RECOMMENDING BEST PRACTICES FOR ACCELERATING HYBRID CLOUD ADOPTION

by

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DISSERTATION
Presented to the Swiss School of Business and Management Geneva
In Partial Fulfilment
Of the Requirements
For the Degree

DOCTOR OF BUSINESS ADMINISTRATION

SWISS SCHOOL OF BUSINESS AND MANAGEMENT GENEVA

May 2025

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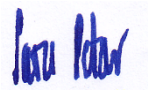

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Dedication

I wish to dedicate this research to all my parents, teachers, mentors, and colleagues. Each of them has played a major part in making me what I am today.

Acknowledgements

Research always looked to me like a distant dream. I always felt that I was not cut out for it and was not capable of dedicating time to it. It all began with encouragement from my wife Manisha. She met me as a student and always holds me in high regard in terms of my learning and teaching skills. The search for the right institute took about six months of research and finally I stumbled upon the DBA course offered by the Swiss School of Business and Management, Geneva. The overall process of application and enrolment was easy and the feeling of excitement that I had when my application was accepted is amongst the finest moments in my career thus far.

I would like to profusely thank my guide Dr Anna L. Provodnikova, PhD. She has been the guiding light in this journey and has always been proactive in her feedback and guidance. In addition to my research specific questions, I found the various webinars conducted by her also very useful.

My gratitude towards my mentor at work Mandar Marulkar cannot be expressed enough. He was the first person to be aware of my DBA pursuit and was instrumental in me choosing my research topic. His contribution was not limited to the selection of the topic but also in guiding me in terms of areas of research, subjects to study and connecting me to industry leaders and peers whom I could reach out to for observations and surveys. My colleagues and customers at Nutanix were very encouraging throughout the journey. They have gone out of their way to accommodate my requests for interviews and sessions on the various aspects of hybrid cloud computing

ABSTRACT
RECOMMENDING BEST PRACTICES
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Manoj Ravindra Mone
2025

Dissertation Chair: <Chair's Name>
Co-Chair: <If applicable. Co-Chair's Name>

The aim of this research is to study hybrid cloud adoption and find the various factors that affect this adoption. This study aims to understand the challenges that bog down the teams embarking on the Hybrid Cloud adoption journey and aims to find various steps that can be taken to accelerate the adoption of hybrid cloud. Through this thesis we intend to investigate the key factors affecting the adoption of hybrid cloud. Given the plethora of applications that a typical organization implements, we wish to study if there are any specific type of applications that are a better choice for deployment on hybrid cloud. This thesis aims to find what are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises. We aim to do this by extensive literature review, face-to-face and Zoom interviews and survey questionnaire.

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CHAPTER I:
INTRODUCTION

1.1 Introduction

The term cloud is often used to refer to “Public Cloud” services, there are a few variants in terms of what cloud is being used and in what manner it is being deployed. Multi-Cloud, Hybrid Cloud deployments are the variants that are being adopted by various organizations and enterprises. Our research focuses on what drives the option of Hybrid clouds. We have derived that the motivations of going Hybrid are varied and will dwell on it in our work. Primarily, the “Hybrid” way of using cloud aims to give organizations, "best of both worlds” experience. A hybrid cloud merges public and private clouds using technology that allows data and application portability (Mell and Grance, 2011). Our studies in the growing interest in the adoption of Hybrid cloud, has brought forth the observation that the reason for adoption of Hybrid Cloud is not just the economics, the technologies alone but the ease at which organizations can adopt them. Hybrid cloud deployments improve economics and business agility (Funahashi and Yoshikawa, 2011).

For the organizations embarking on this journey of Hybrid Cloud adoption, the challenge of making the two cloud platforms (private cloud and public cloud) work together as Hybrid cloud has not been easy. With this background, we aim to present in this research the various factors affecting the adoption of the Hybrid cloud and suggest recommendations to address these issues thereby improving the adoption. While doing so we also aim to identify the applications (workloads) that are best suited to make most of this approach.

1.2 Research Problem

When an organization decides to adopt hybrid cloud deployment as their preferred approach of cloud adoption, they do so with an intent to use a single, integrated, and unified platform to manage their various resources across the public and private cloud. However, it has often been pointed out that the deployment and management of hybrid cloud is not easy. While every organization may have its unique experiences while embarking on the journey, they will benefit from the experiences of other adopters. What worked for other adopters of Hybrid Cloud is likely to resonate with those who are about to the start their adoption journey. The various approaches and accelerators that various adopters are used need to be studied and explained for future adopters to follow and we aim to do the same.

1.3 Purpose of Research

The aim of this research is to enumerate the various challenges that are encountered by the teams embarking on the Hybrid Cloud adoption journey and to list out various steps that can be taken to accelerate the adoption of hybrid cloud. We will perform this research with an intent to understand the complexities involved, options that were considered, what decisions where critical than the rest and what application workloads were prone to benefit more from the adoption of the Hybrid Cloud approach.

1.4 Significance of the Study

We believe that this study will be of immense value to the organizations and teams who are embarking on the hybrid cloud adoption journey as well as a reference point for those organizations which have already deployed hybrid clouds and wish to validate their approach vis a vis the hybrid cloud consumers at large. This proposed research can act as a reference point for both teams embarking on hybrid cloud adoption journey as well as those teams which wish to validate and extend their exiting hybrid cloud adoption.

1.5 Research Purpose and Questions

When an organization decides to embark on a hybrid cloud deployment, they intend to use a single, integrated, and unified platform to manage their various resources across the public and private cloud. However, it has often been pointed out that the deployment and management of hybrid cloud is not easy. The aim of this research is to enumerate the various challenges that are encountered by the teams embarking on the Hybrid Cloud adoption journey and to list out various steps that can be taken to accelerate the adoption of hybrid cloud.

We aim to answer three main research questions (RQs) in this study –

RQ1 - What are the key factors affecting the adoption of hybrid cloud?

RQ2 - Are specific types of applications a better choice for deployment on hybrid cloud?

RQ3 - What are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises?

On the adoption front, we intend to find what are the key factors that determine the adoption of the Hybrid Cloud. The skills involved, peer ratification, ecosystem surrounding the said deployment are likely to be influencers and thus deterministic of whether or not the approach is adopted. The key adoption challenge is rooted from the varied set of tools that the various cloud providers public and private cloud providers expect the cloud team to use and master. Each public cloud provider and public cloud provider presents their own sets of tools to implement, manage and expand their respective clouds. However, if one manages each of these said cloud environments one at a time - individually, one is more likely to use unique and unrepeatable processes which run in silos and do not present the intended output or results to siloed skill base and use processes that are either dated or under-optimised and thus taking up more time and resources. Having a separate set of management tools may lead to environments that are very different from each other and thus not having a uniform level of security. This is especially so in case these environments are unable to communicate in a uniform way due to the lack of uniform security adoption.

On the point of what applications are better suited, we intend to make a studied derivation of what the private, public and Hybrid cloud architectures offer and then choose the appropriate provisioning destination for various sets of applications. Private clouds inherently reduce security risks by the presence of physical and logical boundaries restricting the access of private data to the outside world. Enterprises typically setup private clouds in their own private data centres, of late they have also been leveraging the public infrastructure-as-a-service (IaaS) platforms wherein they can implement these resources. In such scenario the hybrid cloud deployed would enable the enterprise’s users to access the applications hosted on the hybrid cloud platform accessible over a secure network, usually built by implementation of virtual private network (VPN) technology.

The third area of this research is to prescribe a set of approaches for the adoption of the hybrid cloud. When an enterprise adopts a hybrid cloud architecture, they often look to use the functionalities of an IaaS solution and wish to extend it to their private cloud environment. It is here that most friction is likely and therein lies the path of derive the appropriate adoption approach. The approach to adopt would have to ensure that there is sizeable and pointed study towards ensuring that both the environments, private and public are compatible and can easily communicate with each other. Choice of approach would also entail calling out the features to look for while choosing a platform that helps companies deploy an optimised hybrid cloud deployment.

Leading “Infrastructure as a Service” (IaaS) providers such as Microsoft Azure and Google Cloud Platform make application programming interfaces (APIs) available to their customers. These APIs help facilitate the setting up of the connection of private resources to public cloud infrastructure, thereby ensuring interoperability between various cloud services. Additionally, a hypervisor can be utilized to create virtual machines (VMs) and link these VMs to the public cloud through a pre-configured software layer that orchestrates interactions among different cloud environments.

CHAPTER II:

REVIEW OF LITERATURE

2.1 Overview

Our literature review derived that the past studies have primarily focused on defining Hybrid clouds and their benefits. There is room to research for studying the approaches to adoption of Hybrid Cloud. When we use the term hybrid cloud, it refers to a well-defined and well-integrated platform that combines public and private cloud infrastructures, facilitated by either standardized or proprietary technologies. This integration ensures data and application portability (Mell and Grance, 2011). When one studies the growing interest in the adoption of Hybrid cloud, a key factor that comes to fore is that the reason for adoption is not just the economics of hybrid cloud adoption but also the ease at which organizations can adopt them. Hybrid cloud deployments have time and again demonstrated significant advantages, not only by enhancing economic efficiency but also by improving business agility (Funahashi and Yoshikawa, 2011).

2.2 Definitions

Here are the definitions of the key cloud computing patterns.

2.2.1 Cloud Computing

Cloud computing facilitates access to applications and services irrespective of time, location, or platform through an extensive data centre infrastructure. As defined by the National Institute of Standards and Technology, cloud computing is a model for providing seamless and widespread access to a shared pool of customizable computing resources and services that can be rapidly provisioned and deployed with minimal administrative effort (Mell and Grance, 2011). Clouds comprise of a vast array of easily accessible and virtualized resources, including hardware, development platforms, and services. These resources can

be on need basis, reconfigured at the run-time to adapt to varying loads, thereby optimizing resource utilization. Typically, this pool of resources operates under a pay only as much as you use popularly called “pay as you go” model, where QoS commitments are provided by the Infrastructure Provider through tailored Service Level Agreements (Vaquero *et al.*, 2009). This approach of information technology services delivers hardware and software to consumers as and when requested over a computer network, eliminating the dependence on specific devices or locations(Madhavaiah, Bashir and Shafi, 2012).

2.2.2 Private Cloud

The National Institute of Standards and Technology (NIST), describes, the public cloud as cloud resources that are made available to all or in certain cases a select industry groups by organization specializing in the managing and selling cloud services (Goyal, 2014).

A private cloud is managed for one organization or multiple organizations under a single entity. It can be located on-premises or off-premises, but access is restricted to members of the specified organization or others who have been granted authorization (Goyal, 2014).

2.2.3 Public Cloud

As per NIST, the public cloud is defined as the cloud infrastructure that is made available to the public at large or in certain cases to a select set of industries and is owned or made available by an organization selling the cloud services (Goyal, 2014).

2.2.4 Hybrid Cloud

The hybrid cloud computing model, as the name suggests deals with the joint/mix use (hybridization) of both these types of cloud with the intent of delivering a platform that makes optimum use of both approaches. It can be seen as a deployment of private cloud that

efficiently leverages and facilitates use of public cloud as and when needed. (Srinivasan, Quadir and Vijayakumar, 2015).

2.3 Hybrid Cloud Adoption Considerations

On conducting literature review, we can comment that there has been a lot of interest in adoption of hybrid cloud and hence there is a vast body of research dedicated on this subject. While the choice of which type of cloud to choose is a decision that organizations take based on their own considerations, the literature does suggest that there are a few common trends in the way the choice is made and how it influences this decision. The key challenges that the literature review has presented for the hybrid cloud architecture adoption journey are - security, technology challenges, skills, and complexities around return on investments (ROI) derivation.

2.3.1 Security

Organizations which adopt cloud expect that the cloud service provider should ensure that the data lifecycle in the cloud is secure, however industry reports and our interviews suggest that there have been times when this security has been bypassed (Padhy, Patra and Satapathy, 2011), going further we have seen that there are many well documented instances of cloud user organizations having encountered issues related to the security related in some form or other (Hutchings, Smith and James, 2013). It is observed that a well architected hybrid cloud with proper security considerations will be able to host secure services such as financial transactions and payroll processing, but a more difficult ask will be of monitoring or proctoring such solutions and checking them for vulnerabilities before making them available on the hybrid cloud. The governance of such applications presents a major challenge especially so for applications that are not home-grown. The challenge level goes up further when there are interactions between components across the two different types of cloud - private and public (Padhy, Patra and Satapathy, 2011).

What is observed is that most businesses go ahead and choose public cloud providers when they adopt cloud computing and are unaware that by doing so they are opening themselves to the possible risk of the cloud provider decrypting their data (Aleem and Sprott, 2012). On the flip side, using hybrid cloud deployment model (HCDM) and a well architected and in-tandem use of internet based tools and the private cloud has a potential of overcoming these security issues (Aryotejo and Kristiyanto, 2018). We would like to research further on this approach in our study.

2.3.2 Quality of Service Delivery

On the technology front, it is observed that since, the resources in cloud computing systems are provided on-demand, there is always a challenge in terms of ensuring consistent Quality of Services (QoS) of service delivery. The massive adoption of cloud computing has meant that there is a growing ask for defining standards. The proprietary nature of public cloud has often meant that standardization is not even an afterthought. Standardization would lead to introduction of more interoperability, promotion of open-source software (OSS) and low exit barriers when switching vendors. When done right this will in true sense allow easy movement of workloads across the clouds (Ross, 2011).

Furthermore, the expected QoS of applications hosted on cloud and cloud services are measure in uptime percentage. This percentage is expected to be in ranges between 99.5 to 99.999% or as is called the “five nine uptimes”. This puts immense pressure in terms of benchmark. QoS breaches and violations of the SLAs have seen to be common occurrences in organizations where there is non-conformity of standards. This is compounded further when there is inconsistency in metrics. When seen in context of hybrid clouds, the likelihood of inconsistencies is very high as not only do private and public clouds implement varied QoS standards, but each public provider also often has their own approach towards the QoS adherence. (Dhirani, Newe and Nizamani, 2018).

2.3.3 Competency

We observed that another major factor hampering the adoption of hybrid clouds is the competency. The competency needed is not just the skills but also the organization structure. We have come across a study that brings out the need to rethink the way personnel are skilled. It is interesting to note that the adoption of cloud computing may impact the human resource management of information and communication technology (ICT) workers, but it is not researched as much as the other aspects of cloud computing. There is a pressing need to evaluate the HR issues borne out of managing ICT workers within organizations that adopt Cloud computing strategies (Ross, 2011).

2.3.4 Return on Investment (ROI)

Another key factor to consider is the difficulty to accurately calculate the return on investment when organizations opt for hybrid cloud. The primary reasons cited for adopting cloud computing include enhanced scalability of IT resources (45.9%), improved collaboration among teams (40.5%), significant cost reductions (39.6%), and greater operational flexibility (36.9%). (Lee, 2019). However, these studies have limited their purview at cloud computing, and we believe this research can go deeper into identifying if and how return on investment (ROI) affects the adoption of hybrid clouds.

2.4 Summary

The literature review underlined that there are multiple views and ways that influence the adoption of hybrid clouds. The absence of a single standard approach complicates the journey further. We have called out the challenges that the literature has presented in hybrid cloud architecture adoption journey - security, technology challenges, skills, and complexities around ROI derivation. Despite these challenges the hybrid cloud adoption is growing by the day, and our research will try to derive the factors that are fuelling this confidence in hybrid cloud adoption and what else can be done to improve the adoption further.

By conducting this review of existing literature, we can conclude that there has been a massive uptake of cloud computing as a choice for hosting applications. Organizations decide on which type of cloud to use based on their own considerations in terms of application profiles, ease of deployment etc. Hybrid clouds are becoming popular, and a lot of research has been done on the benefits and modalities of the same. There are adoption challenges that the literature has highlighted, and we believe we can conduct further analysis and achieve our research aim that is to call out the various challenges that bog down the teams embarking on the Hybrid Cloud adoption journey and aims at various steps that can be taken to accelerate the adoption of hybrid cloud.

CHAPTER III:
METHODOLOGY

3.1 Overview of the Research Problem

The chief objective of this research is to identify approaches that will help accelerate the adoption of hybrid clouds. Enterprises have various reasons to embark on the hybrid cloud journey. These are distinct sets of clouds, each selected for a particular purpose. The reasons for what application workload go where maybe varied - the reasons could be regulatory wherein certain institutions may be disallowed from using the public cloud, or economic wherein enterprises who have already made significant number of investments into their private cloud infrastructures, may look at the public cloud as an "need basis" extension or the growing adoption of hybrid cloud may be rooted to the safety posture that the enterprise has selected for itself. Particularly, the study has the following sub-objectives:

1. Investigate the key factors that are affecting the decision behind adopting the hybrid cloud.
2. Another objective is to study which applications work the best in hybrid cloud-based hosting and why. By knowing these consumers of this research should be able to make more educated decisions about not only adopting hybrid cloud but also should be able to make better choices in terms of what applications should be able to leverage this better. We will also dwell upon the recent surge in artificial intelligence (AI) and thereby increase in workloads that help in use of AI.

Our next objective is to identify the varied approaches that are or can be used while adopting hybrid clouds along with the strategies that are put in use. The objective here being

not just listing or grouping of the approaches but also understanding why one approach is preferred over another by the decision makers and in what circumstances.

We believe that this study will be of immense value to the organizations and teams who are embarking on the hybrid cloud adoption journey as well as a reference point for those organizations which have already deployed hybrid clouds and wish to validate their approach vis a vis the hybrid cloud consumers at large. This proposed research can act as a reference point for both teams embarking on hybrid cloud adoption journey as well as those teams which wish to validate and extend their exiting hybrid cloud adoption.

3.2 Operationalization of Theoretical Constructs

The operationalizing the theoretical construct for our research topic, "identifying approaches to accelerate the adoption of hybrid clouds", will entail listing of various adoption approaches and then defining specific, measurable variables and methods to empirically test the effectiveness of different approaches.

Theoretical Construct: Approaches to Accelerate the Adoption of Hybrid Clouds

Operational Definitions:

1. Adoption Approaches:
    a. Measurable Variables:
        i. Approaches explored,
        ii. Approach selected.
    b. Method: Conduct survey on what hybrid cloud adoption methods were explored and studied by the various IT teams who went on to attempt hybrid cloud implementation. What approach did they select, what were their observations and status.
2. Adoption Factors:
    a. Measurable Variables:

i. Factors influencing the adoption of hybrid clouds.

b. Method: Conduct interviews with the organizations that have adopted Hybrid cloud and derive what were the factors that led to the adoption of hybrid cloud.

3. Application Affinity:
    a. Measurable Variables:
        i. Applications that were deployed on the Hybrid Cloud.
        ii. Applications that were not deployed on Hybrid Cloud.
        iii. Key reasons for selection of applications that were deployed and not deployed on to the Hybrid Cloud
    b. Method: Conduct interviews with Application architects and technical account managers to find out the criteria for what applications get deployed on the hybrid cloud and tabulate the findings.
4. Proof of Concept Scenarios:
    a. Measurable Variables:
        i. Workloads identified as likely fits for hybrid cloud implementation.
        ii. Actual scenarios tried.
        iii. Results
    b. Method: Survey organizations that identified and conducted proof of concepts for hybrid cloud implementation.

5. OEM and Partner Ecosystem:
    a. Variables:
        i. Identified OEMs, Products and Services,
        ii. Joint Initiatives
        iii. Dedicated practice teams / Centre of Cloud Excellence

iv. Implementation and Support Partners

b. Method: Survey organizations on their satisfaction with vendor support and the impact of vendor partnerships on their hybrid cloud adoption process.

6. Ease of Skill acquisition
    a. Measurable Variables:
        i. Number of training courses conducted and attendees for each of them.
        ii. Number of participants who passed the post training evaluation.
    b. Method: Seek input via interviews on the number of trainings conducted to impart knowledge on hybrid cloud and how many of the participants were able to clear the post training evaluation.

3.3 Research Purpose and Questions

When an organization decides to embark on a hybrid cloud deployment, they intend to use a single, integrated, unified platform to manage their various resources across the public and private cloud. However, it has often been pointed out that the deployment and management of hybrid clouds is not easy. The aim of this research is to enumerate the various challenges that are encountered by the teams embarking on the Hybrid Cloud adoption journey and to list out various steps that can be taken to accelerate the adoption of hybrid cloud.

We aim to answer three main research questions (RQs) in this study –

1. RQ1 - What are the key factors affecting the adoption of hybrid clouds?
2. RQ2 - Are specific types of applications a better choice for deployment on hybrid cloud?

3. RQ3 - What are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises?

On the adoption front, the key challenge is rooted from the varied set of tools that the various cloud providers public and private cloud providers expect the cloud team to use and master. Each public cloud provider and public cloud provider presents their own sets of tools to implement, manage and expand their respective clouds. However, if one manages each of these said cloud environments individually, one is more likely to use unique and unrepeatable processes which run in silos and do not present the intended to siloed skill base and as a result use incorrect processes that take up more time and resources. Having a separate set of management tools may lead to environments that are very different from each other and thus not having a uniform level of security. This is especially so in case these environments are unable to communicate in a uniform way due to the lack of uniform security adoption.

On the point of view of what applications are better suited, one must take a step back take a hard look at what the private, public and Hybrid cloud architectures offer and then choose the appropriate provisioning destination for these applications. Private clouds inherently tend to be prone to fewer security risks given that they restrict the exposure of private data to the outside world. Enterprises typically set up private clouds in their own private data centers, of late they have also been leveraging the public infrastructure-as-a-service (IaaS) platforms wherein they can implement these resources. In such scenario the hybrid cloud deployed would enable the enterprise's users to access via a secure network, usually withing a virtual private network (VPN), the applications hosted on the hybrid cloud platform.

The third area of this research is to prescribe a set of approaches for the adoption of the hybrid cloud. When an enterprise adopts hybrid cloud architecture, they intend to make use of the functionalities of an IaaS solution on their private cloud environment. It is here that most friction is likely and therein lies the path of derive the adoption approach. The

approach to adopt would have to ensure that there is a sizeable and pointed study towards ensuring that the private and public cloud environments are truly compatible with each other and can they seamlessly communicate with each other. Choice of approach would also entail calling out the features to look for while choosing a platform that helps companies deploy an effective hybrid cloud deployment.

Connecting the organization's applications hosted on the private clouds to the public cloud infrastructure is achieved by using the application programming interfaces (APIs) that the major infrastructure as a service (IaaS) providers like Amazon web services (AWS), Microsoft Azure and Google Cloud platform provide. Another approach is to leverage hypervisors like the Nutanix AHV to generate and host virtual machines (VMs) and connect them to the public cloud through a software layer that orchestrates between the different cloud environments.

3.4 Research Design

In this study we have taken a mixed-methods approach, integrating both qualitative and quantitative analysis to derive best practices for accelerating hybrid cloud adoption across various organizations. The research design is built on a critical literature review, leveraging secondary data sources such as peer-reviewed journal articles, conference reports, technology books, OEM white papers, and technical reports.

To substantiate the secondary data, we have also incorporated primary data collection through first-hand interviews with industry experts and by using a survey targeting stakeholders involved in hybrid cloud implementation. This systematic approach ensures a comprehensive exploration of hybrid cloud adoption, the challenges faced, and the lessons learnt in the trenches by teams that embarked upon the hybrid cloud adoption journey. In addition to the open-ended discussions via interviews, we have created a survey of 35 questions that span across the key drivers of hybrid cloud adoption as well as the unique complexities that the respondents would have encountered. The questions were be constructed inline to the three research questions that we intend to answer via my research

- the factors affecting the adoption of hybrid clouds,
- the role that the applications play in this decision and
- the various approaches that are adopted by organizations that embark upon the journey of hybrid cloud adoption.

3.5 Population and Sample

The sample we have chosen is a cross section of decision makers, practioner service providers and operators who chose, designed, implemented, as well as those who manage the hybrid cloud platforms at their organizations. We have reached out to over 25 companies and targeted over 200 respondents. While few people were keen to give their feedback via survey, many more were ready for a Zoom / Telephone based conversation about their hybrid cloud adoption journey. In combination we were able to collect 170 responses.

3.6 Participant Selection

The participants that we selected, for the survey, were based on the various roles that they play in the overall process of Hybrid Cloud Adoption. We have been able to connect with respondents right from the Architects who envision the hybrid cloud strategy to the actual implementation and support teams that are involved in the journey of hybrid cloud adoption. The following table lists the various categories of participants that were reached out to in the survey –

Table 3.6.1
Survey Participants

Participant Category	Details
Cloud Architects	Technical architects who are involved in creating the "to be" vision for the hybrid cloud.
IT Leaders	CIOs, Cloud Infrastructure heads, IT Directors - The project owners for the implementation and running of hybrid clouds.
Sales Engineers	Original Equipment Manufacturer (OEM) Engineers who help design proof of concepts.

Cloud implementation partners	Senior representatives from partner companies that implement and support the OEMs.
Cloud Implementation consultants	Consultants who implement, configure and support the hybrid clouds.
Resident Engineers	Cloud engineers who support the day-to-day operations of the hybrid cloud after its implementation
Technical Account Managers	OEM representatives who handhold the customers in their hybrid cloud journey.

3.7 Instrumentation

With the intent of understanding the hybrid cloud adoption approaches that are being used, we have used following instruments –

- **Literature Review –** We have conducted a detailed study and review of the existing literature about cloud adoption and hybrid cloud. The same has been elaborated in chapter 2 of this document.

