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The Growing Effect of Cloud Computing on Technological Innovation: A Decision-Making Framework for Hybrid Managers

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ABSTRACT

Innovative companies must continually weave together technology, design, marketing and other key specialties into whole products and technology platforms. Innovation management is about creating and managing all these links over time. Hybrid managers are technical decision-makers who can leverage both technology and business aspects to increase revenue and competitive advantage. Cloud Computing is essentially delivering internet-hosted services over the internet through various range of features such as processing, storage, and development platforms. Cloud computing, with an adoption rate of 89 percent as of 2016 in the UK alone, has matured and became increasingly involved in a large-scale of industries. This paper investigates the dissimilar organisational and technical effects of recently-developed cloud computing services, to support the decision-making procedure of the innovation management discipline. The study recommends a scalable framework for hybrid managers to effectively facilitate and utilize cloud computing techniques in managing innovation. The paper argues that adopting a similar framework would assist hybrid managers in simplifying decision-support processes, and increase the business value and competitive advantage amongst rivals with similar innovation management challenges.

KEYWORDS

Innovation, Cloud Computing, Hybrid Management, Information Systems, Decision-making, ICT.

1 NTRODUCTION

One of the key objectives of the MIS (Management Information Systems) industry, is to create hybrid managers. A Hybrid Manager can be defined as an organization-focused decision-maker, who is capable of leveraging information technology through both business and technical means, by effectively managing software-focused employees to gain competitive advantage and increase the business value of the organisation.

Although accurate, this can be deemed as a long definition for a three-letter term. In a simplified manner, MIS is the desire to use technology to improve people's lives [2].

One of the simple definitions of cloud computing, is the use of the internet to achieve computing services [3]. These services broadly vary in today's ICT world, and the management of such services is becoming more complex which contradicts with the purpose of cloud computing to make the access to information and processing capabilities easier for companies and individuals [1]. As a result, hybrid managers are facing a challenge of weighing future costs of cloud computing against facilitating and expanding innovation activities within the organisation.

Invention is the creation of novel and practical ideas, while innovation is the transformation of those ideas into a domain of features and benefits, which uses state-of-the-art technologies that solves

customers' problems. According to most major industry-focused groups [4], Innovation is the lifeblood of all organisations. It enables organisations to adapt, survive and create, which leads to higher profits, stock values, and more jobs. On that note, many procedures and techniques have been developed to help managing innovation. However, it is argued that being innovative is not only about adapting to procedures, it is more about enforcing the interaction and the links between different departments in the organisation, such as purchasing, inventory, processing, R&D, procurement and distribution, which together leads to developing the final product and the supply chain process behind it.

Innovation management is the ability to continually improve those parallel procedures by sustaining the company's wide process under a coherent system. In other words, innovation management is a discipline that organises work to create and maintain the company-wide innovation system. As argued, innovation is not a single action, yet it is a total process of interconnected sub-processes [5].

This paper explores the different organisational and technical effects of recently-developed cloud computing services, to support the decision-making process of the innovation management procedure. The paper focuses on the technological aspects of recent innovations, and the role of hybrid managers to effectively utilise cloud computing to transform invention into innovation. The project outlines a set of procedures for hybrid managers to adopt in a multi-disciplinary organisation in order to achieve a sustainable, economical and user-friendly cloud-based innovation management.

The paper respectively discusses a literature review; an unstructured analysis through case studies of the current affiliation between cloud computing and hybrid managers and their role in managing innovation. Furthermore, a semi-structured analysis is conducted with reference to the impacts and challenges facing ICT decision-makers when applying these aspects on the innovation management process. In addition, the paper conducts a cloud computing management analysis to investigate and test the appropriate techniques to potentially enhance the innovation management process of multi-disciplinary industries. In consequence, the paper introduces a scalable decision-support framework for hybrid managers. Finally, the paper recommends future research to persevere with the fast-paced ICT advancements, and mitigate future challenges facing hybrid managers.

2 LITERATURE REVIEW

Over the past two decades or so, many papers and research projects have been published on the topics of innovation management, cloud computing and hybrid management. However, only few have connected the three areas together and investigated the impacts of utilising recently-developed cloud technologies by hybrid managers to assess potential benefits and limitations on the innovation decision-making process. This section examines the recent literature that interrelates with the former three disciplines and connects the relevant topics to this paper.

Innovation management was described in many contexts as a system composed of four development processes: New product development; new capabilities development; new strategy development; and new business development. All of which consists of sub-processes that, by interacting together, form the innovation management discipline. A study by Rutgers Business School argues that innovative companies engage all personnel in the previous departments in innovation by organising all the company's work into those four processes [4].

