

Data Migration in Cloud: A Systematic Review

Mehreen Ansar^{a*}, Muhammad Waleed Ashraf^b, Mubeen Fatima^c

^{a,b}*Riphah International University Faisalabad, Pakistan*

^c*National University of Science and Technology, Islamabad, Pakistan*

^a*Email: mehreenansar02@gmail.com*

^b*Email: waleed_terhana@hotmail.com*

^c*Email: mubeenfatima340@hotmail.com*

Abstract

Data migration needs to securely transfer for maintaining confidentiality such that migration can strongly and effectively done with no data loss due to active attacks . Many techniques and methods have already been proposed by researchers around the world to secure data migration. This paper provides a critical overview of these problems and solutions and giving a proposed solution for data migration that is Attunity which can help to optimize data for replicating and transferring data thus providing a simple, faster and safer path to accelerate data by providing.

Key words: Cloud Computing; Data Migration; Privacy and Security.

1. Introduction

Cloud computing is most demanding IT trend that provides shared access to configured systems and provide services often over the Internet. Cloud security provide a broader set of policies, rules and technologies to protect data applications, and the associated infrastructure of cloud. Mostly enterprises uses cloud to store and maintain huge data over cloud servers. But security of data over the cloud has become a concern for users and providers. Traditional methods of authentication like password and key generation, has failed. Data confidentiality, data integration and data availability are three main goals of CIA that are harder to achieve inside the cloud. Cloud migration is basic process of moving or transferring data from one cloud to other cloud or moving the data from one database to cloud database.

* Corresponding author.

Data migration in cloud is done due to various reasons such as cheaper cost for usage of cloud. Due to security of not having trust on cloud provider, suppose if the cloud provider is stopping services and user needs to transfer data to another cloud storage provider, it requires safe data migration. These are three basic service models:

IaaS: Infrastructure as a Service

IaaS host applications for third-party data centers and prefer outsource infrastructure for concentrating completely by monitoring deployment and development both.

IaaS takes care of Storage, Virtualization and Networking.

Examples of IaaS: AWS, Google Compute Engine, Azure, Alibaba Cloud.

PaaS: Platform as a Service

PaaS platform is preferred when there is a need of portable applications that provides a full invisible infrastructure environment.

PaaS takes care of Application Platform, Data base, development, integration

Examples of PaaS: AWS Elastic Beanstalk, Engine Yard, Google App Engine.

SaaS: Software as a Service

SaaS is preferred as a model by providing productive software on demand basis.

SaaS takes care of CRM, business management, Security and tools.

Examples of SaaS examples: Google Apps, Office 365, Salesforce, Net suite.

There are three basic cloud types

Public, Private, Hybrid: (Private + Public)

Hybrid Cloud is more secure providing high availability, security, and reduced operations costs.

Data migration is done in several forms like direct cloud to cloud, downloading data from one cloud and upload to new cloud, but downloading and uploading requires a lot of work to be done by user, so direct migration from one cloud to another cloud is the best one for migrating purposes.

- Basic steps to data migration in cloud:
- Need to have a clear plan to migrate data in cloud

- Proper analysis using SWOT technique to get a clear idea about the strengths, weaknesses, opportunities and threats
- A need to assess and select right cloud environment
- Selection of suitable cloud partner
- Determine the cloud architecture
- Selection of suitable cloud provider

2. Need to plan the migration: execute and monitor keenly

Before migrating data to cloud, a user must have clear instructions about the cloud environment and vendors to properly migrate the data. The plan and purpose must be clear. Before continuing, list out the advantages and drawbacks of the process including cost. Need to properly select the infrastructure, storage space, analytics, data generated, selection of network medium and the cost of the data migration. Before migration. Keep the backup of data, deploy it, migrate the data and finally test the migration. Follow following strategies for data migration in Cloud:

- Re hosting → lift-and-shift
- Re platforming → lift-tinker-and-shift
- Repurchasing → Moving to a different product
- Refactoring / Re-architecting → Re-imagining
- Retire → Get rid of.
- Retain → Revisit or do nothing

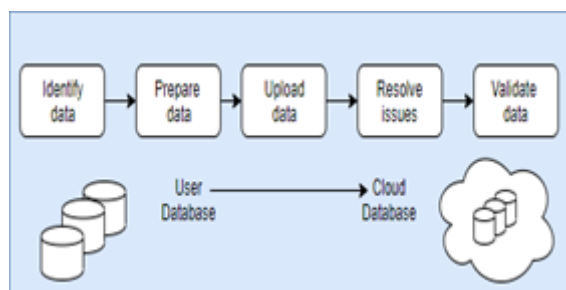


Figure 1 : Basic of data in cloud

Migration to cloud is a strategy of organization to make decision to increase data rate, performance, productivity, growth and competitiveness. The decision to data migration becomes complicated and

sometimes dynamic due to immature nature of the cloud environment.

