TECHNICAL INFRASTRUCTURE MANAGEMENT
- Insights in the digital context

Purpose

This position paper presents an overview of key insights pertaining to the management of the IT technical infrastructure in the digital business context, as derived from pertinent academic and practitioner literature. These insights, together with insights from subject matter experts, have informed the development of IVI's IT-CMF Technical Infrastructure Management (TIM) Critical Capability.

Relevance of Technical Infrastructure Management in the Digital Context

The 'fourth industrial revolution' has started and is rooted in a new technological phenomenon, digitalization. This is reshaping virtually every industry, and presenting real opportunities for most organizations. However, those who are unprepared for the associated transformation risk being left behind, held back by under-investment, outdated IT systems, and digital skills gaps [1]. The advent of this digital revolution has changed the nature of the IT infrastructure conversation from technical to strategic. Customers are clamouring for greater personalization, and companies face new competitors from previously unrelated industries, and an unprecedented pressure to innovate. Thus, the management of the IT infrastructure must cover much more than 'reducing costs while keeping the lights on': it must also earn the trust of the organization by becoming a strategic partner and by providing the required levels of IT services to support digital transformation [2].

A digital business is completely dependent on its IT infrastructure as a dip in application responsiveness or a few minutes outage could mean the loss of customers, an interruption to production, or a risk to safety and security [4]. Modern enterprise IT is now more complex than ever. There are more technologies, vendors, and service providers involved, residing in more domains, for example: on-premises, in data centres, and in the cloud. Mobile, cloud, and hybrid IT architectures require a new kind of IT infrastructure, one that is more automated and that treats a disparate, multi-vendor environment as an integrated whole [5]. Getting all of this IT infrastructure to work together presents a challenge, but supporting it adds another layer of complexity.

Digital transformation requires an IT infrastructure transformation. The resulting infrastructure not only needs to manage the increased scope and scale of incoming and outgoing data, it must also become more agile and flexible. Digital transformation requires a rethink of the strategic importance of the IT infrastructure that will need to encompass not just technology trends, but the underlying people, processes, and methodologies [6].

Managing IT Infrastructure in the Digital Context

As core workloads and business objectives change, the IT infrastructure must reflect a different set of considerations. IT applications and data services are central to enabling the journey towards a differentiated digital business. The infrastructure that supports these applications and data services must be responsive to the business, and dynamic enough to meet the rapidly changing needs of both the technology and IT landscapes. The demands placed on the IT infrastructure can no longer be handled by simply optimizing using the traditional process of routinely upgrading equipment and adjusting architectures for new initiatives [7].

Historically, IT infrastructures were relatively simple and as applications got more sophisticated and complex the IT infrastructure simply got faster. However, more recently the demands placed on the IT infrastructure have grown exponentially, with enhanced functionality and rapid development and deployment of many specialized applications (e.g. email, data warehousing, resource planning), and with the advent of mobile apps, cloud computing, big data, and the Internet of Things. The requirements of a digital business places further demands on the IT infrastructure in terms of scalability, responsiveness, security, innovation, and flexibility, whilst also requiring that this is done at a reasonable cost [8]. A modern IT infrastructure needs to support these requirements, and has resulted in very different environments and technologies where virtualization, automation, and orchestration are to the forefront.

Providing a holistic and integrated framework for the management of the IT infrastructure requires a number of different levels or layers as detailed below. This reflects the structure and contents of the Technical Infrastructure Management (TIM) Critical Capability as described in detail in IT-CMF.

- Architecture and IT service infrastructure management
- IT operations management
- Application platform
- Infrastructure

Architecture and IT Service Infrastructure Management

A primary requirement is an overall IT infrastructure architecture that delivers value to the organization [9]. The IT infrastructure itself needs to be rolled out as a service that is planned, designed, operated, and improved so it can support the demands of Agile and DevOps teams that are the corner stone of a digital business. For example, it has to provide sand-box environments that can be rapidly spun up to create development and test environments, so that initial concepts and ideas can be turned into viable products and services, whilst also providing the required level of access, security, reliability, and support.

