About this paper
A Pathfinder paper navigates decision-makers through the issues surrounding a specific technology or business case, explores the business value of adoption, and recommends the range of considerations and concrete next steps in the decision-making process.

About 451 Research
451 Research is a preeminent information technology research and advisory company. With a core focus on technology innovation and market disruption, we provide essential insight for leaders of the digital economy. More than 100 analysts and consultants deliver that insight via syndicated research, advisory services and live events to over 1,000 client organizations in North America, Europe and around the world. Founded in 2000 and headquartered in New York, 451 Research is a division of The 451 Group.

© 2016 451 Research, LLC and/or its Affiliates. All Rights Reserved. Reproduction and distribution of this publication, in whole or in part, in any form without prior written permission is forbidden. The terms of use regarding distribution, both internally and externally, shall be governed by the terms laid out in your Service Agreement with 451 Research and/or its Affiliates. The information contained herein has been obtained from sources believed to be reliable. 451 Research disclaims all warranties as to the accuracy, completeness or adequacy of such information. Although 451 Research may discuss legal issues related to the information technology business, 451 Research does not provide legal advice or services and their research should not be construed or used as such.

451 Research shall have no liability for errors, omissions or inadequacies in the information contained herein or for interpretations thereof. The reader assumes sole responsibility for the selection of these materials to achieve its intended results. The opinions expressed herein are subject to change without notice.
Executive Summary
Digital transformation is real, and it's happening – our quantitative research tells us that, although there is still a very long way to go. It is an inescapable truth that every business is becoming a digital business, controlled by software, which is the manifestation of these digital transformations. Businesses must react, driven by the imperatives of improving intelligence, agility and their customer-centricity, or be left behind.
In this report, we explain digital transformation, look at enterprise demand and requirements, and explore the potential for implementing the software-defined infrastructure underlying a digital transformation using open source technologies.

Key Findings
A large proportion of organizations plan to enact digital transformation to avoid disruption.

Our research shows significant support for open source infrastructure, which enables the transformation.

Open source tools at the platform layer enable digital innovation at the business layer.
WHAT IS DIGITAL TRANSFORMATION?

451 Research defines digital transformation as the result of IT innovation that is aligned with and driven by a well-planned business strategy, with the goal of transforming how organizations serve customers, employees and partners; support continuous improvement in business operations; disrupt existing businesses and markets; and invent new businesses and business models. But what’s driving this, and why is it happening now? And what exactly is being transformed?

Figure 1: Companies divide into two populations - stay the course vs. transform

Q. Which of the following best describes your organization? n=1734

<table>
<thead>
<tr>
<th>Category</th>
<th>Market Disruptor</th>
<th>Market Maker</th>
<th>Under Reinvention</th>
<th>Staying the Course</th>
<th>Transitioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Disrupter:</td>
<td>9.2%</td>
<td>14.5%</td>
<td>45.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Maker:</td>
<td>14.5%</td>
<td>22.3%</td>
<td></td>
<td>45.5%</td>
<td></td>
</tr>
<tr>
<td>Under Reinvention:</td>
<td>22.3%</td>
<td></td>
<td></td>
<td>45.5%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Staying the Course:</td>
<td>45.5%</td>
<td></td>
<td></td>
<td>8.4%</td>
<td></td>
</tr>
<tr>
<td>Transitioning:</td>
<td>8.4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: 2016 Microsoft Cloud and Hosting Summit

We see a surprising dichotomy in the market when we investigate the companies that are considering digital transformation from the perspective of how much business and technological change is required. Although companies see themselves in many different places in terms of their current markets and opportunities – from all-out disruptors in the market to those staying the course – we can generally break them down into two main classes: there are those that realize that dramatic change is required and are taking action to do so, and those that are staying the course. The former include market disruptors, market makers and existing companies under reinvention. In these companies, high levels of business transformation and IT portfolio transformation are occurring over the next two years – hovering at about 50% overall for both business and technology. However, only about 25% of those staying the course saw themselves as requiring high levels of business transformation, with about 31% indicating a high need for IT portfolio transformation.

In this dichotomy, merely looking at an overall average masks the huge changes afoot at the transforming companies because these changes are obscured when the conservative ‘stay the course’ organizations are added to the mix. This means that in reality, the level of transformation is much greater than that revealed by any single number across the market.

Digital Transformation Imperatives

There has to be a specific business reason for any organization to undergo (or at least attempt) a digital transformation beyond just survival. We believe there are three main business imperatives: intelligence, agility and customer-centricity.