All of common cloud data migration challenges can be avoided by choosing the right cloud migration partner.

Types of data migration

Migration in Data base:

Migrating data from existing database vendor to other database vendor or existing data base is updated to newer version. E.g.: IBM DB2 Database to Oracle Database.

Relocation of Data center:

Moving data center from one location to other location, there is a need to send data in database to target center location.

Application migration:

When an application is migrate from an on-premises enterprise server to a cloud environment or from one cloud environment to another, underlying data also need to be migrated to new application.

Business process migration:

When a business process changes due merger, Acquisition, business optimization takes places, Depend upon nature of business process changes, data need to be moved between various storage system or application or location

Attunity Cloud Beam provides Optimized performance and Security.

Attunity Cloud Beam ensures integrity of data and secures the data transfer to cloud databases.

Proper documentation, avoiding large scale transaction and having large scalability can help us to avoid common cloud migration problems and achieve more productive migration results. As well as Outsourcing data from onsite server to cloud server also occurs some security concerns.

Cloud migration has a lot of advantages like saving huge data storage costs, increased collaboration and flexible scalability, reliable backup facility, pay-per-use billing, superior disaster recovery but also have some limitations with slow internet connection during data migration can cause business downtime, unexpected issues due to regular downloading, data security can be affected. Some cloud applications do not allow data conversion or transfer into the system. All these might compel organizations to move from one cloud accounting market to another, which could be a time consuming and expensive process. Platform dependency can also cause in security while moving critical data to privacy and security vulnerabilities.

Four main rules for cloud migration:

Availability: Guarantee of every possible availability.

Management: To monitor change and support run time info .

Scalability: Scale out basically to fulfill demands

Resiliency: Gracefully handling and recovering from data failure during migration.

Before migration of data consider

- Define data volume in starting of the process.
- Don't always look in the same database in the cloud
- Secure the data, applications, network, and storage.
- The right data migration tool means everything

Basically data owner can insert, modify or delete any related operation on cloud databases with greater efficiency and proficiency.

Different encryption algorithms can also be used for safe data migration and with proper data tunneling methods

Stages and Tools in Cloud Migration include:

Stage 1:Pre-migration:

Consider needs and plans for future, Design a control model, provide proper training, do pre-test and chose best cloud vendor

Stage 2: Migration

Starting from small steps during data transfer and avoids upgrades and down time

Stage 3: Post-migration

Monitor and evaluate migration success by using proper tools. Benefits and Risks of Cloud Migration in cloud is complex and requires proper research, decision making, comparison, before moving data and process relocation. It provide services like on-demand allocation of resources, reduction in operational costs, efficient in IT, fast execution of application, global focus on cheap development site data center. It also provide disaster recoveries like up-gradation of applications, easy tracking, database automation, database backup, up gradation and maintenance. Risks regarding migration in cloud include security and availability of sensitive data, its storage,

backup, data redundancy and transparency. It has also some risks regarding the hardware and shared resources can lead to noisy neighbors, vendor selection, charges, change in policy, and connection reliability. This paper is composed of different issues and different problems to safely migrate data in cloud, classified as Section II. III dedicates for related work. IV for proposed solution and Section V concludes the effort of this review paper.

