed to be secure. Due to security concerns as well as the criticality of the services they provide, these sectors have been slow to embrace cloud and virtualization technologies, thus leading to a greater dependence on permanent test environments.

Indicative proportion of automation of each of the following activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>2018</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of functional test cases that are generated with test generation tools</td>
<td>18%</td>
<td>16%</td>
</tr>
<tr>
<td>% of functional test cases that are executed with test automation tools</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>% of security tests that are executed with test automation tools</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td>% of performance test cases that are executed with test automation tools</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td>% of end-to-end business scenarios that are executed with test automation tools</td>
<td>15%</td>
<td>16%</td>
</tr>
<tr>
<td>% of test data that is generated by test data tools</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>% of API test cases that are automated</td>
<td>14%</td>
<td></td>
</tr>
</tbody>
</table>
An encouraging trend seen this year is the excitement around containerized test environments. Though our survey results show very little change since last year and only 16% of all test environments are being containerized today, we expect to see the adoption of containerized test environments rise over the coming years. This indicates a support for agile, DevOps, and automation and is a sign of increasing QA maturity since automated testing done in a permanent test environment previously used for manual testing usually generates false positives which can increase test times. Using dockers allows organizations to set up specific environments with the exact data they need and reduces false positives so that real defects can be detected faster. Thus, the possibility of greater efficiencies and cost reduction is turning out to be a key driver for dockers or containerized test environments and we expect even greater use of such environments in the future.

This year’s survey also shows that performance testing, functional testing of cloud services, and security testing were the most popular forms of testing done in the cloud environments. All three types of testing have grown over time. Performance testing in cloud environments grew from 44% of respondents in 2016, to 56% in 2017, to 58% in 2018. Additionally, functional testing of cloud services grew from 50% in 2016, to 53% in 2017, to 58% in 2018, while security testing grew from 43% in 2016, to 55% in 2017, before dipping slightly to 53% in 2018. This reflects the increasing focus on cybersecurity practices across organizations today.

When it comes to test data, 66% of our respondents said that they used spread sheets to manually generate new test data for multiple iterations of testing. This is a three-percentage point increase from 2017. Another 62% of respondents said that they copied production data which they anonymized before testing, an increase of 19 percentage points since 2017. Clearly, the maturity in test data provisioning is still not changing in enterprises. Both trends can also partly be explained by the increased number of test runs, which leave test teams with very little time to provision and generate test data. This is just one of the many challenges facing the industry today.

The ever-increasing challenges around data and environments

The adoption of agile and DevOps has led to shorter delivery cycles and more frequent releases for which data and environments need to be provisioned. This pressure on QA departments is further compounded by the increased complexity of test data and environments today. In addition, dealing with digital, front-end applications means dealing with high-volume, high-velocity data that can be hard to create from scratch and, from a data perspective, most organizations in this space are still maturing. While the application of new AI and ML-based technologies can help solve some of these issues, such applications typically have a voracious need for data and a key pre-requisite that the data be fresh.

From an execution perspective, automation too is a huge challenge. An important reason for this is that DevOps tool chain automation still hasn’t become pervasive. Therefore, emerging software tools, including robotic process automation (RPA) in testing, have great difficulty reaching scale as many of them are still relying on clunky, high-investment models, such as sub-setting, or solving their data delivery plumbing problems (for things like synchronicity, distributed referential integrity) by writing more logic.

Another aspect of this problem is that the industry is having to deal with newer types of data and is grappling with how to standardize the data. Take, for example, the rise of IoT and the growth in the number of connected homes, connected cars, and connected health devices. How does one standardize the data from different connected systems? Or, in general, how does one provision test data when different teams request it in different formats without increasing test cycle times?

Both application modernization as well as the move from legacy to cloud and distributed systems, create the need for newer types of data. Similarly, when you talk of AI adoption, take for example connected cars or driverless vehicles, you are essentially talking about a way of doing things for which no precedent or use cases exist. How can we create the data or the environments today to test such use cases? The answer is that such data models or environments simply do not exist and, in such cases, companies might need to look at types of data that have never been dealt with before.

There is no unified view today or standards for how to consume such data, how to set up such environments, or
how to deal with the security issues that are a big concern for connected devices. Moving forward, we are likely to see an exponential increase in the number of connected devices and the industry will need to come up with creative solutions to manage both test data and test environments for testing such devices and networks.

This situation is further compounded by regulatory requirements such as the GDPR and IFRS 9. Since many of these laws have a data protection element, they lead to considerable uncertainty about how to handle test data, what masking techniques to use to protect customer information, or whether to use production data at all.

Each of these issues is reflected in our survey results. For instance, when asked about the challenges faced in managing test data, respondents gave the highest weighting to “maintaining test data consistency across different systems under test.” Sixty-one percent of respondents said that this was a problem, followed by 56% who pointed to “managing the size of test data sets,” and 55% who said that “creating and maintaining test data which are not copies from production data” was an issue. Each of these challenges is related to the problems of volume, complexity and lack of standardization mentioned earlier.

Challenges faced with managing test data

*Figure 25*
Interestingly, most of these challenges seem to have grown over the years, perhaps due to the increasing complexities associated with digital transformation and the adoption of agile and DevOps.

Unlike test data, there seems to have been some improvement over the years when it comes to test environments. For instance, when asked about their test environment-related challenges, respondents gave the highest weighting to “cost of test environment” (54%), followed by “defects due to inaccurate configuration of test environments” (54%), and “lack of facilities to book and manage your own environments” (38%). Interestingly, the percentage of respondents quoting “lack of facilities to book and manage your own environments,” “having to maintain multiple versions of test environments,” “lack of visibility to test environment availability,” and “lack of availability of the right test environment at the right time” as challenges have fallen over time.

**Summary**

All the changes that have taken place in the last few years seem to have had a compounded impact on test data and test environments. Moving forward, we see trends such as IoT, machine learning and blockchain creating fresh challenges for test data and test environment management. However, not everything is doom and gloom, as we can also see notable examples of the industry adjusting and responding to these challenges. Trends such as the growing utilization of containerized test environments, the use of Bots for zero-touch automated testing, the creation of tools for solutions for better test data sampling, as well as initiatives, such as open data projects launched by governments across the world, are all positive developments that will help tackle the challenges facing the industry. The rise of the API economy also holds promise because it will allow testing to be carried out at an API level rather than requiring UI testing all the time. The increase in adoption of service virtualization, along with hardware virtualization, will bring down test environment costs especially during system and incremental system integration testing.

One thing is clear – no matter what challenges or solutions come up in the future, test data and test environments are the two areas which the industry absolutely needs to get right if it wants to move forward on every other front.
Efficiency and cost containment in quality assurance

QA and testing costs showing signs of having stabilized, though a wave of investments in new technologies is expected

Sathish Natarajan
Vice President - Digital Assurance & Testing, Sogeti, Capgemini Group

Maheshwar Kanitkar
Senior Director, Sogeti Testing

Kumar Balasubramaniam
Senior Director, Financial Services, Capgemini

Information technology (IT) has gone through such a rapid period of change that it is almost unrecognizable when compared to what it was 10 years ago. This is due to both the dizzying pace of technological evolution and the emergence of new process frameworks, operating models, and organizational structures over the last few years. When we look at the budgets for quality assurance (QA) and testing, we can see a reflection of all these changes.

Our yearly WQR surveys capture the fluctuations in QA and testing spends over time. For instance, according to this year’s survey, the proportion of the IT budget spent on QA and testing is pegged at 26%. This is the same as last year, though considerably below the highs of 31% in 2016 and 35% in 2015. Before that, QA and testing budgets accounted for 26% in 2014 and 23% in 2013.

This pattern reflects the changes of the last three to five years, when trends such as digital transformation, the move from waterfall to agile and DevOps and from application to product ecosystems, the greater leveraging of cloud, the inclusion of test data management (TDM) and test environment management (TEM), and the use of automation and analytics in IT started gaining real traction. These changes led to a wave of investments in new infrastructure and tools as well as in re-organization, restructuring, and reskilling initiatives. All of this led to the spike in QA and testing budgets that we saw in 2015 (35%) and 2016 (31%).

Since then, as organizations have gained experience and maturity in handling these new frameworks and technologies, they have started reaping the benefits of these changes. A number of testing activities have gained efficiency and this has driven down costs. This is reflected in the fall in the proportion of IT budgets devoted to testing that we have seen over the last two years.

This, however, is just the picture at the aggregate level; it hides a lot of complexity underneath.

Proportion of total IT budget allocated to QA and testing (including testing processes, tools, and resource costs)

![Proportion of total IT budget allocated to QA and testing](image-url)
QA and testing budgets: what’s beneath the numbers?

According to our 2018 survey, when respondents were asked whether they had seen an increase in the proportional effort and cost spending on QA and testing over the last four to five years, a whopping 72% said “yes.” This directly contradicts the overall budgetary trends, which point to a fall in the percentage of IT budget being spent on QA and testing (from 35% in 2015 to 26% today). Each of these numbers come from our respondents, so why is there so much confusion?

Three major factors are clouding the picture and creating all this confusion when it comes to QA and testing budgets.

The first major factor is that, in absolute terms, both effort and spending on QA and testing has indeed been rising. Today, there is a huge focus on the virtualization of test environments, test data management, test automation, and the use of analytics across the testing lifecycle. Many organizations are also exploring the use of robotics process automation (RPA) and artificial intelligence (AI) in testing. This has led to a period of intense investments, similar to that seen two to three years earlier. Additionally, the amount of effort that goes into testing today has drastically increased due to the addition of new capabilities, new systems, and a vastly expanded scope for IT that was not there earlier. This increase in effort put into testing is further heightened by the increased number of release cycles mandated by businesses today.

Thus, both the spending and the effort that goes into testing have increased over the last few years. However, it is important to note that IT budgets have also been increasing with the adoption of these technologies. Therefore, it is entirely possible that, while QA and test budgets and efforts have been rising in absolute terms, in relative terms they have stayed the same or even fallen. This is the first factor that could be causing confusion.

The second factor is that a closer examination of costs, budgets, and efficiencies reveals two different and contradictory trends at play. This is because today, there are two parts to every organization’s IT infrastructure. There are the systems of records (typically, the legacy and back-end systems) and there are the systems of engagement (mostly user-interfacing and front-office systems). We are seeing a lot of efficiencies and reduction in QA and testing costs when it comes to the legacy side today because there is a lot of focus on cutting costs, optimizing processes, etc. However, for the front-office systems, which are usually digital applications, the main driver is speed. As we have seen, huge investments are being made in this area and these are driving up costs. These two opposing, juxtaposed trends, could also be leading to this confusion about QA and testing budgetary trends.

The third and final factor is probably the biggest of them all. This is the difficulty in accurately capturing testing spends due to the coming of age of agile and DevOps. Before agile and DevOps, testing often operated as a separate profit or cost center, with operations centralized in a Test Center of Excellence (TCoE). This made it easier to measure spends and track how much was being spent on what. However, agile and DevOps have made this kind of tracking difficult since testing is now integrated into the project or the Scrum teams. This makes it extremely difficult to track exactly how much time is spent on testing activities, especially with the now-prevalent Software-Developer-Engineer-in-Testing (SDET) profile (who engages in development, analysis, and testing activities). It is entirely possible, for instance, that the efforts of these SDETs, or of entire Scrum teams, is being tagged to the development or the testing budget or allocated on the basis of a thumb-rule percentage between these two budgets.