The first consideration is the overall technical architecture for the IT infrastructure that is required to support and be aligned with the higher-level Application, Data, and Business architectures. Typically, for most organizations there is a mix of legacy and state of the art modern IT infrastructures. The architecture layer deals with the different IT infrastructures, and how both the legacy and modern IT

infrastructures interact and how the legacy infrastructure will be updated, replaced, or retired. It lays down the overall guidelines and defines the standards that will be used, for example, how cloud computing will be implemented and managed, how convergent infrastructure will be managed and controlled, and the level of automation and orchestration required [10].

IT Operations Management

Having considered the high-level architecture, the second consideration is how the IT infrastructure interfaces with customers and users. This is key to the success of a digital business, as this layer determines the customer experience, and how the IT infrastructure appears and behaves as customers and users interact with it. To be a successful digital business an organization needs to provide the following to external customers: access (identity management), support when problems arise (incident and problem management), and timely responses to customer demands (performance management). The IT systems and applications need to be available where and when needed (availability management). If there are problems such as cyber-attacks or external disasters, the IT infrastructure needs to remain available or be made available as quickly as possible (contingency and recovery management). For internal customers, the integrity of the system needs to be assured (configuration and asset management), changes need to be made seamlessly and ideally with no down time (change and application management), transactions need to be performed securely (security management), and the IT infrastructure needs to handle both low and peak demands (capacity planning). This must be done whilst also continually increasing efficiency, reducing costs, and optimizing the IT infrastructure (automation and orchestration). All of the above are needed for a traditional business, however for a digital business there is particular sensitivity due to the demand for speed and scalability (capacity), customer experience (identity, capacity, security, incident and problem management), and responsiveness (performance management) [11].

Application Platform

The third consideration is how to provide and manage the application platform, as a digital business needs a diverse range of applications to interact and communicate seamlessly across many geographic locations and on a diverse range of platforms and hardware. For applications to run successfully they need both their own infrastructure and additional services, which need to be provided by the application platform. Examples of the services required include web services to provide application screens on web browsers, application servers to run the actual application (e.g. Apache, .Net), connectivity services (e.g. FTP server, DNS server), and database services (e.g. Microsoft SQL, IBM DB2).

A modern application platform needs the ability to support many different types of applications including standalone clients, distributed applications with server logic running on-premises or in the public cloud, and applications that use cloud services. The application platform must be consistent to facilitate developers in using the same tools and skills to create a range of applications that run across various different types of hardware [12]. It also needs to consider and manage the operating system of both internal and external platforms such as Infrastructure as a Service (IaaS).

To adequately support a digital business, virtualization, containers, and cloud infrastructures are key enablers, so they all need to be properly controlled and managed. How external and internal platforms interact and communicate, how they can be scaled, and how they provide contingency and recovery in the event of an attack or external disaster needs to be closely planned and managed. Digital and DevOps practices have driven a rapid rate of change in this space, from individual servers in the past, to today's virtualization and container infrastructures. The use of converged, hyper converged, and equivalent infrastructures (e.g. HPE's Synergy) are essential for the support of a digital enterprise [13].

Infrastructure

The fourth consideration is the management of the core elements of the IT infrastructure, i.e. the compute, storage, and network components. Across these core elements, rapid change is being driven by the next wave of corporate IT, which is built upon a foundation of social, mobile, analytics, and cloud technologies. IT organizations need to embrace new requirements such as the digitization of business models and processes, by placing the data centre at the core to host, manage, and deliver a digital experience to the end customer.