Table 1 :Table for finding future gap in cloud

Sr. No	Year	Paper Title	Proposed Algorithm	Pros	Cons	Future Gap
1.	2018	Evaluating cloud data base migration options using workload models	DBL Modeller + Mig Sim + OLTP	Zero down time	Complex for relational to relational data base migration	Random values can be used to check database capacity, No support to relational migrations and Automating cost models.
2.	2018	Data migration in cloud computing using honey encryption	Honey encryption cryptographic algorithm	CIA goals	Used in virtual World	Real world implementation can be done
3.	2018	Optimization of stream-based live data migration strategy in the cloud	Live data migration strategy with (PSO) particle swarm optimization, and non-linear migration cost and balance model	Parallel execution	Not for large-scale and in-stream data. Need clustering algorithm.	Need of improving grouping PSO. And iterative algorithm
4.	2017	Using Homomorphic Encryption to Compute Privacy Preserving Data Mining in a Cloud Computing Environment	Closed patterns using homomorphic algo Dist-CLOSE algorithm in a distributed environment	less communication and computation overhead	Protect the confidentiality of data	Strengthening the ways to exchange data between the sites
5.	2017	A Risk Management Framework for Cloud Migration Decision Support	Risk management framework	Identify + Manage risks	Complex for large values	Can be made efficient for random values
6.	2017	Information Technology Infrastructure Library and the migration to cloud computing	ITIL + CC Migration Framework	Manage + support Better usability and ease	Need of expertise and implemented in Virtual world	Real world implementation need to define, analyze and map in ITIL
7.	2017	A Multi agent Approach to Database Migration for Big Data Systems	Ontology + Data repositories	Flexible and Cost effective solution	Dependent and less secure	Automatic Handling and need of better interface.
8.	2017	A Decision Process Model to Support Migration	DSS Model to support decision making process	Efficient Migration cycle	DSS and tools not available for real testing	Need to implement DSS with right tools

		to Cloud Computing				and patterns + Development of KDD
9.	2017	Polar Particle Swarm Algorithm for Solving Cloud Data Migration Optimization Problem	Polar Particle Swarm Algorithm + Polar function (POLARPSO)	Migration from high loaded to less loaded nodes	Only for meta heuristic optimization algorithms	Need to implement in cloud load balancing and scheduling
10.	2017	Pattern-based Multi-Cloud Architecture Migration	Variability based + Pattern-driven Architecture of Migration V-PAM	Architecture-oriented patterns Can be refactored	Does not provide service to multi layered cloud	Need of Automation Need to work on SaaS and PaaS for usability and completeness
11.	2017	Security Enhancement for Data Migration in the Cloud	Advanced Encryption Standard-256 + Information Dispersal Algorithms + Secure Hash Algorithm-512	Achieving CIA Goals	Not for large business	Can be designed for large business
12.	2017	A Risk Management Approach for a Sustainable Cloud Migration	Dempster Shafer (D-S) theory	Identifying risks	Risk estimation on bases of values	Need to automate the calculation
13.	2017	Runtime Migration of Applications in a Trans-Cloud Environment	Algo for the parallel migration	migration process is fully automated	runtime migration of components	Dealing with downtimes of start and stop migration process
14.	2017	Non-live Task Migration Approach for Scheduling in Cloud Based Applications	Scheduling Algorithm with enhanced-First Come First Serve (TM-eFCFS) method based on task migration	fastest execution	For small number of vms	Implementation with large number of VMs
15.	2017	An exploration of the determinants for decision to migrate existing resources to cloud computing using an integrated TOEDOI model	DOI + TOE frameworks	Reduce complexity	DSS is not good for decision makers	Can be tested with correlation between the identified variables
16.	2017	Migration of a SCADA system to IaaS clouds – a case study	Eclipse SCADA was deployed to the NeCTAR research cloud using the “lift and shift” approach	Monitor and control redundancy, cheaper deployment in different physical devices to increase uptime.	Complex Data can change on increase user	Need of large scale installations and simulators to playback data sets.
17.	2017	SCADA Systems	Monitor using	Highly reliable	Can be locally	Need to support

		in the Cloud	sensors and control using actuators	and dedicated hardware	replicated due to avoid real-time hurdles	storages for big data
18.	2017	Research on Optimized Pre-copy Algorithm of Live Container Migration in Cloud Environment	Gray-Markov prediction model introduced by Optimized pre-copy algorithm (OPCA)	OPCA help reducing number of downtime and iterations.	Load imbalance problems	Workspace concept must be enhanced further
19.	2017	Communication-aware virtual machine migration in cloud data center	Communication-aware VM migration algorithm on the CloudSim simulator	Provide minute number of migrations, inter-VM communication and network cost.	Large volume of inter-VM communication traffic	Need to avoid the congestion problem when migrating VMs in close proximity
20.	2017	A Security Approach for Data Migration in Cloud Computing Based on Human Genetics	Implementing GS-Cloud based on protein biosynthesis and provide encryption based on human genetics	Provide integrity and confidentiality of data.	Matching calculation	Need to strengthen data migration

3. Literature review

This section of literature review reveals some research facts of Cloud Data migration on basis and analysis of many author's work. Some are discussed below:

The author [1] gave the key concept in the estimating the cost and duration in transferring data. By choosing a right kind of cloud services and options e.g. a data base-as-a-service in configured virtual machines.

