Disruptive Innovations in Cloud Computing and Their Impact on Business and Technology

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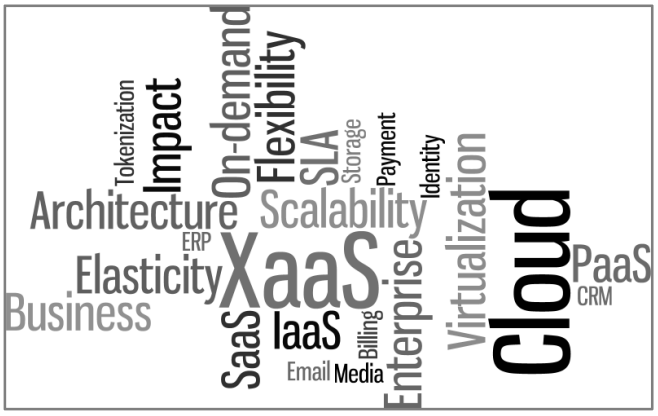
***Abstract*—So far, cloud computing has changed a big deal of the world around us. Through its diverse service models, its impact on business and technology advancements has become obvious to the layman. However, will it continue to influence our daily activities? This paper aims to take a closer looks at some of the emerging cloud service models with the intent to foretell whether their impact will sustain or will shortly fade out, as in the case of many other past technology architectures and services models.**

Keywords—BDaaS; big-data-as-a-service; BPaaS; business-process-as-a-service; cloud computing; cloud service models; DaaS; disruptive innovation; emerging cloud services; everything-as-a-service; foretell impact; IaaS; IDaaS; identity-as-a-service; impact of cloud computing; PaaS; payment-as-a-service; SaaS; tokenization-as-a-service; VDI; virtual desktop infrastructure; XaaS



I. INTRODUCTION

"Disruptive innovations change where or how value is created, and alter the fundamentals of business. When they hit, they have a profound impact on any industry they touch." [1].

Though Cloud Computing has been out there for a while, it hasn't become main-stream until recently. It has evolved from grid and on-demand computing, and has built upon existing advancements in virtualization, and multi-tenant architectures. Since its first appearance, it started taking on the three main areas of operations, infrastructure, platform, and software; and has been categorised accordingly: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). Today we are witnessing the emergence of novel subtypes and technology mutations that are introducing further change to business models, pricing schemes, enterprise system architectures, and operational models; and are even redefining organizational maturity.

Currently, the three main models of cloud services are, IaaS, PaaS, and SaaS. The main purpose of this paper is to introduce other novel models, and discuss their disruptive impact on business and IT. The rest of the paper is organized as follows: Section II describes the methodology used to describe the new service models. Section III discusses the novel models of different cloud services. Section IV concludes the paper and proposes future work.

II. METHODOLOGY

A. Method Type

The method used for this paper is qualitative. Input, discussion, and conclusions provided herein are inspired from the professional observations of domain experts who have been working in the field long enough to witness the evolution of computing during the last twenty years.

B. Dimensions of Impact

Technology is merely a business-enabler. It is not a goal by itself, but rather a means that touches almost all aspects of life; hence changes on it tend to have a ripple effect within business, technology and beyond. This being said, describing the impact of innovations in main-stream cloud computing in an exhaustive manner a far-fetched task. Nevertheless, this document aims to shed light on some of the major areas that are being impacted. These areas include business models, business alliances, enterprise systems architecture, opportunities and challenges.

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III. Novel Models of Cloud Services

A. Desktop-as-a-Service

As defined by Editor of ServerWatch, Forrest Stroud, "Desktop-as-a-service (DaaS) is a form of virtual desktop infrastructure (VDI) in which the VDI is outsourced and handled by a third party. Also called hosted desktop services, desktop-as-a-service is frequently delivered as a cloud service along with the apps needed for use on the virtual desktop" [2].