In a 2018 paper submitted to the International Journal of Innovation Management, Tidd argues that the industry of innovation management has failed to take advantage of the vast reproduction of literature. This was justified given the insufficient coherence and lack of consistency in the relevant work and research [6]. The paper examined two cases of the current notions of innovation malpractices: Business model innovation, and Open innovation. These came as a result of bias viewpoints in adopting, and turning research and publications into contemporary conducts, which

according to the research have been enthusiastically followed by innovative organisations.

Innovation management is not a simple task of combining business and management disciplines for the application of innovation. The process of managing innovation consists of numerous sub-processes that arose from a growing domain of practices and knowledge [7]. This experience continues to grow, and is built from multidisciplinary fields such as product development, research and development, entrepreneurship and market experimentation.

Through the previous two decades or so, most research conceded that a successful implementation of innovation requires taking into analysis various aspects across the organisation, which are not necessarily related directly to each other, such as creativity, marketing and finance. In addition, it requires involving all business and technical departments in the decision-making process even when tension occurs between different areas of the organisation [8]. The current understanding remains the same, however given the active and consistent advancements of disruptive technologies such as cloud computing, the innovation sub-processes have become more mature and increased to an extent where could potentially make the innovation management process more challenging and complex for hybrid managers if not managed thoroughly.

Many studies argued that the key challenges facing hybrid managers today when managing innovation revolve around their abilities to create, identify or exploit new opportunities [18]. This challenge is accompanied with the fact that most decision-makers, particularly in the ICT industry, struggle when attempting to find new ways to serve existing markets through improving internal operations, creating new markets, and rethinking existing services through fulfilling current social needs.

According to a 2017 study by Forbes [30], hybrid cloud computing adoption by innovative organisations has grown three times more than the last year across the US, Canada, UK, France, Germany, Brazil, and Australia. This rate was observed to be currently increasing from 19% to 57%. Moreover, in a year's time it has been estimated that leading names in the innovation market will outsource 80% of all ICT infrastructure and services to cloud platforms. Furthermore, the same study found that 73% of organisations surveyed will be utilising fully cloud-hosted SaaS solutions in the upcoming three years. However, it was pointed out that 49% of innovative firms are postponing major IaaS cloud deployment as a result of security concerns.

Several papers have addressed the key challenges facing innovative firms nowadays when relying on cloud computing technologies in their management and operational processes. Accordingly, various risk analysis models were suggested to assist managers in making effective decisions regarding budget spending, ICT risk-taking, and future planning [31]. Nevertheless, it was noted that not enough literature was addressing this subject from the perspective of hybrid managers who acquire both technical and management expertise, and to a certain extent are deemed as best suited to manage high-end innovative projects [32].

Other studies argued that the Internet of Things (IoT) forms a core target for innovation through the power of cloud computing [33]. This was justified due to the flexible and seamless methods in which IoT can embed into the cloud, which offers numerous opportunities for innovative companies and creative start-ups to exploit while supporting reliability and cutting upfront expenses. Nevertheless, the security aspect of information and infrastructure ownership forms one of the prime barriers against innovation in the previous context [34]. In addition to business challenges, several cloud management concerns were researched, which could potentially prevent innovation from succeeding in current competitive markets. These primarily includes availability and performance of service, data confidentiality and ownership, bugs and integration issues with large-scale distributed systems, scaling flexibility, and licensing of SaaS products.

This paper explores the impacts of cloud computing on the key organisational factors influencing

innovation. The analysis is carried out by studying the core linkages and interrelated characteristics of innovation in accordance with the delivery criteria and deployment models of cloud services. The following section analyses the high-level management concepts and models of cloud computing, prior to discussing the corresponding organizational characteristics leading to innovation, which takes place in section 4.

3 CLOUD COMPUTING MANAGEMENT ANALYSIS

The objective of this paper is to identify the key facilitating connections between cloud computing and innovation management, in order to simplify the decision making process for hybrid managers in different industries and networked organisations. While innovation management is a systematic process of managing interrelated and multidisciplinary sub-processes, cloud computing can play a significant role in improving the interaction between those sub-processes. This will be argued in relation to the scalable characteristics, deployment techniques, and service models of cloud computing. The following section outlines the key principles of cloud computing, prior to connecting the relevant aspects with innovation management.