A digital business requires modern mission critical systems that are no longer siloed or use proprietary technology. They need to be part of an agile and flexible mission critical fabric, running on low-cost, industry standard platforms that support highly consumerized applications, and are to some extent future proofed to handle emerging requirements such as edge computing and the Internet of Things (IoT) [14]. Many of the world's leading platform providers are retooling their flagship product lines around agile concepts. A good example is HPE's Synergy, which builds on the concepts of converged and hyper converged infrastructure to define a composable infrastructure that supports the ability to run physical, virtual, and containerized workloads [13], [15]. This and other offerings from IBM, Microsoft, VMWare, Cisco, Dell, and so on allow IT administrators to build an environment using disaggregated compute, storage, and network resources so that each resource can be scaled or flexed individually depending on requirements.

The next level is to use a Software Defined Infrastructure (SDI) so that all elements of the infrastructure are virtually controlled; they can then be fully deployed and controlled by an application with little or no human involvement. This enables applications to specify and configure the hardware they need to run on as part of their code. SDI can provide integrated hybrid cloud capabilities so workloads can be placed in data centres, or private or public clouds as appropriate, whilst maintaining data integrity with increasing speed and efficiency and decreasing costs [15].

To deliver and house all of the above requires a data centre or equivalent, so an organization must decide what type of data centre to use and how it is to be managed. To illustrate the changes that are being driven by digital transformation, a recent report by Gartner showed that when organizations were asked 'where they expected to host their applications by the year 2020' the response was as follows: 40% of applications will be hosted in a public cloud, 38% will remain on-premise and 22% will be co-located [16]. The requirement going forward is to provide a data centre environment that is secure, that protects the equipment from power spikes and outages, and that has the network

connectivity to interconnect with cloud providers and digital business partners. The other key requirement is to use IT infrastructure outsourcing to co-locate or use cloud-enabled managed hosting to supplement or replace on-premise data centres [17].

Conclusions

Driven by digital transformation and the explosive growth of data, organizations need to urgently design, plan, build, and modernize their IT infrastructure. Innovations across hybrid infrastructure, next-generation security, and software-defined solutions provide the opportunity to upgrade the physical IT infrastructure whilst also transform how that IT infrastructure is supported. More than ever the IT infrastructure needs to be responsive to the demands of the organization and dynamic enough to respond to changing environmental conditions, as the IT infrastructure can no longer be optimized by the traditional process of routinely upgrading equipment and adjusting architectures for new initiatives.

Today's enterprise IT service needs are continually evolving, so IT organizations need to manage and develop their IT infrastructure to match the requirements of the digital age. Almost every aspect of modern business has come to rely on business capabilities enabled by IT services, which in turn run on IT infrastructure. IT infrastructure has become the backbone to supporting interactions between customers, suppliers, employees, partners, and machines. Therefore, the management of the IT infrastructure has a very significant impact on the success or failure of an organization and its digital transformation. By establishing an effective IT infrastructure management capability, an organization can provide the appropriate infrastructure that will support current and future needs such as edge computing. In doing so, the capability will help organizations to support digital transformation, become more efficient, redefine their business models, and improve their customer experiences [18].

References

[1] S. Routledge, 'Clearing the path for digital transformation - how IT infrastructure could be holding your business back', *IT Pro Portal*, 2018. [Online] Available: <https://www.itproportal.com/features/clearing-the-path-for-digital-transformation-how-it-infrastructure-could-be-holding-your-business-back/>.

[2] S. Firth, R. Kline, J. McDonald, and K. Biron, 'New technology, new mindset - strategic IT infrastructure to compete in the digital economy', IBM Institute for Business Value, Sept, 2015.

[3] M. Carcary, E. Doherty, and G. Conway, 'A dynamic capability approach to digital transformation – a focus on key foundational themes', In *Proceedings of the 10th European Conference on Information Systems Management*, 2016.

[4] A. Ganguly, 'Optimization of IT and digital transformation: strategic imperative for creating a new value delivery mechanism and sustainable future in organizations', *European Journal of Business and Innovation Research*, vol. 3, no. 2, pp. 1-13, 2015.

[5] Dimension Data, 'Optimizing IT infrastructure: a strategic imperative for digital transformation', 2017. [Online] Available: <https://www2.dimensiondata.com/en/optimise-it-infrastructure>.

