

Digital Transformation

– A Primer for Practitioners¹

Georgios Doukidis, Diomidis Spinellis, Christof Ebert

Digital transformation (DX) is mandatory for all practically all business to survive. Yet many companies shy away due to perceived risks and insufficient experience. With lightweight platforms which are ready-to use, you can easily start in your own environment, with actions such as a fast deployment of new functions, or a rich user experience. Authors Georgios Doukidis, Diomidis Spinellis show how to get practically started with DX. We provide hands-on guidance along the three stages of transforming customer experience, transforming business model and processes and transforming organization. To facilitate implementing DX in your own environment we tabulate its elements, provide several case studies, and outline platforms for implementing diverse DT use cases. I look forward to feedback from both readers and prospective column authors.

—Christof Ebert

Digital transformation (DX) has revolutionized entire industries, has propelled IT startups to stratospheric stock market valuations, and is sustaining legions of consultants evangelizing its message. Yet, beyond the creative disruption, the hype, and the lip service, we see that many organizations ignore or misapply its principles, ideas, and methods. This gap between theory and practice raises an important responsibility for software engineers and, particularly, for requirements engineers and software architects. If as a professional you specify and design software-intensive systems that ignore how modern digital technology radically transforms customer experience, business processes, business models, and whole organizations, you're short-changing your employer or client.

Based on our industry consulting, government service, and volunteering experience, we provide a taxonomy, a roadmap, and examples of digital transformation opportunities that will allow you to spot and exploit them.

DX is a direct result of the convergence of IT and practically all embedded devices and processes [1,2,3]. A quite simple example of DX in our daily lives as engineers has happened during the COVID-19 pandemic. As engineers and managers, we used to have regular client interactions and team meetings and also attend training events and conferences. This became impossible during the imposed lock-down of the economy, making us adopt digital conferences, collaboration tools, and fully new work flows and business models. For instance, we not simply replaced physical presence training with online training, but developed completely new learning experiences. Both automotive OEM clients and university students said after such training that they had never imagined that training could be improved so much in such fast pace.

As this example shows, DX is irreversible. The time waste and ecological damage of travel will surely shrink. Companies that stagnate will disappear. DX has evolved from making simple changes to benefit from IT. As an example, consider Amazon, Alibaba, Uber, and Netflix. They not only made existing processes digital, which is often both trivial and pointless, but redefined entire business models [2,3,4].

DX needs good software engineering. In fact, many initiatives fail due to focus on technology and business, but poor engineering. Examples which we have seen with clients include insufficient computing

¹ This is the submitted manuscript of an article published in *IEEE Software*, 37(5):13–21, 2020. [doi:10.1109/MS.2020.2999969](https://doi.org/10.1109/MS.2020.2999969). Copyright © 2020 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE.

performance, poor cybersecurity, inadequate architectures of nested databases which won't scale, and much more. Mobility, user-centric development, smart-devices, e-services, ambient environments, e-health, and implantables show the benefits and challenges of DX. Obviously the more we connect services with life, the more we need software engineering excellence from specifying requirements to developing reliable and safe software. Dependable business models demand software security, maintainability, and sustainability.

By expanding two existing conceptual models [2, 5], we argue that the four pillars of DX are customer experience transformation, business process transformation, business model transformation, and organizational transformation (Fig. 1). Digital transformation involves the use and exploitation of new and often disruptive digital technologies to radically improve key business operations, products, processes, business models, organizational structures, and management concepts [3,4]. Be aware that the mere automation of manual processes is by no means digital transformation.