Some of the essential characteristics of cloud computing are rapid elasticity, resource pooling, broad network access, metered service, and on-demand delivery of service. In our previous publication [16], we explored these characteristics in-depth, and identified the management challenges associated with each. In brief, cloud computing is built on the basis of delivering computing services from ICT providers to end-users, via a multi-tenant and self-service delivery model. Users will only pay per-usage, similarly to paying water and electricity bills. Users are to some extent able to provision the rented cloud infrastructure, and releasing it back to the provider as soon as it is no longer needed. As a result, the cloud provider runs an automated system which assigns new resources to new users accordingly.

Cloud computing offers a wide range of services and features. These can be divided into three general models of software, platform and infrastructure, which are known as SaaS, IaaS, and PaaS respectively. The concept is to allow end-users, of different workload sizes and types, to utilise either actual processing infrastructure from the cloud provider, or platforms to develop new applications using the cloud's capability and resources, or simply accessing on-demand cloud-based software.

In relation to the previous cloud characteristics, the cloud resources appear to be unlimited to end-users. Those resources are automatically and elastically provisioned to users at any time and for any quantity. The fundamental aspect in this context is the rapid delivery and flexible management of those resources. This enables organisations to focus the company's core competencies on efforts related to their innovative objectives, by utilising the cloud scalable ICT infrastructure instead of the conventional physical one, which shifts the company's payable time from unnecessary tasks. This paper argues that these burdens can harm the innovation management process and complicates the internal communication channels between the company's different departments.

Cloud computing is deployed using four nonexclusive hosting approaches. These are private, community, public, and hybrid. Those models were discussed in-detail in our previous publication against the potential challenges in a domain of networked organizations. We argued that a hybrid deployment model is more suitable for science-focused firms when managing innovation [17]. While on the other hand, a private and community cloud models are more appropriate for specialist equipment suppliers, and scale-intensive firms. Furthermore, a public hosting approach was deemed as more effective for innovation decision-making when adopted by supplier-dominated firms. The following section analyses the characteristics of innovative hybrid organisations against each cloud computing service characteristic.

4 CHARATERSTICS OF INNOVATION IN RELATION TO CLOUD COMPUTING SERVICE CRITERIA

In this section the paper explores the characteristics of innovative hybrid organisations in relation to the current relevant cloud computing service concepts. As outlined earlier, managing innovation is not a correct science, and there is no right or wrong system or strategies to follow in order to guarantee the success of innovative ICT products [18]. We examine a collective set of real-life characteristics presented by previous research, in relation to the corresponding cloud computing aspects following a nonexclusive order of importance. The following represents various collection of ideas based on different organizational experiences and activities.

Expansion Focus

Innovative organisations are usually driven by an urge for growth in the market, increasing competitive advantage, and manage change in an effective fashion in response to rival firms in similar Industries. This often comes as a result of rising competitors who are often classified as market-disruptors [19].

As previously stated, organisations were divided into three groups as follows: Family-oriented businesses; These are usually not looking to expand beyond their initially desired size and capability, therefore innovation and expansion is not often on the agenda given the limited resources and willingness to take risks. Another group represent firms that are built to exploit a specific opportunity in the market. As a consequence, innovation or expansion is also not essential to these companies work nature. On the other hand, the third group of organisations are those who are driven by a core requirement to grow in the market and increase business value. These firms can be classified as potential innovators.

On that note, cloud computing can play a significant role in expanding the domain of innovator firms from the previous third group, to a wider scale that could potentially include the first and second groups as well. The argument relies on the scalable, pay-as-you-go, rapidly-provisioned and user-friendly features in which cloud computing could offer various types of organizations to facilitate technological innovation as a substitute to the conventional, and in some cases, unnecessarily-purchased ICT infrastructure.

Application and Flexibility

One of the key differences between invention and innovation, is that the latter requires a thorough coordinated activities to achieve a successful market opportunity [20]. This application is often designed and adopted by hybrid managers who are able to leverage digital advancements to increase revenue and competitive advantage in their industry. In order for the innovation coordinated activities to work, companies are forced to adapt to change swiftly, by altering the way their conventional operational and market lifecycle normally runs. In most industries, this is not a simple task to carry out given that management rigidity is a common factor shared by most incumbent firms.

In the ICT domain, this creates an additional barrier where in most market cases, in order to achieve innovation, rapid changes to the company's ICT infrastructure is necessary, whether related to software, hosting, development, or even hardware manufacturing. According to recent case studies [21], over the last decade or so, cloud computing has been observed to offer the previous requirements through flexible service delivery techniques which allows different management-level users, such as hybrid decision-makers and non-ICT experts, to make real-time changes to their ICT infrastructure for the purpose of adapting to significant and undisciplined market fluctuations.

Technology Focus

As discussed in the previous section, technology is an underlying assumption in the systematic process of innovation management. On this note, successful innovators must maintain a persistent commitment to ICT, regardless of the fluctuations in the market and their internal business.