Intelligence, in this context, means getting insight from data and moving to data-driven decision-making. We believe the organizations that own the data will win over those that don’t – in any field. There’s a reason Alibaba, Amazon, Baidu, Facebook, Google and Netflix go to such lengths to understand precisely what you are doing on your laptop, tablet and smartphone. It’s also one of the main reasons Microsoft stretched to buy LinkedIn for $27bn earlier this year. That reason is intelligence – about what customers or prospects want to buy, where they want to travel, where they want to invest their...
money, what they like and what they dislike. Swap the word ‘customer’ for ‘employee’ or ‘citizen,’ and you see the same imperative to gather such intelligence.

The second imperative is agility. Business agility is essential because digital disruption is coming to your industry (if it hasn’t already). When physical assets become digital information, markets experience massive growth and disruption. Such a shift means things become knowable and measurable in ways that were not possible before – and the cost of adding new customers drops dramatically. Look at industries where this has already happened: music, photography, mass media, and (most recently) transport and hospitality with the rise of Uber and Airbnb.

The third imperative is customer-centricity. We’ve been around long enough to recall the previous wave of focus on this around the time of the dot-com boom and into the 2000s, where we the customers were supposedly king, and organizations had to bend to our will. But in reality, we weren’t, and they didn’t. That’s because customer-facing organizations still held the balance of power in terms of technology. They had the CRM systems, the billing systems and so on, and all their customers had was a web browser mostly on a computer tethered to a desk, and an internet connection measured in megabits, rather than megabytes, per second.

In this infrastructure-driven report, we will focus primarily on agility because it is enabled by the underlying software-defined infrastructure. Business agility is essential because every industry is subject to disruption. For example, Uber has disrupted the transportation industry. With Uber, all a potential customer needs to do is install the app, add a credit card and request a driver – all accomplished digitally. Before Uber, travelers often resorted to waving their arms to flag a taxi, or if they called for a taxi, they were usually unfamiliar with local taxi services so were unaware which ones were reliable. The payment process in taxis can be frustrating, and there’s little way for passengers to ensure they obtain a good driver. Digital transformation improves the customer experience, which, in turn, improves customer-retention rates and draws in new customers as well.

Our research shows that over time, a coupled approach to agility and risk becomes increasingly important in IT priorities relative to efficiency and cost-cutting. We advise that companies take a rational view of technology – they should focus on their core differentiators and outsource the rest. Few companies differentiate by providing the best technology infrastructure, and they’re all in the technology industry.

**Figure 2: Business priorities according to IT leaders**

<table>
<thead>
<tr>
<th>Year</th>
<th>Priority 1</th>
<th>Priority 2</th>
<th>Priority 3</th>
<th>Priority 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>12</td>
<td>11</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>2014</td>
<td>15</td>
<td>14</td>
<td>21</td>
<td>30</td>
</tr>
<tr>
<td>2015</td>
<td>17</td>
<td>17</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>2016</td>
<td>16</td>
<td>18</td>
<td>23</td>
<td>24</td>
</tr>
</tbody>
</table>

*Source: Commissioned by Microsoft*

In Figure 2, the key point is the growing area dominated by the light blue and orange priorities over time. This indicates the increasing importance placed on agility and risk as the key technology drivers, a dramatic contrast to the old worldview that was built around efficiency and cost-cutting. Another way to think about this is that ‘new IT’ is focused on ROI and collaboration with the business, while ‘old IT’ is focused on TCO and servicing the business. The ‘new IT’ companies are the same kinds of companies that are reinventing themselves as market makers, market disruptors or those that need to keep up with software-defined businesses in their own verticals.
Facebook’s motto used to be ‘Move fast and break things.’ But as it grew, it discovered this approach didn’t scale, and didn’t work out so well for its customers (ad buyers tend to like when their ads are displayed). Instead, two years ago, it announced a new motto with a very different take and one that meshes with our research – ‘Move fast with stable infrastructure.’ This is exactly where the agility in digital transformation can make the difference that enables enterprises to keep up with their own competitive disruption without falling apart in the process.

What Digital Transformation Means to Enterprises and Customers

Even with that additional level of clarity around digital transformation, it still remains difficult to understand exactly how to make these trends and terms actionable. What do you do to become agile, analytical, or customer-focused? Our research from earlier this year shows how enterprises think about digital transformation from all of the above business priorities into exactly how to execute upon them.