- **Questionnaire -** We developed a questionnaire seeking the practioner views on the various considerations made while embarking on the hybrid cloud adoption journey to measure organizational readiness for hybrid cloud adoption, including items on perceived benefits, concerns, and current infrastructure.

- **Interviews -** Interviews with the stakeholders mentioned in table 3.1 above. The objective of these interviews was to collect in-depth information about the accelerators, obstacles and catalysts for hybrid cloud adoption.

- **Survey -** Targeted surveys that solicited responses from practitioners. we published the survey in specific LinkedIn groups, user forums, via WhatsApp chat and emails.

- **Observations-** Observe IT infrastructure setups and usage patterns in organizations transitioning to hybrid clouds.

3.8 Data Collection Procedures

We followed the prescribed systematic way of data collection. The process began by clear definition of the aim of my research. The next step was to select the data collection method. For this we pursued the data collection via seeking interviews with industry practitioners and targeted online surveys setup using the survey monkey platform. The individual interviews and surveys were shared with practitioners from the categories described in the table 3.6.1 above. The distribution mechanism was via emails, WhatsApp messages and LinkedIn posts seeking inputs. Once we had a sizeable amount of data, we began our data analysis via Excel based data analytics.

3.9 Data Analysis

Tools - we have used the following tools for the survey data analysis –

1. Survey platform – Survey Monkey
2. Statistical software – Excel, R, R Studio, PSPP
3. Data Visualization – Excel, R Studio

Sampling –

Given the roles that various stakeholders play, we have tried to target them all so that we can ensure appropriate representation on each of the types of stakeholders involved. Here is the breakup of the survey respondent roles –

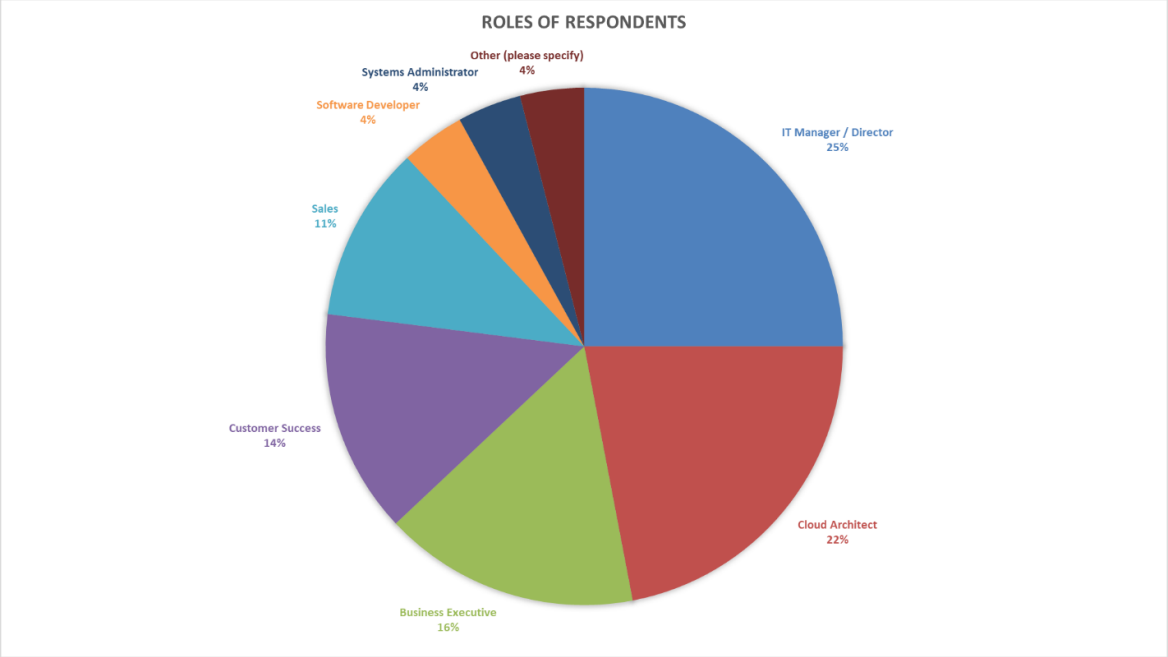

Chart 3.1
Roles of Target Respondents

The other roles which were shared by respondents were “CTO”, “Product Manager” and “Proposal Management”.

3.10 Research Design Limitations

We have remained conscious of the known limitations of online survey-based research and have tried our best not to make the known mistakes for this kind of research.

Avoiding Sampling Bias

We took special efforts to ensure that there is no sampling bias. We have focused on deriving a well-defined target sample that is well versed with cloud technologies and is involved one way or other in the decision to adopt and implement hybrid cloud. This was done by using diverse publishing channels for the survey, such as email, LinkedIn posts, WhatsApp groups and in-person meetings with participants. Most participants were keen to participate and were especially interested in how they can also receive an output of my study.

Self-selection bias

Rather than depending on our personal assessment alone of people's skills, we encouraged our contacts to share the survey link with their colleagues and industry experts who they felt, were willing to share their experiences in adoption and implementation of hybrid clouds.

Survey errors

Use of excel spreadsheets and data analytics tools like PSPP and R Studio have helped us get precise data insights and reduced the possibility of human errors in the survey.

3.11 Conclusion

Having been made aware of the known issues around survey-based data analysis, we have made a conscious effort to address these issues in my research methodology. To summarize, her are the key steps that we have taken in this aspect -

Sampling –

Being practitioners in the same industry, we had the benefit of access to experts in various roles. We sought their advice while choosing the right candidates for my survey. A cross section of roles, industries and tenure in the industry are the key factors that we considered while selecting the survey audience.

Question Design – We divided our interview questionnaire and the survey in same framework and divided it into 5 parts -

1. General Information – To capture role, expertise, tenure of exposure to hybrid cloud technologies.
2. Adopting the Hybrid Cloud – Factors that adopted the selection of Hybrid cloud.
3. Applications and Hybrid Cloud adoption – application affinity derivation – are some applications better suited to be deployed om Hybrid cloud? Are there any specific applications that are easier to deploy and manage on the hybrid cloud?
4. Approaches, tools and strategies that can help the acceleration of the Hybrid Cloud Adoption.
5. Use Cases, Examples of Success and failure, future trends.

CHAPTER IV:

RESULTS

This chapter discusses the results of the interviews and surveys carried out to understand the drivers towards its adoption and the applications that are preferred to be deployed onto Hybrid Cloud. We set out to answer three main research questions (RQs) in this study –

- RQ1 - What are the key factors affecting the adoption of hybrid cloud?
- RQ2 - Are specific types of applications a better choice for deployment on hybrid cloud?
- RQ3 - What are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises?

Table 4.1
Experience in using Hybrid Cloud (in Years): Total Respondents 170

Experience of Using Hybrid Cloud (in years)	Responses	Percentage
Less than 1 year	14	8%
1–2 years	27	16%
3–5 years	78	46%
More than 5 years	37	22%
Not applicable (we do not use hybrid cloud)	7	4%
We have used hybrid cloud in the past	7	4%

4.1 Research Question One - What are the key factors affecting the adoption of hybrid cloud?

For interpreting the factors that influences the decision to opt for hybrid cloud in their organization, following questions were included in the interviews and surveys. All these questions are compiled with the intent of deriving and listing the factors that influenced the decision to opt for the hybrid cloud.

The initiation of the dialog with the respondents was by seeking their role in the organization. We began by seeking this via the question –

Question 1: What is your role within the organization?

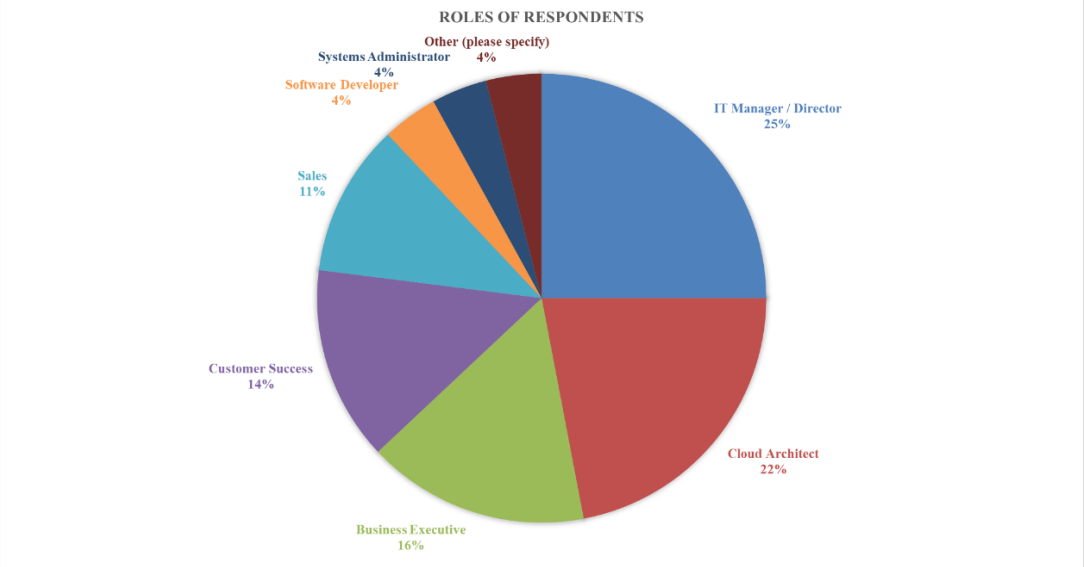

Chart 4.1
Roles of Survey & Interview Respondents

The respondent classification is in line with the sampling goal for the research. A high number of the respondents are the decisionmakers. The highest number of respondents are the IT Managers or directors. The IT Managers (25%), Cloud Architects (22%) and Business Executives (16%), together at 63% influence the data collected and are apt in doing so given their important roles which are directly involved with the decision making as well

as have the first-hand view of what actually happened and thus the right providers of the input for us in deriving the best practices for hybrid cloud adoption.

Question 2: How long have you been using hybrid cloud?

Table 4.2
Experience in Hybrid Cloud usage

Experience of Using Hybrid Cloud (in years)	Responses	Percentage
Less than 1 year	14	8%
1–2 years	27	16%
3–5 years	78	46%
More than 5 years	37	22%
Not applicable (we do not use hybrid cloud)	7	4%
We have used hybrid cloud in the past	7	4%

The results are reassuring as this reflected that our sampling has been good since 96% of the respondents shared that they have either been using hybrid clouds or have used them in the past.

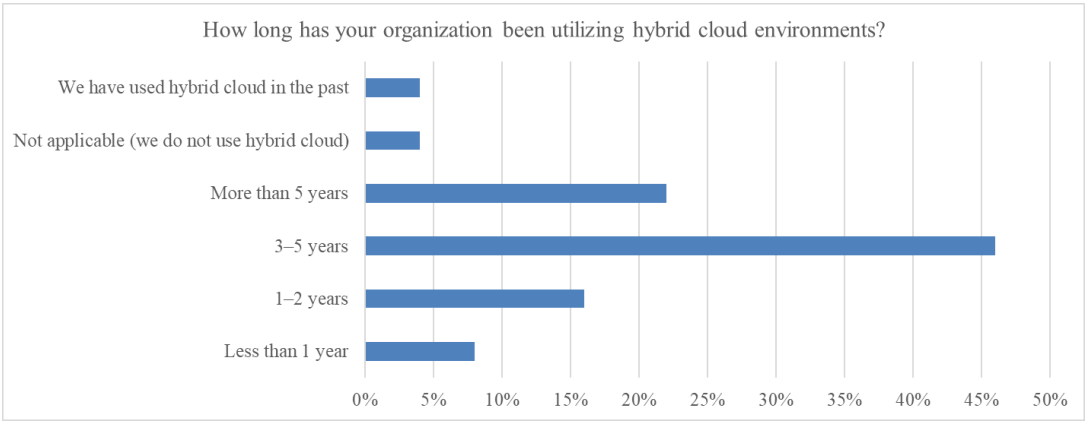

Chart 4.2
How long has your organization been utilizing hybrid cloud?

Having understood the role and the exposure of the respondents to the hybrid cloud (in years), we ask them about the applications that they have deployed on the hybrid cloud.

Question 3: Which type of applications does your organization primarily deploy?

The intent here being understanding their workload needs at a high level. We allowed the respondents to make multiple choices as they would be deploying multiple types of applications in their organizations. Web applications led the count followed by CRM, ERP and as is the growing trend AI – ML applications showed up as well.

Table 4.3
Application Workloads

Answer Choices	**Responses**
Web applications	147
Customer Relationship Management (CRM) software	98
Enterprise Resource Planning (ERP) systems	95
Artificial Intelligence (AI) and Machine Learning (ML) applications	91
Mobile applications	81
Big data and analytics applications	70
Legacy applications	66
Other (please specify)	0

Represented graphically, a clear leader shapes up with Web applications with the highest count.

Chart 4.3
Application Workloads

Question 4: At what stage is your hybrid cloud adoption journey?

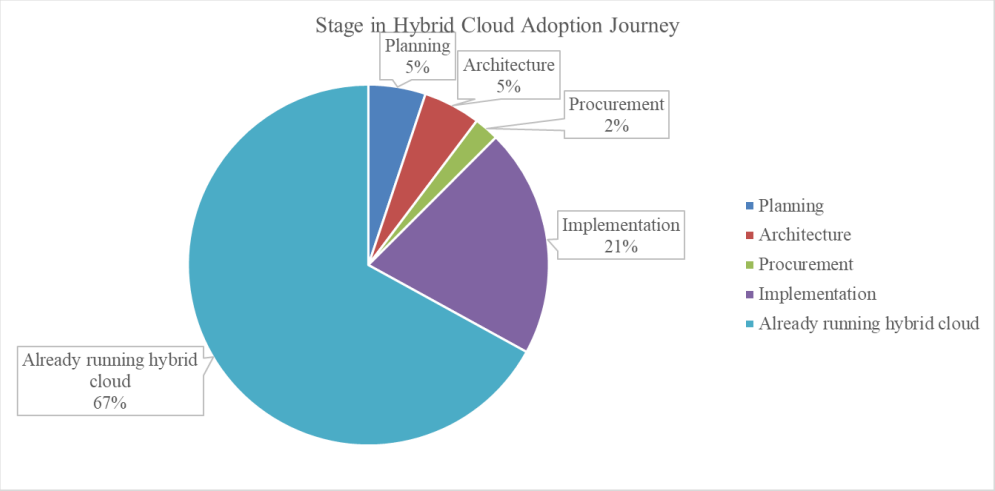

Chart 4.4
Stage in Hybrid Cloud Adoption

So, 67% of our respondents are already running hybrid cloud. This is a good metric, as it will translate to responses and views of professionals who are already practitioners who have firsthand experience of using Hybrid cloud. The respondents who are in

implementation stage were found to be most interested in what has worked for others and along with the respondents in the organizations who were in planning, procurement phase have been very keen and have requested a copy of the research findings. A sidenote, which we think is important - the organizations in the architecture phase have been cautious about sharing their inputs and were not as forthcoming as others in revelations about their views.

Question 5: Which of the following use cases have you selected for implementation on your hybrid cloud?

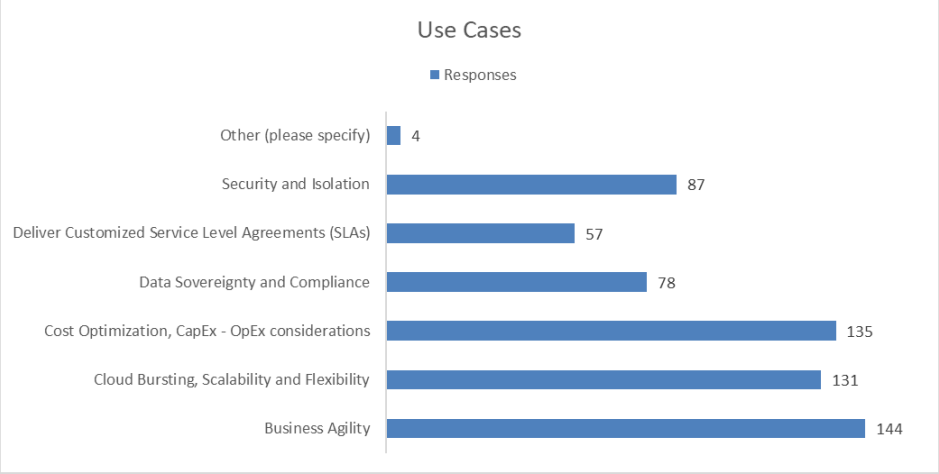

Chart 4.5
Use Cases

Business agility leads the way in terms of the use case selected for hybrid cloud adoption. Within the business agility, the key case that came to the forefront was disaster recovery (DR). This is often the first use case if not the second after test and development environment. Cost Optimization comes second with almost 80% having this as one of the major use case choices and a close third is cloud bursting, scalability and flexibility. A follow up with a few respondents about this finding led to them finding this trend interesting given that scalability is often the most quoted use case.

Question 6: Which of the following do you believe are barriers to adopting hybrid cloud technology? Select all that apply.

Given that majority of our respondents are running hybrid clouds, we were very keen to understand what they saw as barriers for the hybrid cloud implementation. Here are the findings –

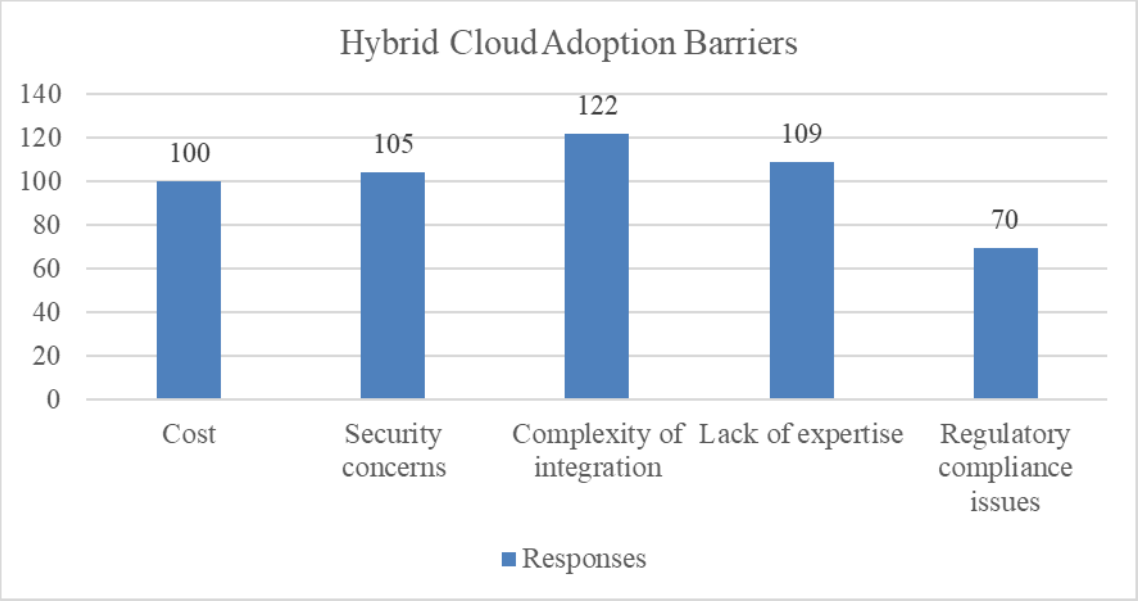

Chart 4.6
Hybrid Cloud Adoption Barriers

Interestingly, the complexity of integration came in as the top barrier to hybrid cloud adoption. Therein lies a whitespace for hybrid cloud management platforms to extend to. In the interviews, the practitioners mention that if the organizations are provided with out of the box abilities to integrate their workloads across clouds this barrier could be overcome. Lack of expertise is also a startling finding, given that hybrid cloud has been introduced as a concept long time back and has been in mainstream for more than a decade. Security concerns coming in third place is in line to the overall thoughts that we gauged during my interviews. The security concern especially on public cloud and for in-flight data has been a prominent discussion point in those conversations.

Question 7: How important is scalability in your decision to adopt hybrid cloud solutions?

We saw in the responses to the question number 5 that scalability featured among the top 3 use cases. This question was intended to go deeper into how important the scalability was need when it came to hybrid cloud adoption.

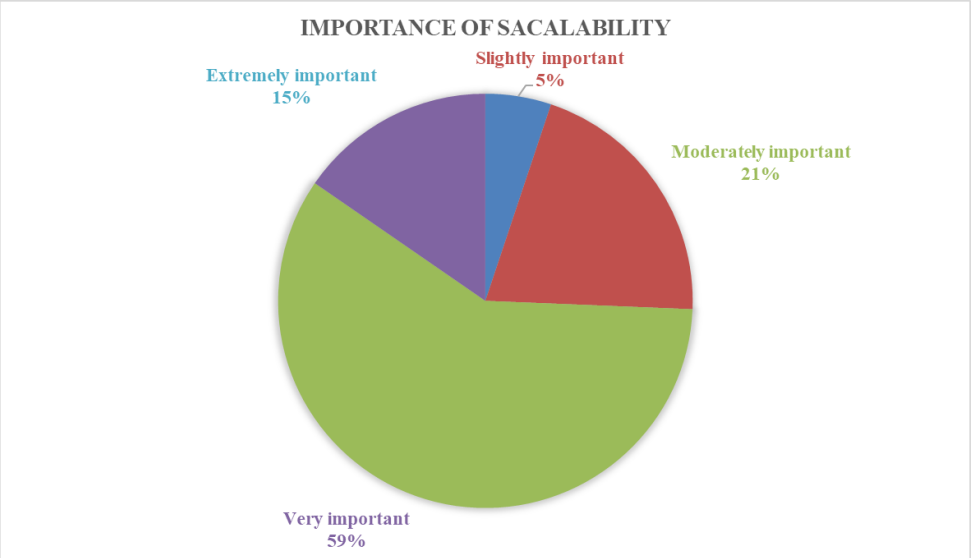

Chart 4.7
Importance given to Scalability

Thus 95% of the respondents mentioned that scalability was a important (59% stating it was very important, 15% stating it was extremely important, 21% stating it was moderately important). Scaling to the public cloud or cloud-bursting are the use cases that the interviewers mentioned the most. It is insightful and interesting to note that none of the respondents mentioned that scalability was not important.

Question 8: How much weightage did you give to data security when considering adoption of hybrid cloud?

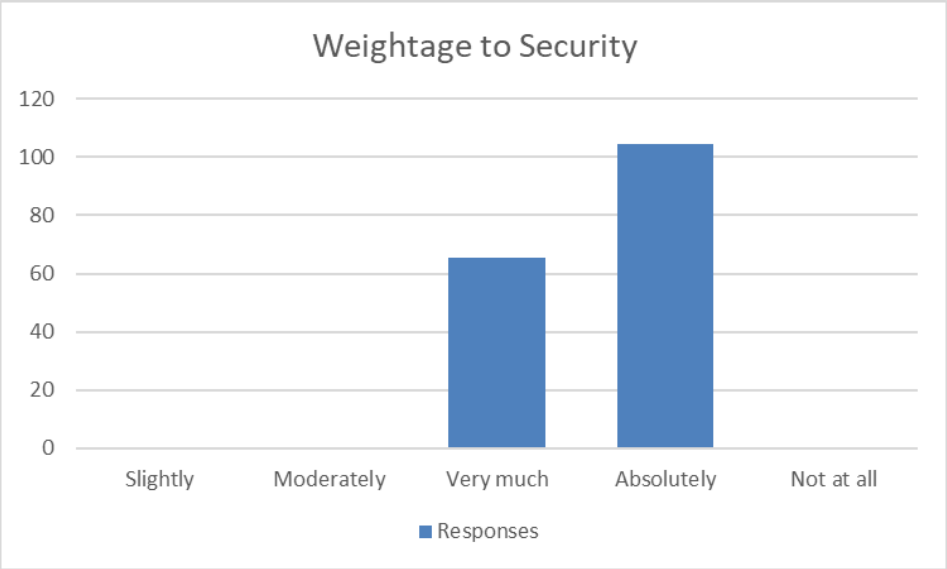

Chart 4.8
Weightage to Security

Security was given high importance. 62% respondents said it was absolutely given weightage while 38% said that it was very much given a weightage. With none of the respondents choosing any of the other three options viz – slightly, moderately or not at all. This reinforces the general understanding that security is top of mind for organizations opting for hybrid cloud adoption.

Data security encompasses the data being stored (data at rest), transaction data (data in use) as well as data in motion (in-flight data). The security of all these types of data lies with the application owners and this responsibility is inherited by the teams maintaining and managing the hybrid cloud for the organization.

Question 9: What are the key concerns about public cloud security that you feel impact the decision to adopt a hybrid cloud solution?

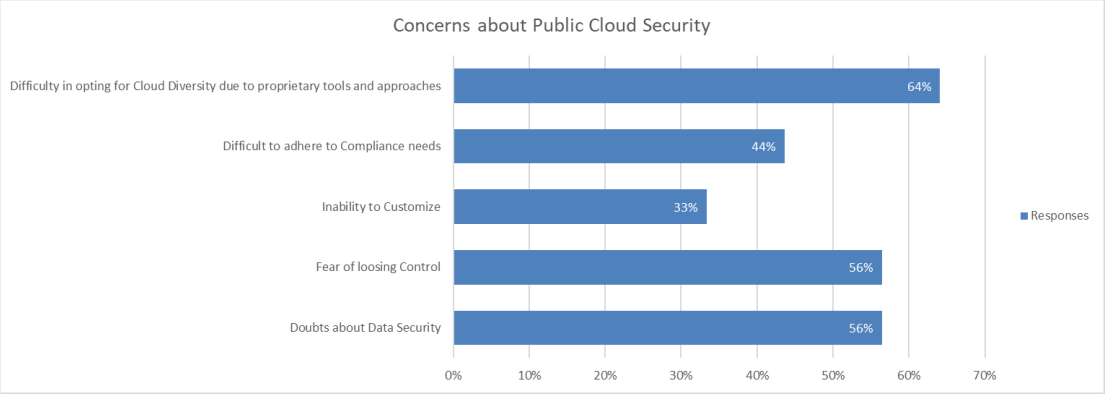

Chart 4.9
Concerns about Public Cloud Security

The respondents called out the proprietary tools as a big hurdle in the goal of cloud diversity which in turn is particularly important when it comes to implementing cloud security. Data security doubts and fear of losing control came in as the next two concerns when it came to public cloud security.