It has been observed that organisations who shift the emphasis from technology to cost cutting strategies often fail as innovators. Successful cases of inventions were seen to occur when the environment is supported by sufficient technological advancements, which often allow the company to continue the development beyond the initial idea. On this ground, hybrid managers can utilise and profit from the unlimited-resource environments of cloud computing to facilitate their technological development strategies while undergoing new inventions.

One current example of the above, is the AI-for-Everybody initiative [22]. Currently, artificial intelligence advancements are being monopolized by leading ICT firms such as Amazon, Microsoft and Google. In particular, Amazon's AWS is acquiring the largest domain of cloud-based AI developments in today's market. Nevertheless, cloud providers like Google and Microsoft are currently working on public AI development platforms, using PaaS technologies, to allow non-expert users and industries such as energy, medicine, and manufacturing, to harness new business opportunities through artificial intelligence. Accordingly, Google has announced two new cloud-hosted public AI platforms, AutoML and TensorFlow.

Moreover, Microsoft has teamed up with Amazon to release Gluon, which aims to simplify the process of building AI systems for all types of industries and users, and shift the AI development process to reach the same difficulty-level of building a simple mobile application. In summary, the previous section emphasises on the argument that once cloud computing releases the AI development technology for the public to use, the real AI revolution begins in various industries.

Outward Looking

According to the literature and background review, innovation only occurs when open and fast communication take place between all departments in the organisations. Current cloud computing project-management tools, provided by SaaS technologies, allow hybrid team leaders to enhance and reinforce these communication channels within the firm. For example, Atlassian JIRA is currently considered one of the market-leading project management platforms, which is fully hosted and managed over the cloud. With the aim of reaching 100,000,000 end-users by 2020 worldwide [23], Jira offers employees in large organisations a scalable and user-friendly environment to deliver innovative projects, which utilises project-management processes via real-time, multi-user task-handling and communication features.

Other examples of fully cloud-hosted platforms which supports a seamless communication between dissimilar departments in one organisation, are Google Docs, Microsoft 360 Office, and SalesForce. The aim is to prevent staff isolation within the firm by providing a real-time open communication platforms to support the innovation management process.

Risk Taking

ICT innovations are always accompanied with major risk. Hybrid managers have a crucial task of weighing the risks against the success probability and market potential to deliver new innovative products. The risk analysis task must be carried out thoroughly by measuring the extent of the risk, and balancing the cost across several projects in order to spread the losses in case of failed attempts to achieve innovation. It is often observed that innovative firms are those who are able to identify the right timing to take risks, in addition to accurately assessing the demand to minimise this risk when required.

On this note, cloud providers offer a wide range of services that allow end users to perform roll-back functionalities even after utilising a cloud-hosted feature. For instance, users can self-manage cloud services without contacting the cloud provider when any issues occur that obstruct the innovation process. Accordingly, and as observed in recent case studies, this allows hybrid managers to take more risks while managing innovation, which as a result reduces the time and effort involved in the decision-making process, and increases revenue by

eliminating unnecessary management overheads which are often related to ICT.

Over Capacity

Most organisations tend to adopt resource-limiting strategies in order to prevent unnecessary expenses from spreading across the different departments of the organisation. This without a doubt forms a significant obstacle for innovation. It has been observed across several industries such as automobiles and ICT, that innovation occurs when employees are given an additional percentage on their salaries for their pet projects. This flexibility allows personnel to invent by thinking outside the box without worrying about the company's conventional regulations and market borderlines.

In today's market, many firms do not have the luxury to allow such freedom for R&D (research and development). Therefore, employees find it challenging to work on novel products and conduct risky market research. As a result, innovation management becomes more difficult for hybrid decision-makers when less flexibility in the research lifecycle is allowed.

On this account, recent case studies have shown that cloud computing is an encouraging solution for managing the previous over-capacity concerns. According to IBM [24], various enterprise-level companies have recently benefited from adopting state-of-the-art cloud solutions across dissimilar industries. For example, recognizable brands such as 1800Flowers, Fleetcor, ShopDirect, Halliburton, Marriott and Anthem, have increased their pet projects R&D, by utilising the latest IBM cloud features like Cloud Object Storage, SAP, Storage-as-a-service, Hybrid VMware, and IBM Connect. This resulted in extending those companies abilities to create and manage innovation, and expand to new industries by 76%. Moreover, those firms were recorded to establish new sources of profit by 71%, and support new markets by 69% [25].