Figure 3: How companies are planning to achieve their digital transformations

As shown in Figure 3, there are a large number of actions that must take place to support an all-inclusive digital transformation. Different companies are likely to focus on different areas, depending on their priorities, whether that is speed to market (i.e., agility), lowering risk, or one of the other categories. Looking across categories, the common threads are business activities that can be better enabled with the support of automation, analytics and customer centricity. All of these activities require putting the right platforms in place, which allows IT to better enable the business as a whole. Of note is that all of these activities include a deeper incorporation of technology into the process, providing a strong opportunity for improved collaboration between IT and the rest of the enterprise.
Containers and Microservices

Tools and trends continue to emerge almost on a weekly basis. Two that we have seen pick up significant traction as software-defined infrastructure that supports digital transformation are containers and microservices. Typically, they are built on open source technologies and serve as an interface layer between the underlying runtime and the software being built and deployed on top of it.

Docker/containers have emerged as a key new technology to help package and deploy applications both within a single container and across an orchestrated cluster. Since the open sourcing of Docker in early 2013, it took a while for enterprise adoption to grow despite surprisingly large developer interest. However, we began tracking enterprise uptake for containers in early 2015 and saw it double over the course of six months, going from 6.3% to 14.1% of IT decision-makers saying their organizations had a containerized application in production by Q3 2015.

While this is still low on an absolute level, nearly one-third of IT decision-makers had containers at least in a pilot phase by then, and we expect that number to continue growing. Why? As with cloud, enterprises have begun adopting containers to increase their agility and decrease their time to market on a business level. On a technological level, they see containers helping them to improve their service uptime and reliability, as well as decrease maintenance overhead – again, qualities that put containers on par with cloud in terms of the perceived benefits. Containers and cloud go hand in hand because they enable both the business and technological benefits to span the entire application and infrastructure stack.

As architects continue to debate applications, ‘microservices’ is the hottest new buzzword following the overwhelming presence of Docker logos on every vendor’s slide decks and product integrations. In short, microservices are loosely coupled services that are maintained and deployed independently. They most closely resemble service-oriented architecture but in a much lighter-weight form, without all the XML and monolithic middleware. The rationale comes back to two of the overarching benefits of DevOps: increasing agility and lowering the risk and its impact. On the agility front, creating interfaces between small services enables teams to move independently of one another, greatly decreasing the coordination and bureaucracy required to innovate. Regarding risk, we know that software will fail, so how can we minimize the problems this causes? Divide software into small chunks so the overall user experience is not significantly impacted when one fails; this creates a dramatic benefit over monoliths that are either up or down.

Microservices are typically either built on a PaaS or from scratch on container orchestration and management tooling, both of which typically run atop IaaS or private cloud. All of the most popular tools at the containers and microservices layer are open source, emphasizing the vital role it plays in enabling software-defined infrastructure transformation.
THE ROLE OF OPEN SOURCE IN DIGITAL TRANSFORMATION

As enterprises adopt new tooling and modernize their infrastructure to support digital transformation, many requirements impact which tools and vendors they choose. In a recent study, we asked enterprise IT decision-makers about their key factors in tool selection and found intriguing results. Integration with legacy applications and processes topped the list with a dominating 59% of respondents, indicating a bias toward existing infrastructure in comparison to innovation. Our previous research has shown an increasing focus on agility in IT priorities, but this does not mean it’s prudent to neglect current environments. Trailing that, three requirements were nearly tied: rapid deployment, open source technology and user-friendly APIs. These responses emphasize the importance of fitting into existing infrastructure, because large enterprises can’t throw away everything from scratch and start over.

Respondents also indicated that fast time to value and a good user experience were important factors, which isn’t particularly surprising. However, our respondents saw open source as a critically important requirement. Even in comparison to other factors with more tangible benefits – namely rapid deployment and user-friendly APIs – open source technology was perceived as equally vital. This underscores the value that these businesses believe they receive from it. Open source provides a variety of benefits, such as the ability to easily make modifications in-house or outsource them to third parties, and it offers a level of insurance in case the vendor disappears or ends support for a given product. In addition, we see open source tools as having a leg up on the competition from the perspective of developer mindshare, in part because open source tools are often easy to obtain and try. It seems that the enterprises among our respondents see things the same way, in placing open source high on their requirements.

In our research, we recently asked 855 enterprise IT decision-makers about their attitudes toward open source infrastructure. The most common response was a pragmatically neutral view, but 50% of respondents were moderately or strongly in favor of open source. Only 16% of respondents were against open source infrastructure to any extent, and these tended to be at companies in the more conservative verticals that are unlikely to consider themselves to be digitally transforming.