While all three factors are important, it is this last point that is probably the most important when it comes to explaining some of the apparent contradictions in our respondents’ answers.
What’s driving testing spend?

When asked about the individual components making up their QA and testing budget, respondents said that they allocated an average of 44% to hardware and infrastructure, 31% to tools, and 26% to human resources.

We can see that the human resources component has fallen over time from 33% of the budget in 2015, to 31% in 2016, 21% in 2017, and 26% today. This reflects a reduction in the amount of manual testing since 2016. At the same time, the rise over the last year is probably due to the increase in the number of test cycles and the overall increase in the amount of testing being done today.

Factors having an impact on increase in QA and testing budget

On the other hand, the percentage of the QA budget spent on tools or software licenses seems to have remained more or less constant over the last three years. Thus, the proportion of the QA budget spent on tools was 30% in 2015, 29% in 2016, 33% in 2017, and 31% today.

According to our respondents, it is the expenditure on hardware and infrastructure that has gone up over time. The percentage of the QA and testing budget allocated to hardware and infrastructure was reported to be 37% in 2015, 40% in 2016, 46% in 2017, and 44% in 2018. This reported rise in the percentage spent on hardware and infrastructure is surprising, given the fact that cloud adoption has been rising recently. Given this cloud adoption, we expect the share of infrastructure cost in the total QA and testing budget to come down significantly in the future.

According to our 2018 survey, when asked about the individual factors that had an impact on the increase in QA and test budgets, respondents gave the highest weighting to “business demands higher IT quality” (27%), followed by “increased inefficiency of test activities” (25%), and “increased complexity of IT applications” (24%). It is interesting to note that the importance of the top-two factors quoted above has actually been falling over the last two years. For instance, the “business demands higher IT quality” came down from 33% in 2016, to 29% in 2017, to 27% in this year’s survey.

Similarly, the “increased inefficiency of test activities” has also come down from 29% in 2016, and 31% in 2017, to 25% today. This perception of increasing efficiency is perhaps a result of greater maturity on the part of organizations in handling the new frameworks and technologies and realizing the benefits of automation. In other words, it seems that organizations have become better at deriving the benefits promised by these technologies and frameworks.
Proportion of QA and testing budget allocated to hardware, infrastructure, tools, and human resources

In addition, expert opinion holds that the increased number of test cycles brought about by the shift to agile and DevOps is perhaps one of the biggest reasons for a rise in testing effort and expenditures.

Summary

QA and testing budgets have been through a period of intense investments, followed by a period of benefits’ realization, resulting in increased testing efficiency. Organizations are seeing a stabilization of spends related to agile and DevOps adoption, which is becoming increasingly mainstream today. However, over the next two to three years, we are likely to see increased investments in testing lifecycle automation, AI, RPA, and analytics in testing. As with every other technology, this is likely to increase QA and testing budgets in the short-term before the expected efficiencies start to kick in and drive costs down. According to our respondents, the percentage of the IT budget dedicated to QA and testing, will rise to an average of 33% within three years.

To gain the maximum benefit from their QA and testing spends, we would recommend that organizations focus on three key areas over the next couple of years. First, work on creating successful use cases (in testing) for new technologies such as AI, machine learning (ML), or robotics process automation. Second, create detailed and elaborate tracking mechanisms to understand exactly how much cost and effort is going into testing in Agile or DevOps teams. It would be impossible to reduce costs without understanding clearly how much is being spent and where. Finally, there is one step that organizations can immediately take to improve testing efficiencies, that is the use of end-to-end automation in testing. While investments are being made, they are nowhere near the optimal levels. All three of these steps will go a long way in improving testing efficiency and the quality of their IT systems in the long term.
Sector Analysis
The Automotive sector is changing, and it’s not an evolutionary change but a revolutionary one. Over the years, the amount of software in a typical car has been rising steadily and today, original equipment manufacturers (OEMs) are investing heavily in next-generation vehicles and drivetrains. They are gearing up for market disruptions caused by autonomous vehicles, ubiquitous connectivity, vehicle electrification, and the declining stocks of fossil fuels. These trends mean that OEMs will need to reorient their organizations (and supply chains) from a focus on mechanical, electrical, or product engineering to a focus on software and, in terms of revenue streams, from a focus on the driver to a focus on the passenger.

This requires a change in the processes, structure and most importantly, the mindset of organizations. Given the emergence of competitors such as Tesla and Uber, automobile companies and their suppliers will increasingly need to think and behave like software companies. This is likely to be an unwieldy and complicated transformation, as almost every piece of hardware going into an automobile today has some software on it, thus giving rise to the need to maintain updated versions across all platforms, for all vehicles. In addition, the inevitability of driverless vehicles means that new revenue streams and models will have to come up which put the passenger rather than the driver at the center of everything. The car will change from being an asset that someone buys or leases to becoming a platform for mobility that can be owned, or leased, or rented by the minute. OEMs will need to figure out what services they can provide to drive this change in consumer behavior and create revenue streams. They have already been collecting vehicle data for a number of years, which has led to huge data lakes that are being leveraged to generate the required insights to help this transformation.

A related trend is that a number of OEMs are beginning to reach the customer directly, bypassing their traditional marketing channels. This means a lot of focus on customer intimacy and digital applications.

These changes increase the complexity of the ecosystem exponentially. This increased complexity and the need to complete testing within shorter timeframes has led to an increased focus on test automation, continuous testing, and the acquisition of tools required for this. This complexity is a huge challenge, especially as the global automobile companies still have a significant legacy component in their IT systems. While the newer, digital applications are usually on the cloud, their core manufacturing, core engineering, and core finance applications are still on legacy systems. The challenge posed by this is further complicated by the need for new skill sets to handle platform migrations, agile processes, and automation efforts.

**QA and testing budgets and what’s driving them**

According to this year’s survey, the percentage of IT budgets spent on QA and testing in the Automotive sector is 29% as against a corresponding figure of 26% across all sectors. In particular, 21% of the respondents in the Automotive sector (as against 10% across all sectors) said that their QA and testing spends were between 40–50% of their IT budget. This wide variation can be explained by the huge investments being made in software for connected car projects and the need to test them. This has also led to a rise in the proportion of the IT budget spent on QA and testing. In our survey, 72% of respondents said that they had observed an increase in the proportional effort and cost spending in QA and test activities over the last four to five years.

Spending on QA and test activities can also be linked directly to IT and testing objectives. For instance, when asked about the objectives of their IT strategy, 50% of respondents from the Automotive sector wanted to “enhance security,” followed by 44% who wanted to “enhance customer experience,” and 39% who wanted “higher responsiveness to business demands.” Similarly, when asked about the objectives of their QA and testing strategy, 43% of respondents from the Automotive sector wanted to “detect software defects before go-live,” followed by 42% who wanted to “increase the quality of software/product,” followed by 41% who talked about “ensuring end-user satisfaction.”

These objectives give us a fair idea of the direction in which the Automotive sector is headed. On the one hand, there is an increased focus on shifting business demands, customer experience, and end-user satisfaction, all of which require a greater alignment between business and IT. At the same time, the results reflect the exponential increase in the importance of software assurance.
of digitalization and IoT in the context of connected cars. They also reveal the motivation behind OEMs’ efforts to reach the customer directly and increase customer intimacy.

### Digitalization and the challenges of test environments and test data

More and more automobile companies are releasing vehicle-related applications today. Even though the use of such applications remains low, a key part of their strategy is to achieve greater customer intimacy and is integral to becoming a more software-oriented company. This has created additional challenges for the QA and testing function. For instance, when asked about their challenges in testing mobile, web, and other types of front-office applications, 53% of Automotive sector respondents said, “not enough time to test,” 36% said that they “don't have the right tools to test,” and 33% said that they “don't have the right testing process or method.”

In the first place, the current QA challenges in the sector are driven by the focus on faster time-to-market and the consequent adoption of Agile and DevOps, which has led to more frequent release cycles and increased the pressure on QA and testing. In addition, the QA challenges are also related to a lack of the right test tools and test processes within the sector. Finally, a lack of the required skill sets, in particular of profiles such as software development engineers in testing (SDETs), test automation experts, and migration architects is a key factor holding back the industry from more modern approaches to QA and testing.

Another key challenge is the huge legacy component that is a part of Automotive IT systems. As mentioned earlier, latest applications in the Automotive sector are being built using newer approaches, such as Agile and DevOps. This leads to issues when these applications need to be integrated back with the legacy applications. One of the biggest challenges is that of recreating test environments on a mass scale due to the complexity and number of permutations/combinations of the environment and data that needs to be replicated. It is also not always possible to just take copies of production data, due to concerns about the privacy and security of customers’ personal data.

According to our survey, an average 33% of testing in the Automotive sector occurs in a traditional permanent test environment. Approximately 19% occurs in a cloud-based temporary test environment, 17% occurs in a temporary non-cloud test environment, and 15% in a virtualized test environment. These percentages show the persistence of traditional approaches to testing. Encouragingly, however, the Automotive sector is also using containerized test environments, with an average 15% of all test environments being of this type.

When asked about the challenges in provisioning test environments, 58% of Automotive sector respondents (as opposed to 54% across all sectors) quoted “defects due to inaccurate configuration of test environments,” followed by 53% (54% across all sectors) who blamed the “cost of test environment,” and 41% (37% across all sectors) who identified a “lack of visibility to test environment availability.” Similarly, when asked about the challenges in managing test data, 63% of Automotive sector respondents (61% across all sectors) said “maintaining test data consistency across different systems under test,” 60% (46% across all sectors) said “finding the relevant test data in large test data sets,” and 59% (51% across all sectors) said a “lack of test data for complex integration testing across systems and organizations.”

These results show that this sector experiences more test data and test environment challenges than others. Things like the lack of visibility, to test environment stability, and issues with test data consistency all point to issues with managing the complexity of test data and environments and issues with integration of data coming from different sources.

### Two major trends – IoT and automation

The rise of the connected car has put a lot of focus on the Internet of Things (IoT) in the Automotive sector. This came through in our survey results, when respondents were asked about their test strategy for testing IoT products. Forty-eight percent of respondents from the Automotive sector claimed to “have a fairly mature IoT test strategy,” as compared to 41% across all sectors. This figure was the second-highest across all sectors surveyed. The results are not surprising when you consider the number of OEMs that have had...
connected vehicles for some time. These OEMs also have a lot of data collected from these vehicles and moving forward, it will be interesting to see how they use these insights to come up with new and innovative services.

Another big trend in this sector is the need for test automation. Even though it is a growing trend, the levels of automation for QA and testing remain low. According to our survey, the most popular activities to automate are the generation of functional test cases (20% generated using test generation tools), execution of security tests (18% executed with test automation tools), and the execution of performance test cases (18% executed with test automation tools). Thus, the levels of automation are still quite basic, but we expect these percentages to increase in the future.