Internal Communication

Tension between unrelated departments in the organisation has been observed to form a key barrier against innovation. To a certain extent, and for the sake of spreading ideas and sharing different viewpoints across the firm, this can be healthy if dealt with effectively by hybrid managers. For instance, organisations that relies on ICT for innovation, often struggle when dealing with intricacies of novel technologies, without first analysing market implications, demands, and potential applications of these ICTs. As previously pointed out, these limitations can be alleviated if appropriate internal communication occur between all departments involved in the innovation management process.

On this account, Real-time cloud-powered communication platforms through (SaaS) has been proven to grow businesses at a rate of three times of those utilising conventional on-premises communication solutions. It has also been shown to offer scalable integration abilities between legacy systems and off-premises ICT environments [26]. Few examples of these real-time cloud communication tools are Combat, which is a mobile-cloud-based communication service [27], Nexmo, Twilio, Skype for business, Speakap, Kandy, which enables independent software providers and solution integrators to seamlessly build and deploy enterprise-level communication channels [28].

Wide-raging Capabilities

As discussed previously in the core definition of innovation management, it is essential for hybrid managers who acquire more than one speciality, and are able to relate advances and functions from one field to another, to make effective decisions when dealing with experts from different departments. These personnel vary from accountants, marketers, R&D researchers, technologists, sales strategies, and product developers. On this note, making crucial decisions that combines technical aspects with commercial ones, forms a challenge against achieving successful innovation.

According to a recent study by Microsoft [29], hybrid managers are currently empowered with various scalable cloud services, which assist them

in making crucial decision to improve the innovation process through methods like data mining, insights analytics, knowledge and cognitive analysis. This is achieved by utilising cloud computing (IaaS) processing power, which alleviates the need to rely on costly ICT third parties, thus reducing on-premises management overheads, and infrastructure administrative resources (e.g. system upgrades, security patching, cooling and heating).

It is important to note that the above analysis is based on personal experiences which resulted from a set of views in a specific organisational context. This plays a significant role in the process of achieving and maintaining innovation through organisational experience. Accordingly, it is challenging for organizations to repeat the same scenario as this collection of views may be inappropriate for different circumstances in dissimilar industries, events, specialists, and time periods. Therefore, the previous discussion serves as a domain of ideas for reflection and reference. The following table illustrates the organisational characteristics of innovation in relation to the relevant cloud computing attributes, which acts as a potential factor for future market development and effective management.

Table 1. Innovation characteristics in relation to the corresponding cloud computing service criteria

Innovation Characteristic	**Corresponding Cloud Computing Taxonomy to Support Innovation**
Expansion Focus	Rapid-provisioning of cloud resources, and on-demand self-service.
Application and Flexibility	Rigid-free cloud computing platforms with real-time adaptability to change, and elastic inward and outward delivery.
Technology Focus	Cloud-based AI development environments via PaaS, for all industries in the public market to utilise (e.g. Auto-ML, TensorFlow, and Gluon).
Outward Looking	SaaS real-time open communication platforms to prevent isolation between internal departments and employees in the organisation (e.g. Jira, Google Docs, and Trello).
Risk Taking	Cloud computing metered pay-as-you-go service, with roll-back functionalities: This enables cloud provisioning without the need to contact the cloud provider, which acts as an incentive for hybrid managers to take more risks while managing innovation.
Over Capacity	Flexibility in corporate venturing through the power of cloud computing: This allows personnel to spend additional time and budget on R&D for pet projects. Recent case studies have shown that cloud technologies such as IBM's SAP, Connect, and Hybrid VMware, has allowed various industries to expand to new markets and unlock new capabilities towards innovation.
Internal Communication	Real-time cloud-powered communication platforms through (SaaS): This allows hybrid managers to rapidly and seamlessly create communication channels between different departments and off or on-premises software via scalable cloud integration features (e.g. Kandy, Twilio, and Nexmo).
Wide-ranging Capabilities	Utilising cloud computing (IaaS) processing power in

	making crucial decision on the innovation process through data mining, insights, knowledge and cognitive analysis.

5 ANALYSIS OF CASE STUDIES

Some of the key characteristics of cloud computing are resource pooling, user-friendly, self-service, broad user access over the network, on-demand, measured service, and rapid elasticity [13]. According to the case study analysis discussed next, the last two characteristics have been observed to positively impact ICT organisations in managing innovation. This is not only argued in response to increasing revenue, but also in simplifying the decision-making process and reducing time and effort involved when various departments and specialties in the organisation work in coherence to manage innovation.