The proprietary nature of public cloud services refers to the tools offered by these providers. Each of these providers have their unique set of tools and when an application uses these tools, they must use an approach that is unique to that provider. If for any reason that application is to be moved to any other public cloud, the application must be at least reconfigured and most of the times redesigned to use a similar tool from the target cloud provider. This is often very tedious and leads to a high exit barrier to move from one cloud provider to another.

Public cloud providers give a logical demarcation for their individual customers to use. However, physically multiple customers may be hosted on the same hardware infrastructure. While utmost care is taken to ensure one customer doesn't have access to other customer's data, cloud operation teams are often weary of this happening. Network segmentations, creation of virtual public clouds, implementing stronger authentication

mechanisms, rolling out robust authorization mechanisms should be implemented to ensure that all bases are covered.

When we spoke to the respondents about the fear of losing control when using public clouds, they elaborated it as an end product of the black box nature of the services offered by the public cloud provider. While the configuration console and configuration files are made available to the operators in the customer team, there is often opacity about what goes on beyond the scenes / under the hood. How an innocuous configuration command gets executed by the cloud's hypervisor is not transparent and hence leads to a sense of "not knowing" and hence not being in control. While public cloud providers are making efforts to garner confidence, a lot remains to be done.

The difficulty of adhering to compliance needs was rated as one of the concerns by 44% of the respondents. This was explained by one of the respondents as "an irritant given the strait jacket approach" of the public cloud providers. They mentioned that they found ensuring compliance in public cloud environments t be daunting, due to varied reasons such as – confusion in accountability as there is confusion about who (cloud provider or customer) is responsible for what. Secondly, the customer teams find themselves short of information that can substantiate the adherence to data privacy laws. It becomes especially complex in case multi-region deployments.

Question 10: Which of the following security considerations impacted your decision to adopt a hybrid cloud solution?

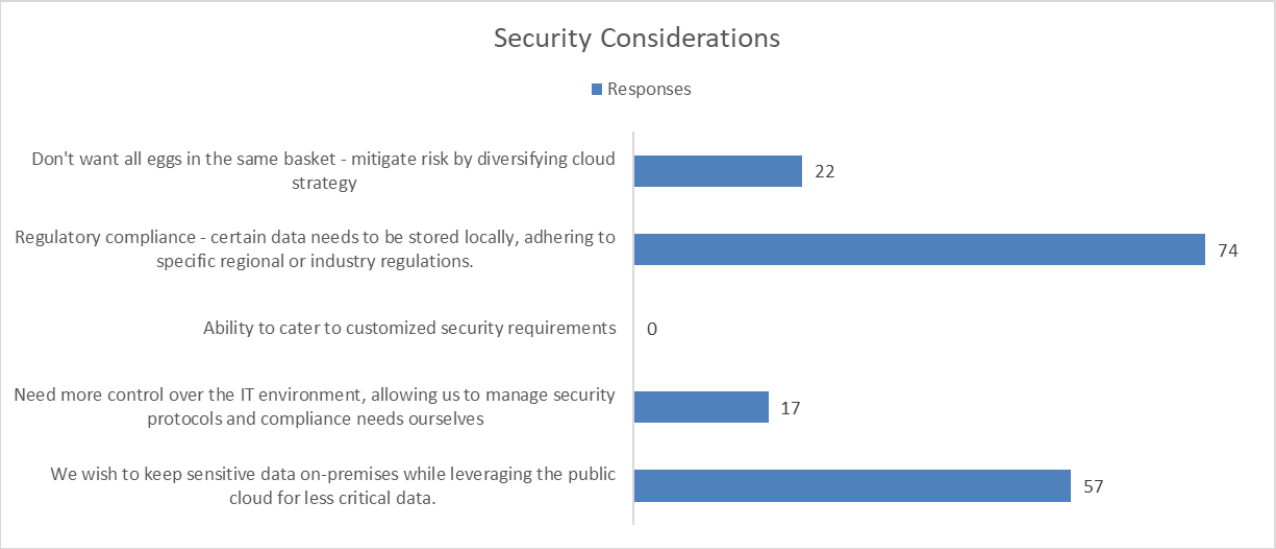

Chart 4.10
Concerns about Public Cloud Security

In line with the response to the earlier question, in this question as well the respondents raised the regulatory compliance as their highest priority. When probed further in the interviews, the respondents mentioned that they are inundated by the ask of having to comply with multiple regulations (e.g., GDPR, HIPAA, PCI DSS) depending on their (or their end customer's) industry and geographic location. Public cloud providers may store or process data across multiple regions based on their own network topology, thereby raising concerns in customer minds about data residency and sovereignty. The traceability of the entire data life cycle is important for the customers to be assured that they are well and truly compliant with regulatory requirements applicable to them. Public Cloud providers may have third-party certifications, but an evaluation if these fully meet an organization's specific requirements is often difficult to derive. Thereby, the customer organization teams to put in extra effort to prove compliance to external regulators.

This in a way is reflected in the second concern which is of inclination to store sensitive information on premise. On premise storage is preferred given the sense of higher security (especially in terms of physical security), by the respondents.

A relatively smaller yet important concern called out is the need for diversity – "don't put all eggs in the same basket".

Question:11 What proportion of your organization / customer's Cloud budgets are apportioned to OpEx

One of the initial advantages that the public cloud providers leveraged was the fact that their services, being billed in a subscription model, are classified as operating expenses (OpEx) as compared to the traditional infrastructure purchases which are classified as capital expenditure. We therefore sought to find out what proportion of the cloud budgets were apportioned to OpEx.

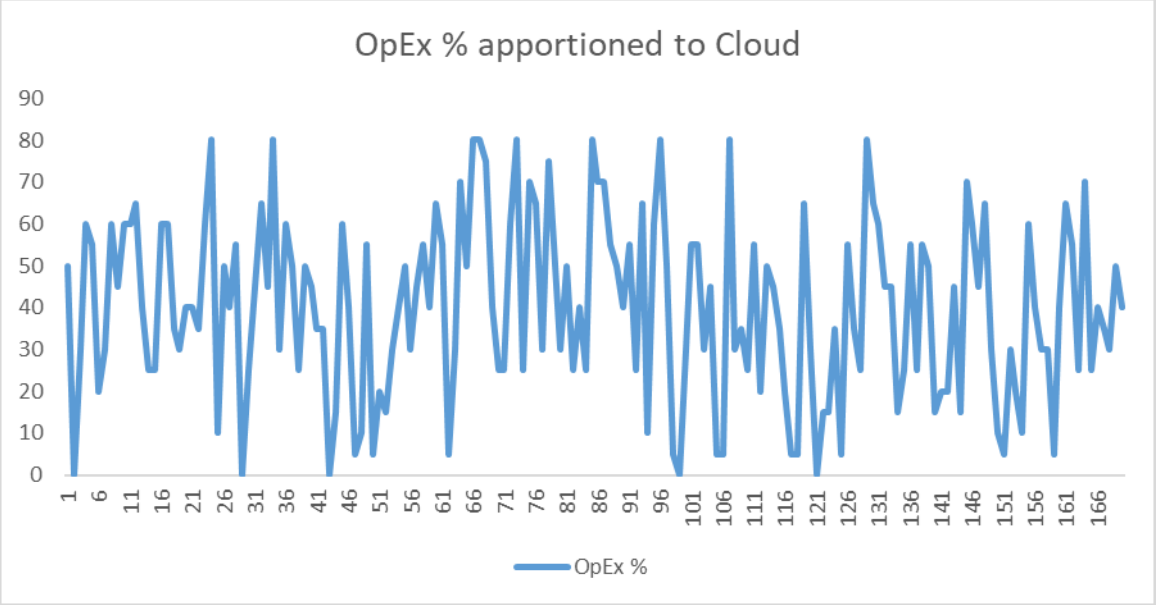

Chart 4.11
OpEx % apportioned to cloud – line chart

Given the vast variation, we decided to opt for a Pareto chart, that would give us a descending order of frequency.

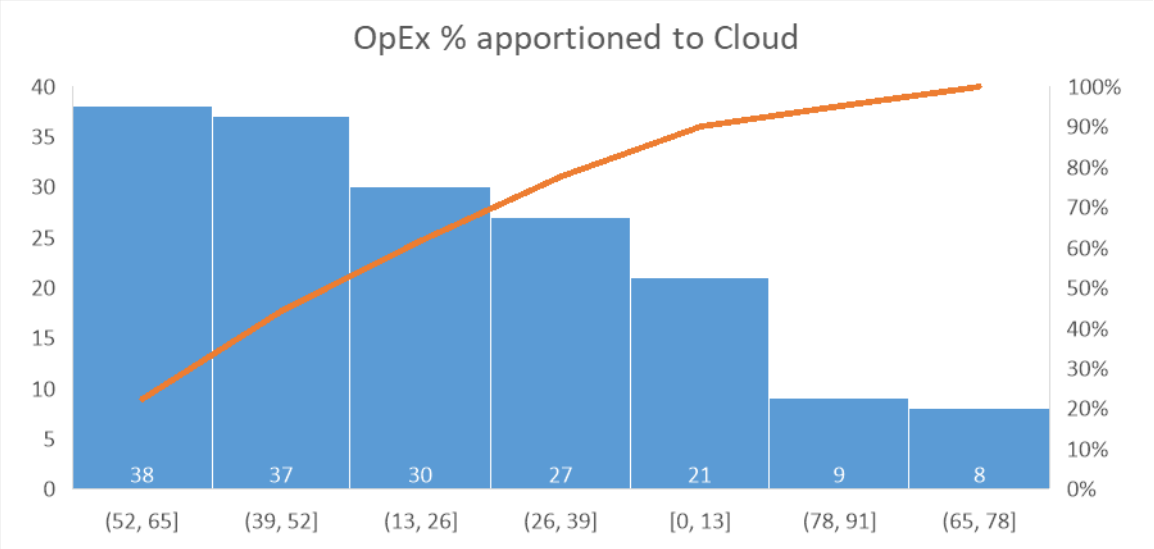

Chart 4.12
OpEx % apportioned to cloud – Pareto chart

A tabular representation shows that 119 i.e. 70% of the respondents apportioned to have over 25% of the OpEx cloud.

Table 4.4
Application Workloads

Range	Responses
0 -13	21
13 - 26	30
26 - 39	27
39 - 52	37
52 - 65	38
65 - 78	8
78 - 91	9

Another point to note is that over 32% of the respondents have over 52% of their OpEx being apportioned to cloud related expenditure.

Question 12: Did you observe any of these effects of vendor lock-in while adopting hybrid cloud? (Select all that apply)

Vendor lock-in is presumed to be a given when one opts for services from OEMs. we have tried to seek if the respondents have a view inline to this perception and sought the effects (if any) they encountered because of the vendor lock-in.

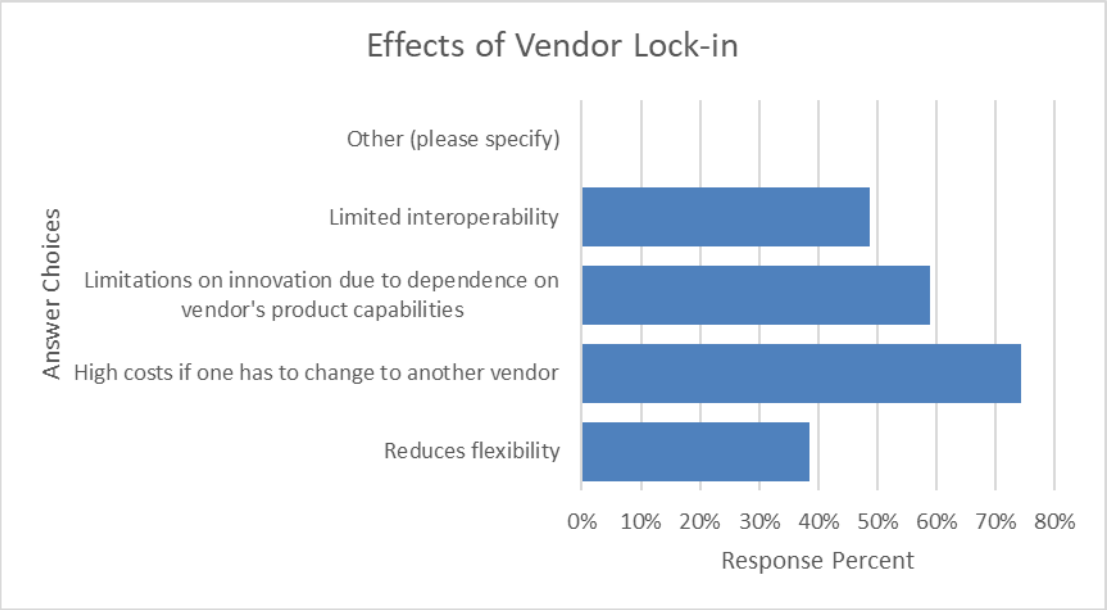

Chart 4.13
Effects of vendor lock-in

Vendor lock-in came as a big irritant during my interviews and discussions with the cloud practitioners. The respondents pointed out that they have often had to make changes in their application designs and at times also in their rollout plans just because their cloud vendor did not offer the required feature but moving to another vendor would be a herculean task.

High Costs / Increased costs if one has to change to another vendor

As derived from the responses charted above, a key effect is increased costs.

These are in the form of data transfer costs in two primary ways –

1. **Egress Fees -** Cloud providers charge significant fees for transferring data out of their platforms, known as data egress fees. For large volumes of data, these fees can become prohibitive (Bagheri and Haghighat, 2020).
2. **Bandwidth Expenses** - Migrating extensive datasets requires high-speed connections, often necessitating additional investments in network bandwidth or specialized data transfer services (Han and Lee, 2022).

Limitations on innovation due to dependence on the vendor's product capabilities

The second biggest Given the fast-paced business needs and evolutionary nature of innovation in cloud technologies, dependence on a vendor's product capabilities in a hybrid cloud scenario can impose significant limitations on innovation. An organization's own innovation plan may get affected due to inability of the vendor to provide the necessary features. Below is an analysis of these limitations:

1. **Bound by vendor roadmap -** Organizations relying on a vendor are bound by the vendor's product roadmap, delaying access to new features or technologies. Vendors may prioritize generic solutions over cutting-edge innovations, which can slow down the adoption of emerging technologies (Mohan and Subramanian, 2021).

   Example: An organization dependent on AWS may need to wait for the release of specific AI/ML tools that are already available on competing platforms like Google Cloud (Smith and Gupta, 2020).

2. **Limited or no access to other vendor's solutions -** Vendor lock-in limits the ability to use best-of-breed solutions from other providers, restricting innovation potential. This is especially critical in hybrid cloud setups where interoperability is key (Han and Lee, 2022).

   Example: An enterprise relying on Azure Stack might face challenges integrating specialized analytics tools available only on AWS (Lillie and Malandrino, 2021).

Limited Interoperability

Another aspect that came to the fore was the applications had to be re-architected to make them work when moved from one vendor's cloud platform to another.

1. **Proprietary Architectures:** Applications often leverage proprietary APIs, tools, and services of the original cloud provider. These dependencies require extensive re-architecting to adapt to a new platform (Lillie and Malandrino, 2021).

2. **Rewrite Custom Code:** Code modifications are necessary to ensure compatibility with the target vendor's ecosystem (Mohan and Subramanian, 2021).

3. **Integration Challenges:** Aligning applications with the on-premises infrastructure or other cloud environments in a hybrid setup further increases complexity and costs (Gartner, 2022).

   An example that a respondent quoted and it was also part of our literature study is that of migrating an application using AWS Lambda and DynamoDB to Google Cloud may involve rewriting significant portions of the codebase (Bagheri and Haghighat, 2020).

Question 13: Did the latency need and QoS influence your decision to adopt hybrid cloud?

Applications are built to perform at speeds that are in line to their respective use cases. When applications have footprints across multiple datacentres the data created and used by the application must traverse across multiple datacentres which are often hosted in varied geographies. This leads to multiples hops that the network packets must take to fulfil the application transactions. This is true in the hybrid cloud scenario as well, wherein the application will have footprint partially on premise and partially on a public cloud or it may be wholly hosted on either public or private cloud but still need to interact with other applications / components hosted on the other cloud. We therefore then sought from the respondents if this QoS need influenced their decision to adopt the hybrid cloud.

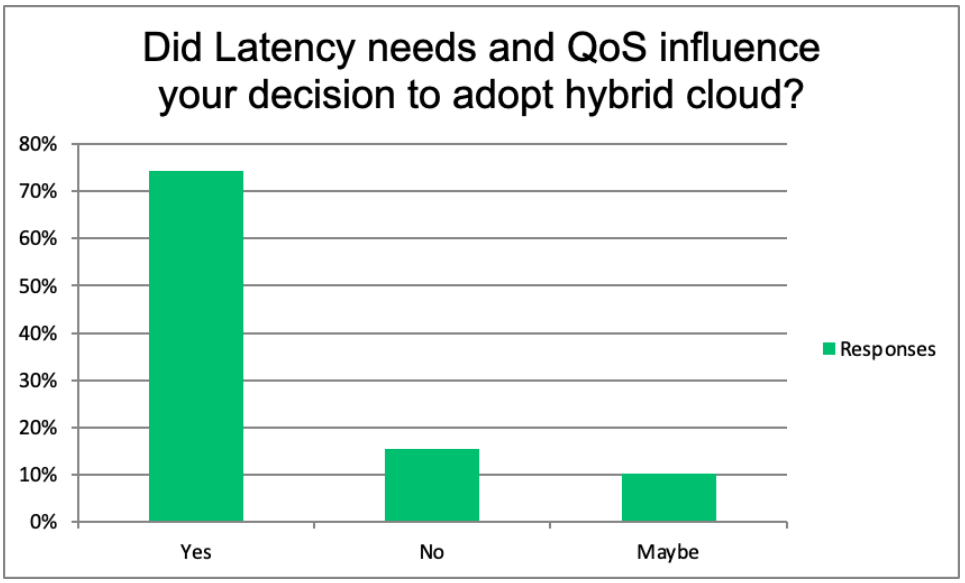

Chart 4.14
Did hybrid cloud adoption get influenced by latency and QoS needs?

Almost 75% of the respondents agreed that their decision to adopt hybrid cloud was influenced by their QoS and latency needs. This is in line to what we had seen in our literature review where in this was called out as one of the factors in deciding which use

cases should be apt for deployment onto the hybrid cloud, based on their latency tolerance and QoS needs (Flexera, 2024).

Question 14: Rank these factors that affect the QOS needs when adopting hybrid cloud computing -

We have further sought the ranking of the factors affecting the QOS needs through this question.

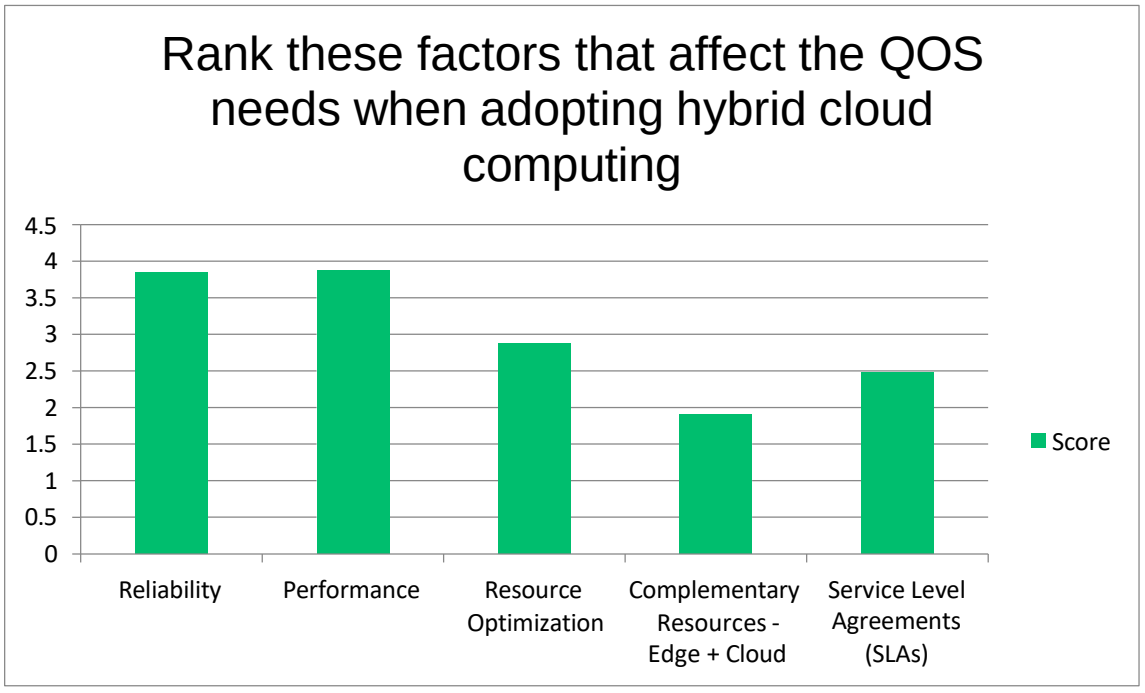

Chart 4.15
Ranking of factors affecting the QoS needs

Reliability and performance top the scale when it comes to the factors affecting the QoS needs when adopting Hybrid cloud. Reliability ensures that all components of the hybrid cloud work together without failures, while performance guarantees that users and applications can access these resources efficiently. Application users expect seamless and responsive applications, making reliability and performance non-negotiable for organizations adopting hybrid clouds.

Moving to the broader view of implementing hybrid cloud, we have further asked for the ranking of the challenges faced while implementing hybrid cloud.

Question 15: Rank the challenges you faced while implementing the hybrid cloud in your organization / customer's organization.

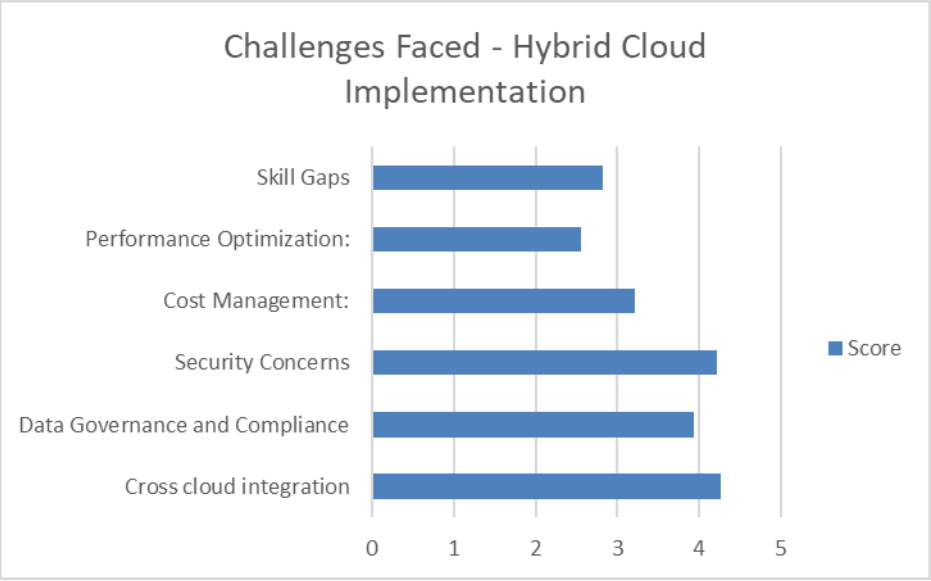

Chart 4.16
Challenges Faced - Hybrid Cloud Implementation

Cross cloud integrations, Security concerns were ranked very high by the respondents. Cross-cloud integration encompasses connectivity and interaction between private clouds, public clouds, and on-premises systems in a hybrid cloud environment. This challenge arises due to the complexity of managing multiple systems and their compatibility. When we asked the respondents during interviews to elaborate on this, they mentioned that the problem is rooted in the fact that the public cloud providers (AWS, Azure, Google Cloud) have unique architectures, APIs, and services. Integrating these public clouds with private clouds and legacy systems often requires bespoke solutions, increasing complexity.

Impact of resource availability is the next ranking that we have sought. The expectation will be to identify what has been the main impact of the resource availability.

Question 16: Rank how availability of resources affected your organization's implementation of hybrid cloud adoption?