In this paper [2] author propose honey-encryption cryptographic algorithm with (Net beans+ my SQL) ensuring data integrity and confidentiality in virtual environment.

The author [3] proposed concept of risk management framework to support users and analyze the risks by applying semi-quantitative approach.

The author [4] gave concept of migrating ITIL information technology to cloud computing to perform a smooth and accurate transition to the cloud.

The author [5] presented in this paper a possible solution for speeding up the integration of various data by automation of the database with ability of creating a common ontology over various data repositories or producers in order to integrate them into big data architecture.

The author [6] proposed DSS a decision-making process model for making right kind of decision to assist them

while making decisions during cloud migration. It also provides a preliminary structure for cloud development to make decisions on basis of knowledge.

The author [7] proposed an optimization algorithm POLARPSO to enhance the PSO and helps avoiding the problems like local minima by using a function for searching points in the search space and is able to find the best possible node to migrate quickly, efficiently and effectively.

The author [8] in his paper presents V-PAM (Variability-based, Pattern-driven Architecture Migration) for selecting and appropriating migration patterns in multi cloud to define a proper migration plan and extend them to identify new patterns.

The author [9] proposed a model to enhance security and privacy of data by combining advanced encryption Standard-256, Secure Hash Algorithm-512 and Information Dispersal Algorithms for small and medium type of thresholds.

The author [10] uses Dempster Shafer (D-S) theory to identify risks on bases of probability values

Cloud computing provides various kinds of services for storing data, load balancing between clouds and provides an infrastructure for developing applications and managing them. Due to various attractive services provided by various cloud service providers, users migrating their data from their storage system to cloud service provider. While migrating data to a cloud service provider there will be security and privacy protection concerns arises. By considering these concerns the author Ravindranadh proposed a secure privacy protection migration using honey-encryption cryptographic algorithm for data which is outsourced data to cloud and we are using migration protocol while migrating data from existing server storage system to cloud server storage system which ensures data integrity and data confidentiality.

The author [4] has proposed particle swarm optimization (PSO) for live data migration to avoid a NP-hard problem during task scheduling.

The author [9] has proposed a new algo using Particle Swarm Optimization (PSO) called POLARPSO that enhances the behavior of PSO and avoids the local minima problem.

This author [14] introduces a confined Task Migration based Scheduling Algorithm using enhanced-First Come First Serve (TM-eFCFS) method to execute tasks in VM.

The author [8] proposed SCADA systems allow users to monitor and control devices using the “lift and shift” approach.

The author [11], proposed an optimized pre-copy algorithm (OPCA) which introduces a Gray-Markov prediction model to reduce the number of iterations and downtime.

Similarly, different techniques of migrating data using randomized encryption technique for migrating data in

encrypted format, but randomized encryption technique is not much will be suited from brute force attackers.

A security approach of data migration based on prediction based encryption by picking an attribute in text and encrypting text with attribute selected but these encryption does not effectively handles the attacks on migrated or migrating encrypted data.

A secure and reliable virtual machine migration in personal cloud in this paper author proposes secure migration of virtual machine from host. In author proposed a technique secure instance migration it is based on introducing a new module in nova application programming interface which is secure instance.

A framework for improving trust in migration to cloud this technique is mainly focuses on customer concerns and migrate according to it but if the customer wants to migrate entire data at a time this technique needs to be parallel done migration by considering customer concerns.

A technique enabling dynamic and indirect mutual trust on storage systems this technique allows to outsource sensitive data to cloud service provider by ensuring that it allows only to authorized users though this technique is effective by allowing authorized users if some unauthorized user enters due to some authorization hacked problem malicious user may steal the data and modify or read or copy the information.

A secure architecture for inter cloud vm migration by using local authentication server and shared key generation using elliptic curve for vm data transfer.