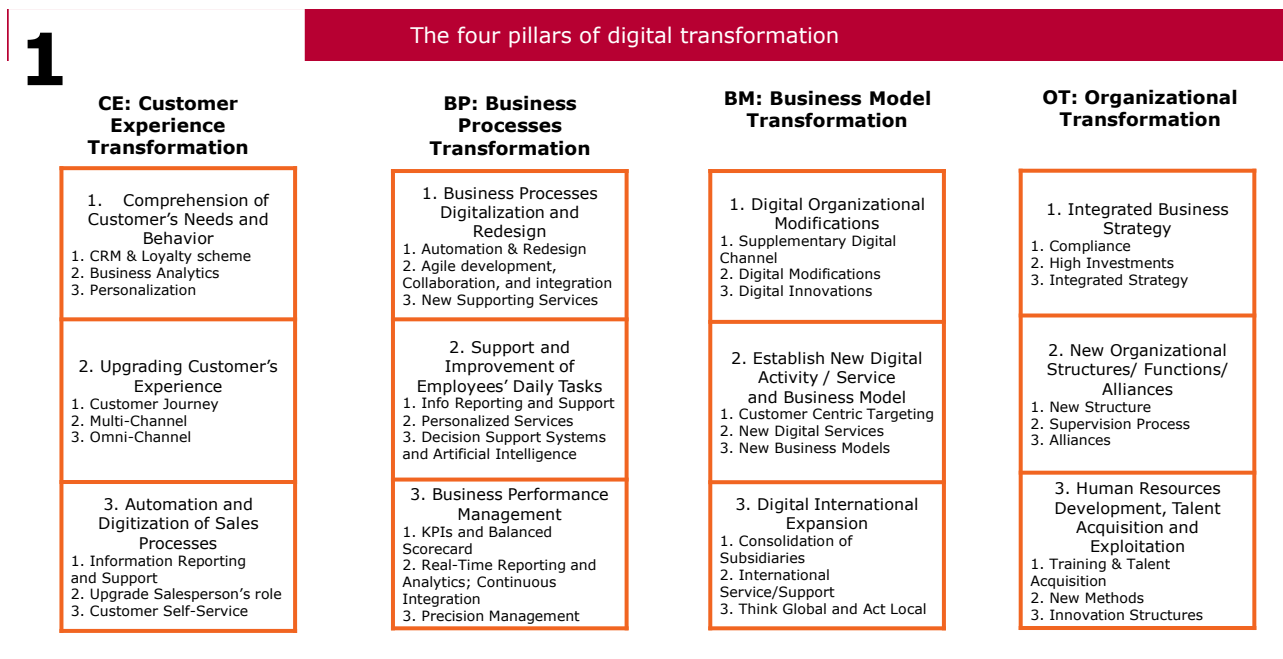


Figure 1. The four pillars of digital transformation

Transforming Customer experience

Examine how your customers interact with the business. Consider how the business comprehends the customer's needs and behavior, how it can upgrade the customer's experience, and how it can digitize and automate the sales processes.

First, ensure that all customer interactions with the business are tied to the customer, recorded, and used through a customer relationship management system. Based on that the business should offer a loyalty scheme tied to the its sales goals and growth strategy. Use business analytics methods to obtain a deeper understanding of the customers' behavior with basket and customer traffic analysis and to personalize offerings with recommender systems [6]. Amazon is an exemplar here, with its trove of customer interactions, the Prime program targeting regular customers, and the suggested purchases appearing on its site.

Then, consider how data and technology can upgrade the customer's experience. This entails mapping and understanding all the ways in which the customer interacts with the business, increasing the channels through which you reach your customers (e.g. through the web, voice, and mobile apps), and integrating the customer's experiences through all channels, moving from a multi-channel to an omni-channel strategy.

Interesting cases here are health care providers who use IT for remote patient management and hospitalization at home as well as major retailers who combine IoT technologies and geo-location services for setting up an omni-channel experience in their physical stores.

Finally, work on improving the effectiveness and efficiency of the sales processes. Provide higher quality information and specialized reports to your salesforce members to support their distance selling abilities and upgrade their role. (Some delivery services are equipping their staff with smartphone apps that allow them to perform sales). Also, invest in customer self-service such as that provided by service kiosks or online end-user customization.

Transforming Business Processes

In parallel, work at transforming the business processes by digitalizing them, by supporting everyday tasks, and by managing performance.

Start by employing IT to automate and redesign processes, to improve collaboration, or to create new supporting services [7]. Examples we've encountered include the use of robotics for retail order fulfillment, electronic ordering and invoicing for improving collaboration with supply-chain partners, mobile apps for real-time information exchange between an airport's stakeholders, and AI for loan screening or fraud detection services in banks.