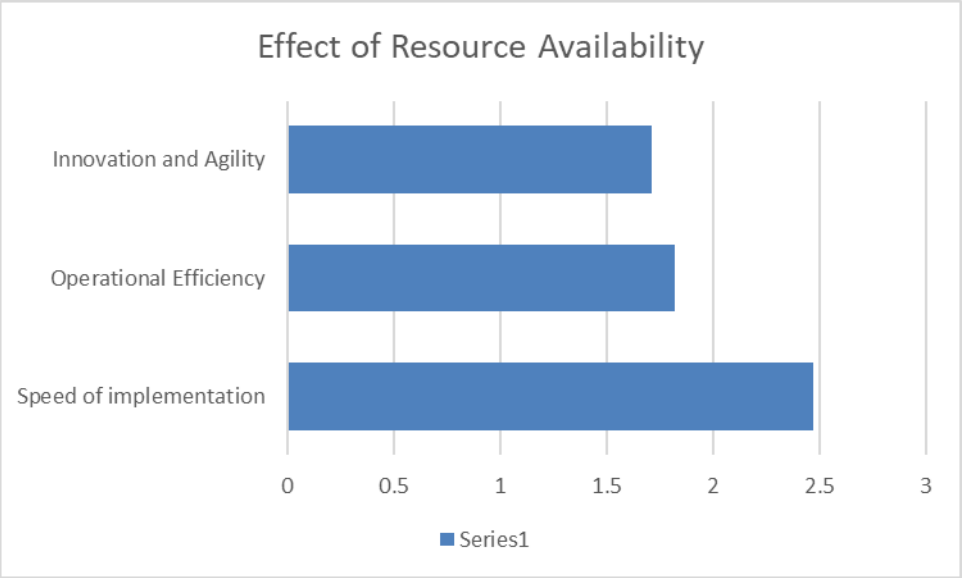

Chart 4.17
Effect of Resource availability

Respondents called out to say that they saw the speed of implementation improved drastically when the resource availability was there. This seems logical and the next two ranks were visible improvement in operational efficiency and accelerated innovation and agility. The resources that were called out spanned from the compute and storage resources, network infrastructure and connectivity, skilled personnel, financial resources, easy access to advanced tools.

1. **Compute and Storage Resources** - The availability of scalable compute and storage resources in hybrid cloud environments is one of the primary drivers for adoption. Organizations often choose hybrid clouds to overcome the limitations of on-premises infrastructure, enabling dynamic scaling during peak demand (Han and Lee, 2022). Access to such resources either on-premises or on public cloud will have a huge impact on the adoption capability for the organization. Hybrid cloud models allow organizations to offload intensive workloads to public clouds during spikes,

ensuring high availability and performance without overprovisioning on-premises infrastructure (Bagheri and Haghighat, 2020).

2. **Network Infrastructure –** A reliable network is the backbone of the hybrid cloud infrastructure. A dependable high-speed connectivity is a basic expectation that the application owners will have from the team managing the hybrid cloud environment on which the applications are deployed. If the data centre is hosted in an area with poor network / internet infrastructure, they may face struggles adopting hybrid cloud. For example, a financial institution attempting to run real-time analytics across hybrid environments might face delays and degraded performance without high-speed, low-latency connectivity (Smith and Gupta, 2020).

3. **Skilled Personnel –** Access to skilled technology and business personnel having expertise in cloud technologies, their management, in-depth handle over networking and security with an eye on compliance are imperative for successful adoption of hybrid cloud. A now and here challenge is access to cloud native experts. Organizations often face difficulties finding personnel skilled in hybrid cloud orchestration and tools like Kubernetes, OpenStack, or multi-cloud monitoring platforms (Gartner, 2022).

4. **Financial Resources –** Respondents pointed out that an upfront investment towards on-premises infrastructure is one of the biggest stumbling blocks for setting up an hybrid cloud environment. This when added to the ongoing costs of hosting applications on public cloud is considered, it often deters organizations from adopting the hybrid cloud model. A fear of sudden unexpected costs such as data transfer fees, high compute environments being kept running inadvertently and license fees, were few of the financial concerns that were called out by the respondents. For organizations with sufficient financial resources, hybrid clouds

provide cost-effective scalability and resilience, reducing the need for over-provisioning (Han and Lee, 2022).

5. **Access to tools and cloud management platforms** – Managing hybrid cloud environments poses a unique challenge of managing and monitoring multiple cloud environments. Cloud management platforms such as Nutanix can help in managing these complex environments. There is also a need to implement advanced tools for orchestration, provisioning, monitoring and infrastructure as a code (IaaC) tool. Organizations that lack access to vendor-agnostic tools may face interoperability issues when connecting different cloud environments (Lillie and Malandrino, 2021).

Thus, in pursuit of hybrid cloud adoption, resource availability is a critical obstacle not only towards ease of deployment but also towards the day-to-day operational efficiency, scalability, and overall success of the solution. It is necessary for adopting organizations to properly assess and address potential needs for infrastructure, human capital, and financial resources. By doing so, organizations can optimize their resource utilization, fully leveraging the inherent flexibility of hybrid cloud architectures. This approach would ensure that the hybrid cloud deployment aligns with the organization's objectives and expectation from the hybrid cloud deployment.

4.2 Research Question Two: Are specific types of applications a better choice for deployment on hybrid clouds?

The second research question dwells upon studying whether certain applications are better suited for deployment on the hybrid cloud. Have organizations seen that certain applications are better suited for deployment on the hybrid cloud and did that preference reflect in the resultant performance seen? We began by asking them about their chosen strategy for taking applications to the hybrid cloud –

Question 17: Which of these strategies did you opt for while moving the legacy applications to deployment on hybrid cloud?

a. Went with a cloud first strategy
b. Prioritized which application to host on hybrid cloud based on business importance, ease of migration and costs involved.
c. Retain only applications that can integrate with new age apps
d. Opted for an app modernization initiative
e. Allocated high budgets and resources to retain legacy applications

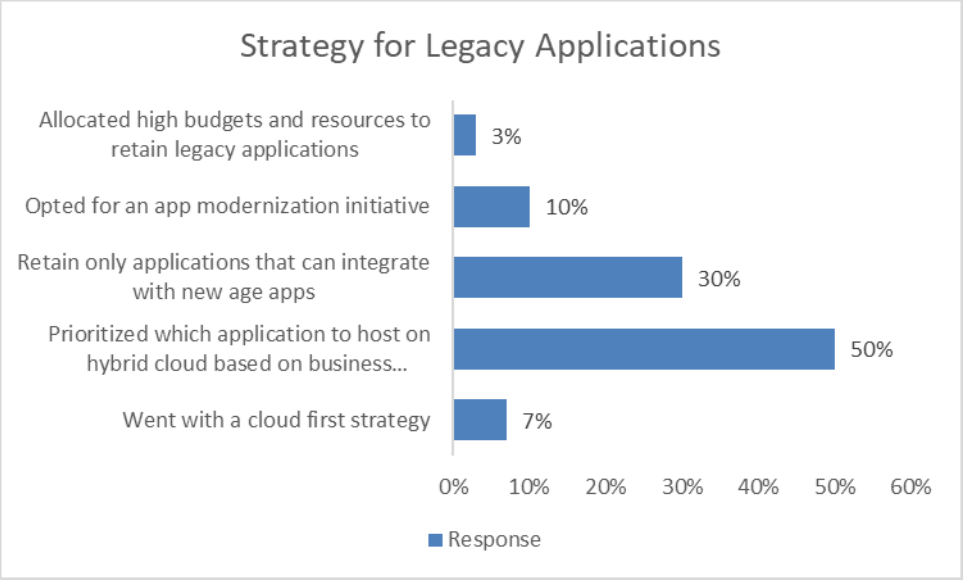

Chart 4.18
Strategy for Legacy Applications

50% of the respondents shared that the strategy they interacted with the business and prioritized applications that could be hosted on the hybrid cloud. Various applications have varying requirements in terms of storage, processing power, and data access. Prioritizing ensures that resource-intensive and scalable applications make best used of elasticity via placement in the public cloud, while applications that due to the regulatory guidelines or because of their criticality are hosted on the private cloud (Flexera, 2024).

Prioritizing applications for hybrid cloud hosting allows businesses to balance performance and cost efficiency effectively (Flexera, 2024). This is especially crucial for latency-sensitive workloads where real-time performance is non-negotiable (Gartner, 2024). Security and compliance also play a key role in decision-making, particularly for regulated industries like healthcare and finance (Microsoft, 2024).

Question 18: Based on your experience, which applications are most suitable for hybrid clouds, rank them (1 is most suited, 11 is least suited)

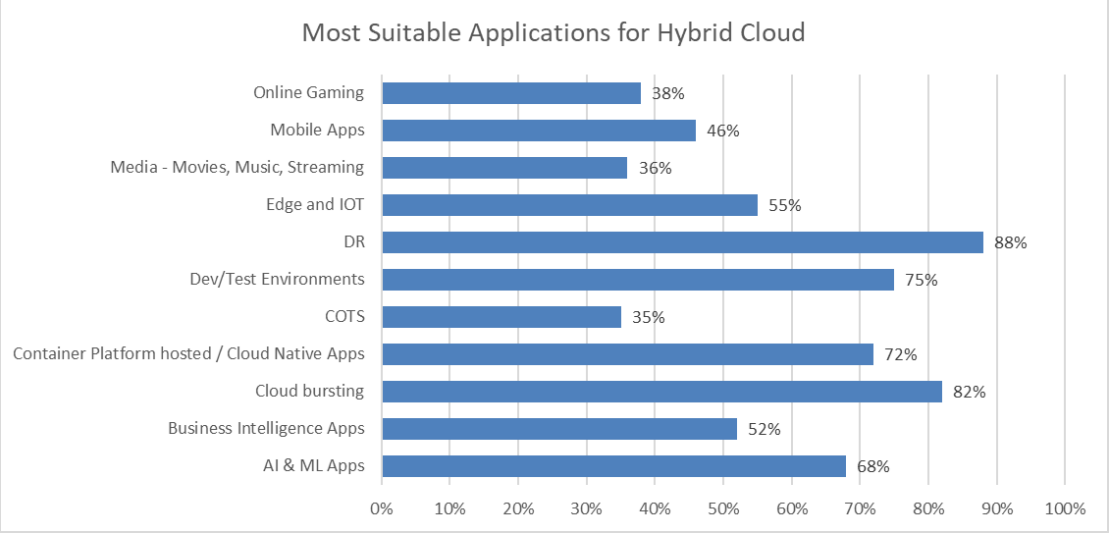

Chart 4.19
Most Suitable applications for hybrid cloud

Having collected strategy preferences, we next sought the views about which applications are most suitable for hybrid cloud. The following applications—Disaster Recovery (DR) – 88%, Cloud Bursting – 82%, Development and Testing (Dev-Test) environments 75%, and Cloud-native applications – 72% have been rated the best choices for hybrid cloud deployment. Each of these types of applications have their unique requirements for scalability, security, and performance.

Disaster Recovery (DR)

Disaster Recovery (DR) is the most popular use case for hybrid cloud deployment. In this model, organizations, as part of their disaster recovery process replicate critical workloads and data across two or more data centres. With the advent of public clouds, they use both public and private cloud environments, ensuring business continuity during unforeseen disruptions. The private cloud can house sensitive data, while the public cloud provides the scalability and cost efficiency required during disaster recovery scenarios. By leveraging the public cloud's elasticity, businesses can minimize downtime without the need for a full on-premises infrastructure (Vouk, 2008). This hybrid approach ensures that recovery operations are both secure and scalable.

Key Benefits: Cost-effective, scalable, secure, and flexible disaster recovery capabilities (Chappel, 2011).

Cloud Bursting

Cloud bursting refers to the practice of offloading capacities from a private cloud to a public cloud during periods of high demand (Gartner, 2024). This allows businesses to scale dynamically and only pay for additional resources when needed. During peak demand, workloads are "burst" to the public cloud, optimizing capacity without overburdening the private infrastructure. This flexibility makes cloud bursting particularly beneficial for applications with fluctuating resource requirements (Rountree and Castrillo, 2013).

Key Benefits: On-demand scalability, cost-efficiency, optimized resource utilization, and seamless workload management (Mell and Grance, 2011).

Development and Testing (Dev-Test) Environment

Hybrid cloud is highly suitable for development and testing (Dev-Test) environments, where organizations need flexibility to scale resources quickly and cost-effectively. In this model, production systems can remain within a private cloud or on-premises for security reasons, while the public cloud is utilized for temporary, resource-intensive development and testing purposes. The ability to ask for (and reserve) resources on-demand in the public cloud enhances the efficiency and speed of the development process, reducing costs associated with maintaining unused infrastructure. The hybrid approach also provides greater isolation between production and testing environments.

Key Benefits: Scalability, cost-effective testing, isolation of production systems, and ease of resource provisioning (Thomas, Zaigham and Ricardo, 2013).

Cloud-Native Applications

Cloud-native applications, designed to fully utilize cloud capabilities such as microservices, containers, and serverless computing, are ideally suited for hybrid cloud deployment (Kavis, 2014). These applications are often distributed and benefit from the flexibility to run different microservices or components in the most appropriate cloud environment, whether public or private. The hybrid cloud model allows for optimized performance, high availability, and reduced latency by placing workloads in the cloud environment that best meets the needs of each microservice (Pahl, 2015). The use of both private and public clouds helps organizations achieve greater resilience and agility for cloud-native applications.

Key Benefits: Flexibility in resource allocation, optimized performance, enhanced scalability, and high availability (Sharma *et al.*, 2021).

Why Hybrid Cloud is Ideal for These Applications

Hybrid cloud provides several key benefits that make it ideal for the aforementioned applications:

Flexibility: Hybrid cloud allows organizations to decide where to run each part of their application or workload based on performance, security, and cost requirements (Mell and Grance, 2011).

Scalability: The model facilitates seamless scaling by leveraging both private and public cloud resources as necessary to handle varying workloads (Rountree and Castrillo, 2013).
Cost Efficiency: Hybrid cloud optimizes resource use by allowing businesses to scale workloads dynamically and only pay for the resources they need (Gartner, 2024).

Security & Compliance: For applications dealing with sensitive data, hybrid cloud offers the flexibility to store confidential workloads in the private cloud while benefiting from the public cloud for the ones that don't require that are less demanding in terms of their security needs (Pahl, 2015).

Business Continuity: Hybrid cloud provides organizations with robust disaster recovery options by shifting workloads to the public cloud in the event of a failure, ensuring minimal downtime (Chappel, 2011).

Disaster Recovery, Cloud Bursting, Development/Testing environments, and Cloud-native applications are all well-suited for hybrid cloud deployment due to their need for scalability, security, and flexibility. Hybrid cloud allows organizations to optimize their infrastructure by running workloads in the most suitable cloud environment, ensuring a more agile and resilient IT architecture. This deployment model not only supports

operational efficiency but also provides a strategic advantage for modern enterprises navigating the complexities of cloud-based computing.

The aspect we sought to understand next was noting the primary requirements of the applications deployed on to the hybrid cloud.

Question 19: Which of the following best describes the primary requirements of the applications you deployed on the hybrid cloud?

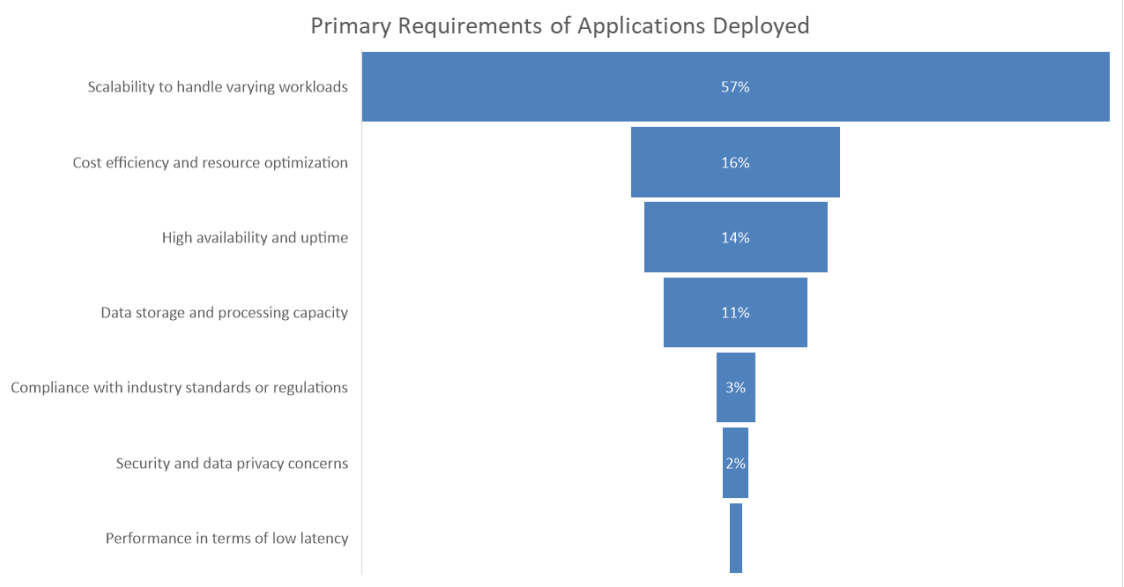

Chart 4.20
Primary Requirements of applications deployed

With 57%, scalability to handle the varying workloads came in as the top requirement for applications for hosting them on to the hybrid cloud. Born in cloud applications are inherently built to leverage the elasticity of the cloud while web applications often have to be modified to make most use of the features that the cloud presents. The key requirements of applications that are met by this approach are because of –

Dynamic Resource Allocation: Hybrid clouds allow organizations to allocate resources dynamically based on real-time demand. For example, during peak usage periods, applications can scale out to the public cloud to avoid performance degradation (Brown and Taylor, 2022).

Cloud Bursting: Critical workloads that exceed on-premises capacity can temporarily burst into public cloud environments, providing the necessary computational power without requiring permanent infrastructure investments (Smith and Taylor, 2021b)

Different types of applications benefit from hybrid cloud scalability, including:

Big Data Analytics: Hybrid cloud environments provide the necessary scalability for processing large data sets during analytics tasks while maintaining cost-effectiveness during idle periods (Johnson and Lee, 2020).

AI/ML Workloads: These workloads often require high computational power during training phases, which can be offloaded to the cloud to meet scalability needs (Brown and Taylor, 2022).

The requirements being understood, next aim was to rank the factors affecting the selection of the environment for the applications.

Question 20: How important are the following factors when selecting an environment for your applications? (Rate on a scale of 1 to 5, where 1 is not important and 5 is very important)

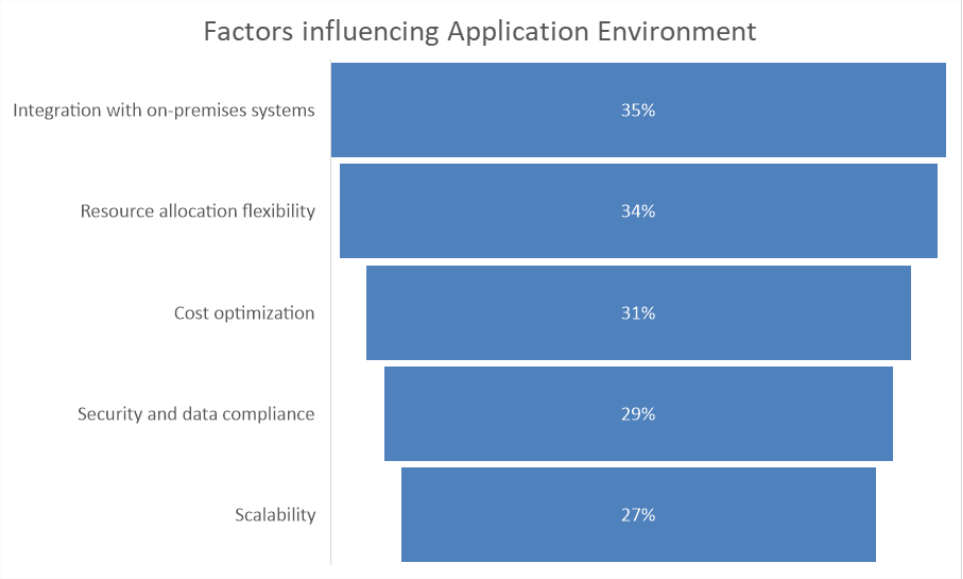

Chart 4.21
Factors influencing application environment

The top ranked factor by the respondents was the ability to integrate with on premise systems. The ability to integrate with on-premises systems is a critical factor when selecting an application deployment environment in the context of hybrid cloud adoption. This integration directly impacts the effectiveness, efficiency, and long-term viability of the hybrid cloud solution. In a hybrid cloud model, organizations often need to maintain some operations on-premises due to regulatory, security, or operational reasons, while utilizing the cloud for additional capacity, scalability, and innovation. Therefore, friction-free and continuous integration between on-premises systems and cloud environments is paramount to achieving optimal performance, data consistency, and overall strategic alignment (Smith and Gupta, 2020; Mohan and Subramanian, 2021).

When we sought more information on what the reasons for this high rank towards integration are, here is what we found –

1. **Data Consistency -** Many business-critical applications run on local servers, and for cloud solutions to be effective, immediate data synchronization is required. The failure to integrate properly can result in data silos, leading to inefficiencies and operational errors (Han and Lee, 2022). An example for this is an e-commerce platform that uses a hybrid cloud setup might need to synchronize inventory data stored on-premises with the cloud-based order management system. Without proper integration, discrepancies in stock levels could occur (Gartner, 2022).

2. **Operational Needs -** A company running a hybrid cloud solution for customer relationship management (CRM) may need to connect on-premises legacy CRM tools with cloud-based analytics. If the systems do not integrate seamlessly, it could lead to delays in customer data processing, affecting sales strategies (Smith and Gupta, 2020).

3. **Legacy Systems Integration -** Many organizations have a substantial investment in on-premises legacy systems that cannot be easily migrated to the cloud. These systems may house critical business functions such as financial reporting, customer records, and product inventories. Ensuring that these systems integrate smoothly with newer cloud applications is essential to extend their usefulness and avoid costly replacements or complete overhauls (Mohan and Subramanian, 2021).

   Another example would be a financial institution with a hybrid cloud model may still rely on legacy mainframe systems to store transaction histories. Integrating these with cloud applications helps facilitate advanced analytics without the need to entirely retire existing infrastructure (Lillie and Malandrino, 2021).

Then we proceeded to gauge which type of application workloads are a better fit for hybrid cloud deployment.

Question 21: For which types of applications do you consider hybrid cloud deployment a better fit? (Select all that apply)

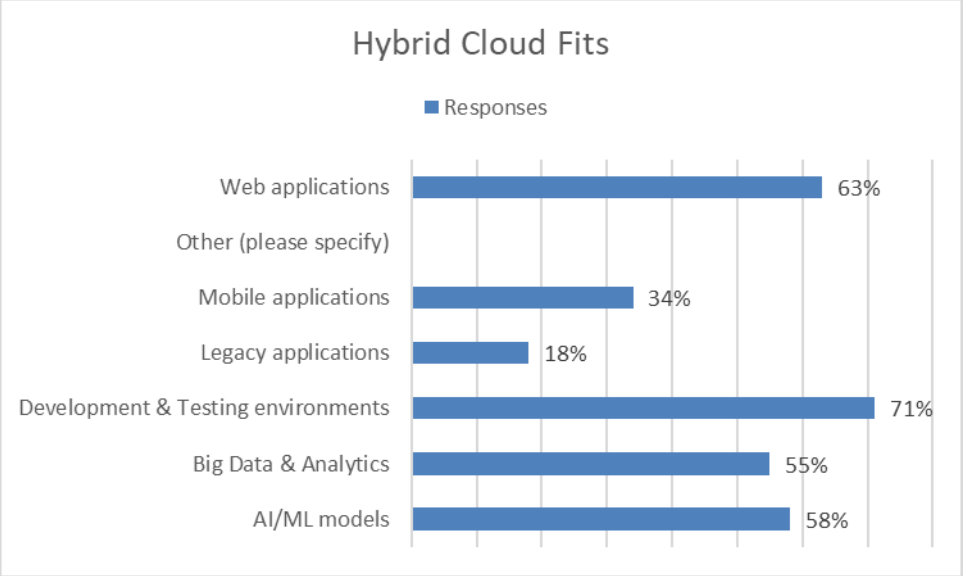

Chart 4.22
Hybrid Cloud Fits

Development and test environments

These came in at the top of the application workloads that are best suited for hybrid cloud deployment. The development and test environments are generally required for a shorter duration of time however the need for these environments to be setup is often dynamic. Respondents told us that they have very short turnaround times to deliver dev and test environments. Hybrid cloud if used effectively can present a good solution for on-demand scaling of infrastructure resources without risk of on-premises over provisioning. We did further literature study as well to ratify our on-field findings.

Scalability: Developers can leverage public cloud resources to provision environments quickly for testing new code or features, and then decommission them once testing is complete (Mohan and Subramanian, 2021).

Cost Efficiency: By using on-premises infrastructure for long-term or sensitive development work and the cloud for short-term, resource-intensive testing, organizations can optimize costs (Bagheri and Haghighat, 2020).

Security and Compliance: Sensitive code or applications can be developed on-premises, while testing can be done in the public cloud, providing a balance between security and scalability (Smith and Gupta, 2020).

Web Applications: Web applications or browser applications are mainstay of all enterprise software. Many of these applications experience varying traffic loads or have seasonal spikes in usage. Such applications are better served by hybrid cloud deployment. A respondent aptly pointed out a scenario wherein they said that the hybrid clouds allowed their organization to deploy web applications on-premises for sensitive data processing and selectively leverage the public cloud infrastructure to scale quickly during peak traffic periods.

Seasonal scaling: During high-demand events, such as sales or marketing campaigns, the public cloud can provide additional compute resources to handle traffic spikes, without requiring permanent infrastructure investments on-premises (Lillie and Malandrino, 2021).

Multi-location flexibility: Web applications often require multi-region deployment, which is easily achievable using hybrid cloud infrastructure, allowing the application to scale across different regions efficiently (Mohan and Subramanian, 2021).