At present, there are many challenges holding back the adoption of automation. For instance, 66% of Automotive respondents (61% across all sectors) said they found it difficult to automate as their “applications changed with every release,” 62% (42% across all sectors) said that they “didn’t have the right automation tools,” and 55% (48% across all sectors) said that they had “challenges with test data and environment availability and stability.”

Despite these challenges, there is an emerging trend around the use of analytics and artificial intelligence (AI) for optimizing test automation. According to our survey, 44% of Automotive sector respondents said that they were leveraging analytics and AI for intelligent automation. An additional 41% said that they were leveraging these technologies for “self-learning cognitive platforms” to help optimize QA activities.

Summary

The Automotive sector is going through a period of transition that will place great demands on its QA and testing function. The QA and testing in this sector will have to scale up rapidly with greater adoption of automation, agile and DevOps. To make this move successfully, OEMs will have to move up the maturity curve in terms of testing digital capabilities and digital offerings. They also need to aggressively deal with their legacy applications on a priority basis as the challenges around this will become more and more complicated as QA and testing evolves.
Consumer Products, Retail & Distribution

Customer-centricity and speed-to-market call for improvement in QA approach

Cyndi Fulk Lago  
Vice President,  
CPRD Practice, Capgemini

Adam L Agnew  
Executive Vice President,  
CPRD Practice, Capgemini

Anand Banka  
Associate Vice President,  
CPRD Practice, Capgemini

Hitesh Naidu  
Senior Manager,  
Application Services, Capgemini

The Consumer Products, Retail and Distribution (CPRD) sector is the most customer-centric sector included in our survey. Due to this, some of the most important trends in CPRD today relate to driving end-user satisfaction, data, and analytics.

The CPRD sector was one of the first to be a part of the Digital Revolution. Starting with the first, tentative steps of e-commerce sites and multi-channel engagement, today digitalization is impacting almost every part of the CPRD sector from the shopping experience, to the supply chain and the distribution network. Brick-and-mortar operations are becoming obsolete and a lot of the smaller organizations that have not embarked on the Digital Transformation journey are simply not able to compete and are being pushed out of the market.

Another big trend impacting the CPRD sector is a wave of investments in ERP upgradation. This is a challenge, as most organizations are trying to make this move in an agile manner and within a limited timeframe. Moving to the latest ERP business suites successfully also involves a lot of quality assurance (QA) and testing work and to speed it up many organizations are looking at ways of doing progressive automation.

Consumer centricity, quality, and testing

In CPRD, everything revolves around the consumer. According to this year’s WQR survey, when asked about the objectives of their QA and testing strategy, CPRD respondents gave the highest weighting to “ensuring end-user satisfaction,” with as many as 50% of CPRD respondents (the highest across all sectors), pointing to this as an important objective. This was followed by 47% who said, “enhance customer experience” (once again, the highest rating across all sectors), and another 47% who said, “higher quality of software solutions.” The implications are clear — factors such as quality, brand name, and customer experience are extremely important here. Additionally, the multi-channel engagement with consumers also increases the importance of security. There have been a number of high-profile data leaks over the past few years, all of which have received widespread condemnation and adversely impacted the brand images and customer relationships of the organizations concerned.

The importance of security has also been increased by CPRD’s move to the cloud. This has created a bit of an issue for many organizations, as they suddenly have to deal with a number of very stable but non-business critical applications, which they had not bothered to get upgraded earlier. Moving such applications to the cloud, calls not just for an upgrade but also for a lot of additional QA and testing work.

These trends are also having an impact on QA and testing budgets. According to our CPRD respondents, the percentage of the IT budget allocated to the QA and testing function was 26% in 2018, down from 28% last year. However, it is important to note that while the proportional share has decreased slightly, both the overall IT budget as well as the absolute spends on QA and testing have been rising for most organizations. Importantly, it is the composition of this spend which has changed.

As we have already noted, some of the QA and testing spend is being driven by the move to the latest ERP business suites as well as security testing linked to the move to the cloud. QA and testing spends today are no longer oriented only towards items such as black-box testing, package testing, or automation testing. Instead, a growing proportion of the QA and testing budget can be called architectural spend, since it arises from the integration of testing ecosystems with external and internal partners or from the move to the cloud and the integration efforts on various applications.
In general, the CPRD sector is moving toward an open architecture model, as everyone is moving away from monolithic ERP applications and trying to create nimble systems using SaaS-based applications and open-architecture tools. This has increased the spends on integration testing. In addition, there are significant investments being made today in tools, organization, and processes related to automation, test-driven development (TDD), and DevOps.

These investments are expected to lead to multiple efficiencies and bring down the QA and testing costs in the long run. However, in the short term, this spate of investments has led to a bump in QA and testing spends. According to our survey, as many as 72% of CPRD respondents said that they had seen an increase in the proportional effort and cost of QA and test activities over the last four to five years. Of course, when going through these results, one should also keep in mind that the adoption of agile and DevOps have made it more difficult to track exactly how much is being spent on QA and testing versus other activities.

A head start in agile, DevOps, and omni-channel testing

Another big trend in the CPRD sector is omni-channel engagement. As already mentioned, CPRD has always been ahead of the curve when it comes to this. This year’s survey reveals an increased demand for reducing the test cycle times for these types of applications. When asked about their greatest challenges in testing mobile, web, and other types of front-office applications, 51% of CPRD respondents said, “not enough time to test,” followed by 42% who said, “don’t have the right tools to test,” and 30% who said, “don’t have the right testing process/method.”

The adoption of Agile and DevOps is driving the focus on reducing test cycle times in this sector. According to this year’s survey, 100% of our CPRD respondents said they were using DevOps principles for at least some processes in their organization. Similarly, when asked about how test activities were organized, 54% of CPRD respondents (as against an average of 45% across all sectors) said that “test activities are performed by all team members, supported by a test professional,” while another 46% (43% across all sectors) said that “test activities are performed by all team members, without a specific test professional.” Both these statements reflect agile organizations and the data demonstrates the greater adoption of agile in the CPRD sector, as compared to other sectors. With agile and DevOps adoption we also see increased challenges around efficiency of testing the incremental elements. As a consequence, CPRD organizations have increased their focus on test automation to solve these agile quality challenges.

When asked about the challenges in applying testing to agile development, as many as 59% of CPRD respondents pointed to a “lack of appropriate test environment and data.” This was the second-highest figure across all sectors. According to the survey, the biggest challenges in establishing test environments for test teams were “cost of test environments” (55% of CPRD respondents), “defects due to inaccurate configuration of test environments” (53% of CPRD respondents), and “having to maintain multiple versions of test environments” (40% of CPRD respondents). Similarly, the biggest challenges with regard to test data management were “creating and maintaining test data which are not copies from production data” (59% of CPRD respondents), and “maintaining test data consistency across different systems under test” (58% of CPRD respondents).

Finally, another big challenge being faced by the CPRD sector is a lack of the new skill sets required by some of the new technologies or frameworks such as Agile and DevOps. For instance, when asked about the technical challenges they faced in developing applications, 47% of CPRD respondents replied with “lack of proper skills for QA and testing.” Some of the skills which are in short supply in the CPRD industry relate to automation testing and architecting the move to the cloud.

Summary

The CPRD sector today, displays an interesting mix of trends. While it has always taken the lead when it comes to Digital Transformation and omni-channel engagement, today the aspiration is to use these channels to customize the end-user experience for each individual customer. Organizations are also experimenting with the application of some emerging technologies such as artificial intelligence (AI), and machine learning (ML), to QA and testing. In the CPRD industry this is mostly seen in the form of chatbots to interact with consumers. CPRD organizations are also massively moving to the cloud and this trend is expected to pick up over the coming years.

Despite all these encouraging signs, serious QA challenges still exist today. The biggest among them is related to a lack of the kind of skill sets required by trends such as agile, DevOps, cloud migrations, and automation. To tackle this challenge, the industry will have to find ways and means to attract younger people towards the testing function and put the right training programs, internships, and retraining programs in place. To some extent, this lack of skills can be alleviated by better automation, powered by the coming together of technologies, such as AI and ML. This combination of automation, AI, and ML is likely to be the focus over the next two to three years.
When we look at the Quality Assurance (QA) and testing trends in the Energy and Utilities sector something rather interesting emerges. While on one hand, the assets-heavy, capital-intensive sector seems to be experiencing disruption in a big way with the onset of the “smart” era, the dependency on legacy systems and a lack of the required skills is slowing down the move toward this digital era.

Though at a broad level, the sector is going through a period of disruption, there is a lot of variation across different regions and organizations. This is due to the fact that, while Energy broadly means Oil and Gas, the word Utilities is different in the US, Canada, and Europe. In Europe, the bulk of utilities remain regulated as opposed to some of the non-regulated trends we see in North America. While regulated utilities are still trying to work their way towards agile and DevOps environments from legacy systems and waterfall-type approaches, non-regulated utilities players have made more impactful digital strides, particularly in their interaction with customers.

Need for speed

The utilities space is witnessing massive disruption at the moment. Ten years ago, we had an electric grid that was reliant on coal-fired power plants and nuclear power plants. Now, you see several dynamics at play: (i) a slow down or lack of expansion in nuclear power generation (more acute in the US), (ii) a move away from the “dirtier” coal-fired generation, and (iii) an uptick in “cleaner” burning natural gas as a generation source. Utilities are investing in meter services, for example putting in smart devices in homes so that a customer can manage their energy usage, know when usage peaks, and get an insight into the energy consumption patterns of various appliances, etc. Companies are also supporting other tangential services, such as landscaping, to keep the transmission lines and power lines clear of vegetation.

Despite these major disruptions, Energy and Utilities organizations have been slow to move to the cloud. According to this year’s World Quality Report (WQR) survey, an average 72% of applications in this sector are based in the cloud. There is a clear preference for private cloud in this sector, with an average 25% of all applications based in the private cloud and just 14% in the public cloud. This is most likely a result of security concerns, though we expect the percentage of applications in both private and public cloud to rise in the future.

Another major issue is the heavy dependency on legacy systems which have been a major hindrance in the digitalization of the sector. However, digitalization is clearly a focus area, given the competitive pressures and the need to attract and retain customers. Of course, there are significant challenges here as well. When asked about the biggest challenges in testing mobile, web, and other types of front-office applications, 56% (versus 52% across all sectors) said, “not enough time to test,” followed by 48% (versus 43% across all sectors) who said, “we don’t have the right tools to test” and 37% (versus 34% across all sectors) who said, “we don’t have the right testing process or method.”

Our survey also revealed that an astounding 99% companies are working with Internet of Things (IoT) products, a statistic that is the highest across all sectors. That said, most respondents (42%) shared that they do not have any specific test strategy for IoT products, but plan to include one in the near future. This is despite the fact, that the industry is already very asset-intensive and has sensors everywhere helping to collect data and monitor assets. This trend is likely to become even more prevalent and important in the future.