Then, look for ways to support and improve the employees' work through better reporting, personalized services, and decision support systems. Here we've seen retailers pull and push reporting throughout the enterprise with mobile apps and, in another company, the assignment of personalized tasks to account managers. In two other cases technicians and medical personnel tap into case-specific data and medical diagnosis support provided through machine learning algorithms.

Use these changes to improve performance management by upgrading established tools, such as key performance indicators (KPIs) and the Balanced Scorecard, with real-time reporting and increased precision. For example, many enterprises use internet of things (IoT) technologies in combination with predictive analytics to obtain actionable real-time information on supply chain performance, factory productivity, and sales operations in large retail networks.

Transforming the Business Model

More fundamentally, look at how IT can provide new revenue streams through innovations on existing ones, through new digital activities, or through international expansion.

Initially, explore opportunities for adding digital channels to existing services, offering digital modifications to existing services, or introducing digital innovations. Examples here include Netflix supplementing its traditional DVD renting business with online streaming (new digital channel); banks which embrace open banking (digital modifications to existing services); and the dynamic pricing offered by many car insurers (digital innovation).

More ambitiously, look for new activities in the digital domain based on service or business model innovation. These can include customer-centric targeting or segmenting as is done by some banks, entirely new digital services as Amazon did when it launched its AWS cloud offering, or completely new business models, as a major delivery services company did when it began working as an intermediary between suppliers and end-customers.

Digital transformation can also drive international expansion through consolidation of control and globalization of operations. Cases we've seen here involve the provision of common ERP/CRM (enterprise resource planning / customer relationship management) platforms across entire multinational organizations for consolidating their subsidiaries, the global on-demand supply chain management by a leading metal processing company, the establishment of an international on-line customer service center by a travel group, and the localized provision of a luxury brand's e-commerce platform catering to local consumer preferences.

Transforming the Organization

The business revolution that digital transformation brings about requires corresponding strategic, structural, and workforce changes. In the areas of customer experience, business processes, and business models, your role as a software engineer is to spot and act on digital transformation opportunities. In the organizational transformation front, your role is different: to advocate for the required changes when you spot gaps between words and deeds.

On the strategy front, digital transformation often requires hefty investments in IT and research—we've seen companies making billion-euro bets. In many cases, complying with labyrinthine international standards and regulations is both a prerequisite challenge and an opportunity. We've seen this in Europe where some retail businesses are deftly navigating the General Data Protection Directive (GDPR) requirements and banks are exploiting the current Payment Services Directive (PSD2). The ideal should be for the transformation drive to be integrated into the organization's overall and long-term strategy: one telco is coupling it with its sustainability drive, a bank with its international expansion plans.

The required structural changes often involve top-management commitment, the setup of a dedicated digital transformation division or department, new reporting lines [8], regular progress monitoring of the various interrelated projects and initiatives, as well as setting up alliances and finding synergies with partners and other institutions.

Finally, on the human resource front digital transformation comes both with new requirements and prospects. To succeed, the organization must acquire and train talent. The staff development can range from the mundane (a bank training staff on its new digital services; a manufacturer offering digital training to all employees), to the transformational changes required for adopting design thinking and agile software development practices. On top of this, the open innovation programs run by some large companies can help attract new talent and source digital innovations.

DX Industry Use cases

To see how DX applies in practice, let us look to several use cases. Fig. 2 provides an overview of popular software platforms that can form the basis of key digital transformation tasks. Via its references to specific tasks, we can map use cases to technology platforms. We focused on open source software, because this can often be procured by engineers cost-effectively and without excessive red tape. For the sake of simplicity, we're often using the terms "business" and "customer", but these correspondingly refer equally well to government departments or other organizations and to citizens or individuals in general. Each bracketed sequence appearing in the text refers to a Fig. 1 element. As a software engineer, try to think how your team's existing or new projects can launch or support similar initiatives.