Control Costs - By offloading only the peak traffic to the cloud, businesses can better manage costs by using on-premises infrastructure for regular usage and cloud resources only during high-demand periods (Smith and Gupta, 2020).

AI / ML Workloads

These came in at the third rank with 58% of the respondents alluding to these being found fit for hybrid cloud deployment. This is a new trend and given the fact that these workloads are resource hungry and require high performance compute (HPC), huge storage capacity. The hybrid cloud model is found to be particularly advantageous in this domain as it allows organizations to perform compute-heavy tasks in the public cloud while storing and processing sensitive data on-premises. Here is what we found in this context in our literature study –

1. Hybrid cloud environments provide the flexibility to leverage powerful cloud computing resources for training large machine learning models, while using on-premises infrastructure to manage datasets and ensure data sovereignty (Mohan and Subramanian, 2021)).
2. Many AI and ML models demand accessibility to large datasets, some of which might be regulated or sensitive. By implementing hybrid cloud, organizations can retain sensitive data on-premises while using cloud resources to store, process and analyse non-sensitive data (Smith and Gupta, 2020).
3. Instead of investing heavily in on-premises hardware, organizations can rent cloud resources for intensive AI/ML tasks, significantly reducing capital expenditures (Gartner, 2022).

And finally, we sought the obvious misfits for deployment onto the hybrid cloud. This would help future adopters to have an idea about which applications will not be good choices for deployment onto the hybrid cloud.

Question 22: Hybrid Cloud Misfits - Which of the following types of applications do you think would NOT be suitable for hybrid cloud deployment?

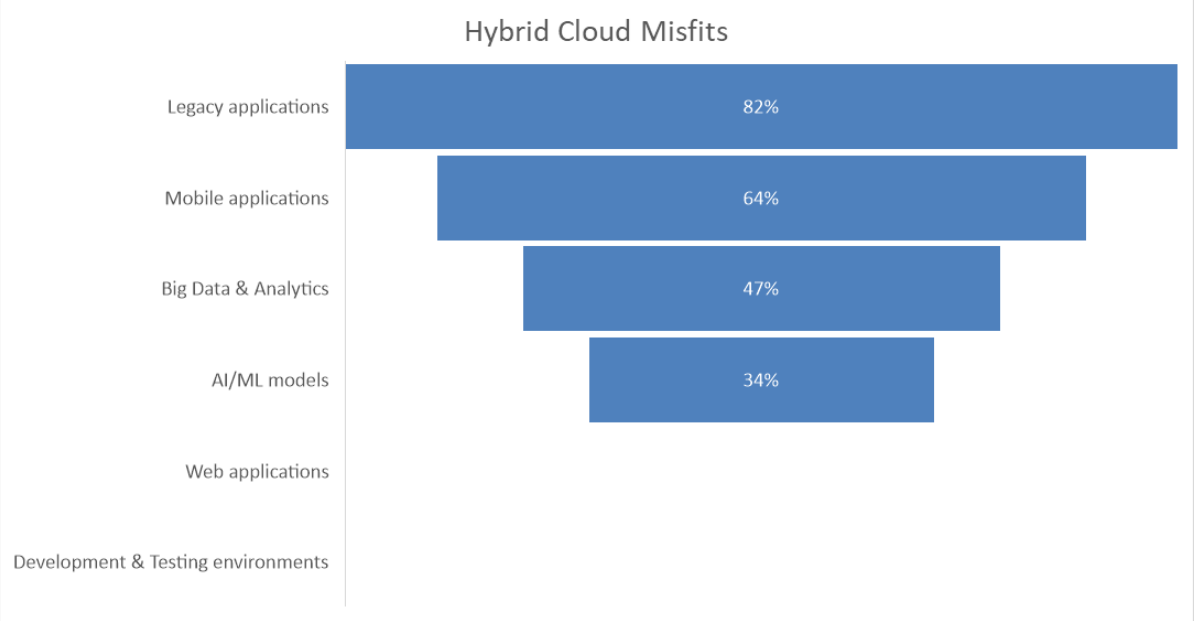

Chart 4.23
Hybrid Cloud Misfits

There was an interesting response to this question. Big Data analytics and AI / ML which featured in good fits for hybrid cloud also cropped up here. The challenges that were mentioned by the respondents included difficulty connecting systems, performance problems, high costs of transferring data, and the need for powerful resources that hybrid clouds may not always provide. Because of these issues, organizations might find it better to use either fully cloud-based or fully on-premises solutions for these types of applications instead of hybrid cloud.

4.3 Research Question Three: What are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises?

This is an important goal of this research and answers to this question can help us guide future adopters of hybrid cloud accelerate their adoption in true sense by learning from the experiences of the existing adopters of hybrid cloud.

To find the various approaches, tools and strategies that can help accelerate the hybrid cloud adoption by enterprises. Here, we began by seeking the primary reasons why the organizations have decided to opt for hybrid cloud deployment.

Question 23: What are the primary reasons your organization is considering or has adopted a hybrid cloud strategy?

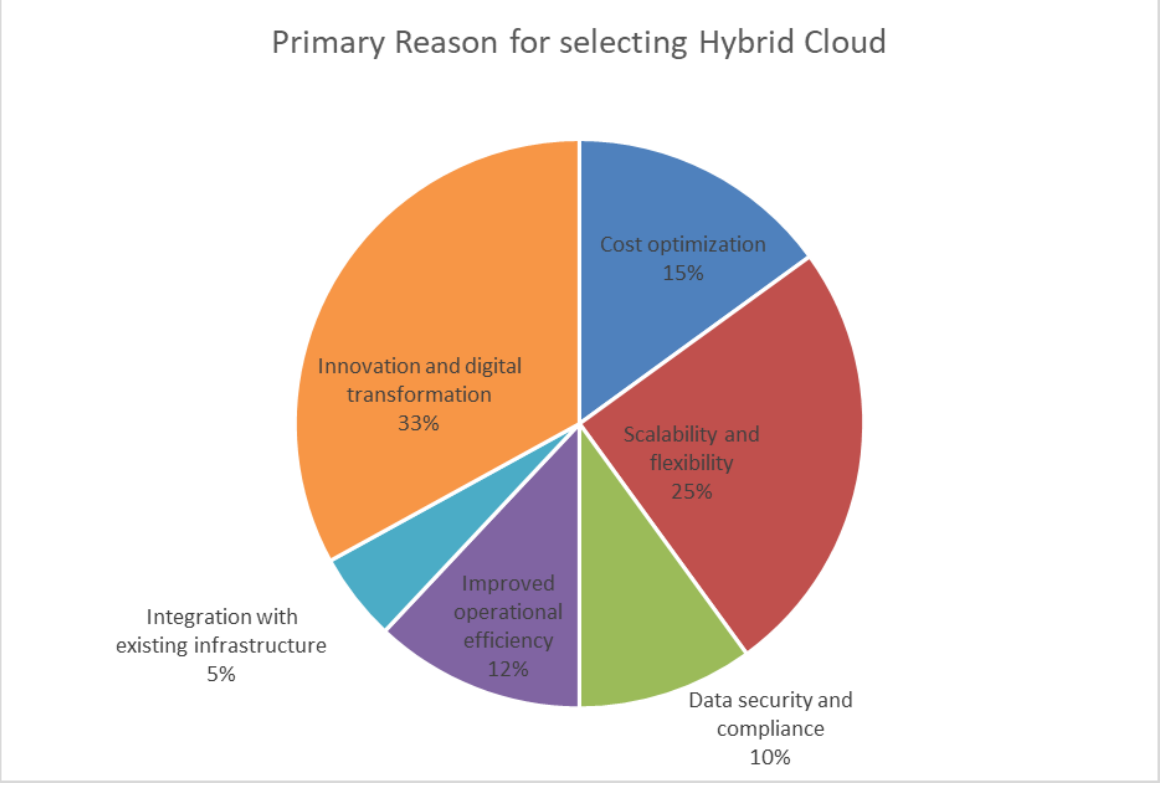

Chart 4.24
Primary reasons for selecting Hybrid Cloud

The top reason provided was innovation and digital transformation with one-third of the respondents opting for this. The respondents mentioned that the adoption of public cloud and hybrid cloud at large was the cornerstone of their digital transformation journey. Scalability and flexibility came in second with one-fourth of respondents stating this as an option. The respondents were vocal about the freedom that the hybrid cloud infrastructure provided towards scaling, on demand. While the architects and operations team underlined the fact that resources could be spawned on demand and brought down with equal swiftness was of immense value, the business personnel called out the cost effectiveness of this approach as a big positive.

This is further underlined by the third choice – cost optimization. Respondents expressed that the cost optimization has been a big focus area and opting for hybrid cloud was an important step towards this goal. The pay only for what you use ("pay as you go") model of public cloud and the ability to leverage existing on-premises investments at one go by use of hybrid cloud has been seen as a big advantage. In a few interviews, the respondents brought up the fact that they are now able to plan their infrastructure investments better because anything that is short term, experimental now goes to the public cloud way while anything that is long term is evaluated for up-front investments on-premises. Some examples for this were also seen in our literature study –

During peak traffic seasons, retailers can increase cloud usage to handle customer demand without the upfront costs of extra physical servers (Mohan and Subramanian, 2021). When we spoke to banking customers they resonated with this example - A financial institution may keep its core banking systems on-premises, while offloading customer analytics and web applications to the cloud (Smith and Gupta, 2020).

On the aspect of avoiding over-provisioning thereby resulting in cost optimization, an e-commerce company can use public cloud resources during holiday seasons and scale back during off-peak months, avoiding the need to purchase costly extra hardware (Han and Lee, 2022).

We have seen DR is one of the key use cases for adopting hybrid cloud, in that aspect as well, there is reduction in costs as organizations no longer need to replicate multiple data centers with similar configurations as their primary on-premises setup. Cloud backup services are seen to be more cost effective. A healthcare provider can back up patient data in the cloud to ensure disaster recovery without investing in costly on-premises backup hardware (Bagheri and Haghighat, 2020).

Another cost optimization example is the “horses for courses” approach that a few respondents pointed out. They mentioned that they decide on using the right cloud or vendor, so going beyond the just on-premises or public cloud choice a choice about which vendor to use for what purpose is also made available in the hybrid cloud context. This choice can be capability based and / or feature based as well. A media company may use one cloud provider for storage services, which offers better pricing, and another provider for computational tasks, depending on the cost structure (Gartner, 2022)

The operational costs too get optimized and in fact reduced by way of automation of monitoring, managing and scaling tasks, thereby reducing need for human intervention and thus reducing labour costs. Automating workload scaling during periods of high traffic helps businesses minimize the time IT staff spends on managing resources manually (Lillie and Malandrino, 2021).

While understanding the primary reasons gives insight at the aim for going the hybrid cloud way, we thought it was prudent to also seek the biggest driver for adopting the hybrid cloud, we sought that by asking this question –

Question 24: What is the biggest driver for adopting a hybrid cloud over a single cloud or on-premises solution?

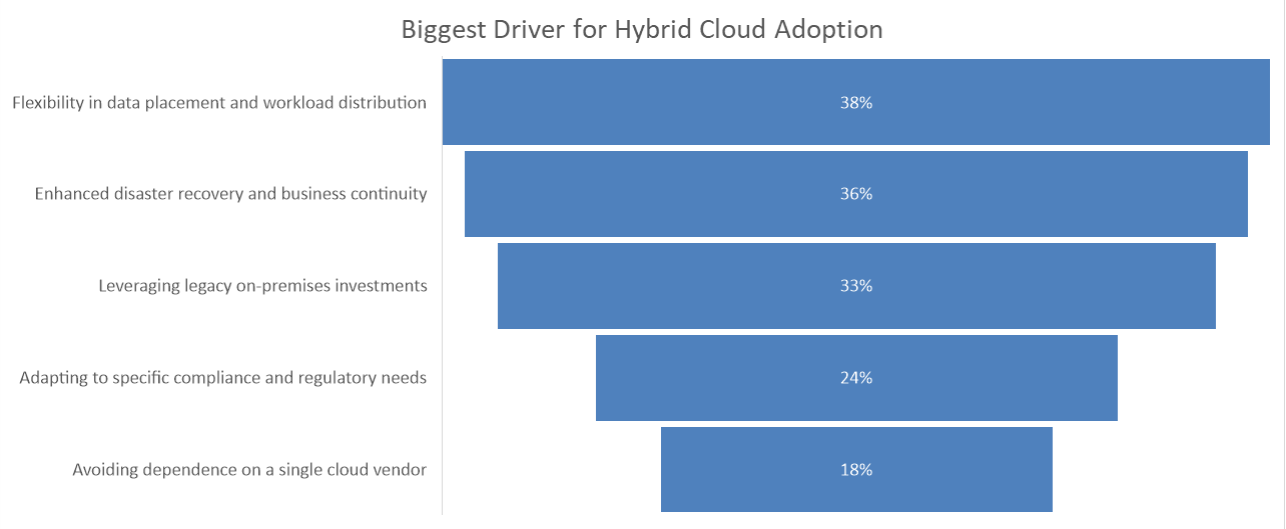

Chart 4.25
Biggest driver for hybrid cloud adoption

Flexibility in data placement and workload distribution

38% of our respondents selected the flexibility in data placement and workload distribution as their biggest driver. Hybrid cloud provides flexibility in terms of data placement. We had decided to ask this question based on this statement we came across in my literature study - Flexibility in data placement is one of the most quoted benefits driving the embracing of hybrid cloud models. This capability allows organizations to strategically decide where to store, process, and analyse their data based on factors such as cost, compliance, performance, and security requirements (Mohan and Subramanian, 2021).

We have seen earlier in our thesis that the data governance and compliance norms play an important role in choice of public cloud providers and hybrid cloud. Different countries and regions have specific laws governing data storage and transfer, such as the General Data Protection Regulation (GDPR) in the European Union or data residency laws in China. Hybrid cloud models allow organizations to comply with these regulations by keeping sensitive data on-premises or in specific geographic locations while leveraging the public cloud for workloads of less sensitive nature (Bagheri and Haghighat, 2020).

An apt example for this is that of a multinational corporation which may store personal customer data in local on-premises servers to comply with data residency laws while using a public cloud provider for global analytics (Han and Lee, 2022).

Enhanced disaster recovery and business continuity

This came in as the second biggest driver for hybrid cloud adoption, with 36% of respondents choosing it. We have covered this aspect in the earlier questions in the thesis (question # 18), that disaster recovery and business continuity are one of the primary drivers for hybrid cloud adoption. Hybrid cloud allows organizations to implement effective disaster recovery strategies by placing backups in the cloud while keeping critical operational data on-premises. This guarantees the continuity of business even in the case of localized downtimes, such as natural disasters or hardware failures (Bagheri and Haghighat, 2020).

A related example is of a financial institution can store transaction logs on-premises for operational use and replicate them in the cloud for disaster recovery purposes (Mohan and Subramanian, 2021).

Leveraging legacy on-premises investments

At 33% the ability to leverage on-premises investments came in as the third most selected driver for adoption of hybrid cloud. When we spoke to the business leaders about this, they mentioned that opting for hybrid cloud, they were able to leverage their existing capital investments towards on-premises data centers, networking setups, software licenses. What they already had thus remained relevant in the bigger scheme of things when hybrid cloud adoption approach was chosen. A manufacturing company with a well-equipped on-premises data centre can use it for daily operations while leveraging the public cloud to manage fluctuating workloads like seasonal production demand (Mohan and Subramanian,

2021). The investments made towards on-premises setups can help avoid upfront costs and this can be a starting point to gradually transition selected workloads to the cloud.

A financial institution may keep legacy systems on-premises to save costs while modernizing customer-facing applications in the cloud (Smith and Gupta, 2020).

This approach can be effective especially so in case of organizations who continue to operate legacy applications that are rooted into the on-premises infrastructure. Opting for hybrid cloud model, enables such organizations to integrate the modern cloud services with existing legacy systems without a need for overhaul and any probable resultant disruptions. An energy company can link its cloud-based analytics platform with on-premises systems managing power grid operations to improve data insights without disrupting existing workflows (Bagheri and Haghighat, 2020).

An interesting observation we heard from one of the respondents was that adopting hybrid cloud while leveraging existing legacy systems helped them roll out a gradual transformation that “did not rock the boat”. An incremental modernization is thus a possibility. A retail chain can begin by hosting its e-commerce platform in the cloud while maintaining inventory management systems on-premises during the transition phase (Lillie and Malandrino, 2021).

Next, we move our attention to ranking the approaches based on their impact on acceleration of the adoption of hybrid cloud.

Question 25: Rank the following approaches based on their impact for accelerating hybrid cloud adoption? Please rank them (high impact to low impact), as per your point of view.

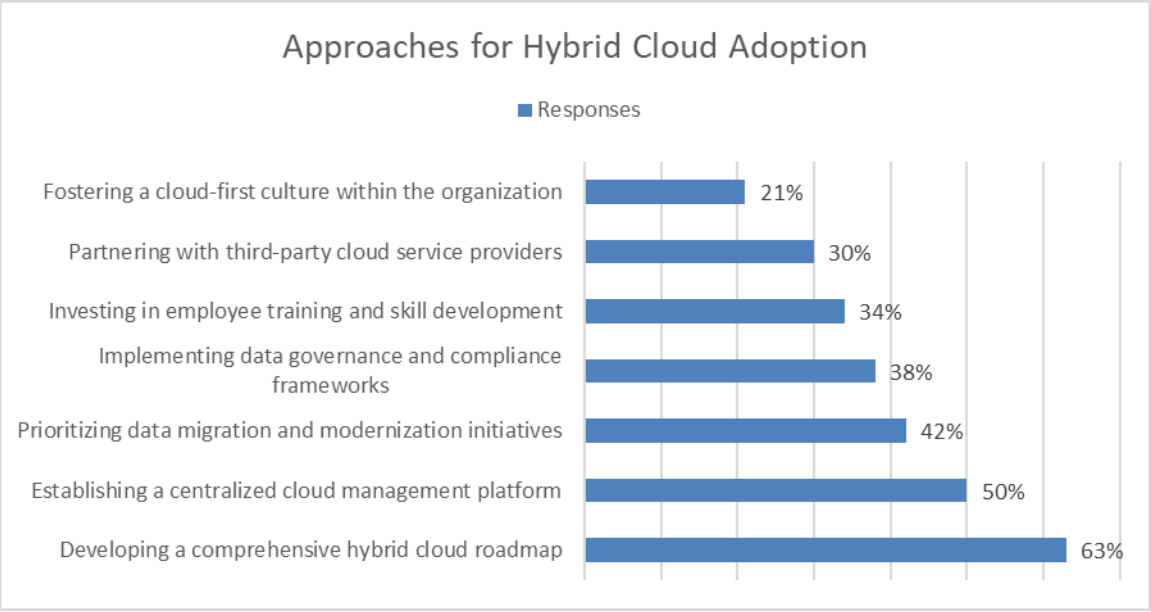

Chart 4.26
Approaches for hybrid cloud adoption

The respondents to survey and interviewees rated the development of comprehensive hybrid cloud strategy as the top-most ranked approach for successful hybrid cloud adoption. Second in the ranking is establishing a centralized cloud management platform and third in the pecking order is the prioritization of data migration and modernization initiative.

A. **Development of comprehensive hybrid cloud strategy**

Respondents stated that adopting a hybrid cloud as a set of piecemeal deployments without a well-defined strategy can lead to inefficiencies, security vulnerabilities, and suboptimal performance. Respondents were vocal that a comprehensive hybrid cloud strategy not only ensures alignment with organizational goals but also optimizes resource

utilization, mitigates risks, and enhances long-term success. The key reasons for favouring this approach are elaborated as follows -

1. **Business Goal Alignment**

   A comprehensive hybrid cloud strategy ensures that cloud adoption aligns with an organization's overall objectives, such as cost reduction, agility, or innovation. It therefore derives the metrics and methodology that identifies the workloads best suited for on-premises infrastructure or the cloud, ensuring an optimized deployment model tailored to business needs.

   For example, a bank may develop a strategy to use hybrid cloud by keeping sensitive workloads on private cloud for regulatory compliance while simultaneously leveraging public cloud analytics for customer insights (Han and Lee, 2022).

2. **Optimized Resource Utilization**

   In absence of a comprehensive strategy, organizations may underutilize the existing on-premises resources or overcommit to public cloud services, leading to inefficiencies.

   An example could be a manufacturing company could use on-premises systems for stable workloads and public cloud resources for peak demand periods to avoid unnecessary infrastructure expansion (Mohan and Subramanian, 2021).

3. **Enhanced Security and Compliance**

   Hybrid cloud environments are inherently complex, involving multiple vendors, environments, and data flows. A comprehensive strategy helps address security and compliance challenges by establishing clear policies for data placement, encryption, and access control.

An example for this could be a healthcare provider may use a strategy that ensures patient data remains on-premises for compliance while using the cloud for research on anonymized datasets (Smith and Gupta, 2020).

A comprehensive cloud strategy will also encompass integration, security, cost management, and scalability proactively, organizations can fully realize the potential of hybrid cloud environments while minimizing risks.

B. Establishing a centralized cloud management platform

This came in as the second ranked choices amongst approaches that our respondents have taken for their hybrid cloud adoption. Respondents were of the view that a centralized cloud management platform (CMP) plays an important role in ensuring the success of hybrid cloud adoption. It offers unified control, visibility, and automation across diverse cloud environments. CMP addresses key challenges associated with managing hybrid cloud infrastructures. Here are the reasons why this approach is found to be very effective:

1. Single pane of glass for monitoring and control –

A centralized CMP provides a single elaborate to monitor and manage resources across on-premises and cloud environments. This unified view ensures better oversight, reduces management complexity, and allows administrators to respond swiftly to issues. Few of our respondents mentioned that they have either deployed or are in a process of deploying a cloud management platform.

Case in point would be, an organization using multiple cloud services can track resource utilization, performance metrics, and compliance status from a single dashboard, reducing operational silos (Smith and Gupta, 2020).

2. **Improved Operational Efficiency –**

A centralized CMP minimizes manual intervention in managing workloads and infrastructure by its inherent automation and infrastructure automation capabilities. Tasks like VM provisioning, scaling, and patching can be automated, leading to minimal human intervention which in turn translates into reduced errors and improved efficiency. Nutanix Prism and ServiceNow were the examples quoted by our respondents.

3. **Cost Optimization –**

A detailed tracking of costs deployed over constituent cloud environments can be made possible by a centralized CMP. Insights about resource usage, unutilized provisions, usage patterns are made available by the CMP. An example for this is a retail company can use the platform to identify underutilized cloud instances and scale them down, saving operational costs (Lillie and Malandrino, 2021).

C. Prioritizing data migration and modernization initiatives

Our respondents ranked prioritizing data migration and modernization initiatives as the third most effective approach for accelerating hybrid cloud adoption. A key pointer mentioned in interviews with them was that such prioritization ensures data accessibility and readiness. Respondents advocated moving data to appropriate environments and doing so with the intent that the data is easily accessible from where it is needed the most. Prioritizing data migration ensures that the critical data is easily accessible to the applications that need it, across the hybrid cloud footprint. An example of this would be a retail company prioritizing the migration of customer transaction data to the cloud can quickly leverage analytics tools for insights, accelerating hybrid cloud utilization (Smith and Gupta, 2020).

Prioritizing data migration and modernization initiatives serves as an effective approach for accelerating hybrid cloud adoption by addressing critical requirements such as, data accessibility, application readiness, and scalability.

1. It helps in reducing technical debt and aligning legacy systems with modern cloud architectures.
2. This approach strengthens security, ensures compliance, and enhances the organization's ability to leverage advanced cloud-native capabilities.
3. It is a proactive strategy that not only streamlines the transition to hybrid environments but also mitigates risks, minimizes operational disruptions, and unlocks the full potential of hybrid cloud models.

Ultimately, it lays the groundwork for long-term scalability, efficiency, and competitive advantage, establishing hybrid cloud adoption as a transformative enabler of digital innovation.

Proceeding further, we sought information about the cloud migration strategies with focus on hybrid cloud adoption. We gave the options we had derived and gave a choice of choosing more than one option –

Question 26: Which of the following cloud migration strategies is your organization pursuing for hybrid cloud adoption?

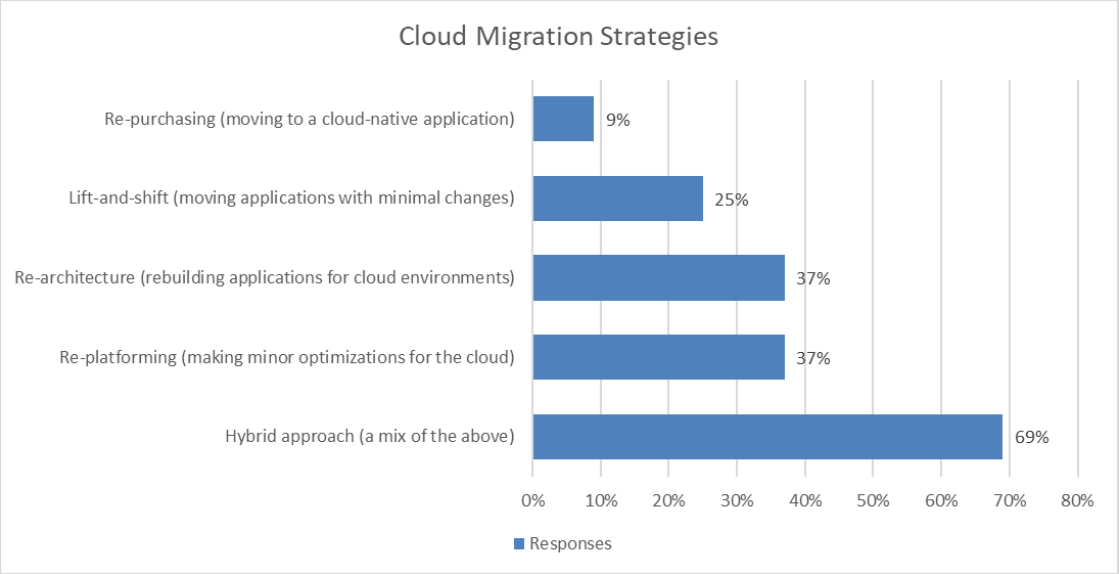

Chart 4.27
Cloud migration strategies

While re-platforming and re-architecture along with lift and shift are popular cloud migration approaches, our respondents were of the view that they don't just use only one of these strategies and use a hybrid approach which is a mix of these strategies for their hybrid cloud adoption.