Similarly, another emerging trend is related to blockchain, with 80% of Energy and Utilities sector respondents saying they are using blockchain in their portfolio today or plan to use it in the coming year. These trends create a huge opportunity as the journey to the cloud will help unlock the ability to be more agile, as well as to leverage artificial intelligence (AI) and IoT products.
Lagging behind in agile and DevOps adoption

Historically, the sector has been slow to adopt frameworks, such as Agile and DevOps, with teams typically working in large silos. However, most organizations seem to have caught up with this trend over the last two years. According to our survey, 97% of Energy and Utilities respondents (as opposed to an average 99% across all sectors) are using DevOps principles in at least a subset of their projects. Of the companies using Agile, 38% said, “test activities are mostly performed by test professionals,” and another 38% said, “test activities are performed in a distributed team.” As opposed to this, 25% of respondents said, “test activities are performed by all team members, supported by a test professional,” and 42% said, “test activities are performed by all team members, without a specific test professional.” These results not only show that there is an almost bimodal split between agile and non-agile methods of organization of QA and testing activities, but that the split is still weighted towards waterfall methods.

The slower move to Agile and DevOps is linked to the general lack of maturity of QA and testing in this sector. When asked about the challenges faced in applying testing to agile development, 52% of Energy and Utilities respondents (as opposed to 50% across all sectors) said, “inability to apply test automation at appropriate levels,” followed by 48% respondents (48% across sectors) who cited, “difficulty in slicing test activities for more than one location for distributed Agile,” and 46% respondents (39% across all sectors) who said, “difficulty to re-use and repeat tests across sprints/iterations.”

Expert opinion holds that challenges related to test data and environments are also very important in holding back this sectors transition to agile and DevOps. The steady albeit slow adoption of agile and DevOps is also driving the adoption of automation in this sector. At present, automation is most popular for execution of test cases (17% automated versus 16% across all sectors), followed by test data generation, (17% versus 15% across all sectors) and execution of end-to-end business scenarios (16% versus 15% across all sectors).

The Energy and Utilities sector also faces significant challenges when it comes to the adoption of automation. An overwhelming 71% of respondents (as opposed to 61% across sectors) said that they had difficulties in automation because their applications changed too much with every release. In part, this could be due to an increased number of releases being mandated by business as well as an inability to define requirements as robustly as required. Some of the other responses include, “we have too many automation tools” (42% in the Energy and Utilities sector versus 29% across all sectors), “poorly defined project requirements impeding decisions on right test scenarios” (38% in Energy and Utilities versus 25% across all sectors), and “a lack of skilled and experienced test automation resources” (38% in this sector versus 46% across all sectors). Overall, the Energy and Utilities sector seems to suffer from a lack of enterprise standards related to automation.

Test budgets, cloud, and bimodality

According to our survey, 81% companies spend more than 10% of their IT budget on testing and QA, with most companies allocating 21%–30% to the function. This covers testing processes, tools, and resource costs. Additionally, 77% of Energy and Utilities sector respondents have seen an increase in the proportional effort and cost spending on QA and test activities over the last few years, as opposed to an average 72% across sectors. This possibly reflects the investments taking place in terms of agile, DevOps, automation, and IoT.

As already mentioned, this sector has a significant legacy component, which creates a kind of bimodality in their IT systems as most as most front-office apps are often hosted on the cloud, while their back-office systems are based on legacy systems. These monolithic IT systems are often not conducive to agile and DevOps approaches, making it very difficult for enterprises to integrate the newer, front-end solutions with this legacy back-end. This is a knotty issue, which defies any quick-and-easy solutions.

Many of the trends seen in this survey are a direct reflection of this bimodality which also leads to several of the challenges in adopting more modern methods of QA and testing. Lack of the required skills is another issue which needs to be solved on a priority basis. For instance, 98% of respondents reported difficulties in testing with agile and 52% of respondents cited the “inability to apply test automation at appropriate levels.”

This is a clear indication of the lack of maturity and proper skills persisting in the public sector. Experts believe that lack of professional test expertise is one of the biggest challenges faced in the sector.

Summary

The Energy and Utilities sector needs to accelerate in digitizing its operations and move to an agile and DevOps environment. This sector must overcome the challenge of poorly defined project requirement to get the right test scenarios and deploy proper tools. The biggest trends to watch out for in the Energy and Utilities sector are grid modernization and customer engagement.

More and more consumers are expecting to engage with their utilities companies as they engage with Amazon or any other leading retail company. Digital operations/manufacturing will continue to see adoption of AI and IoT, and business cases put together around the new technologies. Experts believe we will see an increase in the use of smart analytics, insights and data-related trends in QA and test activities in the future. In the coming years, the sector will also increase its focus on assuring quality, and testing and deploying rapidly. We believe that it will be the organizations which can scale agile and DevOps to the enterprise level quickly, which will emerge as winners in the future.
Financial Services organizations are going through a fundamental change in outlook and modes of operation. Over the last couple of years, this sector has seen a lot of disruption caused by digitalization and competition from technology companies. While FinTech companies still lead in terms of innovation, it is interesting to note that today even the large financial institutions consider themselves to be FinTech companies as far as speed and innovation is concerned.

This year, we see an acceleration of all the trends pointed out in last year’s World Quality Report (WQR). Take Digital Transformation, for instance. While Financial Services organizations have always been slightly ahead of the curve when it comes to digitalization, this year has seen even greater strides being made in this direction, with a number of smaller and mid-tier organizations embarking upon their Digital Transformation journeys. In addition, while initial Digital Transformation efforts were focused on customer experience, today we are witnessing a more broad-based movement towards the digitalization of back-end processes.

Another trend that has picked up is the automation of quality assurance (QA) and testing. Certain parts of testing such as performance and regression testing have always been automated but today, there is a growing interest in automating the entire testing lifecycle. There is also a great interest in the combination of artificial intelligence (AI) and automation to optimize and cut down on cycle time in testing. Organizations are experimenting with analytics, AI, and machine learning (ML) to optimize the automation of QA and test activities. One such example is the use of AI dashboards, which have helped agile teams work better, by providing easy project visibility to all the stakeholders.

Financial Services (FS) organizations are going through a fundamental change in outlook and modes of operation. Over the last couple of years, this sector has seen a lot of disruption caused by digitalization and competition from technology companies. While FinTech companies still lead in terms of innovation, it is interesting to note that today even the large financial institutions consider themselves to be FinTech companies as far as speed and innovation is concerned.

This year, we see an acceleration of all the trends pointed out in last year’s World Quality Report (WQR). Take Digital Transformation, for instance. While Financial Services organizations have always been slightly ahead of the curve when it comes to digitalization, this year has seen even greater strides being made in this direction, with a number of smaller and mid-tier organizations embarking upon their Digital Transformation journeys. In addition, while initial Digital Transformation efforts were focused on customer experience, today we are witnessing a more broad-based movement towards the digitalization of back-end processes.

Another trend that has picked up is the automation of quality assurance (QA) and testing. Certain parts of testing such as performance and regression testing have always been automated but today, there is a growing interest in automating the entire testing lifecycle. There is also a great interest in the combination of artificial intelligence (AI) and automation to optimize and cut down on cycle time in testing. Organizations are experimenting with analytics, AI, and machine learning (ML) to optimize the automation of QA and test activities. One such example is the use of AI dashboards, which have helped agile teams work better, by providing easy project visibility to all the stakeholders.

The adoption of agile and DevOps also continues apace this year. This, along with all the above trends shows up as an increased demand for software development engineers in testing (SDETs) and, in general, a higher demand for testers with advanced technical skills. This factor is likely to become even more important as the complexity of applications increases. Moreover, advances in technologies such as robotic process automation (RPA), ML, and AI, and their use in testing, are likely to drive the demand for newer types of skills in project teams.

Agile teams taking control

FinTechs and larger financial organizations have been working with agile and DevOps project teams for a couple of years now. This is now spreading to the small and middle-tier companies as well. According to our survey, 98% of our Financial Services respondents said they were using DevOps in at least a subset of their projects. In addition, 35% of Financial Services sector respondents reported that implementing agile or DevOps was an important aspect of their IT strategy, as opposed to an average of 30% across all sectors. Today, FinTechs and the larger organizations in the Financial Services industry have successfully adopted agile as a mindset and not just a fancy set of tools.

When asked about the organization of their QA and testing activities, 47% of our Financial Services respondents (versus 45% across sectors) said that “test activities are performed by all team members, supported by a test professional,” 43% (versus 43% across sectors) said that “test activities are performed by all team members, without a specific test professional,” 40% (versus 39% across sectors) said that “test activities are performed in a distributed team,” and 23% (versus 33% across sectors) said that “test activities are mostly performed by test professionals.” This shows that while testing is organized according to both agile and waterfall frameworks, there is today, a greater usage of Agile rather than waterfall for QA and testing activities in the Financial Services sector.

For financial services companies, distributed agile is also an important factor, given their global presence. Teams work across different regions and different time zones. The ability to manage these teams well will spell increased success for these institutions. But, 47% of respondents state that they have difficulty in slicing test activities for more than one location.

Agile teams also create a demand for more automation tools. The speed at which an agile team operates simply cannot be matched by manual testing. The Financial Services sector has employed automation tools in the past, but now there is a need to widen the scope of automation.
A wider scope for automation

One trend that has gained traction since last year’s WQR survey is test automation. Today, the automation of the regression test pack is almost a given in most Financial Services organizations and now there is a clear movement toward progression/in-sprint automation and end-to-end automation. In other words, automation is no longer confined to test design and test data execution – it is increasingly entering areas such as test data and environments, reporting, and dashboards, etc.

We expect that these trends will continue to gain strength with the increasing adoption of agile and DevOps in the future. In addition, there is also a move toward reducing operations costs by reducing paperwork, digitizing most processes, and increasing the levels of automation. However, the overall levels of test automation remain low, and several challenges stand in the way of greater adoption. For instance, when asked about the challenges in achieving their desired level of test automation, 64% of Financial Services sector respondents (vs. 61% across all sectors) said they had difficulties in automating as their applications changed too much with every release. A further 62% of respondents (vs. 48% across all sectors) said they faced challenges with test data and environment availability and stability, while 40% of respondents (vs. 42% across all sectors) said they didn’t have the right automation tools.

Encouragingly, 71% of Financial Services respondents said that automation had led to better test coverage, 71% said it had led to a reduction in test cycle time and a further 69% said it had led to better reuse of test cases. It is important to note that today, one of the biggest drivers for the adoption of automation is better time to market rather than cost, which has become a secondary concern. In this regard, automation seems to be delivering on its promises.

Making the most of data

To further improve their speed-to-market, companies are turning to analytics. With predictive analytics, companies can identify patterns in testing and predict pitfalls in advance. Fifty-nine percent of respondents say that predictive analytics is an upcoming trend in the coming year.

Another interesting development for Financial Services organizations is the Internet of Things (IoT). Although, the impact of IoT is not as huge as in manufacturing, many financial companies now use data captured from connected devices to predict patterns in their customer behavior. For instance, car insurance companies analyze the driving data of their customers to offer them the right premium.

This means an added layer of testing for companies to ensure that data is accurate. However, according to our survey, twenty seven percent of Financial Sector respondents said that their products have IoT functionality but lack a specific test strategy. This is something that needs to change in the future to accommodate the growing usage of IoT in the Financial Services sector.

Intelligent QA – the science behind testing

The financial services sector also has a growing appetite for intelligent or predictive QA tools. Twenty-four percent of respondents say that cognitive capabilities are an important AI research area for their business. Companies are now investing in cognitive QA to make testing more scientific. With cognitive QA there are lesser chances of human error and more control on important parameters like test environment and test data management.