DaaS has been around for a while and is becoming popular due to reasons like, being able to provision large numbers of corporate users in a relatively short period of time, having access to the personal desktop environment from anywhere, managed backup, controlled environment (e.g. for schools), etc. Nevertheless, this flexibility brings with it some new challenges. As stated by Dr. A. Sigh, "In desktop-as-a-service cloud computing, user applications are executed in Virtual Desktop on remote servers. This offers great advantages in terms of usability and resource utilization; however, handling a large amount of clients in the most efficient manner poses important challenges. Especially deciding how many clients to handle on one server, and where to execute the user applications at each time is important. Assigning too many users to one server leads to customer dissatisfaction, while assigning too little leads to higher investments costs" [3].

B. Big Data-as-a-Service

With today's wide-scale social media and e-Commerce application platforms the size of data being produced and consumed is becoming exponentially "Big"; and so is the value of the information hidden within it. According to Gartner, by year 2016, 50% of the data in organizations will be stored in cloud-based systems [4]. The following chart shows the projected growth of data by 2020, along with the geographic distribution of these data.

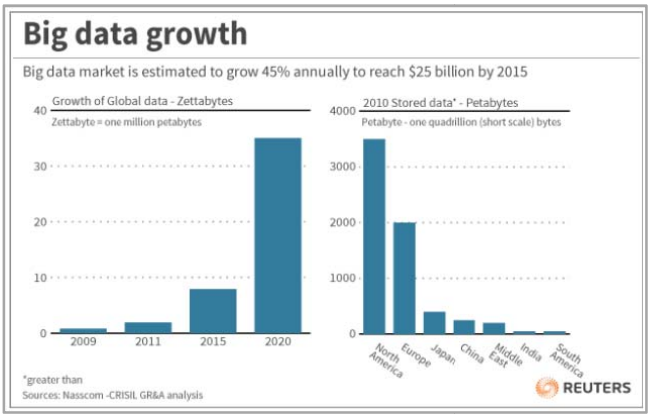

Fig. 1. Projected growth of data [5]

This growth has caused Big Data-as-a-Service (BDaaS) to emerge. Senior Business Systems Integrator at Google, B. Bhagattjee describes the driver for the emergence of BDaaS: "There is significant interest in academia and industry in combining Big Data and cloud computing to create new technologies that can solve the Big Data problem. Big Data based on cloud computing is an upcoming area in computer science and many vendors are providing their ideas on this topic. The combination of Big Data technologies and cloud computing platforms has led to the emergence of a new category of technology called Big Data as a Service or BDaaS" [5].

Alongside the emergence of Big Data, a number of new technology disciplines and architectural patterns have come into play; such as Hadoop (MapReduce), key-value stores, stream processing, graph processing, structure of network, distributed file systems, distributed shared memory. As a result, enterprise architecture and business opportunities have changed accordingly.

C. Business Process-as-a-Service

The term Business Process-as-a-Service (BPaaS) was first coined by Wang et al. back in 2010 [6]. The term grabbed attention; however, the definitions may have seemed conflicting. Accorsi defined it as "a special SaaS provision model in which enterprise cloud offerors provide methods for the modelling, utilisation, customisation and (distributed) execution of business processes" [7]. IBM defined it as "any business process (horizontal or vertical) delivered through the Cloud service model (Multi-tenant, self-service provisioning, elastic scaling and usage metering or pricing) via the Internet with access via Web centric interfaces and exploiting Web-oriented cloud architecture." [8]. Despite perceived differences in definitions, all seemed to agree that "BPaaS offers packaged or predesigned business services that may in turn be reused by different service applications, service providers or business processes" [9]. Using BPaaS means minimal management effort or coordination for specific company processes, freeing up time for core/other business activities [10]. Adopting BPaaS is hence expected to introduce changes to the business architecture; in particular the organisation structure of units, roles and responsibilities.

D. Identity-as-a-Service

As described by principal architect at Oracle, N. Kaushik, the data that comprises an identity come from multiple sources, and is constantly in flux. He adds that Identity-as-a-Service (IDaaS) aims to devolve application identity silos into a common enterprise layer, by enabling integration of identity services into application development and application runtime environments [11].