1. **Lift-and-shift**, this is the least disruptive approach for cloud migration. It involves migrating applications as-is to the cloud. It is seen as a quick and cost-effective approach and recommended for non-critical or legacy workloads where immediate cloud adoption is required with minimal leverage of cloud features beyond hosting.

2. **Re-platforming** aims at moving on-premises applications to the cloud by making minimal changes to them. The aim is to take advantage of cloud capabilities while retaining the core structure of the applications. It is

recommended for workloads that can benefit from enhanced performance or scalability without requiring significant redesign. A good example for this is the move of database hosting from on-premises onto a hosted cloud database service provider like Amazon RDS or Azure SQL. During migration, minimal optimizations are applied, such as indexing for faster queries or switching to a cloud-native database engine to reduce costs and improve performance.

3. **Re-architecting**, on the other hand, involves a complete overhaul of application architecture to fully embrace the cloud-native features. This strategy is often chosen for applications critical to innovation and business growth, such as those relying on microservices or AI/ML.

Question 27: Which tools do you believe are critical for successful hybrid cloud adoption? Rank them as per criticality.

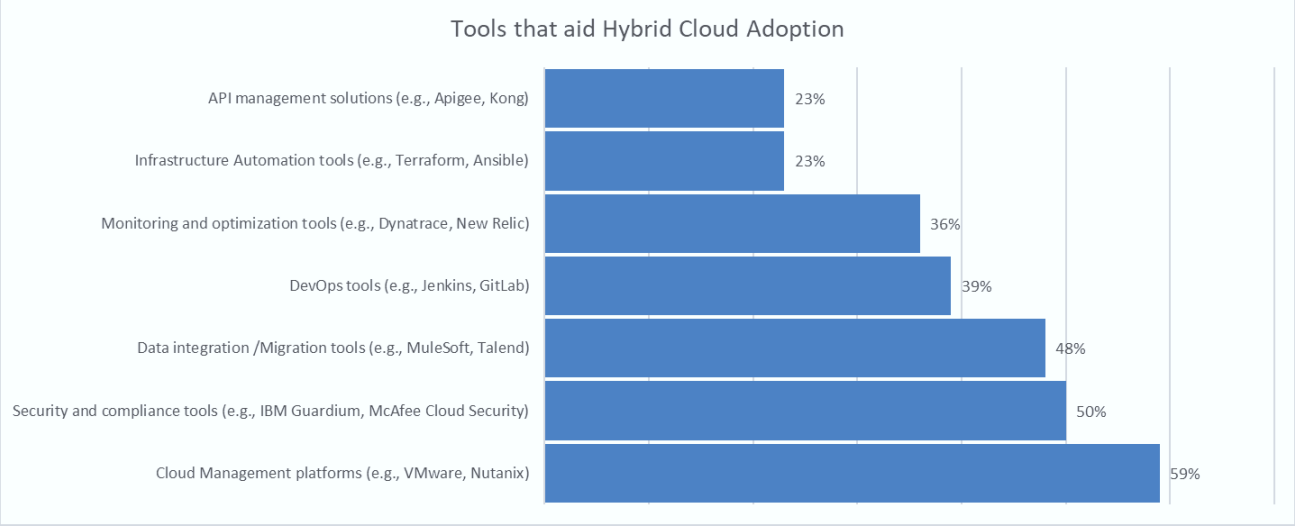

Chart 4.28
Tools that aid hybrid cloud adoption

The tools that are used to manage and monitor the hybrid cloud setup are a key ingredient for the adoption of hybrid cloud. In our survey the top three tools as per ranking were – Cloud Management platforms (e.g., VMware, Nutanix), Security and compliance tools (e.g., IBM Guardium, McAfee Cloud Security), Data integration /Migration tools (e.g., MuleSoft, Talend). They address the complexities of managing diverse cloud infrastructures, ensuring security, compliance, and seamless integration across on-premises and cloud-based systems.

Cloud Management Platforms

As mentioned in the earlier question #25, cloud management platforms are a key component, and this response has in away underlined their importance. VMware vRealize Suite, Nutanix Prism, and Microsoft Azure Arc. Cloud management platforms (CMPs) are responsible for orchestrating workloads across hybrid environments. They provide a single pane of glass for managing on-premises and cloud resources, offering capabilities such as automated provisioning, performance monitoring, and cost optimization. The key benefits of using CMPs are as follows –

1. Simply the orchestration of workload across diverse environment.
2. Enable granular resource allocation and cost management (Smith and Jones, 2020).
3. An example could be a retail company uses VMware vRealize to manage seasonal spikes in e-commerce traffic by dynamically scaling resources across private and public cloud infrastructures (Johnson and Lee, 2021).
4. Another example is what one of our interviewees quoted, they are using a combination of Nutanix Prism and ServiceNow as a CMP. The catalogue is published in ServiceNow and post the usual ITSM process the actual provisioning takes place in Nutanix and can be monitored by the cloud management team by using the Nutanix Prism tool.

Security and Compliance Tools

Security and compliance tools like IBM Guardium, McAfee Cloud Security, and Trend Micro Cloud One are used for addressing the risks associated with hybrid cloud environments. The risks are chiefly in the form of data breaches and regulatory non-compliance. These tools ensure data protection through encryption, real-time threat detection, and automated compliance reporting. The at-rest, inflight and in-vault data are all under purview of these tools. Here are few benefits of using these tools –

1. Protect sensitive data and ensure regulatory compliance across regions while ensuring compliance to local jurisdictions.
2. Provide advanced threat intelligence and automated remediation(Han and Wang, 2022).
3. Ability to generate Ad hoc, custom reports thereby ensuring adherence to the compliance needs while facilitating monitoring.
4. An example could be A financial institution leverages IBM Guardium to monitor and secure transactional data, ensuring compliance with GDPR and PCI DSS regulations (Miller and Patel, 2023).

Data Integration and Migration Tools

MuleSoft, Talend Data Fabric, and Informatica PowerCenter are the leading data integration and migration tools that our respondents quoted. These tools are used by hybrid cloud adopters to connect disparate systems, ensure data consistency and friction-free data transfer workloads from on-premises to public cloud. The benefits of using these tools are –

1. Accelerate data migration while maintaining data integrity.
2. Of late these are also being used for enabling real-time data synchronization for hybrid analytics and AI/ML workloads.
3. Last but not the least, facilitate seamless integration between on-premises systems and cloud applications (Brown and Taylor, 2021).

Then we sought the challenges that the organizations encountered while adopting their hybrid cloud strategy –

Question 28: What challenges has your organization faced in adopting a hybrid cloud strategy?

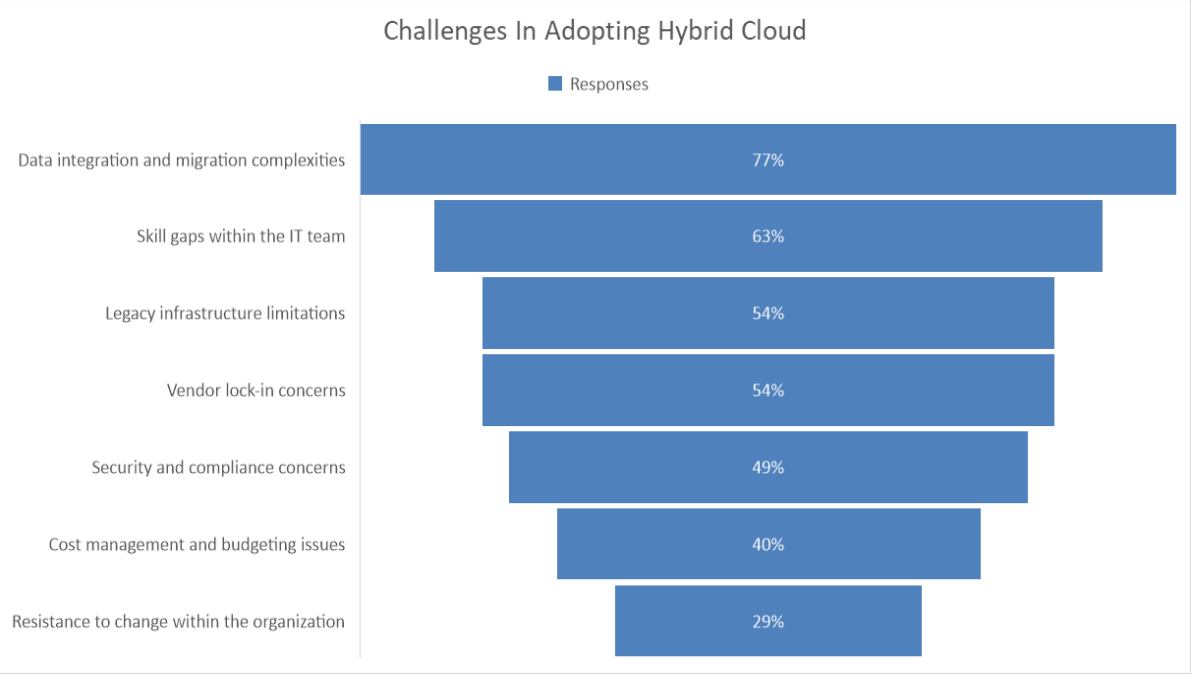

Chart 4.29
Challenges in adopting Hybrid Cloud

When we sought the challenges that the organizations encountered while adopting their hybrid cloud strategy –The top three challenges that our respondents mentioned were –

1. Data integration and migration complexities
2. Skill gaps within the IT team
3. Legacy infrastructure limitations

Data integration and migration complexities

The key issues that the respondents pointed out in terms of challenges related to data vis a vis hybrid cloud adoption were –

1. **Latency –** Given the distributed and diverse nature of the network infrastructure involved, there is always a risk of high latency which can play havoc with the data synchronization.
2. **Data Volume -** Migrating large datasets can strain network bandwidth and increase costs (Brown and Taylor, 2022).
3. **Heterogeneous Systems -** Integrating disparate systems across hybrid environments can lead to compatibility issues (Smith and Taylor, 2021b).

Skill Gap within IT Team

We have already spoken at length about the skill gaps. The skill shortages are a big concern and are seen as a major hurdle. As mentioned in the analysis of the response to question # 16, access to skilled technology and business personnel having expertise in cloud technologies, their management, in-depth handle over networking and security with an eye on compliance are imperative for successful adoption of hybrid cloud. A now and here challenge is access to cloud native experts. Organizations often face difficulties finding personnel skilled in hybrid cloud orchestration and tools like Kubernetes, OpenStack, or multi-cloud monitoring platforms (Gartner, 2022).

Legacy infrastructure limitations

The third most polled option was the limitations of the legacy infrastructure. Legacy systems usually lack compatibility with modern cloud technologies, rendering the integration with hybrid cloud environments challenging. Legacy applications and systems may use protocols or interfaces that are not supported in cloud environments, requiring complex middleware solutions (Brown and Taylor, 2022). Performance bottlenecks are seen

rooted mostly at the lack of elasticity. Legacy infrastructure typically lacks the elasticity needed for hybrid cloud operations, causing performance bottlenecks during workload surges (Miller and Patel, 2023).

We dig deeper on query about how availability (or non-availability) of skilled resources affected their hybrid cloud implementation –

Question 29: Rank how availability of skilled resources affects / has affected your organization's implementation of hybrid cloud adoption?

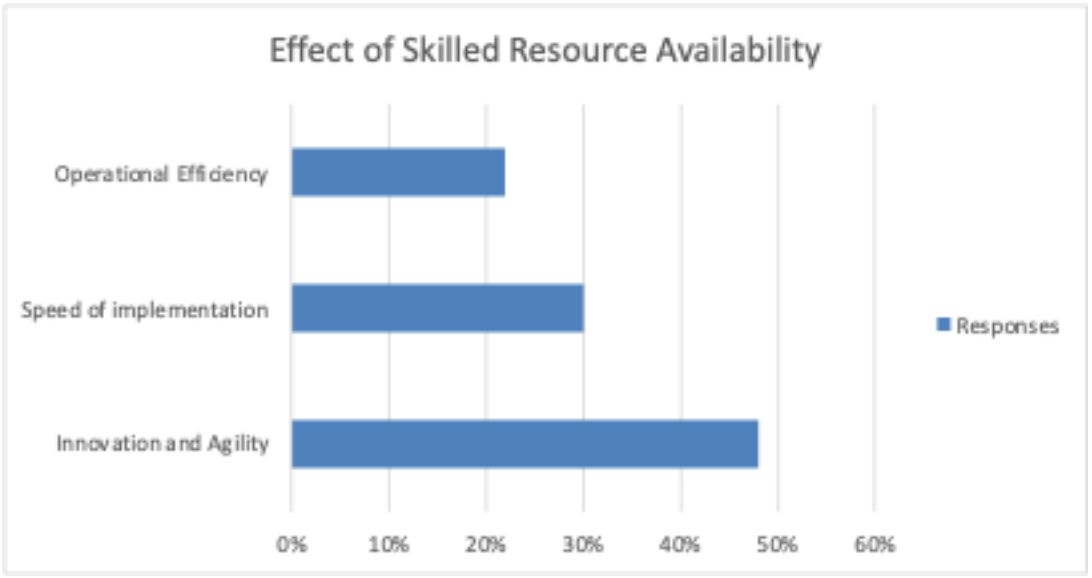

Chart 4.30
Effect of skilled resource availability

48% of the respondents were of the opinion that the innovation and agility is affected the most by the availability of skilled resources. Speed of implementation came in second rank with 30% and operational efficiency at 22% came third.

Innovation and Agility

The availability of skilled resources has maximum impact on innovation and agility while deploying the hybrid cloud. Skilled resources are necessary to drive innovation and ensuring agility in hybrid cloud deployments. While our respondents have already rated

this high, the literature study also seconds the impact that the skilled resources can have on innovation and agility, the same is listed below:

Accelerating Cloud-Native Innovation: Cloud native application development is fast becoming the go to way of building new applications. Team members with expertise in cloud-native technologies, such as containers, microservices, and serverless computing, enable the rapid development of innovative solutions tailored to hybrid environments (Johnson and Lee, 2020).

Quick Turnaround to Business Needs: Skilled teams can reconfigure workloads between on-premises and cloud environments, ensuring flexibility to meet changing business requirements (Miller and Gupta, 2023).

Speed of Implementation

Respondents told us that the availability of skilled resources within their cloud operations team, accelerated the deployment of hybrid cloud solutions. They also helped by being “first-time right”. Their inputs were also very useful in streamlining deployment and provisioning processes and minimizing delays in implementing the workloads. Our study on the effect of availability of skilled resources and their impact on speed of implementation brought up these benefits -

Efficient Deployment of Applications: Skilled teams can rapidly implement hybrid cloud configurations, ensuring faster go-to-market timelines for applications(Brown and Taylor, 2022).

Streamline Integration Processes for on-premises with cloud platforms: Expertise in integrating on-premises systems with cloud platforms minimizes downtime and avoids complications during deployment (Smith and Taylor, 2021b).

Our respondents maintained that the absence of skilled personnel has often led to bottlenecks in the deployment process, resulting in delays in implementation timelines and thus increased costs.

Question 30: Have you experienced enhanced business continuity by adopting Hybrid Cloud Deployment?

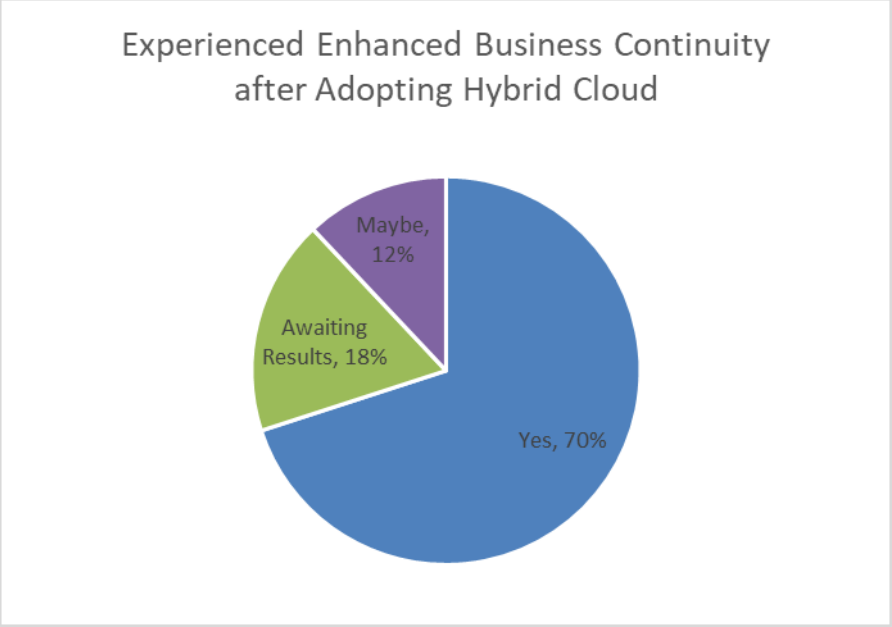

Chart 4.31
Enhanced business continuity after Hybrid Cloud Deployment

70% of the respondents have stated that they have experienced enhanced business continuity after adopting hybrid cloud. This is a big positive and is in line to our literature study. The 12% responses in "Maybe" bucket needs further investigation. When we asked about similar response in my in-person interviews, the respondents were inclined to say yes

but hesitated as they had not experienced any downtimes and were not confident of their preparedness if a downtime were to occur.

We have seen in our earlier responses that Hybrid cloud setups are used for DR use case. They provide a dependable disaster recovery (DR) mechanisms by replicating critical on-premises workloads and data across multiple environments.

Key benefits that contribute towards business continuity observed are:

Reduced Downtime: Hybrid cloud solutions allow organizations to maintain backup systems in the cloud, ensuring seamless failover in the event of on-premises system failures (Johnson and Lee, 2020).

Geographical Redundancy: In the same vein, data and applications can be distributed across different regions, mitigating the impact of localized disruptions such as natural disasters (Brown and Taylor, 2021).

Load Balancing: Hybrid setups allow dynamic workload distribution between cloud and on-premises systems, reducing the risk of overload or failure in either environment (Miller and Gupta, 2023).

Storage Resilience: Data can be stored redundantly across cloud and on-premises environments, ensuring that critical business information remains accessible even during outages (Han and Wang, 2022)

Cloud Bursting: Organizations can temporarily extend workloads to public cloud environments to manage peak demand without overloading their on-premises systems (Smith and Taylor, 2021b).

Rapid Resource Allocation: Hybrid cloud deployments enable quick provisioning of additional resources, ensuring businesses can maintain operations under challenging circumstances (Brown and Taylor, 2022).

Data Segmentation: Sensitive data can remain on-premises while less critical data is stored in the cloud, balancing security with operational flexibility (Johnson and Lee, 2021).

Automated Security Updates: Cloud providers often handle routine security updates, reducing vulnerabilities and maintaining compliance with industry standards (Miller and Gupta, 2023).

This concluded the research query-based questionnaire.

4.4 Summary of findings

Our interviews and survey results have given us insights into all three aspects of the objectives of our research – factors affecting adoption of hybrid cloud, what application workloads are better suited for the deployment on hybrid cloud and the approaches, tools and strategies that can help in the acceleration of hybrid cloud adoption by the enterprises.

- With 170 responses and coverage of over 50 organizations, we have been able to collect in depth insights. While quite a few of these ratify the literature study, we have been also able to identify trends in newer workloads like AI / ML.
- IT managers, cloud architects, business executives formed over 63% of the respondents while we were able to get an adoption related view from customer success representatives as well who formed 14% of the respondents.
- 46% of the respondents have been using hybrid clouds between 3 – 5 years, thus giving us a good insight on adoption over a long period of time.
- 22% of the respondents had over 5 years of exposure to hybrid cloud.

- By web application exposure was highest in terms of the workloads being managed by our respondents.
- 67% of the respondents are already running hybrid cloud.
- Business agility, cloud bursting and cost optimization are the key business cases for adopting hybrid cloud.

4.5 Conclusion

The key factors affecting the adoption have been derived and listed.

1. We have been able to get details of the typical tenure of hybrid cloud usage and have strengthened our understanding about the acceptance to the hybrid cloud approach.

2. 67% of our respondents are already using hybrid cloud while 21% are in their implementation phase of hybrid cloud implementation, this was of immense help as it gave us a practitioner's first-hand view about the hybrid cloud adoption experiences and challenges.

3. We have been able to confirm that business agility, cost optimization and cloud bursting have been the top three use cases for hybrid cloud adoption.

4. The barriers to adoption range from the complexity of integration to lack of expertise to serious security concerns.

5. As expected, scalability is of immense importance with 95% of the respondents stating it to be moderately or more important.

6. The weightage to data security was found to be extremely high while deciding about considerations for adoption of hybrid cloud.

7. The concerns about security were further explained when we asked the respondents about their specific concerns about the public cloud security.

8. Regulatory concerns and guidelines and policy decisions have meant that most organizations still prefer to keep sensitive data on-premises.

9. An increasing amount of OpEx is getting allocated to cloud related expenditure.

10. High costs and limitation on innovation due lack of features have been concerns brought up about vendor lock-in.

11. Latency and QoS influenced the decision to opt for and decide the scope of the hybrid cloud adoption.

12. QoS is the metric that was tracked specifically in terms of performance as well as reliability of the hybrid cloud.

13. Cross cloud integration remains the top challenge in adoption of hybrid cloud followed by the security concerns,

14. Resource availability was key in driving the speed of implementation, the operational efficiency and innovation agility too very highly dependent on the resource availability to a large extent.

Similarly, we have been able to zero in on what applications are the best suited for deployment onto hybrid cloud.

1. Prioritization of which applications to host on hybrid cloud based on the business needs was the most favoured strategy for moving legacy applications for deployment to hybrid cloud.
2. There is a growing trend of decision to retain only those application that can integrate with new age applications.
3. Dev-Test environments, container-based apps and DR are the top three workloads for deployment onto hybrid cloud.
4. The primary requirement of the applications from the hybrid cloud environment is the scalability to handle various workloads. This followed by the cost efficiency and resource optimization.
5. While setting up and selecting the application deployment and provisioning environments on to hybrid cloud, ability to integrate with on-premises systems ranks the highest followed by resource allocation flexibility and cost optimization.
6. In terms of application workloads, hybrid clouds are a model of choice for development- testing environments, followed by web-based applications and AI and ML based workloads which are fast picking up in terms of adoption and deployment onto the hybrid cloud models.
7. Legacy applications, mobile applications and Big Data analytics are seen as hybrid cloud misfits.

And, we have also been able to substantiate with survey responses and literature study the approaches, tools and strategies that have shown positive results in adoption of hybrid clouds.

1. Amongst the top reasons for adopting hybrid cloud are innovation (and digital transformation), scalability and flexibility and cost optimization.
2. The biggest driver for hybrid cloud adoption is the flexibility it provides in terms of data placements and workload distribution. This is followed by the enhanced DR and business continuity capabilities and finally the ability to leverage the existing investments made towards the on-premises infrastructure.
3. Developing a comprehensive hybrid cloud roadmap is the number one ranked approach followed by establishing a comprehensive cloud management platform and prioritizing data migration and modernization initiatives.
4. When it comes to cloud migration strategy a mix of re-architecture, lift and shift and re-platforming is the most favoured strategy.
5. Cloud management platforms (CMPs) are ranked to be the most critical tool for success of hybrid cloud adoption. Security tools and data integration tools follow on second and third rank.
6. Data integration and migration complexities are seen as the biggest challenge faced during the implementation of hybrid cloud. This is followed by skill gaps within the IT team and limitations of the legacy applications.
7. The availability of skilled cloud experts has the highest impact on innovation and agility. It also improves the speed of implementing the hybrid cloud and applications on it and brings operational efficiency.
8. 70% of our respondents have reported that they have experienced enhances business continuity after adopting hybrid cloud.

CHAPTER V:

DISCUSSION

5.1 Discussion of Results

The overall results of the survey have been very insightful. We have been able to understand in lot of detail the drivers and rationale for the adoption of the hybrid cloud, the factors that lead to its adoption and the applications and use cases that are best suited for it. Our research has been focused towards answering these three research questions -

- RQ1 - What are the key factors affecting the adoption of hybrid clouds?
- RQ2 - Are specific types of applications a better choice for deployment on hybrid cloud?
- RQ3 - What are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises?

5.2 Discussion of Research Question One - What are the key factors affecting the adoption of hybrid clouds?

As part of this research, we have conducted interviews and have also sought feedback over an online survey. One of the questions sought the effect of availability of skilled resources. The top ranked answer to that was innovation and agility.