Case Study 1: DeepFakes

One of the case studies of the heavy cloud computing involvement in innovation, is the current applications being developed to detect and prevent artificial intelligence-based systems to create fake news. These systems are usually politically-motivated, or revenge-based, for the purpose of harming and ruining individuals' reputations, or changing worldwide opinions through the internet. These events take place particularly during crucial social, economic, or political times such as voting, and other hidden motives. One of these platforms, which noticeably surfaced in 2017 is Deepfake. Deepfake is defined as an artificial intelligence human-learning image, video, and voice synthesis method, which utilizes automated techniques to associate and overlap existing videos, pictures and audio files, onto a new superimposed source file [9].

These tools have been proven to successfully cause damage and effect audiences opinions through millions of geographically-targeted, and auto-generated fake source-files over the internet [10]. It can be argued that without a scalable cloud-based processing power, it would have been impossible to create innovative systems to detect and prevent techniques such as Deepfake, and other similar ones like FakeApp and TensorFlow which all emerged in 2018. Nevertheless, market-leading ICT organisations have admitted to struggle to stop these fake content from spreading, or even detect them after spreading [11].

Organisations like Youtube, DFyCat, Facebook, and Twitter are some of the names currently utilizing cloud-based technologies to detect, combat, and prevent Deepfake files from spreading on social platforms. This effort is particularly being developed using the cloud IaaS (Infrastructure as a Service) processing features [13]. This cloud service model enables these companies to run and test heavy and complex machine-learning algorithms to detect superimposed audio, images and video source files. However, even with cloud computing scalable processing power involved, the algorithms can still take hours, or days to detect the source files and then take them down. Furthermore, the algorithms are currently only applied to newly uploaded posts on social media. Therefore, Deepfake files that are already on social media platforms will have to be first reported, and then manually removed. Whereas, even with the cloud computing support, it is extremely difficult to run the AI detection algorithms on all content already uploaded on social media datacentres.

Nevertheless, new AI algorithms are currently being developed by leading ICT organisations using cloud computing PaaS (Platform as a Service) features. Some of these algorithms will analyse a subject's facial pulsives to detect fake internet files in a more comprehensive and time-effective manner [12]. For example, if the pulse in the cheeks does not match the heart rate in the neck, then this video could be fake. Another innovative approach currently being developed by the University of Albany, is analysing unrealistic eye blinking patterns. Another company, Truepic, which provides photo authentication services to online users, has announced adding big investments on cloud computing services to join the fight against fake internet content.

Case Study 2: Samsung's AI Voice-Recognition, Bixby

Another example of the substantial cloud computing involvement in managing innovation, is Samsung's next generation voice-recognition, Bixby. This service is fully hosted over the cloud, and utilises IaaS processing power entirely for its application and AI learning algorithms [14]. The objective is to enable the machine to adapt and learn human needs from a large domain of user requests worldwide. The system achieves this by exploiting one of the key cloud computing characteristics discussed in the previous section, Resource Pooling. According to Samsung's Executive Vice President, InJong Rhee, cloud computing is the number one factor behind the success of Bixby's newly added features. These range from image recognition, language translation, executing touch commands, and the cloud-based user-learning over time. According to IJong, once any software becomes Bixby-enabled, the following characteristics have been achieved via the substantial support of cloud computing technologies:

Context Awareness: With the support of cloud computing PaaS development of external parties, this means that the cloud-hosted voice-recognition service will be able to adapt to any continuous state of any bixby-enabled application. As a result, users are able to interact with these applications by simply sending voice requests from other applications running simultaneously.

Task Completeness: The objective is to simplify the user-education process on the capability of the voice-recognition system. In essence, only few tasks of external applications are usually supported by voice-recognition systems. However, this cloud-based service will utilise a conventional single interface for all Bixby-enabled applications. As a consequence, this will allow users to control all functionalities of the application by sending voice requests to achieve normal touch commands.

Cognitive Tolerance: Many humans are cognitively-challenged to recall the same pattern of the voice request they used each time for the same objective. This fully cloud-deployed service will learn from repeated sets of unfixed forms of commands, stated by different users, and in relation to the corresponding applications. In this event, Bixby will automatically learn the application-request behaviour and adjusts those commands in the future based on the user's desire. Whereas, according to Samsung's Executive Vice President, the majority of the current voice-recognition services depend upon users to say the same exact requests in a fixed pattern.

One of the argued negatives of Bixby is that it currently does not work with all applications on the phone device. However, given the cloud computing PaaS wide range of services, Samsung will enable developers to build and run their own integration software to work with Bixby programming interfaces (APIs). As a result, Bixby will also employ this new knowledge in its core machine learning processes, thus further adapt to human needs over time [15].