Robotic process automation (RPA) is also an important feature of intelligent QA and helps companies to reduce the time wasted on repetitive tasks. In fact, 34% of respondents say that they are considering using bots for data generation.

Further, such technologies can also provide companies with interactive dashboards that can be accessed by different stakeholders to get a comprehensive view of testing activities. Cognitive QA can also make automation smoother, thus helping agile teams deliver much more efficiently.

Another interesting aspect within AI is the need for testing business processes created on AI platforms. For instance, companies are also using AI tools for creating more intuitive and engaging tools for customers such as chatbots. Testing the functionality and security of chatbots will be a new experience for testing teams.

Companies are also investing more money to test their AI applications with real devices. Twenty-three percent of users say that they test with real users and real devices before launching an application. For companies, using real devices is an expensive option but guarantees better testing results.

Further, 18% of respondents say that they use virtualization technologies to test before launch. This clearly points to a need for creating a robust virtualization infrastructure by combining real devices, simulators, and emulators to test their new AI applications.

Technical developments impacting QA in the Financial Services sector

As mentioned earlier, there is today an increasing focus on digitalization of back-end applications. This means a greater stress on integration of the customer-facing applications with back-end systems and processes. This has increased the importance of integration testing which helps ensures that the different components in a system work smoothly together. However, there are a few challenges in this regard.
For instance, 21% of respondents said that an inability to test integration at an early stage is a challenge in developing applications today. In addition, 50% of Financial Services sector respondents also said they lack proper test data for complex integration testing.

Today, Financial Services sectors companies are increasingly harnessing the power of the application programming interface (API) economy. With a rise in platform-based business models, APIs help in bringing stakeholders on a common platform to create innovative customer-facing applications.

For testing organizations, APIs present a unique challenge owing to many participants and here too, integration testing can help companies test the performance and security of APIs.

Multi-channel testing will also be an important focus area for Financial Services companies. Presently 23% of respondents state that automation of customer experience testing is a challenge in multi-channel testing. Another 21% state that establishing the test data for customer-experience testing is also a challenge in this area.

Summary
This year’s survey reveals not just a continuation but rather an intensification of the trends seen over the last few years in the Financial Services sectors. There is a continuing increase in digitalization, agile, DevOps, and automation along with the emergence of new technologies such as blockchain, IoT and AI which are reshaping the way QA and testing is done. Over the next two to three years, it is the combination of automation, AI, and analytics that will emerge as a key competitive differentiator and shape the evolution of QA and testing.
Mallick Azfar  
Vice President, Life Sciences, Sogeti, Capgemini Group

Healthcare and Life Sciences

The rise of digital health

The Healthcare and Life Sciences sector consists of biotechnology, pharmaceutical, animal health, crop science, and medical device companies on the Life Sciences side and healthcare service providers and payers on the Healthcare side. The entire sector is heavily regulated and has historically had a high degree of quality consciousness. Over the years, it has seen a growing trend of patient centricity, a fact reflected in this year’s WQR survey. For instance, when asked about the objectives of their QA and testing strategy, Healthcare respondents gave the highest weighting to “ensuring end-user satisfaction,” with 43% of respondents indicating this as an important objective.

This focus on patient centricity drives some of the important trends that are shaking up this sector today. Firstly, the need to provide end-to-end servicing of patient’s needs is bringing together various entities across the Healthcare and Life Sciences spectrum. Secondly, in the last two years, social, mobile, analytics, and cloud (SMAC) solutions have majorly impacted this sector, changing how organizations run their business and interact with their patients, hospitals, and regulatory authorities.

These solutions have also given rise to the concept of digital health. Where once, pharmaceutical companies would merely create the pills for managing your blood pressure, today, they also create lifestyle apps to help you monitor and manage that blood pressure. Such apps might allow you to get advice from doctors, connect with other patients, track your progress, and send alerts to hospitals.

Just like the wider sector, these apps also have a regulatory aspect connected to them and thus require testing and due diligence. Such regulatory challenges have further complicated the traditional application development challenges, which continue to persist. When quizzed about the technical challenges in developing applications, 48% of Healthcare and Life Sciences respondents indicated the “lack of end-to-end automation from build to deployment,” followed by 45% who said, “too slow testing process,” and 42% who said, “lack of proper skills for QA and testing.”

Another major trend in the Healthcare and Life Sciences sector is the adoption of a slew of new technologies such as digital manufacturing, 3D printing, and blockchain. For instance, 51% of Healthcare and Life Sciences survey respondents said that blockchain was already a part of their portfolio or would be within the next year. The Healthcare and Life Sciences sector is also seeing an increasing number of IoT-enabled devices coming out every year, to the extent that a new term – Software-as-a-Medical Device (SaMD) has been coined for this class of devices, which require a different kind of lifecycle testing.

According to our survey, 46% of Healthcare and Life Sciences respondents said they had a mature IoT test strategy, as opposed to 42% across sectors. Expert opinion, however, holds that most organizations in the sector do not differentiate between IoT and standard enterprise application testing. Therefore, one could question the true maturity of IoT testing strategies in this sector. For example aspects like security, connectivity, reliability, and interoperability of IoT devices would typically not be covered to the required level. Regardless, the fact is that more and more IoT devices are being released in the market today and the testing strategies themselves must mature within the next three years.

Cloud and digital transformation

Just like the Public sector, the Healthcare and Life Sciences industry has been slow in moving to the cloud and the reasons are similar. Both sectors provide services that are essential to the well-being of people and have, over a long period of time, depended upon monolithic IT systems that delivered well. That factor, coupled with the critical nature of the services provided, help explain why organizations in this sector are reluctant to move to the cloud.

Security concerns are equally important since Healthcare and Life Sciences organizations often hold sensitive personal data. In general security is very important to all organizations in this sector. When asked about the objectives of their IT strategy, 47% of Healthcare and Life Sciences respondents said they wanted to “enhance security,” making it the most important objective. This importance placed on security and the sensitive nature of the personal data in their possession, has held back many organizations in this sector from moving to the cloud.

We can see the impact of these factors in our survey results. According to our respondents, approximately 70% of
applications in Healthcare and Life Sciences organizations are based in the cloud, versus roughly 73% across sectors. On average, 22% of Healthcare and Life Sciences applications run in a private cloud, 19% run in a public cloud, 13% run in a hybrid cloud and 16% on an on-premises cloud.

Apart from the cloud, another major area of transformation in the Healthcare sector is the concept of digital health. As mentioned earlier, digital health involves the mobile and web-based lifestyle apps being launched by organizations across the sector. This new trend has given rise to a number of specific challenges when it comes to QA and testing. According to Healthcare and Life Sciences respondents, their biggest challenges in testing mobile, web, and other types of front-office applications were, “not enough time to test” (54% of respondents), “don’t have the right tools to test” (46% of respondents), “don’t have in-house testing environment,” and “don’t have devices readily available.”

Underlying each of these challenges is the fact that the adoption of agile and DevOps has increased the frequency of releases and the amount of testing required. The pressure this puts on QA and testing is further compounded by the sheer number of scenarios that need to be tested. To solve these challenges, organizations need to stop treating testing as an after-the-fact activity and embrace test-driven development (TDD). This is a shift that has not yet happened, as most organizations are still working along the lines of requirements-driven development.

The other step that will help to deal with the increased testing workload is the adoption of automation.

Summary

The Healthcare and Life Sciences sector has lagged behind in the adoption of the latest technologies and frameworks for smarter and faster QA and testing. This sector has also seen the persistence of a significant legacy component and an over-reliance on permanent test environments (34% of testing done using permanent test environments in Healthcare and Life Sciences vs. 31% across all sectors). Moreover, the adoption of agile has been held back by this legacy component. While agile has been a buzzword with the big health companies for at least two years, it is mostly applied to front-end and customer-facing applications, with the back-office processes still using waterfall methodologies.

When asked about the challenges in applying testing to agile development, Healthcare and Life Sciences respondents gave the highest weighting to, “lack of appropriate test data and environments,” with 60% of respondents (the second highest across all sectors surveyed citing this as a challenge). Test data and test environments are a big challenge, simply because of the sheer number of possible scenarios that must be tested. It is virtually impossible to deal with this relying solely on manual testing, and this is what increases the importance of automation and more specifically, of smart automation in this sector.

It is clear that digitalization and smart automation are going to be a core theme for this sector over the next two to three years. However, to adopt these technologies successfully, organizations need to overcome the following challenges:

- **Clarity of roadmap:** Organizations need to have a well-thought out testing strategy and roadmap in place. Currently, we see many organizations adopting different automation frameworks or pieces on an ad-hoc basis for different business processes without thinking of a cohesive, end-to-end automation strategy.

- **The digital labor workforce:** Testing is still extremely manual and is struggling to handle the increased workloads brought on by digitalization, agile, and DevOps. Technologies such as IoT, automation, and AI all require specialized skills for which the existing labor force needs to upgrade its skills. Organizations need to put in place skill development plans to make this happen.

**Automation and AI**

When asked about the technical challenges in developing applications today, “the lack of end-to-end automation” from build to deployment came out as the biggest challenge across sectors, with 48% of Healthcare and Life Sciences respondents indicating this as an issue.

According to our survey, test automation in this sector is mostly used for the generation of functional test cases (18% of such cases are automated), followed by the execution of end-to-end business scenarios and the execution of functional test cases (approximately 16% each). The low adoption rates are directly related to the underlying lack of a well-developed and thought-through test strategies.

One of the keys to making test automation more effective is the application of AI in testing and automation. Given the testing workloads today, the reality is that organizations need to figure out what to automate, what not to automate, and what to automate first. This level of cognitive planning or smart test automation will become essential over the next two to three years as it is not humanly possible to test, for example, 3,000 scenarios every four weeks. This is where smartness or the use of predictive analytics comes in.

There are signs that companies are looking at AI seriously. 56% of Healthcare and Life Sciences respondents said they had AI projects for QA in place or planned for the next 12 months. Similarly, 45% of Healthcare and Life Sciences sector respondents said they were leveraging analytics and AI for intelligent automation. The focus on intelligent automation is increasing for two main reasons. The first is the belief that intelligent automation will increase speed-to-market and the second is the belief that it will reduce or eliminate human error.
High-Tech

Ahead of the curve in technological change and the adoption of QA and testing to validate new technologies

Vivek Jaykrishnan
Senior Director - Technology, Engineering Services Global Business Line, Capgemini

Sidharth Kapila
Vice President, High-Tech Portfolio Leader, Capgemini

Malavika Athavale
Vice President, Head-Product V&V Practice, Engineering Services, Capgemini

Rapid and ever-increasing change has been a theme we have already seen in many of the other WQR chapters this year. The IT industry has changed so much that it is virtually unrecognizable from what it was ten years ago. While every sector has been impacted by the relentless pace of advances in technology, business models, and organizational frameworks, it stands to reason that the High-Tech sector (covering manufacturers of hardware products, electronics, aerospace and advanced defense technologies) which itself underpins many of these technological evolutions is feeling the effects of this rapid evolution more than other sectors. The velocity of change is even greater here and this basic fact imbues this sector with characteristics that set it apart.