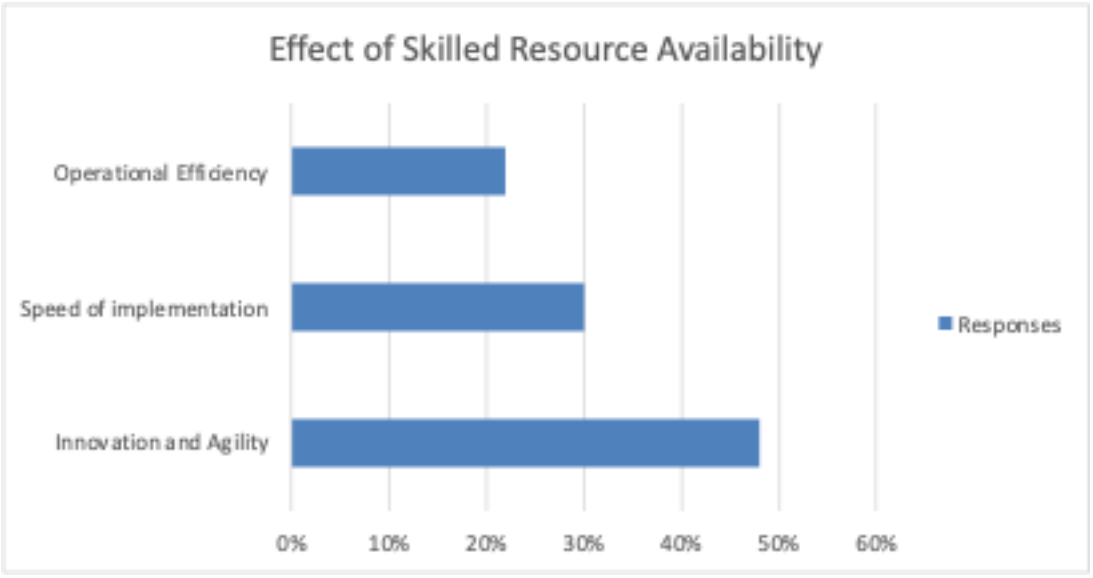

Chart 5.1
Effect of skilled resource availability

The adoption of hybrid cloud solutions has emerged as a critical strategy for organizations not only seeking flexibility, scalability, and cost optimization in their IT infrastructure but also has been a choice of the innovators. The responses that we have received are a testimony to the fact that 48% of them look at hybrid cloud adoption fuelling innovation when skilled resources are made available to them.

We saw this as an opportunity to map the adoption patterns with Everett Rogers' Diffusion of Innovation (DOI) theory, that provides a useful framework for technology adoption. We have tried to analyse the factors influencing the acceleration of hybrid cloud adoption vis a vis Roger's framework (Rogers, 2003).

1. **Adopter Categories and Hybrid Cloud Adoption**
    a. **Innovators –** Innovators were the first to experiment with hybrid cloud solutions. These are typically technology-driven organizations, such as tech startups or enterprises in highly competitive markets, which prioritize agility and innovation. They often adopt hybrid cloud environments to gain a

competitive edge through early access to cloud-native tools and resources (Smith and Taylor, 2021a)

b. **Early Adopters -** Early adopters include organizations with forward-thinking leadership that recognizes the strategic value of hybrid cloud. These companies leverage hybrid cloud to enhance operational efficiency, enable digital transformation, or improve customer experiences. Case studies reveal that early adopters in industries such as healthcare and finance often pave the way for broader adoption by sharing their success stories (Johnson and Lee, 2020).

c. **Early Majority -** The early majority includes risk-averse organizations that adopt hybrid cloud solutions once proven by early adopters. These companies seek hybrid cloud environments for cost optimization and resource flexibility but require clear evidence of ROI and reliability before committing (Miller and Gupta, 2023).

d. **Late Majority -** The late majority consists of organizations hesitant to adopt hybrid cloud due to concerns about complexity, skill gaps, or legacy system compatibility. These companies often require significant external support and assurances, such as managed services or detailed migration roadmaps, to overcome adoption barriers (Brown and Taylor, 2022).

e. **Laggards -** Laggards are the last to adopt hybrid cloud solutions, often driven by external pressures such as regulatory requirements or competitive forces. Their hesitancy is rooted in scepticism or limited resources, and they may only transition to hybrid cloud when on-premises systems become unsustainable (Han and Wang, 2022).

While there are numerous factors that affect the adoption, our research has been able to bring out these key factors –

1. Data integration and migration complexities
2. Skill gaps within the IT team
3. Legacy infrastructure limitations
4. Concerns about locking in with a vendor or set of vendors
5. Security and compliance considerations
6. Cost management and budgeting issues
7. Resistance to change within the organization

If we were to see these considering Rogers' theory, it brings out interesting facets. The innovators would have been the first ones to try out hybrid cloud and they are the ones who would have overcome some or all these challenges listed above.

5.3 Discussion of Research Question Two - Are specific types of applications a better choice for deployment on hybrid cloud?

Not all applications are suited for deployment onto the hybrid cloud. Our study and survey (question# 22), contained in it brought out these following applications as hybrid cloud misfits –

1. Legacy Applications
2. Mobile Applications
3. Big Data Analytics

These applications are difficult to connect to other systems, are prone to have performance problems when moved out of infrastructure that they are tuned to run upon and often have high costs of transferring data to them or from them. Because of these issues, organizations might find it better to use either fully cloud-based or fully on-premises solutions for these types of applications instead of hybrid cloud.

As seen to the response to our survey question #21, the applications that work best with the hybrid cloud are –

1. Development and Test environments
2. Web Applications
3. AI / ML training Models

Development and test environments

The development and test environments are generally required for a shorter duration of time however the need for these environments to be setup is often dynamic. Respondents told us that they have very short turnaround times to deliver dev and test environments. Hybrid cloud if used effectively can present a good solution for on-demand scaling of infrastructure resources without risk of on-premises over provisioning.

Web Applications

Web applications or browser applications are mainstay of all enterprise software. Many of these applications experience varying traffic loads or have seasonal spikes in usage. Such applications are better served by hybrid cloud deployment. A respondent aptly pointed out a scenario wherein he said that the hybrid clouds allowed his organization to deploy web applications on-premises for sensitive data processing and selectively leverage the public cloud infrastructure to scale quickly during peak traffic periods.

AI / ML Workloads

These came in at the third rank with 58% of the respondents alluding to these being found fit for hybrid cloud deployment. This is a new trend and given the fact that these workloads are resource hungry and require high performance compute (HPC), huge storage capacity. The hybrid cloud model is found to be particularly advantageous in this domain as it allows organizations to perform compute-heavy tasks in the public cloud while storing and processing sensitive data on-premises.

Instead of investing heavily in on-premises hardware, organizations can rent cloud resources for intensive AI/ML tasks, significantly reducing capital expenditures (Gartner, 2022).

5.4 Discussion of Research Question Three - What are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises?

Based on our study and the inputs received via interviews and surveys, we have observed that there are certain common approaches that were taken that led to the success in hybrid clod adoption by the early adopters. Here is what they did to address these challenges –

1. **Data integration and migration complexities**

    a. **Middleware Solutions:** One of our respondents mentioned they created a switchboard like code that connected the APIs of cloud providers to their infrastructure as a code (IaaC) scripts and began with semi-automated provisioning. In literature review, we came across this example - Middleware platforms and APIs were used to bridge compatibility gaps between on-premises systems and cloud environments (Brown and Taylor, 2022).

    b. **Phased Migration Strategies:** Many organizations migrated workloads in stages, prioritizing fewer complex applications first to reduce risks and learn from initial implementations (Smith and Taylor, 2021b). This is something that our respondents also alluded to when asked about their migration strategy.

2. **Skill gaps within the IT team**

    a. **Upskilling:** Many of our respondents mentioned that they have tried to build a culture of continuous learning, wherein they are encouraging team

members to upskill and stay abreast with the latest updates in cloud technology. Related example is - Focused training programs and certifications were implemented to prepare IT staff for hybrid cloud management and operations (Miller and Gupta, 2023).

b. **Partnering with Cloud Vendors**: Our respondents stated that on the flip side of vendor lock-in is a tight partnership. The OEMs have been more than willing to provide support to customer teams to help them master their cloud technologies. Collaborations with cloud service providers and system integrators allowed organizations to leverage external expertise while building internal capacity (Han and Wang, 2022).

3. Legacy infrastructure limitations

In response to question #26, respondents had given the following input –

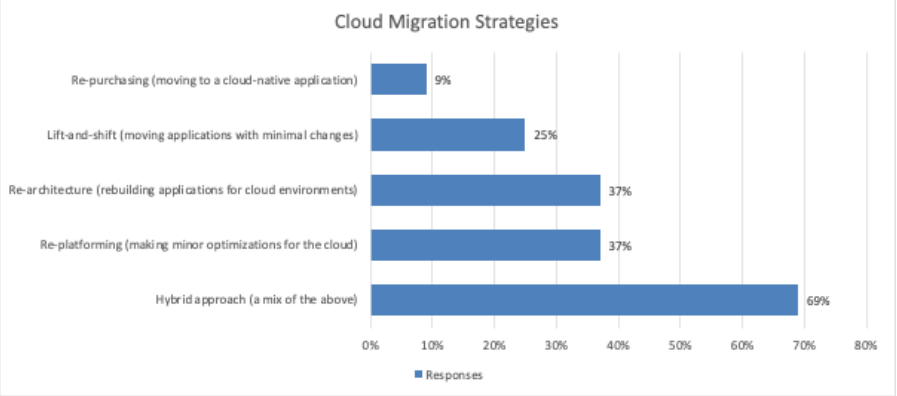

Chart 5.2
Cloud Migration Strategies

A hybrid approach was taken by most of the respondents (69%). They thus adopted the hybrid cloud by doing some or all from the following -

a. **Re-platforming and Refactoring:** Applications were modernized to align with hybrid cloud architectures, enabling better performance and scalability (Johnson and Lee, 2020).

b. **Re-architecture:** Strategic upgrades to storage, networking, and computing hardware facilitated better integration and hybrid cloud readiness (Brown and Taylor, 2022).

Thereby making their legacy infrastructure compatible with the hybrid cloud requirements.

4. **Vendor lock-in concerns**
    a. In our study we have seen via literature reviews, interviews as well as focused survey questions that vendor lock-in is another major challenge faced by organizations when adopting hybrid cloud environments.
    b. The effects of vendor lock-in can be immense, impacting the flexibility, scalability, and cost-efficiency that hybrid cloud environments aim to offer. Vendor lock-in imposes significant challenges, including reduced flexibility and scalability, which hinder hybrid cloud adoption (Brown and Taylor, 2021).
    c. This was countered by tighter partnerships with the OEMs and getting a white glove treatment as an early adopter of a cloud product or products.
5. **Security and compliance concerns**

Our study has found that the adopters of hybrid cloud took proactive efforts to resolve these issues –

a. **Advanced Security Tools:** Solutions such as cloud access security brokers (CASBs) and encryption technologies ensured data protection across hybrid environments (Smith and Taylor, 2021a).
b. **Governance Frameworks:** Organizations have created detailed policies for regulatory compliance with hybrid cloud use (Miller and Patel, 2023).

6. Implementing Centralized Management Platforms

As noted in the response to question # 27, centralized management platform has been quoted by our respondents to be the top ranked tool for successful hybrid cloud automation. Hybrid cloud inherently poses challenges in managing multiple cloud infrastructures and presence of a centralized management platform goes a long way towards managing the diverse cloud infrastructures.

a. **Unified Management Tools:** Platforms like VMware's vRealize and Nutanix's Prism Central provided centralized control over on-premises and cloud resources, streamlining operations (Han and Wang, 2022).
b. **Automation and Monitoring:** Our respondents mentioned extensive use of playbooks, web methods and scripts to monitor and manage the cloud infrastructure. Automated workflows and advanced monitoring tools were employed to optimize resource usage and maintain performance (Johnson and Lee, 2020).

7. Organizational Buy-In

Resistance to change is the biggest barrier that any team that implements new technology adoption faces. Early adopters of hybrid cloud overcame this by –

a. **Demonstrating Value Through small wins:** Small-scale hybrid cloud deployments showcased tangible benefits, building trust and enthusiasm among stakeholders (Brown and Taylor, 2022).
b. **Link Cloud Strategies to Business Outcome:** By linking hybrid cloud initiatives to business outcomes like cost reduction and improved agility, organizations gained executive and cross-functional support (Smith and Taylor, 2021b).

CHAPTER VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

Hybrid cloud adoption has become mainstream constituent of the IT strategies of the organizations. Promising the best of both worlds - flexibility of public clouds and control of private cloud as per the need. The combination benefits of public and private cloud have led to enhanced flexibility, scalability, and security (Maayan, 2023). By 2024, hybrid cloud computing has become very important constituent in digital transformation strategies across industries (Maayan, 2023).

The annual survey by Flexera indicates that organizations are embracing multi-cloud strategies, with Amazon Web Service (AWS) and Microsoft Azure being the front runners (Flexera, 2024). Having said that, adopting the hybrid cloud environment is not easy. A report by backup leader Veeam states that in 2024, 33% of businesses experienced outages due to human error, and 31% faced disruptions because of public cloud unavailability (Schillereff, 2024).

In gist, hybrid cloud adoption is accelerating as organizations seek to leverage the combined advantages of public and private cloud solutions. While offering substantial benefits, it also presents challenges that require careful planning and management to achieve a reliable and efficient infrastructure. These findings are a clear indication that there is a need for in-depth planning, appropriate use case mapping, clear mapping of responsibilities amongst the various providers and stakeholders. The constant evolution of technology and proprietary nature of leading service providers has meant that organizations often must play a catch-up game.

Technologies like AI, machine learning, and edge computing in hybrid cloud frameworks are improving management of resources, data analytics, and data processing capabilities in real-time. This progression is facilitating more efficient operations and supporting the digital transformation initiatives of various industries (Maayan, 2023).

Hybrid cloud computing being crucial in digital transformation is a conclusion that is derived from the fact that it provides IT Operations teams the flexibility to adapt to business changes, scalability for increased workloads, and security for sensitive data. These factors make hybrid cloud essential in digital strategies (Maayan, 2023). While we have enumerated the various advantages that the hybrid cloud approach has to offer, one can't overlook the challenges that still exist –

1. IT teams continue to cope up with the problems pertaining to safe keeping of data, adhering to organization guidelines, ensuring seamless communication amongst applications and datacentres.
2. Ability to have true portability of workloads, absolute interoperability remains a distant dream
3. Skilling teams remains as big a challenge as it ever was.

But this is not stopping the organizations from embracing the adoption of hybrid cloud (Maayan, 2023). Considering these facts, our research would be a good reference for those who wish to implement their hybrid clouds. We believe that our research will be useful for organizations who are at the vision / planning stage of research as well as to those organizations who have already implemented hybrid clouds.

6.2 Implications

Our study of available literature and first-hand research by way of interviews, survey and derivation of results has been an insightful process. An ever-evolving training plan that is built in partnership with the OEMs and service providers, Operations management that is in tune with the needs of current day and age and comprehensive disaster recovery plans need to stitch together to ensure success of the hybrid cloud infrastructures. Our research has been focused towards answering these three research questions

- RQ1 - What are the key factors affecting the adoption of hybrid clouds?
- RQ2 - Are specific types of applications a better choice for deployment on hybrid cloud?
- RQ3 - What are the various approaches, tools and strategies that can help the acceleration of hybrid cloud adoption by the enterprises?

Answers derived against each of the three research questions has potential to guide the readers on the respective individual aspects of the hybrid cloud adoption journey. Our first research query sought the key factors that affect the adoption of hybrid cloud. While there are numerous factors that affect the adoption, our research has been able to bring out these key factors –

1. Data integration and migration complexities
2. Skill gaps within the IT team
3. Legacy infrastructure limitations
4. Concerns of being locked in with a set of vendors
5. Concerns about security and compliance
6. Cost management and budgeting issues
7. Resistance to change within the organization

Data Integration and Migration Complexities

Our respondents called out that the data integration and migration as the topmost challenge in the hybrid cloud adoption. The process involves consolidating data from diverse systems, ensuring seamless communication between on-premises infrastructure and cloud platforms, and migrating large datasets while maintaining data integrity, security, and performance. The complexities associated with these tasks often serve as significant barriers to the successful implementation of hybrid cloud environments (Sharma et al., 2021).

A. Integration Challenges

1. Heterogeneous Systems

Hybrid cloud environments by design, host multiple systems, including legacy on-premises systems, private cloud infrastructures, and public cloud services. Integrating these heterogeneous systems requires standardized data formats, protocols, and interfaces, which are often lacking. For instance, legacy systems may use outdated protocols incompatible with modern cloud services, necessitating custom solutions for integration (IDC, 2022a).

2. Data Silos

Organizations often struggle with data silos—isolated pockets of data residing in different systems or departments. These silos hinder the free flow of information across the hybrid environment, complicating integration efforts and reducing the overall efficiency of data utilization (Gartner, 2024).

3. Real-Time Synchronizations

Ensuring real-time data synchronization between on-premises systems and cloud platforms is another critical challenge. Differences in data update frequencies, latency issues, and bandwidth limitations can lead to inconsistencies, impacting operational decision-making (Cisco, 2021).

B. Migration Complexities

1. Large Dataset Transfers

Transferring loads of data from on-premises systems to cloud platforms can be a demanding and resource-intensive process. Bandwidth limitations, network latency, and the risk of data corruption during transfer add to the complexity of the migration process (White and Sjelin, 2022).

1. **Data Integrity and Security**

Maintaining data integrity and security during migration is paramount. Data corruption, loss, or unauthorized access during migration can have severe implications for business operations and compliance. Organizations must implement robust encryption, validation, and monitoring mechanisms to mitigate these risks (AWS, 2020).

2. **Application Dependencies**

Data migration often involves moving interconnected applications and their associated data. Resolving application dependencies, such as linked databases or hardcoded configurations, is a complex task that requires thorough planning and execution (Sharma *et al.*, 2021).

3. **Downtime and Business Continuity**

Managing downtime and keeping it to minimum during migration is critical to ensuring uninterrupted business operations. However, achieving a seamless transition often requires advanced planning, redundancy mechanisms, and testing, which can increase the complexity and cost of the migration process (Forrester Research, 2020).

C. Tools and Strategies for Mitigating Challenges related to data integration and migration complexities

1. Data Integration Platforms

Leveraging modern data integration platforms, such as Apache Kafka, MuleSoft, and Talend, can simplify the integration of diverse systems. These tools provide connectors and APIs for seamless communication between on-premises and cloud environments (Gartner, 2024).

4. **Hybrid Data Management Solutions**

Hybrid data management tools, such as Azure Arc and Google Anthos, enable organizations to manage and integrate data across on-premises and cloud platforms using a unified interface, reducing the complexity of multi-environment data operations (IDC, 2022a).

5. **Phased Migration Approaches**

Adopting a phased approach to data migration—starting with non-critical data and applications—allows organizations to test and refine their migration strategies before scaling up. This reduces the risk of disruption and ensures a smoother transition (AWS, 2020).

6. **Data Governance Frameworks**

Implementation of effective frameworks for governance of data helps organizations address challenges related to data quality, security, and compliance. These frameworks ensure that data migration processes adhere to industry regulations and organizational policies (Cawthra *et al.*, 2020).

D. Organizational Challenges

1. **Lack of Expertise**

The technical expertise required to manage complex integration and migration processes is often scarce, particularly in the not so large enterprises. This skill gap can delay adoption and increase costs (Gartner, 2024).

2. **Budget Constraints**

The financial resources needed for purchasing integration tools, hiring skilled personnel, and implementing advanced migration strategies can be prohibitive for some organizations, especially those operating on tight budgets (IDC, 2022a).

E. Significance for Adoption

It is derived that addressing the complexities of data integration and migration is a critical factor enabling the successful adoption of hybrid cloud environments. These data integration and migration complexities, which are often rooted from heterogeneous systems, multiple data silos, and real-time synchronization needs, require strategic actions.

Organizations can mitigate these challenges by utilizing advanced data integration platforms such as Apache Kafka and Talend, adopting phased migration strategies, and implementing robust data governance frameworks (Cawthra *et al.*, 2020). Additionally, investments in skill development and training for IT personnel are pivotal in ensuring seamless execution and long-term operational success (Sharma *et al.*, 2021). By adopting such approaches, organizations can not only overcome barriers to hybrid cloud adoption but also unlock its transformative benefits, including scalability, cost efficiency, and enhanced innovation potential (Forrester Research, 2020).

Skills and Expertise

The availability of skilled personnel is a decisive factor in the pursuit of selection, adoption and management of hybrid cloud environments. Hybrid cloud solutions involve the integration of multiple platforms, requiring a unique combination of technical, managerial, and strategic capabilities. A shortage of expertise in these areas can pose a significant barrier to adoption, particularly for organizations transitioning from traditional IT infrastructures (Gartner, 2024).

A. Core Technical Skills

Adoption and running of Hybrid clouds require a skilled workforce having skills in multiple technical domains –

1. **Cloud Platform Management:** Proficiency in configuring and managing public cloud platforms is essential. Each platform has unique features and tools that require specialized knowledge (AWS, 2024).
2. **Network Architecture:** Understanding the intricacies of networking in hybrid environments, including virtual private networks (VPNs), cloud interconnects, and software-defined networking (SDN), is critical for seamless connectivity (Cisco, 2021).
3. **Security and Compliance:** Expertise in implementing security measures that are robust is a key skill. Teams that can implement foolproof encryption and design and deploy identity and access management (IAM), and compliance with regulations like GDPR and HIPAA are in demand (White and Sjelin, 2022).
4. **Automation and Orchestration:** Knowledge of automation tools such as Terraform, Ansible, and Kubernetes is increasingly important for streamlining deployment and management processes (Forrester Research, 2020).

B. Soft Skills and Strategic Thinking

In addition to technical expertise, the successful adoption of hybrid cloud environments requires strong soft skills and strategic capabilities:

1. **Change Management:** Individuals must manage resistance to change and foster collaboration among teams to facilitate the transition to the change, in our case - hybrid cloud (Kotter, 1996).
2. **Problem-Solving:** The ability to diagnose and resolve complex issues in hybrid environments is essential for minimizing downtime and ensuring operational continuity (Gartner, 2024).

3. **Project Management:** Skills in planning, resource allocation, and risk assessment are critical for overseeing hybrid cloud implementation projects (PMI, 2021).

C. Training and Skill Development

To address skill gaps, organizations must invest in comprehensive training and skill development sessions. These initiatives could include:

1. **Vendor-Specific Certifications:** AWS and Microsoft's certifications AWS Certified Solutions Architect, Azure Administrator (from Microsoft), Nutanix's NCP - Nutanix Certified Professional and Google's Cloud Professional Cloud Architect help professionals gain expertise in managing specific cloud platforms (Comptia, 2024).

2. **Workshops and Bootcamps:** Hands-on training sessions and bootcamps enable IT teams to acquire practical knowledge in deploying and managing hybrid cloud solutions (Greenspan, 2024).

3. **Ongoing Learning:** Given the rapid evolution of cloud technologies, continuous learning through online courses, instructor led trainings and design workshops is necessary for the team to stay updated (Nutanix, 2024) .

D. Organizational Challenges

Despite training, bootcamps and ongoing training from OEMs many organizations still face challenges in bolstering the required cloud expertise and keeping it up to date. Here are a few of these challenges that we came across in interviews with the teams and in literature review –

1. **Talent Shortages:** Globally, the demand for cloud professionals far exceeds the supply, leading to increased competition for skilled talent (IDC, 2022a).

2. **Resource Constraints:** Smaller organizations often struggle to allocate sufficient resources for training and development programs (Sharma *et al.*, 2021).
3. **Knowledge Retention:** A major challenge that we saw being quoted was the high employee turnover rates. These may result in the loss of acquired knowledge and expertise, necessitating ongoing recruitment and training efforts (Gartner, 2024).

E. Importance of Collaboration

To bridge skill gaps, organizations can adopt collaborative approaches, such as:

- **Partnerships with Cloud Providers:** Collaborating with cloud service providers for customized training programs and design workshops. Signing up for dedicated resident engineers and technical account managers, is also a good option to bolster the skills and keep them updated with the latest developments in the products.
- **Outsourcing:** Another good approach would be to look beyond the internal teams and OEMs and engage managed service providers (MSPs) with specialized expertise to manage hybrid cloud operations (Forrester Research, 2020).
- **Cross-Team Knowledge Sharing:** In this age of DevOps, silos cannot be allowed to thrive. Special efforts need to be taken for encouraging collaboration between IT and business teams to align technical capabilities with organizational goals (Kotter, 1996) .

E. **Significance for Adoption**

Our finding through the literature reviews and conversations with the IT leaders has got us to the conclusion that the availability of skilled personnel is not just a technical requirement but a very important strategic enabling factor for hybrid cloud adoption. Organizations should focus and prioritize skill development, incubate internal programs for

continuous learning. This will help the organizations overcome barriers to adoption, optimize resource utilization, and achieve long-term success in hybrid cloud environments.

Security and Compliance

We see concerns being raised, regarding data security and compliance with various regulations as a critical adoption factor for hybrid cloud environments. Organizations seek expert guidance to ensure that sensitive data is handled securely across public and private cloud platforms. This must be done while adhering to regulatory requirements such as GDPR, HIPAA, and other industry and country specific standards. IT / Cloud teams thus seek to balance the benefits of cloud flexibility vis a vis the risks associated with distributed cloud environments born out of hybrid cloud. The hybrid cloud model necessitates managing data and applications across public and private cloud platforms, as well as the organizations on-premises infrastructure. This cross platform, cross data centre and multi-provider distributed nature introduces unique challenges in ensuring the security of sensitive information and adhering to regulatory requirements. This distributed nature introduces unique challenges in ensuring the security of sensitive information and adhering to regulatory requirements (Sharma *et al.,* 2021).