Additional Case Studies

There is a wide variety of innovation case studies that can be mentioned in this context, which have been impacted by cloud computing throughout the hybrid management process. Some of which is the Internet-of-Things (IoT). Recent innovations in (IoT) has shown promising abilities in sectors like green energy analytics and sustainability intelligence. For example, recent studies have measured the amount of gas and electricity smart homes are able to save annually by utilising cloud power to analyse data in response to heating and cooling demands based on trends, temperature data, and smart meters.

Another example of innovation through cloud computing is Blockchain. This movement has adopted decentralised cloud datacentres to perform heavy processing power through the cloud for various projects that require faster and more effective data analysis. Major cost cuts and simplified management efforts have been recorded as a result, which led to new innovative opportunities for other markets to exploit such as

Quantum Computing, Algorithmic Systems and others.

Companies like Uber has primarily relied on cloud computing services in creating and sustaining a world-leading innovative mobile platform where individuals can locate, book, and track their taxi rides in real-time across a global footprint of 71 countries [35]. It can be argued that without the utilisation of cloud datacentres through (IaaS) virtualisation, resource-pooling algorithms, and hybrid cloud bursting for load-balancing techniques, this system would have failed in its premature phases in the market.

Nevertheless, it is noted that the complexity of the Uber innovation process would have turned into a very challenging one, and potentially would have failed due to increasing costs and reputation issues [36]. This was prevented due to the thorough and collective management activities of the Uber application process, which turns most of its features into automated ones, like signing-up as a new driver, signing-in as a passenger, writing reviews, filing a complaint, requesting refunds and so forth.

The following table outlines each of the previous ICT innovation case study in connection to the corresponding cloud computing impact on the hybrid management process.

6 DECISION-MAKING FRAMEWORK

In this section we outline a decision-making framework for hybrid managers to utilise when adopting cloud computing services to manage innovation. In a previous publication [37], we presented a decision-support system which evaluates the economic, sustainability, and management value of cloud computing by non-experts across multidisciplinary industries.

It can be argued that the key techniques for creating value through innovation is inspired by a collective set of organisational activities [6]. This paper suggests that these fundamental mechanisms are significantly interrelated with recent cloud computing advances. The following illustrates key considerations and abilities for hybrid managers to adopt and take into account when making decisions regarding the innovation process, through the help of cloud computing, in interdisciplinary industries:

- The ability to identify cloud motives and drivers of change in relation to the relevant projects before committing to any contracts with the cloud provider.

- The ability to thoroughly analyse exiting cloud maturity and ICT infrastructure already in use, which potentially cut costs by partially integrating on-premises services with new cloud services.

- The ability to predict and analyse long-term cloud computing challenges and limitations in relation to the relevant areas of the innovation process.

- The ability to simulate cloud demand patterns across both off-peak, and heavy service demand periods prior to committing to long-term contracts with the cloud provider. And in response, measure ICT budgets against future changes in the cloud cost, and alter the cloud contract with the provider according to relevant findings.

Once the previous initial factors are achieved, hybrid managers can focus their organisation's core competencies on the following considerations to ensure the successful implementation of innovation:

- The ability to deliver novel services through faster and user-friendly processes, by understanding the advantages and disadvantages from favouring a certain cloud service models over the other.

- The ability to master a complex task in which other rival firms struggle to adopt.

Table 2. Case studies summary of analysis: impact of cloud computing on the innovation process.

Cast Study Overview	**Cloud Computing Effect on the Innovation Process**	**Challenges facing the current Hybrid Management Process**	**Current Development of Future Innovation**
Deepfake: The detection and prevention of the widespread of fake news via Deepfake source files on the Internet. Youtube, DFyCat, Facebook, and Twitter are some of the organisations currently heavily utilizing cloud-based technologies to detect, combat, and prevent Deepfake files from spreading on social platforms.	IaaS (Infrastructure as a Service): Heavy cloud processing of complex machine-learning algorithms through cloud technologies to detect superimposed audio, images and video source files.	Even with cloud computing scalable processing power involved, the algorithm can still take hours, or days to detect the fake source files. In addition, the algorithm is currently only applied to newly uploaded posts on social media.	New AI algorithms are currently being developed by leading ICT organisations using cloud computing PaaS (Platform as a Service) feature to analyse a subject's facial pulsive and eye blinking patterns to detect fake internet files in a more comprehensive and time-effective manner.
Samsung's AI Voice-Recognition, Bixby: Market leading voice-recognition system, with next generation features such as image recognition, language translation, executing touch commands, and cloud-based user-learning over time.	IaaS deployment and processing of accumulated knowledge and user requests. The employment of resource pooling and rapid elasticity cloud characteristics which supports the machine learning process to further adapt to human needs.	Heavy rivalry and market competition from other market-leading services such as Microsoft's Cortana, Apple's Siri, Google's assistant, and Amazon's Alexa. This prevented Bixby from conducting further testing on specific sub-features on external applications, before releasing the first version of Bixby in March, 2017.	PaaS utilisation by external organisations to develop customised integration between Bixby and other mobile applications. This enables Bixby to achieve key characteristics such as Cognitive Tolerance, Context Awareness, and Task Completeness.
Internet of Things (IoF), Blockchain, and Uber.	Studies have measured the amount of gas and electricity smart homes are able to save annually through (IoF) by utilising cloud power to analyse data in response to heating and cooling demands based on trends.	Uber's innovation management process is 100% cloud-based, which adopts hybrid resource-pooling algorithms in its operation. Yet challenges facing Uber currently revolve around reliability and availability of service, and licensing issues given that it operates across a global footprint of 71 countries.	Blockchain movement is currently applying fully decentralised datacentres with rapid processing power via (IaaS) techniques, which is expected to offer new innovative opportunities to other markets such as Quantum Computing and others.