Being the sector driving many of these changes, High Tech has also been among the first to adopt them. This has led to it being ahead of the curve when it comes to the maturity of its information technology (IT), quality assurance (QA) and testing practices. Over the last three to four years, there have been a spate of investments in agile, DevOps, and automation projects. This has had an impact on QA and testing as well; something that came through clearly in this year’s WQR survey results.

According to our survey, an average 77% of all applications in the High-Tech sector are cloud-based as opposed to an average of 73% across all sectors.

and testing practices. Over the last three to four years, there have been a spate of investments in agile, DevOps, and automation projects. This has had an impact on QA and testing as well; something that came through clearly in this year’s WQR survey results. For instance, when asked whether they had seen an increase in proportional effort and spending on QA and test activities, as many as 79% of High-Tech respondents said yes as against an average 72% across all sectors. Similarly, when asked about objectives of their IT strategy, 37% of respondents from the High-Tech sector said “faster time to market” was important as opposed to 30% across all sectors. This emphasis on time to market as well as other business goals has led to the increased adoption of cloud and reinforced the adoption of agile, DevOps, and automation mentioned earlier.

There are two other factors, both deriving from its history, which make the High-Tech sector unique. The first is that large parts of the High-Tech industry (the aerospace and defense product manufacturers) have traditionally been heavily regulated with a significant proportion of their business coming from government contracts. This historic focus on meeting regulatory and compliance requirements has led to a high level of quality consciousness, with a lot of emphasis placed on QA and testing in this sector.

The second factor that sets High Tech apart, is its considerable experience with handling of connected products. This gives the sector a lead in terms of IoT testing. According to our survey, 48% of High-Tech sector respondents said they have a fairly mature IoT strategy, compared to an average of 41% across all sectors. Here, it's important to add the cautionary note that a number of these respondents might have been referring to the testing of their embedded products rather than the complete end-to-end testing required for IoT products.

Technological changes have also brought about business disruption particularly for the High-Tech manufacturing industry, which has moved from selling products to selling subscriptions. This is known as the subscription economy and success in this new model depends upon speed and customer satisfaction. This has led to a much greater integration of IT and business, with business goals becoming all-important. Thus, when asked about the goals of their QA and testing strategy, 48% of High-Tech industry respondents pointed to “enhance user satisfaction” as opposed to 42% across all sectors. Similarly, when asked about objectives of their IT strategy, 45% of respondents from the High-Tech sector said “higher quality of software solutions.” The focus on quality is understandable, given the levels of cloud adoption as well as the work with connected devices. Similarly, the focus on quality results from the historical factors pointed out earlier, while the focus on
customer experience can be explained by the rise of the subscription model and the process of Digital Transformation which has impacted every sector.

**High-Tech: Being the change**

As already mentioned, the High-Tech sector is ahead of the other sectors in terms of the maturity of its IT and QA and testing practices. This is clearly reflected in our survey results.

The first place we see this is in the adoption of agile and DevOps. For instance, when asked how test activities were performed, 62% of High-Tech respondents (as opposed to 45% across all sectors) said “test activities were performed by all team members, supported by a test professional,” and 50% said “test activities were performed by all team members, without a specific test professional” (as opposed to 43% across all sectors). These two statements reflect that QA is much more integrated in each process step and everyone’s business, as compared to other industries.

At the same time, the stress on time-to-market has resulted in a greater adoption of cloud. Per our survey, an average 77% of all applications in the High-Tech sector are cloud-based as opposed to an average of 73% across all sectors. Out of the different cloud models, private cloud is the most popular (23% of all applications), followed by public cloud (18%), on-premises cloud (18%), and hybrid cloud (15% of all applications).

The impact of this high level of cloud adoption can also be seen when it comes to test environments. For instance, according to High-Tech respondents, on average, only 26% of their testing occurred in a permanent test environment, compared to the 31% average across all other sectors. Additionally, an average 22% of their testing occurred in a cloud-based temporary test environment (as opposed to 19% across all other sectors) and 18% of testing took place in containerized test environments (compared to 16% across all other sectors).

There is also a lot of interest in the use of both AI as well as predictive analytics in testing. For instance, 65% of respondents from the High-Tech sector, as opposed to 57% across all sectors, said they had AI projects in place or planned for the next year. Organizations are also looking at ways to use descriptive analytics in test lifecycle management data which we can see from the 60% of WQR High-Tech respondents who want to use AI in smart dashboards.

**The perils of being an early adopter**

Most of the challenges faced by the High-Tech sector stem from its two distinguishing features; namely, its early adoption of emerging technologies and the rapid pace of change in the industry. These challenges include issues with test data and test environments, as well as the lack of the kind of skill sets required by the new testing approaches.

For instance, when asked about the challenges in applying testing to agile development, 47% of the High-Tech respondents said that lack of appropriate test environment and data was an issue. These issues stem from the increased complexity as well as greater number of releases today. In a situation where some companies, are coming out with new releases every week, if not every day, how do you understand the incremental functionality of the new release and how do you design test environments to provide adequate risk coverage? To solve such problems, organizations are now looking at the next level of predictive analytics solutions to automate the identification of risk areas. This also came up in our survey results. For instance, when asked about the opportunities for AI in testing, 58% of the respondents from the High-Tech sector pointed to the use of AI to automatically create test cases which ensured the right risk coverage.

Similar challenges exist with regard to test data as well. In general, test data management today has to deal with several issues related to the complexity of data, newer forms of data as well as integrating different formats of data derived from different sources. These problems are made worse in the High-Tech manufacturing sector, where most companies outsource manufacturing to original device manufacturers (ODMs), who, in turn source parts from multiple smaller organizations. Setting up accurate data sets that mirror an end-to-end business transaction becomes very difficult in such situations as a lot of the data sits outside the organization. Sharing such data with partners also leads to questions around privacy and security. This is an ongoing challenge with no universally accepted answers having been developed as yet.

Finally, there is also a huge challenge around skill sets. The combination of changes related to agile, DevOps, continuous engineering, and automation have all led to a change in the job profile of a tester. The specialized manual tester of yesteryear is no longer relevant. Instead there is an increasing requirement for software development engineers (SDEs) and software development engineer in test (SDET). At present, there is a shortage of skills in the market but given the amount of re-skilling and training programs that companies are going in for, we expect this problem to go away over the next few quarters.

**Summary**

The High-Tech sector has been one of the early adopters for many new frameworks and technologies. This basic fact is the source of both the maturity of its QA and testing practice as well as the challenges faced by its QA and testing teams. The rapid pace of change and the newer technologies all place great demands on its QA teams and moving forward, the sector is increasingly going to look towards newer technologies such as AI, machine learning, and predictive analytics to solve some of these issues.
Our 2018 survey results reveal some very mixed trends for quality assurance (QA) and testing in the Public sector. On the one hand, we see a maturation of some of the broad themes pointed out in last year’s WQR. On the other, we see considerable variation across regions mainly due to Public sector budgets as well as policy imperatives being driven by political considerations, which themselves vary from country to country. Despite this variation, three basic facts hold across different regions and they explain many of the survey results for the Public sector.

The first is the evolution of a theme we talked about last year – the disaggregation of contracts. More and more governments are switching to smaller deals with multiple suppliers, on the premise that the huge, single prime IT contracts that used to be in vogue earlier have not delivered the agility, flexibility, or value for money that was expected of them. Ironically, this has added a lot of complexity to the IT ecosystem and given rise to a new set of challenges. Mostly challenges around integration and end-to-end testing, their influence can be seen when we look at the survey results for questions relating to agile and DevOps, cloud, and automation.

The second fact is the continuing reliance on legacy systems. This leads to a kind of bimodality in the Public sector IT systems, with newer, more front-end apps often being hosted in the cloud and developed using agile and DevOps, while older apps continue to be hosted on these legacy systems. These are large, stable, monolithic IT systems which often handle masses of data and deliver services that can be critical to the security or well-being of a country. Such systems are often not very conducive to the newer QA approaches and technologies. In fact, integration of the newer, front-end solutions with this legacy back-end is one of the biggest challenges facing this sector. The criticality of these systems (and the services they deliver) makes this a very delicate problem that defies quick solutions.

The third fact is QA and testing for Digital Transformation projects. While there is considerable variation across different regions, there is no doubt that today, Digital Transformation (and the associated QA and testing) is a top priority for the Public sector all over the world.

The rocky road to digitalization

Digital Transformation is driven by the growing awareness that the Public sector needs to up its game to provide the same levels of comfort, convenience, and service as the private sector. This came through loud and clear in this year’s survey. When asked about the objectives of their QA and testing activities, 41% of respondents in the Public sector, pointed to “ensure end-user satisfaction” as an important objective. It is important to note that this figure has risen sharply over the last two years: in 2017, only 34% of Public sector respondents mentioned this as a priority, while in 2016, this figure stood at 31%.

To meet these objectives, governments everywhere are simplifying access to information and services by making them available online or through mobile apps. This gives rise to new challenges for QA and testing. When asked about their challenges in testing mobile, web, and other front-office applications, Public sector respondents gave the highest weighting to “not enough time to test” (44% of respondents), followed by “don’t have the right tools to test” (38%), “don’t have the right testing process/method” (28%), and “don’t have an in-house testing environment” (28%). Many of these issues arise due to the lack of a consistent end-to-end testing and tooling strategy, a task made harder by the integration challenges resulting from disaggregation and the preponderance of legacy systems.

Agile and DevOps adoption hampered by legacy

The desire to serve citizens better, faster, and more efficiently is also driving the adoption of agile and DevOps. But the Public sector is slower in adopting the distributed and self-empowered team approaches that come with this transition. According to this year’s survey, 39% in the Public sector (as opposed to 43% across all sectors) said that “test activities are performed by all team members, without a specific test professional,” while 34% (as opposed to 33% across all sectors) said that “test activities were mostly performed by test professionals.” This shows that the Public sector still lags other sectors in the maturity of its agile practices. In addition, the Public sector is slower in the change in processes,
When asked about the objectives of their QA and testing activities, 41% of respondents in the Public Sector, pointed to “ensure end-user satisfaction” as an important objective.

workflows and culture that come with the transition to agile. As a result, we often see the existence of both agile and waterfall within the same ecosystem in many Public sector organizations.

The survey results reflect this bi-modality, a feature which gives rise to several specific challenges. For instance, when asked about their challenges in applying testing to agile development, 57% of respondents reported “a lack of appropriate test environment and data,” 46% reported “an inability to apply test automation at appropriate levels,” and 44% reported “difficulty in identifying the right areas on which test should focus.” All three of these statements can be explained by the Public sector’s lack of maturity in agile and DevOps as well as a serious challenge regarding skills and capabilities. The challenges that we see here also apply to the adoption of cloud and automation.

Slowly taking root: cloud and automation

Even though there is a noticeable move towards both cloud and automation, the Public sector still lags behind when it comes to the adoption of these two technologies. Survey results indicate that an average 67% of applications in the Public sector (vs. 73% across all sectors) are hosted in the cloud. It is important to note, that this 67% is an average figure with results varying widely across different regions depending upon the country’s laws and regulations regarding customer’s personal data. 67% is also the lowest across all sectors surveyed. This is mostly due to the wide dependency on legacy systems in handling huge volumes of data and supporting critical applications and services. The satisfactory performance of the legacy systems along with the risks involved in migrating critical applications have both weakened the business case for a move to the cloud.