A. Data Security

In interviews, cloud architects and IT leaders were very vocal about the concerns is the security of "data in transit", i.e. data as it moves between different environments within the hybrid cloud deployment. This inflight data must be protected from threats like data injection, unauthorized access, and loss of data. The specific data security challenges called out can be resolved in following ways –

1. **Data Encryption:** Organizations should ensure that the data in their purview is always protected and encrypted. Irrespective of whether it is at rest and while in transit they will have to prevent access by those who are not authorized to do so (White and Sjelin, 2022).

2. **Role Based Access Control (RBAC):** Cloud management platforms and public cloud providers, both provide identity and access management (IAM) features which can be leveraged to provide secure user authentication and authorization to cloud based assets irrespective of where they reside and state of the data (Turner *et al.*, 2021).

3. **Threat Identification and Reporting:** The need to conduct real-time monitoring across the hybrid cloud infrastructure for the detection of malicious activities, unauthorized intrusions or even ransomware attacks can be addressed by deploying real time threat monitoring and detection in a centralized manner with focus on distributed workloads (Sabahi, 2011).

4. **Security Patches:** It is recommended that all the systems are updated to the latest versions of their respective software. Operating Systems (OS) should especially be regularly updated to address vulnerabilities and prevent exploitation by cyber attackers (Microsoft, 2023).

B. **Regulatory Compliance -** Hybrid Cloud infrastructure is deployed across environments that may span across countries. This amplifies the compliance challenges in manifold way. This is so because the applications may store and process data across regions which are governed by multiple jurisdictions and varying legal guidelines. The hybrid cloud model must support compliance with diverse regulatory frameworks, such as:

1. **GDPR (General Data Protection Regulation):** For organizations handling data of European Union residents, ensuring compliance with stringent data protection requirements is critical (European Commission, 2020).

2. **HIPAA (Health Insurance Portability and Accountability Act):** For the organizations from the healthcare sector, compliance with HIPAA ensures the protection of patient data (HHS, 2021).

3. **Indian Regulatory Frameworks:** In India, organizations must comply with laws such as the IT Act, Data Protection Bill (if enacted), and sector-specific regulations like those issued by the Reserve Bank of India (RBI) for financial institutions (MeitY, 2021).

Organizations must adopt a proactive approach by establishing clear data residency and sovereignty policies (Sharma *et al.*, 2021). Another recommendation would be of implementing compliance automation tools to continuously monitor and ensure adherence to regulatory standards (IDC, 2022a) and by working closely with cloud service providers to understand shared responsibility models and ensure compliance support (AWS, 2020).

C. **Risk Mitigation** –

To address the security and compliance challenges in hybrid cloud environments, organizations should focus on implementing the following strategies:

1. **Zero Trust Architecture:** Adopting a "never trust, always verify" approach ensures that all access requests are thoroughly validated, regardless of their origin (Turner *et al.*, 2021).
2. **Security Posture Management:** Leveraging tools for centralized visibility and control over security configurations across all environments (Gartner, 2024).
3. **Data Classification and Segmentation:** Categorizing data based on sensitivity and ensuring critical data remains in highly secure environments, such as private clouds or on-premises infrastructure (Sharma *et al.*, 2021).

4. **Incident Response Plans:** Continued and persistent developing and testing of response protocols with the aim of minimizing downtime and data loss in the event of a security breach (IBM, 2024).
5. **Collaboration with Providers:** Ensuring that cloud service providers offer robust security features, including encryption, compliance certifications, and auditing capabilities (AWS, 2020)

C. **Challenges in Implementation**

Despite the availability of advanced security tools and compliance frameworks, many organizations face challenges, including -

1. **Lack of Expertise:** Managing complex security and compliance requirements across hybrid environments often requires specialized skills (IDC, 2022a).

2. **Cost Implications:** Implementing robust security measures and compliance frameworks may require significant financial investment (Gartner, 2024).

3. **Dynamic Threat Landscape:** As cyber threats evolve, organizations must continuously update their security systems to address new vulnerabilities (IBM, 2024) .

4. **Integration Complexities:** Ensuring seamless integration of security tools across diverse hybrid environments can be technically challenging (Dissanayake et al., 2022).

D. **Significance for Adoption**

Addressing security and compliance concerns effectively can significantly enhance trust in hybrid cloud adoption. Cloud providers, cloud management platforms and end customers should implement and strengthen the ability to protect sensitive data and adhere to regulatory standards. By demonstrating the ability to protect sensitive data and adhere to regulatory standards, organizations can overcome one of the primary barriers to hybrid

cloud adoption, paving the way for greater operational flexibility and innovation (Sharma *et al.*, 2021).

6.2.4 Legacy Infrastructure Limitations

Seamless integration is a cornerstone for the adoption of hybrid cloud environments. The on-premises infrastructure (private cloud) and the public cloud platforms need to be integrated for the functioning of the applications that they host. However, legacy infrastructure often presents a significant barrier due to their inherent limitations, which impede the transition and optimal utilization of hybrid cloud solutions. These limitations arise from outdated technologies, rigid architectures, and operational inefficiencies that conflict with the ever-evolving footprint of hybrid cloud environments (Gartner, 2024).

A. Inability to Support Cloud-Native Features

Container based applications are a norm these days. The legacy infrastructure is not designed to support modern cloud-native technologies such as dockerized application images, microservices, containerization, and orchestration tools like Kubernetes. The dynamic resource management that these technologies depend upon is non-existent in the legacy infrastructure. These new “born in” and “born for” the cloud technologies form the backbone of hybrid cloud environments, enabling agility, scalability, and flexibility. Legacy systems, which often operate on monolithic architectures, lack the modularity required for hybrid cloud integration, forcing organizations to undertake extensive refactoring or replacement of their existing systems (IDC, 2022a).

B. Integration Barriers

Our respondents alluded to the fact that a key challenge in hybrid cloud adoption is ensuring seamless integration between legacy systems and cloud platforms. Legacy systems often utilize proprietary protocols, outdated APIs, and incompatible data formats that do not align with modern cloud standards. These incompatibilities necessitate the use of

middleware or custom integration solutions, which increase complexity and cost while introducing additional points of failure (Forrester Research, 2020).

C. Performance Constraints

Hybrid cloud environments rely heavily on the efficient transfer and processing of data between on-premises systems and the cloud. Legacy infrastructure often struggles to meet the performance requirements of hybrid cloud due to limitations in network bandwidth, outdated storage mechanisms, and insufficient processing power. These constraints lead to bottlenecks that can degrade the performance of hybrid applications and impact user experience (Sharma *et al.*, 2021).

D. Security and Compliance Challenges

Legacy systems are seen to be lacking the advanced security features necessary to meet the stringent requirements of hybrid cloud environments. The absence of real-time monitoring, modern encryption protocols, and automated compliance mechanisms makes legacy systems vulnerable to breaches. Additionally, integrating these systems into a hybrid cloud setup often exacerbates security risks, as sensitive data must be transferred and accessed across multiple environments (White and Sjelin, 2022).

E. Operational Rigidity

Hybrid cloud environments offer scaling and elasticity. They therefore require flexible and scalable infrastructure to adapt to dynamic workloads. Legacy systems, however, are characterized by their rigidity, often requiring manual intervention for scaling or configuration changes. This lack of agility conflicts with the automated and elastic nature of hybrid cloud platforms, creating operational inefficiencies and limiting the ability to respond quickly to business needs (Gartner, 2024).

F. Dependency on Legacy Applications

Many organizations are locked into legacy applications that are critical to their operations but are difficult to modernize or migrate. These applications may rely on outdated databases, hardcoded configurations, or vendor-specific technologies that are incompatible with cloud platforms. Resolving these dependencies often requires significant investment in re-architecting or rebuilding applications, which delays hybrid cloud adoption (IDC, 2022b).

G. High Costs of Transition

The financial implications of addressing legacy infrastructure limitations are substantial. Organizations must allocate resources for upgrading hardware, modernizing software, and training personnel to manage hybrid environments. These costs, combined with the potential for operational disruption during the transition, deter many organizations from fully embracing hybrid cloud solutions (Forrester Research, 2020).

H. Impact on Hybrid Cloud Adoption

The limitations of legacy infrastructure pose a substantial challenge to the adoption of hybrid cloud solutions. Overcoming these barriers requires a strategic approach that includes:

Incremental Modernization: Start with an application portfolio review, classify and prioritize which applications can be refactored. Then, initiate a gradual refactoring of legacy systems to align with cloud-native principles.

Hybrid Integration Platforms: We would recommend the adoption of tools such as MuleSoft or Talend to facilitate the evolution gap between legacy and cloud systems. Evaluate these tools by trying out representative use cases as problem scenarios. An

assessment of the effort involved, results achieved can then be made and appropriate integration policy can then be drafted.

Skills Development: A well thought through, cloud training initiative is a must. This must be aligned to the route to cloud plan of the organization. The rapid enhancements in the various cloud technologies can be overwhelming for the practitioners, let alone newbies. We recommend that organizations foster partnerships with OEMS and seek their input while investing in training for IT staff to manage and optimize hybrid cloud operations. By addressing these challenges, organizations can accelerate their hybrid cloud adoption and realize its full potential.

6.2.5 Vendor Lock-in

In our study we have seen via literature reviews, interviews as well as focused survey questions that vendor lock-in is another major challenge faced by organizations when adopting hybrid cloud environments. Vendor lock-in refers to the dependency on a particular cloud service provider (CSP) for infrastructure, services, and tools, resulting in challenges and high exit barriers to migrate to another provider or even to adopt a multi-cloud or hybrid cloud strategy. The effects of vendor lock-in can be immense, impacting the flexibility, scalability, and cost-efficiency that hybrid cloud environments aim to offer. Vendor lock-in imposes significant challenges, including reduced flexibility and scalability, which hinder hybrid cloud adoption (Brown and Taylor, 2021).

A. Reduced Flexibility

While there are quite a few similar services offered by various cloud providers, there are vendors who are preferred for certain services, certain workloads as well as in certain industries and geographies. Cloud service providers often use proprietary technologies and APIs that are incompatible with other platforms, making it difficult to integrate or migrate workloads seamlessly across hybrid environments (Gartner, 2024).

Case in point is serverless functionality. For example, an organization which is heavily reliant on AWS-specific tools like AWS Lambda may face significant hurdles if it decides to adopt Microsoft Azure for part of its workload due to differences in API structures and toolset. The code written for Lambda will not work as is in Microsoft functions.

B. Increased Costs

In the long run, dependency on one provider is prone to a risk of having limited say in the cost of services. Cloud providers already charge an egress fee for data flowing out of their cloud workloads. Additionally, reliance on a single provider may result in higher subscription costs due to a lack of competitive pricing pressure (Forrester Research, 2020). The cost saving potential of hybrid cloud adoption is thus restricted due to such cost escalations which creep in due to the vendor lock-in.

C. Interoperability Challenges

Vendor lock-in can limit interoperability between on-premises systems and cloud platforms, which is crucial for hybrid cloud environments. Proprietary tools and formats often create data silos, complicating the integration of workloads across environments. This limitation hinders an organization's ability to achieve real-time data synchronization and seamless operations, reducing the overall efficiency of hybrid cloud adoption (Sharma *et al.*, 2021)

D. Impact on Innovation

When signed up for a cloud provider, the organizations are at their mercy in terms of their architecture, deployment and monitoring approach. This is so especially because they must build their roadmap around the features made available by the cloud provider. A big cause of this is that it's near impossible to try a new technology or approach. This dependency prevents organizations from adopting emerging technologies or best-of-breed

solutions available from other providers, reducing their ability to innovate and adapt to changing business needs (IDC, 2022).

E. Security and Compliance

Security norms supported by the cloud provider takes the front seat, thereby adding an additional set of security and compliance related challenges. Organizations may find it difficult to implement consistent security policies and compliance frameworks across different environments if they are restricted to the tools and features of a single provider. This lack of uniformity increases the risk of non-compliance and data breaches, particularly in industries with strict regulatory requirements (White and Sjelin, 2022).

F. Mitigating the Vendor Lock-in impact –

We would recommend following strategies to minimize the effects of vendor lock-in –

1. **Technology Roadmap –** Focused priority should be extended towards using open standards as far as possible. It always gives importance to portability. For example, instead of going for AWS or Microsoft's proprietary technologies i.e. Amazon's "Elastic Kubernetes Service" (EKS) and their "Managed Kubernetes Service" (AKS), we would recommend the use of portable technologies such as plain vanilla Kubernetes or OpenShift or Nutanix NKP. These are not bound to the public service provider thereby making it easy to host them elsewhere if the initial choice is no longer a viable one.

2. **Go Multi-Cloud** – Diversification is the key, don't put all eggs in the same basket! Having diversified workloads across multiple cloud providers as a policy decision will be of immense help in fulfilling the aim of reducing dependence on a single vendor.

3. **Data Governance** – Invest in compiling an exhaustive data governance framework that calls out the governance practices and makes it easy to migrate data across multiple cloud platforms.
4. **Contracts and Agreements -** Careful evaluation of vendor contracts and terms can help organizations avoid restrictive agreements and ensure greater flexibility (Forrester Research, 2020).

F. Significance for Hybrid Cloud Adoption

Vendor lock-in hits flexibility, scalability, and cost optimization which are the core principles of hybrid cloud adoption. Organizations must proactively focus on ensuring that they follow a multi-vendor policy and ensure that the application design and deployment strategy uses multiple cloud providers as a standard operation procedure. Secondly, adoption of open standards, multi-cloud strategies, and well thought through migration frameworks can surely help organizations in mitigating the risks of vendor lock-in and ensure a seamless hybrid cloud adoption journey.

6.3 Recommendations for Future Research

When we started this research three years back, hybrid cloud adoption although mainstream was not being looked at as anything beyond the state of the overall infrastructure when public and private clouds are used by the same organization. Quite a few things have changed and there are a few more aspects that can be researched further.

1. **Multi cloud management platforms –**

A growing number of organizations are turning to multi-cloud strategies to mitigate risks associated with vendor lock-in and ensure resilience. Future research could explore the

creation of advanced multi-cloud management platforms that seamlessly integrate and manage workloads across diverse cloud providers, out of the box. The focus could be on developing tools that offer centralized control, automation, and optimization of workloads across private and public cloud infrastructures.

Potential Outcome: Derivation of specs for the potential tools and frameworks that enable businesses to optimize workloads across multiple cloud environments, enhancing performance, flexibility, and disaster recovery capabilities while avoiding dependency on a single cloud provider.

1. **Optimum use of Hybrid Cloud for hosting cloud native technologies –**

As noted in our research, Cloud-native technologies such as microservices, containers, and Kubernetes are being deployed in hybrid cloud environments in a big way. A key driver to this move is the aim to improve scalability and efficiency of application deployment and provisioning environments.

We believe that future research should investigate how hybrid cloud environments can be optimized and integrated with cloud native technologies to provide a seamless deployment, provisioning and management experience to the organizations deploying cloud native applications. As mentioned above, this should be aimed at providing greater flexibility, scalability, and resilience for enterprise applications.

Potential Outcome: Templates, accelerators for use of hybrid cloud solutions that are built for enhanced performance of cloud-native technologies.

2. **Hybrid Cloud Resource Allocation using AI**

Artificial intelligence (AI) and machine learning (ML) have disrupted many aspects of technology creation and deployment. There is potential to study how AI and ML can be leveraged in Hybrid cloud adoption. Future research should focus on how AI and ML can predict workload demands and automatically allocate resources across hybrid clouds. This

research should explore how these technologies can help optimize performance, reduce costs, and ensure that resources are effectively distributed.

Potential Outcome: AI-driven hybrid cloud resource allocation systems capable of predicting workload requirements, dynamically adjusting resource distribution, and improving efficiency and cost-effectiveness in hybrid cloud infrastructures.

6.4 Conclusion

In conclusion, successful acceleration of hybrid cloud adoption requires organizations to address both technical and organizational challenges. This thesis outlines the key drivers and barriers associated with hybrid cloud adoption, highlighting the need for comprehensive strategies that encompass cost management, security, interoperability, and governance. The proposed research areas present opportunities to further refine hybrid cloud solutions, making them more accessible, secure, and efficient for businesses of all sizes. As organizations continue to embrace hybrid cloud, the insights presented here underscore the importance of ongoing research and innovation in this field. By overcoming the current obstacles and addressing the emerging needs of the digital economy, businesses will be well- positioned to leverage the full potential of hybrid cloud infrastructures and achieve sustained growth and competitiveness in the future.

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APPENDIX A

SURVEY COVER LETTER

Accelerating adoption of Hybrid Clouds

Doctorate Research Study of Manoj Mone

Survey form for collecting information for doctoral research being pursued by Manoj Mone

Researcher Name: Manoj Mone

Researcher Contact details: manoj@ssbm.ch

https://www.linkedin.com/in/manojmone

Research details: Doctoral Research at Swiss school of Business & Management, Geneva

Time Required: Up to 25 Minutes

Introduction:

You are invited to participate in a research study being conducted by Manoj Mone for fulfilment of his DBA (Doctorate in Business Administration) program requirements. If you have any questions or feedback, please feel free to reach out to him on manoj@ssbm.ch

Description of Research:

The aim of this research is to study hybrid cloud adoption and find the various factors that affect this adoption. This study aims to understand the challenges that bog down the teams embarking on the Hybrid Cloud adoption journey and aims to find various steps that can be taken to accelerate the adoption of hybrid cloud.

Risk associated & Confidentiality:

This study will have no risk associated with any of the participants. It simply asks participants to reflect on their observations without holding any liability on them. The result of this participation will be confidential and used only for the specific purpose of supporting the research. This is an online survey, and all personal details will be treated confidentially & de-identified post the conclusion of research.

Acknowledgement & Gratitude:

Your time and expertise are valuable and your participation in this study will contribute significantly to this research that aims to help the future initiatives in hybrid cloud adoption.

APPENDIX B

INFORMED CONSENT

Research title: Recommending best practices for accelerating Hybrid cloud adoption

Researcher: Manoj Mone

Research Participants name:

Participation and Consent Agreement

Thank you for agreeing to participate in this research project. This document outlines the terms and conditions of your participation, including your rights, the purpose of the research, and how the information you provide will be used. Your participation is entirely voluntary, and by signing this agreement, you acknowledge and accept the following terms:

Duration of Participation:

The interview is expected to last approximately 25 minutes.

Right to Withdraw:

You retain the right to discontinue your participation in the interview or withdraw from the research project at any time without providing any explanation or incurring any penalty.

Purpose and Scope:

This research aims to study hybrid cloud adoption and find the various factors that affect this adoption. The information collected during the interview will be used solely for the purposes outlined in the accompanying information sheet, which forms an integral part of this agreement.

Ethical Considerations: Ethical research standards require participants to explicitly consent to the interview and to the use of the information they provide. This consent

agreement is intended to confirm that you understand the purpose of the research and the conditions of your participation.

Confidentiality and Data Security:

All information provided during the interview will be treated as confidential and will be stored in compliance with applicable data protection laws and institutional guidelines. Your identity will not be disclosed in any reports or publications resulting from this research unless you have provided explicit written consent to do so.

Acknowledgment of Understanding: By signing this agreement, you acknowledge that:

A. You have read and understood the attached information sheet.
B. You agree to participate in the research under the terms specified.
C. You consent to the use of your responses for the purposes stated, subject to the conditions outlined.

No Anticipated Risks:

While no risks are anticipated as a result of your participation, you have the right to terminate the interview or withdraw at any time should you feel uncomfortable or unwilling to continue.

Contact Information:

For any questions or concerns regarding your participation or the research, you may contact the research team at manoj@ssbm.ch

Next Steps: Please review the attached information sheet carefully. If you agree to the terms and conditions outlined above and in the accompanying document, kindly sign and date this agreement to indicate your informed consent.

Consent to Quotation, Publication, and Use of Interview Content

I, the undersigned, acknowledge and agree to the following terms regarding the use of the information and statements I provide during the interview:

Direct Quotation Consent

I, understand that my words may be quoted directly in the research. With regard to being quoted, I agree to the statements I have initialled below:

_____I wish to review the notes, transcripts, or other data collected during the research pertaining to my participation.

_____I agree to be quoted directly.

_____I agree to be quoted directly provided that my name is not published, and a pseudonym is used.

_____I agree that the researchers may publish documents that include quotations from me.

Use of Interview Content

I understand that all or part of the content of my interview may be used in the following ways:

1. In academic papers, policy papers, or news articles.

2. On the research project's website and in other media produced by the researchers, including spoken presentations.

3. At feedback events related to the research. As part of an archive of the project as described in the accompanying Information Sheet. **Acknowledgment and Agreement By** signing this form, I confirm that I have read, understood, and agree to the following terms:

1.I am voluntarily participating in this research project.

2. I understand that my participation is entirely optional, and I may withdraw from the interview at any time without consequence.

3. The transcribed interview or extracts from it may be used in the manner described above.

4. I have reviewed the accompanying Information Sheet and understand its contents.

5. I do not expect to receive any compensation or other benefits for my participation in this research.

6. I may request a copy of the transcript of my interview and have the right to propose edits to ensure that any agreement regarding confidentiality is upheld.

7. I have had the opportunity to ask questions about the research and my participation, and

8. I understand that I may contact the researcher in the future with any further questions or concerns.

Participant Name: _____

Signature: _____

Date: _____

Researcher Name: _____

Signature: _____

Date: _____

This research has been reviewed and approved by the Swiss School of Business Management. If you have any further questions or concerns about this study, please contact:

Name of researcher – Manoj Mone

Full address – A9/28, Comfort Zone, Baner – Balewadi Road, Pune 411045

Tel - +91 9860367070

E-mail: manoj@ssbm.ch

You can also contact Manoj's supervisor:

Name of research supervisor - Dr. Anna Provodnikova

Full address - Avenue des Morgines 12, 1213 Petit Lancy/Geneva, Switzerland

Tel - +41 (0)22 508 7796

E-mail: anna@ssbm.ch

APPENDIX C

INTERVIEW GUIDE

The following section presents the comprehensive interview guides employed to collect data across various methods. These guides are tailored for diverse communication channels, including face-to-face interactions, observations, Zoom/WhatsApp conversations, emails, and telephone interviews. Each guide is designed to ensure consistency, depth, and relevance in data collection, regardless of the medium used.

A Semi Structure Interview Guide (Face to Face)

A1 Research Topic

Recommending best practices for accelerating Hybrid cloud adoption.

A2 Researcher Introduction and General Information

We began by introducing myself, providing an overview of the research context, and explaining the purpose of the study to the participants. Following this, we presented the consent forms, obtained their informed agreement, and addressed any concerns they might have had regarding the interview process. We also introduced the materials for the session, clearly explaining the purpose and use of recording devices to ensure transparency and build trust.

A3 Participants Background

Participants were invited to introduce themselves by sharing key personal and professional details, including their gender, age group, educational background, work experience, organizational role, national or ethnic background, and other relevant aspects.

A4 The Interview Process and its duration

The conditions governing the interview process were clearly outlined, emphasizing its exploratory nature and key characteristics. Participants were informed about the number of interview questions, the expected duration, their freedom to express themselves without constraints, and the use of recording to ensure accuracy. This transparency fostered a supportive and open environment for meaningful engagement.

B: Observation with Semi-Structure Interview Guide (Face-to-face)

B1: Research Topic

Recommending best practices for accelerating Hybrid cloud adoption.

B2: Researcher Introduction and General Information

We began by introducing myself, providing an overview of the research context, and explaining the purpose of the study to the participants. Following this, we presented the consent forms, obtained their informed agreement, and addressed any concerns they might have had regarding the interview process. We also introduced the materials for the session, clearly explaining the purpose and use of recording devices to ensure transparency and build trust.

B3 Participants Background

Participants were invited to introduce themselves by sharing key personal and professional details, including their gender, age group, educational background, work experience, organizational role, national or ethnic background, and other relevant aspects.

B4. Conditions Attached to the Observation

Participants were briefed on the observation approach, which emphasized seeking meaningful illustrations and explanations to understand individual views and experience with adoption of Hybrid Clouds. They were also informed that targeted probing questions might be employed during the observation to uncover deeper insights and enrich the understanding of their demonstrated actions.

C: Semi-Structure Interview Guide (Zoom)

C1: Research Topic

Recommending best practices for accelerating Hybrid cloud adoption.

C2: Researcher Introduction and General Information

Given this was to be done over Zoom, we first shared a brief introduction in the message / meeting invite. When the Zoom meeting began at the designated time, we started by introducing myself, providing an overview of the research context, and explaining the purpose of the study to the participants. We sought their permission to take notes and told them that we are not recording the call. Following this, we shared our screen and presented the consent forms, obtained their informed agreement, and addressed any concerns they might have had regarding the interview process. We also introduced the materials for the session, clearly explaining the purpose and use of recording devices to ensure transparency and build trust.

C3 Participants Background

Participants were invited to introduce themselves by sharing key personal and professional details, including their gender, age group, educational background, work experience, organizational role, national or ethnic background, and other relevant aspects.

C4. Conditions Attached to the Observation

Participants were briefed on the observation approach, which emphasized seeking meaningful illustrations and explanations to understand individual views and experience with adoption of Hybrid Clouds. They were also informed that targeted probing questions

might be employed during the observation to uncover deeper insights and enrich the understanding of their demonstrated actions.