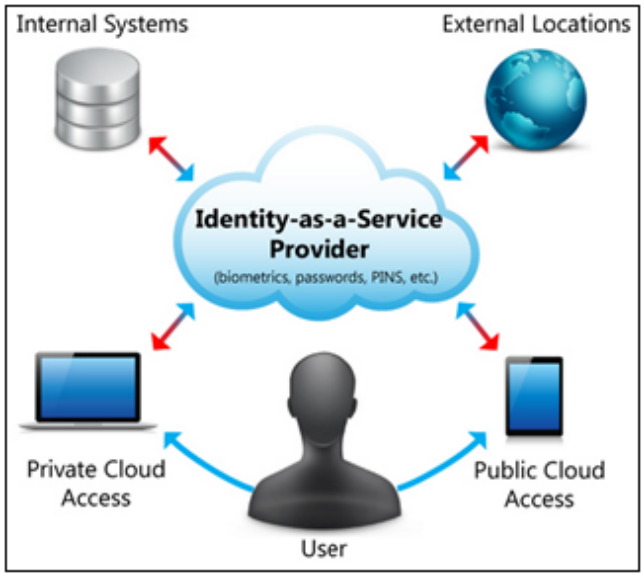

Fig. 2. Idenity-as-a-Service [12]

This model of cloud services is promoting the adoption of the Services-oriented Architecture (SOA) model for enterprise systems development, and is further opening up opportunities for entities that possess identity data to ally and collaborate with other potential business partners in order to provide more comprehensive and integrated enterprise solutions.

E. Integration-as-a-Service

Integration has been traditionally deemed by organizations as a burden, since it adds dependencies on internal parties that could increase the time needed for implementation, and reduce service levels (such as availability and security). This has inspired IT solution providers (especially vendors of Enterprise Service Bus products and integration frameworks) to provide secure and reliable integration services over the cloud. As defined by Mulesoft, a leading provider of integration open source products and services, Integration-as-a-Service is "a cloud service delivery model for integration. Integration-as-a-Service delivers an integration solution that provides connectivity to backend systems, sources, files, and operational applications through the implementation of well-defined interfaces, web services, and calls between applications and data sources. This provides users with a more loosely coupled environment, safe from complex interdependencies. The Integration-as-a-Service delivery model enables integration across the cloud, making it possible to share data between systems as well as third party vendors in real-time" [13].

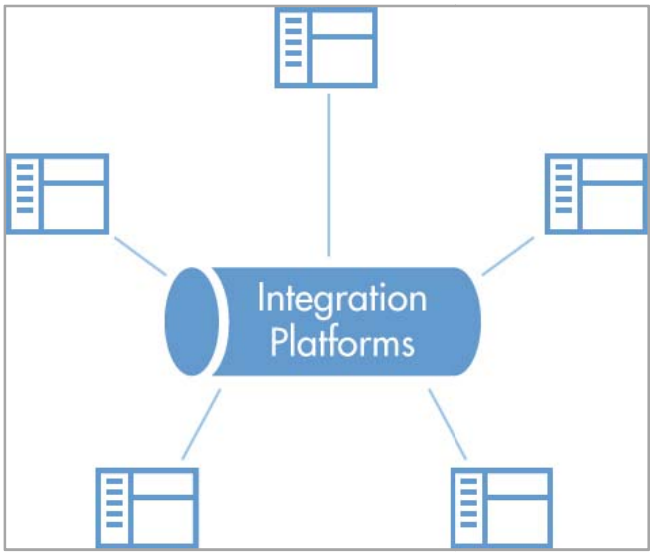

Fig. 3. Integration-as-a-Service [14]

As in the case of IDaaS, this model also promotes SOA, and opens up more opportunities for business collaboration.

F. Payment-as-a-Service

With the recent explosion of mobility and the emergence of certain proximity communication technologies, such as Near Field Communication (NFC) and Host Card Emulation (HCE); electronic payments using mobile phones is becoming an attractive alternative to conventional e-payment methods. Major market players in the electronic payment industry (e.g. Mastercard, VISA, and Amex) have already operationalized their NFC-based payment solutions (PayPass, Paywave, and Express Pay, respectively), and have published their standards to enable vendors to build and certify cloud-based payment solutions.