Similar trends hold for test automation. When asked about the percentage of test automation for different activities, Public sector respondents gave the third lowest responses (across all sectors) for “percentage of performance test cases that are executed with test automation tools,” at 15.3% and “percentage of end-to-end business scenarios that are executed with test automation tools,” at 14.2%. This lower adoption can be explained by the existence of a legacy estate as well as the lack of automation testing skills. For instance, when asked about the challenges in achieving their desired level of test automation, 55% of respondents from the Public sector (as opposed to 46% overall) pointed to the lack of skilled and experienced test automation resources. This was the second highest across all sectors surveyed. This lack of the required skill-sets impacts most of the QA trends seen in this year’s survey.

The skills gap: addressing the elephant in the room

The trend towards disaggregation means that Public sector organizations now need to have a certain level of in-house IT skills to manage multi-vendor contracts as well as agile constructs. This is in sharp contrast to the earlier scenario, in which many organizations would leave most IT decisions in the hands of their suppliers. In addition, the existence of both waterfall as well as agile methodologies within the same ecosystem means that both the old, classic QA testers as well as the newer, T-shaped testers (QA professionals with a deep expertise in testing, development and business) have a role to play in the Public sector.

The difficulties in finding some of the newer skills required have been clearly brought out by our survey. For instance, when asked about their greatest challenge in testing mobile, web, and other front-office applications, 31% of Public sector respondents said they did not have the right experts. This was the second-highest weighting across all sectors. Skills were also an issue when it came to the adoption of agile. This year, 41% of Public sector respondents, as opposed to 39% last year, pointed to the lack of professional test expertise in agile teams as a challenge. To address this issue, organizations need to focus on creating capability as well as a pipeline of talent by setting up training programs, apprenticeships, and on-boarding capabilities.

Apart from the above trends, there is also a lot of talk about AI and cognitive technologies and a desire to move towards more predictive testing, though this is still at a very nascent stage. The organization of testing activities too is seeing some interesting shifts. While we saw a move away from managed testing services over the last two to three years,
it appears TCoEs are again coming back, though in a newer iteration. This new, more evolved form of the TCoE is almost a hybrid, with some components centralized and others decentralized. The roles suited to centralization tend to be around performance, security, and integration. This was also reflected in our survey results, in which the most centralized roles in the Public sector were those of business domain-based testers (22% for the Public sector vs. 19% across all sectors) and software development engineer testers (SDETS) (20% for both the Public sector as well as across all sectors).

Considerable challenges also exist with test environment and test data management. According to our survey, the most important issues with regard to test environments in the Public sector were “the cost of test environments” and “defects due to inaccurate configuration of test environments.” Similarly, the biggest issues for test data management were “maintaining test data consistency across different systems under test,” “managing the size of test data sets,” and “creating and maintaining test data which were not copies of production data.” To some extent, these issues can be addressed by a greater use of automation, which can help in creating re-usable data and environments as well as reduce defects and errors.

There are many challenges hindering the greater usage of automation in testing. In some sense, it is a vicious circle in which Public sector is stuck, i.e. the existence of legacy systems holds back the adoption of cloud, Agile, and Digital Transformation - all of which would have naturally lead to higher levels of test automation techniques, which in turn could have helped solve challenges related to data and environments.

Summary
At some point, the Public sector will have to bite the bullet with regard to its dependence on legacy systems. However, this cannot happen overnight. Over the next two to three years, we expect to see a lot of focus on integration, on developing skills and capabilities within organizations and a focus on delivering end-to-end test assurance. We also expect a convergence in testing processes as the evolution of automation technologies allows a more integrated and automated approach to testing.
Telecom, Media and Entertainment
Convergence and changing business models driving a focus on business adaptiveness and flexibility

Darren Coupland
Executive Vice President and Chief Operating Officer, Sogeti U.K.

Madan Sundararaju
Vice President and Portfolio Leader – Media, Capgemini

The Telecom, Media and Entertainment (TME) industry is the midst of a shakeup. While this market has always been a dynamic and fast-moving one, it has today entered a period of particularly rapid change, driven by cost pressures, a highly competitive market, and technological development. On the one hand, emerging technologies such as 5G are driving organizations to update their estate and their services. Thus, we see big investments being made in network innovation, with a move toward software-defined networks (SDN) and network function virtualization (NFV). On the other hand, viewership habits have also changed in the Media and Entertainment industry, with more and more content being consumed via smartphones. This in turn has sparked a wave of mergers and acquisitions as big Telecom companies try to control both the content and the channels through which it is consumed. As big Telecom companies push ahead with such quad-play strategies, there is a convergence between the Telecom and Media and Entertainment worlds. In addition, internet-based media companies, such as like Netflix or Amazon, have also caused massive disruptions by increasing competitive pressures.

All of this has implications for quality assurance (QA) and testing. Increased competition has led to a fight to attract and retain customers, thus increasing the importance of customer satisfaction. With disruptors, such as Netflix and Amazon, working on rapid cycles and producing a lot of content very quickly, time to market has emerged as a key competitive differentiator. This is driving the movement to the cloud as well as the adoption of agile and DevOps. Overall, there is movement toward service-type operating models, with QA and testing services also being bundled and offered through service catalogs. The need for speed and flexibility has also led to a desire for greater automation.

These changes have also led to QA and testing challenges. For instance, there is a tendency in certain quarters to push for speed, even at the cost of quality. This is an unfortunate development, and, in some sense, it implies a faulty application of agile and DevOps. In addition, there are challenges around test data and environments, as well as with the skill sets required by the new operating frameworks.

The increasing adoption of cloud, agile, DevOps, and automation

This year’s survey clearly reveals the value placed on customer satisfaction and the increasing alignment between IT and business. When asked about the objectives of their IT strategy, 50% of TME respondents (versus 47% across sectors) said, "to enhance security", followed by 43% (42% across sectors) who said, "to enhance customer experience," and 36% (36% across sectors) who said, "higher responsiveness to business demands." Similarly, when asked about the objectives of their QA and testing strategy, 47% of TME respondents (39% across sectors) said, "to protect the corporate image and branding,"46% (42% across sectors) said "to detect software defects before go-live," 44% (42% across sectors) said "to ensure end-user satisfaction," and another 44% (41% across sectors) said, "to contribute to business growth and business outcomes."

Almost all the answers (other than "enhance security") are directly related to business outcomes. The high premium put on security in this sector can be explained by the large subscriber base of a typical Telecom company. These organizations have access to their customers’ personal data and breaches can have an adverse impact on brand value and corporate image. In addition, regulations, such as the General Data Protection Regulation (GDPR), have introduced penalties that increase the costs of such breaches.

It is this focus on adaptive business objectives that drives the increasing adoption of cloud, agile and DevOps. According to our survey, an average 74% of applications (versus 73% across sectors) in the TME sector are based in the cloud. Given the concerns regarding security pointed out earlier, there is a preference for private cloud, with an average 24% of applications in the TME sector being hosted in a public cloud. In addition, an increasing movement toward hybrid cloud started this year, with organizations trying to get the best of both worlds (the cheapness of the public cloud, together with the security promised by private cloud solutions). We expect that this percentage will rise in the future.
Today, there are encouraging signs of at least a few big TME companies resolving to move their entire estate to the cloud. For many years, the TME sector simply avoided dealing with these issues, due to the age of the application estate and the complexity of applications such as customer relationship management (CRM) applications and billing systems. The focus was on achieving efficiency and improving time-to-market, without making hard, strategic choices about the legacy estate. This is what led to the bimodality in a number of the WQR survey results we saw in last year’s TME chapter.

Today, however, the desire for a greater adoption of agile, DevOps, and automation (driven by promised benefits, such as greater efficiency, speed, and better risk coverage) are forcing organizations to take these hard decisions. However, given the complexity of the legacy estate, this will be neither quick, nor easy. It will also involve a large amount of investments as a new stack will have to be prepared, tested, and configured – following which data migration will start. Throughout this process, two operations will have to be up and running, requiring huge operating expenses. These expenses present a major challenge. However, the good news is that a few organizations have at least started trying to solve these challenges posed by the legacy estate.

The same imperatives that are driving cloud adoption are also driving the adoption of agile and DevOps. According to our survey, 100% of TME organizations have adopted DevOps for at least some of their projects. When asked how test activities were performed, 55% of TME respondents (versus 33% across all sectors), said that “test activities were mostly performed by test professionals.” The fact that just a little over 50% of Scrum teams have specialized testers is worrying, as it indicates that QA and testing has perhaps still not found its place within agile teams. This is typical, as both agile and DevOps are developer-driven activities and it can be difficult for testing to get equal importance. In such cases, if an organization does not have a well-defined QA methodology that enables them to understand the demands of testing in an agile framework, it can put quality at risk and lead to a speed versus quality dynamic, which can prove disastrous. This is one of the biggest challenges for QA and testing when it comes to the adoption of agile.

When asked about the challenges in applying testing to agile development, TME respondents gave the highest weighting to “a lack of appropriate test environment and data” (58% of respondents), followed by “the difficulty in slicing test activities for more than one location for distributed Agile” (56%), “early involvement of the test team in the inception phase or sprint planning” (53%), and “a lack of professional test expertise in agile teams” (53%).

A move toward intelligent automation

The “speed-versus-quality” dynamic brought about by the adoption of agile and DevOps shows up in a number of places in our survey results. For instance, when asked about their greatest challenge in testing mobile, web, and other types of front-office applications, TME respondents gave the highest weighting to “not enough time to test” (60% of respondents), followed by “we don’t have the right tools to test” (49% of respondents), and “we don’t have the right testing process/method” (34% of respondents).

The perceived lack of time is not surprising, given that TME organizations are usually marketing-led organizations in which business puts a lot of pressure to get new releases out before the competition. Agile has led to more frequent release cycles and this also adds to the problem. The lack of tools to test is a result of the complexity of the applications estate as the sheer number of applications, all using different technologies requires multiple tools to test, thus making end to end testing a huge challenge. Finally, the issues around not having the right testing process or method, possibly reflects the aforementioned “speed-over-quality” dynamic as well as a very real lack of skill sets required by new technologies, such as automation and artificial intelligence (AI), as well as the new frameworks, such as Agile that call for profiles such as software development engineers in test (SDETs).

The TME sector’s desire to automate is propelled by the same objectives driving the adoption of cloud, agile and DevOps. According to our survey, 17% of all functional test cases in the TME sector are generated with test generation tools, 17% of performance test cases are executed with test automation tools and another 17% of security tests are executed using test automation tools. These percentages will certainly increase in the future, particularly as AI and analytics is applied to QA and testing.

According to our survey, 51% of TME respondents (45% across all industries) said that they were leveraging analytics and AI for intelligent automation. Given the time pressure on QA and test activities, this is a very welcome trend, for the use of AI can help define the scope of testing, make sure testing is focused on the right areas, and reduce false positives, thus reducing the time, effort, and cost of QA and testing.