Finance. The digital strategy of a bank started as a response to three main external developments: customers demanding advanced digital services, galloping digital technologies, and the removal of entry barriers for FinTech startups due to open banking regulations [OT.1.1]. The priority was customer experience excellence. It was brought about by optimizing customer journeys [CE.2.1] and providing a unique digital experience both at digital as well as physical touch-points [CE.2.3]. For the successful customer journey mapping, the bank applied design thinking methods [OT.3.2] personalizing loan services [CE.1.3]. The bank also emphasized digital operations excellence to simplify operations and reduce costs by promoting the digital on-boarding of new customers [BP.1.1] as well as new supporting services, such as fraud detection [BP.1.3]. It also invested in innovative digital services [BM.1.3], offering its B2B customers an electronic invoicing platform as a service [BM.1.1]. This provided the bank with data used to launch a small business micro-lending and factoring scheme [BM.2.2]. To accomplish these changes, the bank established a 'digital factory' within the bank, which provided digital skills training to all employees [OT.3.1] and ensured their active involvement in the development process. In addition, it launched an innovation incubation facility for FinTech startups with new disruptive ideas [OT.3.3].

Consumer electronics. A major electronics and home appliances retailer started its digital transformation initiatives with a five-year integrated strategic plan [OT.1.3] aligning business objectives with digital technologies under a new digital transformation division [OT.2.1]. The retailer implemented consumer analytics systems to obtain real time signals regarding the status and sentiment of customer satisfaction

[CE.1.2] per customer segment. It then used recommendation systems to provide personalized coupons to high-frequency buyers [CE.1.3] participating in a loyalty scheme [CE.1.1]. It also focused on upgrading customer experience in the multi-channel environment by automatically loading the customer's last online shopping list onto their e-shop basket [CE.2.2]. It thus simplified and streamlined the shopping process, extending the range of products its customers browsed.

Automotive. Many OEM and tier-1 suppliers are radically changing their traditional engineering towards DX. With accumulating control units dispersed within a vehicle, complexity today is overwhelming. DX is introduced to migrate to new business models [BM.2.3] and engineering processes [BP.1.1]. Tesla is often quoted as the pacemaker, but others are following fast. Rather than simply changing architectures, the key is to develop an integrated strategy [OT.1.3] around new business models: From cars to mobility, from owning to sharing, from functions to services. On the technology level replace the functional controllers by a service-oriented architecture and delivery model. More important yet is to change engineering culture. Development in the future will be a continuous collaborative process which will fully decouple the rather stable hardware from its functionality driven by software upgrades [BP.1.2]. Engineers and managers must start thinking business needs, payment schemes, and then translate it to services [BM.2.2]. Hierarchic modeling of business processes, functionality, and architecture from a systems perspective allows early simulation while ensuring robustness and security. Agile service delivery models [BP.1.2, 3.3.2] combining DevOps, micro-services and cloud solutions will allow functional changes far beyond the traditional "V-shaped" approach.

Industry automation. An international lifts manufacturer started its DX initiatives by using networking technology to sever the ties of its B2B (business to business) sales people with their work location. These enabled virtual communication and collaboration with all back-office divisions [BP.1.2], providing the salesforce with specialized reports regarding the forthcoming week's customer visits [CE.3.1]. It also developed a B2B portal where customers could first see all the lift technical and functional details, and then configure the lift specifications to match their own functional requirements [CE.3.3]. Finally, with intelligent sensors and a mobile app it provided its customers a user-friendly Omni-channel environment showing the quality status of their lifts with pre-specified KPIs [BP.3.1]. The increased interactivity resulted in higher quality customer support [CE.2.3].

Building industry: A major international cement company with more than a century of successful operations started in 2015 its digital transformation drives with new organizational structures [OT.2.1]. It moved from hierarchical and geographical silos to cross-functional teams spanning the globe [BM.3.1], while also enabling and encouraging networking through innovative information systems [BP.1.2]. It launched its international digital expansion with a common ERP and human resource management system coupled to a data-warehouse infrastructure covering all business units of the international group [BP.3.1]. This provided worldwide digital reporting and coordination of all subsidiaries, enabling round-the-clock operation and collaboration [BM.3.1]. Later on it focused on improving productivity across the group's factories through an IoT infrastructure in all cement production parts. This involved about two thousand smart readers measuring and communicating the data required for precisely assessing the state of production facilities [BP.3.3]. Through the collected data it implemented machine learning and predictive analytics systems [BP.2.3] that forecast maintenance requirements and productions hickups. Without altering the factory environment, this improved productivity by 10%.