**Figure 5: Attitude Towards Open-source Infrastructure**

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly in Favor</td>
<td>19.5%</td>
</tr>
<tr>
<td>Moderately in Favor</td>
<td>30.4%</td>
</tr>
<tr>
<td>Neutral</td>
<td>33.7%</td>
</tr>
<tr>
<td>Moderately Against</td>
<td>12.0%</td>
</tr>
<tr>
<td>Strongly Against</td>
<td>4.3%</td>
</tr>
</tbody>
</table>

*Source: 451 Research, Voice of the Enterprise Cloud Transformation, Organizational Dynamics 2016. Percent of Sample n=855*

This result supports the ability of open source to serve as a significant differentiator in favor of any software, or at worst, in the vast majority of cases, as something that enterprises consider unimportant or unrelated to the other benefits provided by that software. While this may not come as an enormous surprise, it is encouraging to see it quantified and to understand the notable bias toward open source software for software-defined infrastructure.

**The OpenStack Ecosystem**

While initially conceived as a multi-tenant IaaS alternative to Amazon Web Services, OpenStack has become a credible alternative for building and operating private clouds since the project’s establishment more than six years ago. It has captured the mindshare of hardware and software vendors, service providers, enterprises and the investment community. In previous years, the OpenStack ecosystem has proven to be fertile ground for M&A, typically involving startups and established giants.
OpenStack has maintained momentum as more globally diverse developers, providers and customers work together to build out its capabilities and ecosystem. Today, the open source cloud project still has its shortcomings, but it has become a top priority and credible cloud option for many IT professionals and suppliers based on our independent view.

Our Market Monitor service expects total OpenStack-related revenue to exceed $5bn by 2020 and grow at a 35% CAGR. Revenue overwhelmingly comes from the service provider space, with an increasing portion coming from private cloud deployments rather than public IaaS. We expect an uptick in revenue from all sectors, especially from companies in the OpenStack products and distributions category that are primarily targeting enterprises. Based on our research, we continue to believe the market is still in the early stages of enterprise use and revenue generation.

OpenStack mindshare continues to grow for enterprises interested in deploying cloud-native applications in greenfield private cloud environments. However, its appeal is more limited for legacy applications and for those enterprises comfortable with hyperscale multi-tenant cloud providers. There are several marquee enterprises with OpenStack as the central component of cloud transformations, but many enterprises are still leery of the perceived complexity associated with configuring, deploying and maintaining OpenStack-based architectures.

Processes for installation and upgrades, tooling, and API standardization across projects have improved over the last few releases because operators have become more vocal during the requirements phase. While OpenStack is competing with other private and public clouds and their providers, it is also gaining interest and use among enterprises and service providers that include OpenStack among these other clouds in hybrid multi-cloud deployments.

Based on our Cloud Price Index, enterprises achieving labor efficiencies of 400-500 virtual machines per engineer are poised to have lower TCO for self-managed cloud than public or managed cloud options. Where the private cloud is being operated at scale with labor efficiencies, it can be cheaper than public cloud – and in this case, OpenStack is likely the best way forward.

And at the PaaS layer, for on-premises environments, open source is dominant. Although we have not released numbers on the size of the market for private PaaS adoption, we don’t see the race as open vs. proprietary because open has already won. Rather, it’s a contest of open source options – whether enterprises choose a more structured PaaS vs. a more composable option requiring more effort but enabling more flexibility.

As more companies move to cloud environments of all sorts, they seek to adopt complementary and underlying technologies that can keep up with the shift to cloud. One of the most impacted technologies has been storage; the adoption of software-defined storage has grown in concert with cloud as customers expect their storage to act ‘cloudy.’ Open source storage has been enormously popular in the OpenStack ecosystem, with the competition (as with PaaS) being more between open source variants than between closed and open source. Because most digital transformation requires development of new software to support it, we see this as a particularly interesting use case. And of those enterprises with application development workloads, they on average put roughly 50% on software-defined storage today with the expectation to move to 65% in the next two years.