[6] D. Leonhardt, I. Haffke, J. Kranz, and A. Benlian, 'Reinventing the IT function: the role of IT agility and IT ambidexterity in supporting digital business transformation', 2017. [Online] Available: <https://www.researchgate.net/profile/Daniel_Leonhardt/publication/317380735_Reinventing_the_IT_function_The_Role_of_IT_Agility_and_IT_Ambidexterity_in_Supporting_Digital_Business_Transformation/links/5937d18e0f7e9b374c363ab2/Reinventing-the-IT-function-The-Role-of-IT-Agility-and-IT-Ambidexterity-in-Supporting-Digital-Business-Transformation.pdf>.

[7] N.D. Evans, 'Digital transformation needs a modern, mission-critical infrastructure', *cio.com*, 2014. [Online] Available: <https://www.cio.com/article/2598707/it-leadership-digital-transformation-needs-a-modern-mission-critical-infrastructure.html>.

[8] C. Châlons, and N. Dufft, 'The role of IT as an enabler of digital transformation', In *The drivers of digital transformation*, Springer, Cham, pp. 13-22, 2017.

[9] S. Miniman, 'The data center: past, present and future', *Wikibon*, 2014. [Online] Available: <http://wikibon.org/wiki/v/The_Data_Center:_Past,_Present_and_Future>.

[10] G. Kousalya, P. Balakrishnan, and C. Pethuru Raj, 'The hybrid IT, the characteristics and capabilities' In *Automated workflow scheduling in self-adaptive clouds*, Springer, Cham, pp. 199-221, 2017.

[11] S. Laan, *IT infrastructure architecture - infrastructure building blocks and concepts*, Third edition. Lulu.com, 2017.

[12] D. Chappell, 'What is an application platform', 2011. [Online] Available: <http://www.davidchappell.com/writing/white_papers/What_is_an_Application_Platform-Chappell.pdf>.

[13] I. Chung, B. Abali, and P. Crumley, 'Towards a composable computer system', In *Proceedings of the international conference on high performance computing in the Asia-Pacific region*, ACM, pp. 137-147, 2018.

[14] G. Westerman, D. Bonnet, and A. McAfee, *Leading digital: turning technology into business transformation*, Harvard Business Press, 2014.

[15] S. D. Lowe, *HPE Synergy for dummies (composable infrastructure)*, HPE Wiley, 2017.

[16] D. C. Plummer, et. al., 'Top strategic predictions for 2018 and beyond: pace yourself for sanity's sake', Gartner.com, 2017. [Online] Available: <https://www.gartner.com/doc/3803530/top-strategic-predictions-pace-sanitys>.

[17] L. Leong, G. Petri, M. Warrilow, M. Dorosh, and R. Blair, 'Magic quadrant for public cloud infrastructure managed service providers worldwide'. Gartner.com, 2017. [Online] Available: <https://www.gartner.com/doc/3627018/magic-quadrant-public-cloud-infrastructure>.

[18] J. Luftman, H.S. Zadeh, B. Derksen, M. Santana, E.H. Rigoni, and Z.D. Huang, 'Key information technology and management issues 2012–2013: an international study', *Journal of Information Technology*, vol. 28, no. 4, pp. 354–66, 2013.

Recommended Reading

C. Black, and P. Goransson, *Software defined networks: a comprehensive approach*, 1st ed. USA: Morgan Kaufmann Publishers, 2015.

S. Laan, *IT infrastructure architecture - infrastructure building blocks and concepts*, 3rd ed. USA: Lulu Press Inc, 2017.

A. Mouat, *Using docker - developing and deploying software with containers*, 1st ed. USA: O'Reilly Media, 2015.

K. Morris, *Infrastructure as code: managing servers in the cloud*. 1st ed. USA: O'Reilly Media, 2016.

Contributing Author

Gerry Conway, Senior Research Fellow, Innovation Value Institute.

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