In author proposes technique to achieve security based on classifying data elements based on its value of usage and type of access control. Author proposes a technique of securely outsourcing data with verification in cloud storage by encrypting data blocks before uploading them to cloud by improved bcp encryption.

Migration technique of protocol ensures integrity problem by migrating data between storage systems but if data is sensitive integrity alone is not sufficient to ensure that data is confidential because even a passive attack is also loses confidentiality.

4. Problem Statement

Basic migration process is moving data from one cloud to another cloud database. Data migration in cloud is done due to various reasons such as cheaper cost for usage of cloud i.e pay per usage. Due to security (or) not having trust on cloud provider, suppose if the cloud provider is stopping services and user needs to transfer data to another cloud storage provider it requires data migration where security issues arises in migration. Data migration in several aspects such as form direct cloud to cloud (or) downloading data from one cloud and upload to new cloud, but downloading and uploading requires a lot of work to be done by user, so direct migration form one cloud to another cloud is the best one for migrating purposes. As well as Outsourcing data from onsite server to cloud server also occurs some security concerns. In data migration there are several factors which can influence to improper migration and most influencing factor is security. Data migration need to be securely transfer for maintaining confidentiality such that migration can strongly (or) effectively done even

some active attacks are occurred . So data migration should be effectively done using some encryption techniques which can securely transfer the data with no data loss of control even when some severe active attacks are happened

5. Proposed solution

Migrating data is a process of moving data from one cloud system to another and can be performed for

- Merger and acquisition of business unit/organization to bring change.
- For improving reliability, performance efficiency, scalability and proficiency, of any software application.
- For adapting new changes in tools, market practice patterns, technology, and operational efficiency for better customer service.
- For bringing computation cost, efficiency by removing and streamlining bottleneck in application process or group data centers
- Use hybrid cloud for migrating data with specific tools and techniques.
- Clear your goals
- Set source to destination path
- Migrate your applications in secure manner

To simulate proposed work few steps should be followed

Net beans 8.0.2 and My sql tools in source server for computation of encryption.

A database is created for uploading and logging records and content records for source server.

To obtain virtual server AWS account can be used. For authentication and graphical user interface winscp can be used for migration between source servers to virtual cloud server.

Data can be available in host or network based, file or block form. However, proper tools and specific data set is intended to migrate such data safely and securely in array or block form.

V. Table for finding risks in data migration process

Table 2: Table for finding risks in data migration process

	Name	Problem	Solution
1	Data loss	When data is not available after migration process in legacy system Highest risk and Costly	Reconciliation Count Reconciliation Key financial column reconciliation
2	Data Corruption and integrity	Content of data if changed or duplicated	Need to Validate data at both ends
3	Semantics risk	Meaning of data remains same while unit changes during migration results in complete change in data. Example: Rs to \$	Need of testers in test cases to identify risks
4	Interference risk	Simultaneous usage of same data source application Example: Accessing same table and locked by one of the user.	Need to plan multiple mock run in pre-production environment Or need of third party

Future trends in cloud

Storage in cloud is growing exponentially there is a need to manage and monitor the data in a secure manner.

Artificial Intelligence and Machine Learning can be used to manage data protection, its analysis abilities.

Proper cloud infrastructures are needed to help admins and analyst with proper tools and products. Need to adopt hybrid cloud to increasing the effectiveness and to reduce operational costs. Need to lessen infrastructure overload.

Iaas is responsible for storage, virtualization and networking. Paas is responsible for database development and integration and SaaS is responsible for security tools and protocols.

- Simplicity can be achieved with no coding by using configurable GUI to quickly set data migrations.
- Zero downtime can be achieved with minimal impact.

Table 3: comparisons of cloud migration tools and vendors

Tools / services in Data Migration	Basic Function	Vendor name	Nature of services Dynamic	Cloud type Public, Private, Hybrid	Cloud platform	Support migration of		
						Data	Application	Process
Azure	Suggests a remodeling and right sizing, by doing a test run for Azure data migration tools and SQL database	Microsoft	✓	Hybrid	Azure	✓	✓	✓
AWS Cloud data	Move data via networks, storage gateways, and using specific acceleration tools. Less costly	Amazon	✓	✓	AWS	✓	✓	✓
Live Migration	Cloud Endure Live Migration offers reducing complexity risk and provide continuous replications	Cloud Endure	✓	✓	AWS, Azure, GCP, VMWare, OpenStack, Oracle	✓	✓	✓
IBM Tool	Soft Layer is company to support workloads and web apps	IBM	✓	✓	IBM Soft Layer	✓	✓	✓
Racemi Dyna Center	It offers flexibility in data integrity and simplifies cloud transformation	Racemei	✓	✓	AWS, Azure	✓	✓	✓
CloudVelox One hybrid cloud	It is a fully automated	CloudVelox	✓	✓	AWS	✓	✓	✓
CloudAtlas Cloud Migration Tools	The Cloud Pilot and Cloud Origin provide	CloudAtlas	✓	✓	Azure	✓	✓	✓