Agility: Key to the Success of Digital Transformation

Agile development continues to grow in adoption. Nearly two-thirds of IT decision-makers in our latest survey said they use agile processes to some extent. The overall traction for agile processes, and similarly for DevOps, is up for argument, but what is clear is that all of these approaches support faster iteration. As enterprises iterate on technology, they’re looking to move faster and remove single points of failure in their infrastructure. Databases are a significant part of that, so every time they’re able to outsource database administration, that’s one more piece of the puzzle they effectively no longer have to worry about. As the pressure for more frequent releases continues to increase, it’s critical that enterprises focus on their core priorities so they can maintain that quickstep. Although the current pace of releases centers around monthly, companies universally aim to move faster.
Figure 6: Key benefits of software-defined infrastructure

Q. What do you believe are the key benefits of implementing Software-Defined Infrastructure? n=544

- Improvement in Agility/Flexibility (e.g. Roll-out New Applications/Services Faster) 65.1%
- Reduction in Management/Overhead Costs Through Greater Automation, Standardization 38.4%
- Improvement in Infrastructure Resilience/Reliability 32.4%
- Reduction in Hardware Costs by Moving to Standard/Commodity Hardware 24.4%
- Better Fit for New/Emerging Applications 12.9%
- Improvement in Security 6.3%
- Reduction in Vendor Lock-in 4.4%
- There are No Benefits in Software-Defined Infrastructure 1.7%
- Other 0.4%


Impact on IT Organizations

In software development, massive process transformation has been happening for a few years now, and through DevOps, it is having a significant effect on the wider organization – beyond the development team. Many software development teams have moved from so-called waterfall processes to agile methods. Our research shows about 65% of IT decision-makers are using agile methods, and about 40% are adopting DevOps today.

Figure 7: Does your organization currently utilize DevOps approaches?

Source: 451 Research, Voice of the Enterprise: SDI Q4 2015 n=568

Critically, agile processes alone are not enough because even with them, developers could be developing the wrong application, albeit in an agile way. DevOps is a good example of effective process transformation, whereby teams are involved not just in the planning, coding and building phases, but beyond into testing, release, deployment and operations. Teams, therefore, have a shared understanding of how software is being used in the organization. DevOps enables organizations to react faster to customers’ demands, so it directly affects – and benefits – the overall customer experience. Having the right software-defined infrastructure in place supports this DevOps transition. This is particularly true in terms of enabling agility through automation – whether it’s via continuous-delivery pipelines or automating the underlying infrastructure using clouds, configuration management and containers.
Impact on Artificial Intelligence, Machine Learning and Advanced Analytics

Cognitive and self-learning systems and the data that drives them play an increasing role in the evolution of customer-facing business applications, whether they focus on sales, service or marketing. Intelligent business applications are really the only way to understand, contextualize and embed data intelligently into business processes. Embedded machine learning and artificial intelligence provide the self-learning attributes to eliminate human intervention through smart automation. Smart bots and robotic process automation are also critical elements of the digital platform. Because the new model for interaction is conversation, smart bots can be embedded from open protocols such as SMS or email for better customer-engagement processes. Smart bots will also further enhance the capabilities in all digital transformation initiatives, but today, they are most popular in customer-engagement use cases that enable personalized, structured responses and automating services and business workflows. The advanced analytics markets around machine learning in particular are showing healthy growth, about 19% year-over-year from 2016-2020.

As these analytics workloads require increasing amounts of scale and highly dynamic loads, such as the demands of training large deep-learning models, they tend to be a good fit for cloud environments that can cope with that scale and mix it into a heterogeneous set of other workloads to compensate for changing requirements over time.

Much like the other areas we have discussed, this analytical tooling is frequently built using open source software. Whether it’s the most popular languages for data science such as R and Python or frameworks for machine learning and deep learning, the dominant approach and much of the innovation occurs with open source tooling and ecosystems.

CONCLUSIONS

Digital transformation is imperative for enterprises that wish to survive in a rapidly changing world. With new entrants in every market and the ever-weaker geographic borders that previously held back some competition, it is imperative for all companies to become software-defined businesses to thrive. Unfortunately, only half of them seem to realize this change is necessary – but that enables a Darwinian approach, where those that fail to adapt to this new world may simply become extinct.

Enabling digital transformation in terms of agility, analytics and customer-centricity requires a technological shift as well as a business shift. IT must move toward collaboration with the business on the business rather than just keeping the servers running, and IT must provide the software-defined infrastructure required for transformation.

A sizable proportion of that infrastructure is open source, and we see enterprises showing a great deal of favor toward that open source technology. The more that companies must invest in innovation, the more likely they are to adopt open source because all of the dominant tooling in the most innovative areas of infrastructure is open source – whether PaaS, containers or microservices – and typically underlying that infrastructure are other open source layers of the stack, including cloud, storage and the operating system.