Platform	Description	Applies to	URL
Fat Free CRM	Customer relationship management platform featuring group collaboration, campaign and lead management, contact lists, and opportunity tracking.	CE.1.1	http://www.fatfreecrm.com/
InfluxDB	Time series platform with APIs for storing, querying, and processing data. Can be used for dashboarding, visualizing, monitoring, and alerting.	CE.1.2 BP.2.1 BP.2.3 BP.3.2	https://www.influxdata.com/
D3.js	Library for producing dynamic, interactive web-based data visualizations	CE.1.2 CE.3.1 CE.3.3 BP.1.2	http://d3js.org/
R	Programming language and software environment for statistical computing and graphics	CE.1.2 CE.3.1 BP.2.1 BP.2.3	https://www.r-project.org/
TensorFlow	Platform of libraries and tools for developing machine learning applications	CE.1.3 BP.2.3 BM.2.1	https://tensorflow.org/
Keras	High-level neural networks API focusing on fast experimentation	CE.1.3 BP.2.3 BM.2.1	http://keras.io/
Serverless	Framework for building serverless web, mobile, and IoT applications	CE.2.2 CE.2.3 BP.3.2 BP.3.3	https://serverless.com/
Apache Airflow	Platform for authoring, scheduling, and monitoring workflows	BP.1.1	https://airflow.apache.org/
Activiti	Platform for workflow and business process management	BP.1.1	http://www.activiti.org/
PrestaShop	E-commerce software for building online stores	BM.1.1 BM.2.2	https://www.prestashop.com/
OpenCart	Online store management system.	BM.1.1 BM.2.2	http://www.opencart.com/

Fig. 2: Popular Open Source Digital Transformation Technology Building Blocks

Get Started and Deliver Results

Digital transformation is not necessarily a top-down process. Often it can be started at the grassroots level addressing a specific use case in a given environment. With initial success, it can further grow. This approach helps especially SMEs and companies with diverse business models. When specifying and designing software-intensive systems you can employ modern digital technology to radically transform customer experience, business processes, business models, and entire organizations. Starting with how the customers interact with the business, reconsider how the business comprehends the customer's needs and behavior, how it can upgrade the customer's experience, and how it can digitize and automate the sales processes. In parallel, work at transforming the business processes by digitalizing them, by supporting everyday tasks, and by managing performance. More fundamentally, exploit IT to provide new revenue streams through innovations on existing ones, through new digital activities, or through international expansion. To ensure these changes take place be ready to advocate within your organization for the corresponding strategic, structural, and workforce changes

Given the diverse and often dramatic changes that digital transformation can bring about, such an exercise should be preceded by a technology assessment. This will examine the legal, regulatory, ethical, societal, and economic consequences associated with the planned course of action. Although as a software developer you may lack the skills and experience required to perform a technology assessment, recognizing the need for one and pressing for it to be conducted can save your company from embarrassing or even catastrophic mistakes.

The mere automation of manual processes is by no means digital transformation. It's similar to striving for faster carriage horses, rather than replacing them with an engine. Only when a business purposely adjusts its strategy, structure, and workforce aiming for IT to transform its customers' experience, its internal business processes, and its business models can it reap the benefits of digital transformation and thrive in the modern economy.