- The ability to offer a unique service in which other rival firms require a costly license to utilise.

- Expand the domain of competitive advantage attributes amongst rival organisations (e.g. focus more on the quality and choice rather than the product itself).

- The ability to predict appropriate market timings when releasing new novel products.

- The ability to make effective decisions on crucial new innovative projects, by recognising when to act as a fast-follower or a first-mover when releasing novel products to the market.

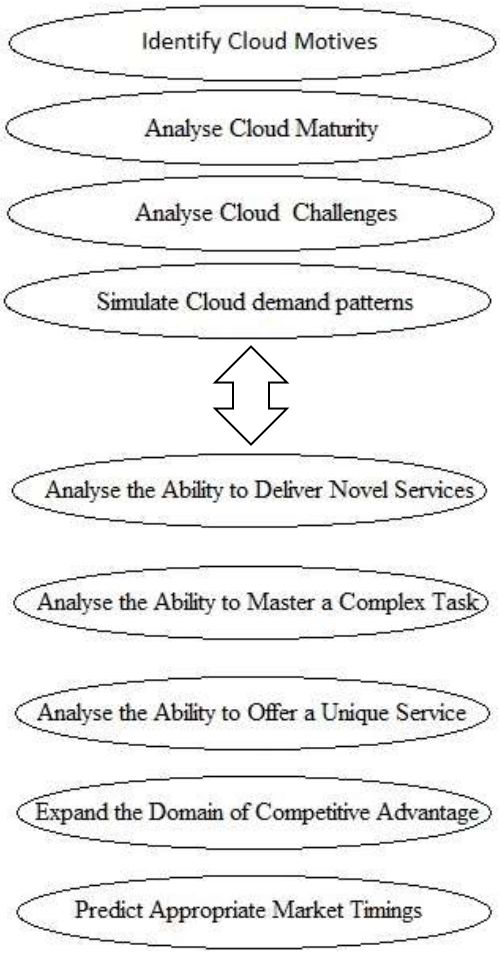

Figure 1. Cloud computing decision-making framework for hybrid managers to manage innovation.

7 CONCLUSION AND FUTURE WORK

In this paper we explored the key facilitating connections, between cloud computing and innovation management, to simplify the decision making process for hybrid managers in different industries and networked organisations.

The paper identified various organisational and technical effects of recently-developed cloud computing services, to support the decision-making procedures of the innovation management process. The analysis focused on the technological aspect of recent innovations, and the role of hybrid managers to effectively utilise cloud computing to transform invention into innovation. The project outlines a set of procedures for hybrid managers to adopt in a multi-disciplinary organisation, to achieve a sustainable, economical and user-friendly cloud-based innovation management.

In this paper we outlined a literature review which followed an unstructured analysis supported by case studies to demonstrate the role of cloud computing on recent innovations. The analysis highlighted the current affiliation between cloud computing and hybrid managers, and their role in managing innovation. Moreover, a semi-structured analysis was conducted with reference to the impacts and challenges facing ICT decision-makers when applying these aspects on the innovation management process. As a result, the paper carried out a cloud computing management analysis which investigated the appropriate techniques to potentially enhance the innovation process of multi-disciplinary industries.

The paper recommends future work on this topic which sheds light on industry-specific case studies where cloud computing played a significant role in the innovation management process. Future projects will focus on the hybrid decision-making characteristics of specific industries with innovation contribution, in order to persevere with the fast-paced ICT advancements, and mitigate future challenges facing hybrid managers.

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