	correct deployment.							
Dynatrace Cloud Migration and Operations	It provides automated troubleshooting and use AI for recognition	Dynatrace	✓	✓	Azure, Amazon, Open stack	✓	✓	✓
Science logic	Analytical activity for understanding of network activity.	Science Logic	✓	✓	AWS, Amazon, IBM, VM ware	✓	✓	----- --
App Dynamic	This tool help fix the problems and track crash issues	Cisco	✓	✓	AWS, Azure	✓	✓	----- -
Dyna trace	Data analysis tool, use Davis, a 24/7 front line support tool	Dynatrace	✓	✓	All	✓	✓	✓
RISC Networks Cloud Scape	CloudScape is cloud migration and performs analysis	RISC Networks	Static	✓	AWS, Azure, GCP	✓	✓	✓
BitTitan MigrationWiz.	low cost and automated use the MSP platform to migrate emails and documents	BitTitan	✓	✓	All	✓	✓	✓

6. Conclusion

To prevent data migration problems, organization needs a reliable methodology to enable plan, validate and migrate data migration.

There is a need to accelerate and move data to cloud with automatic data transfer and integration with control cost and resources for disaster recovery with the demanding standards and protocols.

Data scalability is a great source of concern for the cloud vendors while storing or migrating data in cloud.

Enterprises are taking advantage of cloud platforms, like Amazon, Google Cloud and Microsoft Azure for minimizing big data issues and their migration.

Attunity can optimize cloud data transfer and replication to provide a simple, faster and safer path to accelerate data.

References

- [1] Ellison, M., Calinescu, R., & Paige, R. F. (2018). Evaluating cloud database migration options using workload models. *Journal of Cloud Computing*, 7(1), 6.
- [2] Ravindranadh, K., Kiran, M. S., Kumar, B. D. S. P., & Priyanka, D. (2018). Data migration in cloud computing using honey encryption. *International Journal of Engineering & Technology*, 7(2.8), 230-234.
- [3] Ma, K., Yang, B., & Yu, Z. (2018). Optimization of stream-based live data migration strategy in the cloud. *Concurrency and Computation: Practice and Experience*, 30(12), e4293.
- [4] Hammami, H., Brahmi, H., Brahmi, I., & Yahia, S. B. (2017, September). Using Homomorphic Encryption to Compute Privacy Preserving Data Mining in a Cloud Computing Environment. In *European, Mediterranean, and Middle Eastern Conference on Information Systems* (pp. 397-413). Springer, Cham.
- [5] Islam, S., Fenz, S., Weippl, E., & Mouratidis, H. (2017). A risk management framework for cloud migration decision support. *Journal of Risk and Financial Management*, 10(2), 10.
- [6] Cardoso, A., Moreira, F., & Escudero, D. F. Information Technology Infrastructure Library and the migration to cloud computing. *Universal Access in the Information Society*, 1-13.
- [7] Zaharia, M. H. (2017). A multiagent approach to database migration for big data systems. *New Mathematics and Natural Computation*, 13(02), 159-180.
- [8] Alkhalil, A., Sahandi, R., & John, D. (2017). A decision process model to support migration to cloud computing. *International Journal of Business Information Systems*, 24(1), 102-126.
- [9] Al-Sayyed, R. M., Fakhouri, H. N., Rodan, A., & Pattinson, C. (2017). Polar Particle Swarm Algorithm for Solving Cloud Data Migration Optimization Problem. *Modern Applied Science*, 11(8), 98.
- [10] Jamshidi, P., Pahl, C., & Mendonça, N. C. (2017). Pattern-based multi-cloud architecture migration. *Software: Practice and Experience*, 47(9), 1159-1184.
- [11] Ngnie Sighom, J. R., Zhang, P., & You, L. (2017). Security Enhancement for Data Migration in the Cloud. *Future Internet*, 9(3), 23.
- [12] Abdul Rahman, A. A. L., Islam, S., Kalloniatis, C., & Gritzalis, S. (2017). A Risk Management Approach for a Sustainable Cloud Migration. *Journal of Risk and Financial Management*, 10(4), 20.
- [13] Carrasco, J., Durán, F., & Pimentel, E. (2017, November). Runtime Migration of Applications in a Trans-Cloud Environment. In *International Conference on Service-Oriented Computing* (pp. 55-66).