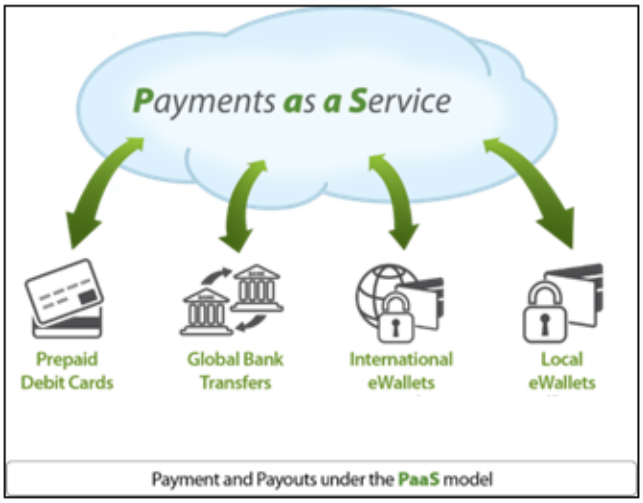

Fig. 4. Payment-as-a-Service [15]

While the above-mentioned methods are mostly geared towards card-present open-loop payment scenarios, other market players are providing cloud-based payment checkout solutions that enable merchants to integrate with them to provide their consumers with services for card-not-present scenarios. The emergence of cloud-based open-loop and closed-loop e-Wallets is also being witnessed nowadays; and at the end of the day, all these solutions provide users and merchants with more flexibility and less costly alternatives.

G. Tokenization-as-a-Service

Payment card data is considered sensitive data that, if compromised, would allow for fraudulent activities to occur. The standard that organizations are audited against to ensure that the right measures are taken to safeguard cardholder data is called the Payment Card Industry Data Security Standard (PCI DSS). The standard is mandated by the card brands and administered by the Payment Card Industry Security Standards Council.

Securing card data as per PCI DSS requires strict measures at the application, network and infrastructure levels; which not all organization (among those which provide electronic payments to their customers) wish to get involved in. This has created an opportunity for specialized technology vendors to provide Tokenization-as-a-Service (TaaS); which involves substituting sensitive card data elements with non-decryptable references. Sensitive data are kept safe in a secure vault at the PCI-DSS-compliant TaaS provider; while tokens instead are stored and passed on between participating parties.

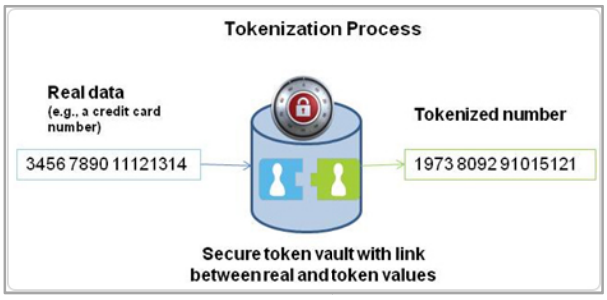

Fig. 5. Tokenization-as-a-Service [16]

This cloud service model provides flexibility to merchants who wish to pass security regulations, without bearing the burden of implementing and managing security infrastructure. It also promotes SOA interoperability through integrating with external TaaS provider, and opens up new opportunities for technology professionals and business entrepreneurs.

H. Everything-as-a-Service

In order to indicate that the innovation in cloud service models continues, the industry has crafted the term XaaS (Everything-as-a-Service). In principle, all XaaS variations; including the few ones mentioned herein, as well as the many others that exist today or will come to existence later, inherit cloud computing characteristics, which make them appeal to both business owners and technology professionals. According to NIST, these characteristics include:

- "On-demand self-service. A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
- Broad network access. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops and workstations).
- Resource pooling. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory and network bandwidth.
- Rapid elasticity. Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
- Measured service. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service" [17].

IV. Conclusion

The wide range of XaaS variations and their inherent appealing characteristics of cloud computing will continue to promote the acceptance and adoption of cloud services at a large scale, and will push forward technology and business advancements; which will introduce disruptive changes, not only to business and technology, but consequently, to all aspects of life which technology has penetrated.

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