Test data and environment challenges

One of challenges that kept coming up throughout the survey results was related to test data and environments. For instance, when asked about the challenges in achieving their desired level of test automation, TME respondents gave the highest weighting to “our applications change too much with
“every release” (69% of respondents), followed by, “challenges with the test data and environment availability and stability” (53% of respondents). While the first can be explained by the dynamic delivery environment in the TME sector, the second has to do with the number and complexity of applications and associated environments.

The degree of these challenges came through clearly in our survey results. For instance, 63% of TME respondents (versus 54% across sectors) said they faced challenges arising from “defects due to inaccurate configuration of test environments”, followed by 59% (54% across all sectors) who pointed to “the cost of test environments,” and 45% (38% across all sectors) who indicated “the lack of facilities to book and manage your own environments.” Similarly, when asked about the challenges in managing test data, 68% of TME respondents (versus 61% across sectors) said, “maintaining test data consistency across different systems under test,” followed by 61% (56% across sectors) who said, “managing the size of test data sets,” and 60% (50% across sectors) who said, “having to maintain the right test data set versions with different test versions.”

Summary

The TME sector is going through a period of rapid change and we can see the impact of this on QA and testing. The need to be more responsive, flexible, and customer-centric is driving an increasing number of organizations to adopt cloud, agile and DevOps. In addition, there are a number of challenges around test data and environments, skill sets, and the pressure brought to bear on QA and testing in this competitive environment. Over the next two to three years, the challenge before TME organizations is going to be how to remain competitive while investing hugely in upgrading and re-platforming.

For QA and testing to perform, the most important factor will be managing the cultural change that is required by frameworks such as agile and DevOps. Challenges related to skill sets, test data, and environments as well as the “speed-over-quality” mindset will need to be tackled and testing will need to find its natural place in agile and DevOps teams. Technologies such as automation, analytics, and AI hold a lot of promise and are likely to revolutionize QA and testing in the future.
About the study
Survey Sample

For this year’s research, we selected only organizations with more than 1,000 employees (in the respondent’s national market) – an approach used for the last three years to provide us with valid trending data.

Research participants were selected so as to ensure sufficient coverage of different regions and vertical markets to provide industry specific insight into the QA and testing issues within each sector.

With the inclusion of product heads/CTO for the third time, we are able to bring in their views and insights in the space of Product and Engineering Services (P&ES) for Automotive, HealthCare and Life Sciences, and High-Tech Sector.

The research sample consists mainly of senior-level IT executives as shown in Figure 33.

To ensure a robust and substantive market research study, the recruited sample must be statistically representative of the population in terms of its size and demographic profile.

The required sample size varies depending on the population it represents – usually expressed as a ratio or incidence rate. In a business-to-business (B2B) market research study, the average recommended sample size is 100 companies. This is lower than the average sample size used for business-to-consumer (B2C) market research because whole organizations are being researched, rather than individuals.

This year, the B2B market research conducted for the World Quality Report is based on a sample of 1,700 interviews from enterprises with more than 1,000 employees (26%), organizations with more than 5000 employees (34%) and companies with more than 10000 employees (40%). The approach and sample size used for the research this year enables direct comparisons of the current results to be made with previous research studies conducted for the report, where the same question was asked.

During the interviews, the research questions asked of each participant were linked to the respondent’s job title and the answers he/she provided to previous questions where applicable. For this reason, the base number of respondents for each survey question shown in the graphs is not always the full 1,700 sample size.

Questionnaire and Methodology

The survey questionnaire was devised by QA and Testing experts in Capgemini, Sogeti and Micro Focus (sponsors of the research study), in consultation with Coleman Parkes Research. The 41 question survey covered a range of QA and Testing subjects, enriched by qualitative data obtained from the additional in-depth interviews. The quotations shown in the report are taken from these in-depth interviews.
Interviews by sectors

Figure 31

Financial Services industry, including Capital Markets, Banking and Insurance 19%
Public Sector/Government 15%
Telecommunications, Media and Entertainment 13%
Consumer Products and Retail/Distribution and Logistics 10%
High-tech, including hardware vendors + Aerospace and Defence 8%

Healthcare and Life Sciences 8%
Automotive 8%
Energy, Utilities, and Chemicals 7%
Manufacturing 6%
Transportation 5%

Interviews by job title

Figure 33

CIO 27%
IT Directors 22%
QA/Testing Manager 20%
VP Applications 18%
CMO/CDO 7%
CTO/Product Head 6%
Interviews by Region

Figure 32

<table>
<thead>
<tr>
<th>Country</th>
<th># of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>280</td>
</tr>
<tr>
<td>France</td>
<td>149</td>
</tr>
<tr>
<td>Germany</td>
<td>130</td>
</tr>
<tr>
<td>UK</td>
<td>125</td>
</tr>
<tr>
<td>Netherlands</td>
<td>100</td>
</tr>
<tr>
<td>Sweden</td>
<td>85</td>
</tr>
<tr>
<td>Australia</td>
<td>80</td>
</tr>
<tr>
<td>Brazil</td>
<td>79</td>
</tr>
<tr>
<td>Canada</td>
<td>65</td>
</tr>
<tr>
<td>China</td>
<td>60</td>
</tr>
<tr>
<td>Italy</td>
<td>50</td>
</tr>
<tr>
<td>Japan</td>
<td>50</td>
</tr>
<tr>
<td>Spain</td>
<td>35</td>
</tr>
<tr>
<td>Portugal</td>
<td>35</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>32</td>
</tr>
<tr>
<td>Hungary</td>
<td>30</td>
</tr>
<tr>
<td>Finland</td>
<td>30</td>
</tr>
<tr>
<td>Belgium and Luxembourg</td>
<td>30</td>
</tr>
<tr>
<td>Norway</td>
<td>30</td>
</tr>
<tr>
<td>Denmark</td>
<td>30</td>
</tr>
<tr>
<td>Poland</td>
<td>30</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>25</td>
</tr>
<tr>
<td>Singapore</td>
<td>25</td>
</tr>
<tr>
<td>Ireland</td>
<td>25</td>
</tr>
<tr>
<td>Switzerland</td>
<td>20</td>
</tr>
<tr>
<td>UAE (excluding Dubai, Abu Dhabi)</td>
<td>15</td>
</tr>
</tbody>
</table>
About the Sponsors

About Capgemini and Sogeti

A global leader in consulting, technology services and digital transformation, Capgemini is at the forefront of innovation to address the entire breadth of clients’ opportunities in the evolving world of cloud, digital and platforms. Building on its strong 50-year heritage and deep industry-specific expertise, Capgemini enables organizations to realize their business ambitions through an array of services from strategy to operations. Capgemini is driven by the conviction that the business value of technology comes from and through people. It is a multicultural company of 200,000 team members in over 40 countries. The Group reported 2017 global revenues of EUR 12.8 billion.

Sogeti is a leading provider of technology and engineering services. Sogeti delivers solutions that enable Digital Transformation and offers cutting-edge expertise in Cloud, Cybersecurity, Digital Manufacturing, Digital Assurance & Testing, and emerging technologies. Sogeti combines agility and speed of implementation with strong technology supplier partnerships, world class methodologies and its global delivery model, Rightshore®. Sogeti brings together more than 25,000 professionals in 15 countries, based in over 100 locations in Europe, USA and India. Sogeti is a wholly-owned subsidiary of Capgemini SE, listed on the Paris Stock Exchange.

Learn more about us at:
www.capgemini.com/testing or
www.sogeti.com/testing

About Micro Focus

Headquartered in Newbury, United Kingdom, Micro Focus is a leading global enterprise software company uniquely positioned to help customers extend existing investments while embracing new technologies in a world of Hybrid IT – from mainframe to mobile to cloud. With operations worldwide, and over 40 years of software experience, Micro Focus helps customers solve the most complex technology problems through the delivery of world-class, enterprise-scale solutions in key areas including Hybrid IT Management, Enterprise DevOps, Security & Risk Management, and Predictive Analytics.

For more information, visit www.microfocus.com.
Thank you

Capgemini, Sogeti and Micro Focus would like to thank

The 1,700 IT executives who took part in the research study this year for their time and contribution to the report. In accordance with the UK Market Research Society (MRS) Code of Conduct (under which this survey was carried out) the identity of the participants in the research study and their responses remain confidential and are not available to the sponsors.

All the business leaders and subject matter experts who provided valuable insight into their respective areas of expertise and market experience, including the authors of country and industry sections and subject-matter experts from Capgemini, Sogeti and Micro Focus.

Main Report Authors
Mark Buenen and Ajay Walgude

Writer for Main Chapters
Rahul Mitra

Writer for country pullouts
Jayant Kumar

Program Manager
Balaji Narasimhan

Project Manager
Archit Revandkar

Partner Management
Malcolm Isaacs and Christine Ewing

Content Proof Reading
Monica Kwiecinski

Market Research
Stephen Saw, Rachel Leafe and Ian Parkes
(Coleman Parkes Research)*

Creative Design
Palash Naskar, Ajoy Das and Rakesh Biswas

Printing and Distribution
David Cole and Gerry Court (Crucial Colour)

*Ian Parkes, CEO and co-founder of Coleman Parkes Research, is a full member of the Market Research Society. All research carried out by Coleman Parkes Research is conducted in compliance with the Code of Conduct and guidelines set out by the MRS in the UK, as well as the legal obligations under the Data Protection Act 1998.

www.worldqualityreport.com
©2018 Capgemini, Sogeti and Micro Focus. All Rights Reserved.

Capgemini and Micro Focus, and their respective marks and logos used herein, are trademarks or registered trademarks of their respective companies. All other company, product and service names mentioned are the trademarks of their respective owners and are used herein with no intention of trademark infringement. Rightshore® is a trademark belonging to Capgemini. TMap®, TMap NEXT®, TPI® and TPI NEXT® are registered trademarks of Sogeti, part of the Capgemini Group.

No part of this document may be reproduced or copied in any form or by any means without written permission from Capgemini and Micro Focus.
Micro Focus
Malcolm Isaacs
ADM Solutions Marketing Manager
Malcolm.Isaacs@microfocus.com

Christine Ewing
Senior Director, Product Marketing,
christine.ewing@microfocus.com

Sogeti
Sathish Natarajan
Vice President - Digital Assurance & Testing, Sogeti, Capgemini Group
sathish.natarajan@us.sogeti.com

Mark Buenen
Vice President, Global Leader, Digital Assurance and Testing Practice
mark.buenen@sogeti.com

Capgemini
Anand Moorthy
Vice President, Testing Leader, Financial Services, North America
anand.moorthy@capgemini.com

Shyam Narayan
Head of Managed Services, Australia and New Zealand
shyam.narayan@capgemini.com

Sanjeev Deshmukh
Vice President, Testing Leader, North America
sanjeev.deshmukh@capgemini.com

Ramesh Mahadevan
Senior Director, Testing Leader, Continental Europe
ramesh.mahadevan@capgemini.com

Ajay Walgude
Vice President, Financial Services, Testing Leader
ajay.walgude@capgemini.com

Dhiraj Sinha
Vice President, Financial Services-Testing, Asia Pacific
dhiraj.a.sinha@capgemini.com