References

1. Ebert, C. and Alpana Dubey: Convergence of Enterprise IT and Embedded Systems. IEEE Software, ISSN: 0740-7459, vol. 36, no. 3, pp. 92-97, May 2019
2. Sebastian, M., J.W. Ross, C. Beath, M. Mocker, K.G. Moloney, and F.O. Nils: How Big Old Companies Navigate Digital Transformation. MIS Quarterly Executive, vol. 16 : no. 3, article 6, 2017.
3. Matt, C., T. Hess, and A. Benlian: Digital Transformation Strategies. Business and Information Systems Engineering, vol. 57, no. 339, 2015. <https://doi.org/10.1007/s12599-015-0401-5>
4. Ebert, C. and H. C. Duarte, Digital Transformation. IEEE Software, vol. 35, no. 4, Jul 2018, pp. 16–21. <https://doi.org/10.1109/ms.2018.2801537>
5. G. Westerman, D. Bonnet, and A. McAfee. "The nine elements of digital transformation." MIT Sloan Management Review, vol. 55, no. 3, 2014, pp. 1-6.
6. Sarantopoulos, P., A. Theotokis, K. Pramatar, and G. Doukidis: Shopping missions: An analytical method for the identification of shopper need states. Journal of Business Research. vol. 69, no. 3, 2016, pp. 1043-1052.
7. Karagiannaki, A., G. Doukidis, and K. Pramatar: A Framework for mapping the RFID-enabled Process Redesign in a Simulation Model. Journal of the Operational Research Society, vol. 65, no. 7, 2013.
8. Singh, A. and T. Hess: How Chief Digital Officers Promote the Digital Transformation of their Companies. MIS Quarterly Executive, vol. 16, no. 1, article 5, 2017.

Sidebar: DX Practitioner Guidance

Stepwise extend business models [BM.2.3] towards user integration and ecosystems. Do not exaggerate with a one-dimensional hype, such as big data, but rather ask which technology and changes best suit your own needs. Let DX grow incrementally with a clear vision which data to use and how to extend your business. Move from classic functional split towards integrated business processes [BP.1.2]. Model business processes, functionality and architecture from a systems perspective, while ensuring robustness and security.

Develop innovative services for your products [BM.2.2], by linking products with company IT to intelligent services and business models. Examples include predictive maintenance, adaptive configurations, and multi-sensor fusion for enhanced functionality [BP.3.3] and user experience [CE.2.1]. Invest in new ecosystems that connect your entire value chain from suppliers to end-users. Stimulate customers, vendors, and their own employees with creative methods to develop the few but crucial value features that make your product different [OT.2.3].

Simplify your product portfolio, reduce product complexity, and streamline operations [BP.1.1]. Focus on cost innovation over the entire life cycle. Use targeted benchmarks [BP.3.1] and continuously learn from other companies. Invigorate and clarify innovation processes with stringent guided ideas, very short decision-making phases and faster development of solutions [OT.3.3].

Modernize your engineering and make it and the associated R&D part of the business [OT.2.1]. Ask yourself if your work and each step will generate money or create waste [BP.3.1]. Replace classic process models and quality management with flexible agile structures [BP.1.2]. Process matters in DX, but frameworks disappear. Be it CMMI, PRINCE2, or SAFe, complex frameworks will not prevail under today's cost and efficiency pressures. Development, operations, and service must become one continuous process. Look to value chains. Today we see a wealth of innovative ecosystems and delivery models in systems engineering and IT-driven services.

Use DX to innovate in your delivery [CE.3.3] and operations [BP.2.3] models. Collaborate with established experts to reinvent your processes. Take a fresh look at your value chain. Ask which core-competencies you need or must grow, what to outsource, and how to reduce or innovate saturated products [OT.1.3].

Most important from our own experience as consultants: Don't attempt to scale DX on your own. Your key competence is your business. DX has its specific methods which we described in this article which need understanding. Look for partners with external experiences to challenge your current situation and help to successfully master your transformation.

Authors:

Georgios Doukidis is a Professor of eBusiness in the Department of Management Science and Technology at the Athens University of Economics and Business (AUEB). He is the founder and director of ELTRUN (the eBusiness Research Center of AUEB). Contact him at gjd@aueb.gr.

Diomidis Spinellis is a Professor of Software Engineering in the Department of Management Science and Technology at the Athens University of Economics and Business, Greece. Dr. Spinellis is a senior member of the ACM and the IEEE. Contact him at dds@aueb.gr.

Christof Ebert is the managing director of Vector Consulting Services. Prior to that, he had senior management positions for twelve years with a global IT market leader. A senior member of IEEE, he serves on the editorial board of IEEE Software. Contact him at christof.ebert@vector.com