Springer, Cham.

- [14] Panwar, N., Negi, S., & Rauthan, M. M. S. (2017, October). Non-live Task Migration Approach for Scheduling in Cloud Based Applications. In *International Conference on Next Generation Computing Technologies* (pp. 124-137). Springer, Singapore.
- [15] Alkhalil, A., Sahandi, R., & John, D. (2017). An exploration of the determinants for decision to migrate existing resources to cloud computing using an integrated TOE-DOI model. *Journal of Cloud Computing*, 6(1), 2.
- [16] Church, P., Mueller, H., Ryan, C., Gogouvitis, S. V., Goscinski, A., & Tari, Z. (2017). Migration of a SCADA system to IaaS clouds—a case study. *Journal of Cloud Computing*, 6(1), 11.
- [17] Church, P., Mueller, H., Ryan, C., Gogouvitis, S. V., Goscinski, A., Haitof, H., & Tari, Z. (2017). SCADA systems in the Cloud. In *Handbook of Big Data Technologies* (pp. 691-718). Springer, Cham.
- [18] Nie, H., Li, P., Xu, H., Dong, L., Song, J., & Wang, R. (2017, June). Research on Optimized Pre-copy Algorithm of Live Container Migration in Cloud Environment. In *International Symposium on Parallel Architecture, Algorithm and Programming* (pp. 554-565). Springer, Singapore.
- [19] Xue, W., Li, W., Qi, H., Li, K., Tao, X., & Ji, X. (2017). Communication-aware virtual machine migration in cloud data centres. *International Journal of High Performance Computing and Networking*, 10(4-5), 372-380.
- [20] Hammami, H., Brahmi, H., Brahmi, I., & Yahia, S. B. (2017, September). A Security Approach for Data Migration in Cloud Computing Based on Human Genetics. In *European, Mediterranean, and Middle Eastern Conference on Information Systems* (pp. 384-396). Springer, Cham.
- [21] Hosseini Shirvani, M., Rahmani, A. M., & Sahafi, A. (2018). An iterative mathematical decision model for cloud migration: A cost and security risk approach. *Software: Practice and Experience*, 48(3), 449-485.
- [22] Jamshidi, P., Pahl, C., & Mendonça, N. C. (2017). Pattern-based multi-cloud architecture migration. *Software: Practice and Experience*, 47(9), 1159-1184.
- [23] Rai, R., Mehruz, S., & Sahoo, G. (2018). Efficient migration of application to clouds: analysis and comparison. *GSTF Journal on Computing (JoC)*, 3(3).
- [24] Odun-Ayo, I., Agono, F., & Misra, S. (2018). *Cloud Migration: Issues and Developments*.
- [25] Chandrakala, N., & Rao, B. T. (2018). Migration of Virtual Machine to improve the Security of Cloud Computing. *International Journal of Electrical and Computer Engineering (IJECE)*, 8(1), 210-219.

- [26] Balobaid, A., & Debnath, D. (2018, June). Cloud Migration Tools: Overview and Comparison. In World Congress on Services (pp. 93-106). Springer, Cham.
- [27] Aslam, M., bin AB Rahim, L., Watada, J., & Hashmani, M. (2018). Clustering-Based Cloud Migration Strategies. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, 22(3), 295-305.
- [28] Raj, P., & Raman, A. (2018). Multi-cloud Management: Technologies, Tools, and Techniques. In *Software-Defined Cloud Centers* (pp. 219-240). Springer, Cham.
- [29] Gholami, M. F. (2017). A Methodological Approach to Support Cloud Computing Migration.
- [30] Kumari, E. (2017). Security Challenges Faced in Cloud Computing Environment. *International Journal of Advanced Research in Computer Science*, 8(5).