Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 3 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189

http://amresearchreview.com/index.php/Journal/about

AI-Driven Security Enhancement and Vulnerability Mitigation in Computing Environments

Farman Ali
University of Lahore Email: Farman.ali@ai.uol.edu.pk

Muhammad Ali Khan
School of Information Technology, Minhaj University Lahore
Email: alikhan.cs@mul.edu.pk

Hafiz Muhammad Arsalan
University of Lahore Email: muhammad.arsalan@ai.uol.edu.pk

ABSTRACT

This research give an overview on analysis of security enhancements in virtualization environments and explore development of challenges, vulnerabilities and improvement in future virtualization technologies in modern computing systems. Virtualization become important technology of cloud computing, data center, edges and distributive system which improve the flexibilities and scalabilities also efficiency in cost. . Although the usage of virtualization also increase the security risks like hypervisor attacks, virtual machine attacks, malware and side channel also data leakage or denial of service or unauthorized access in multitenant cloud system. The main problem in this is weakness of current of virtualization security, protection of hypervisor, VM isolation, intrusion detection, container security and monitoring systems. Multiple virtualization platforms like VMware, Xen, Docker, and cloud base virtualization system are analyze to assess the security capabilities or limitations. The finding show the frameworks of traditional security which is against the unknown or advanced cyber threats, lack of standardized security frame works and intrusion detection systems and AI in virtualization is limited. This research also include future enhancement of virtualization like Artificial intelligence, secure hypervisor or automatic monitoring frameworks to fine the security, scalabilities and intelligent virtualization frameworks.

Keywords: Virtual Machine, Machine Learning, Containerization, Network Virtualization, Hypervisor Security, Cybersecurity, VM Isolation, Xen Hypervisor, Kvm Virtualization, Resource Management, Docker And Block Chain

Introduction:

Virtualization is a technology that is a fundamental concept of modern computing in **past,** that play very important role in computing. Virtualization built in 1960s in which multiple users can share data into physical data. In that time is was only use by special environment with limited access. In 1990s and 2000s the virtualization spread and gain growth on internet. In early ages virtualization only focus on working not on

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security. Virtual machine monitor initiate to allow VMs to run on single physical machine. Two types of it. Type1: bare-metal which directly run on hardware.Type2: hosted which running on top of operating system. There are features isolation, flexibility and scalability for the cloud computing. On that time security is not primary concern. In **present,** virtualization is very important and a structure of cloud computing like Iaas, PasS, container and network virtualization. Modern system have advance technologies like hardware or virtualization, Intel VT-container base virtualization like Docker and network function virtualization. These are the advance technology used in present and improve performance of system, scalabilities and automation. Advance or modern system face some threats: hyper jacking or VM escape, Side channel attacks, data will be leak in it, misconfigured in virtual network and rootkits and malware in virtualization. These threats introduce some techniques which is VMI (virtual machine introspection), IDS (intrusion detection system), access control and encryption will be developed to reduce threats. And for the **future** virtualization predicted to become more effected and integrated with technologies like AI based system, block chain for data integrity and for trusted management, edge computing, architecture with hybrid and combing VMs, containers and unikernels. The aim of future is build a strong isolation mechanisms and for threat detection the system is automatic and immediately response, secure VM journey and storage and the main system standardized frame work for cloud security. The **Main problem** is security which is the main or one of the biggest challenge for developer or others. Although virtualization improve resource utilization and flexibility it also introduce attack surface where the attackers can attack and vulnerabilities. The main problem is explained first is virtual machine share same physical hardware and second single point of control is fail and the third one is human error will be reveal these are the main problems. The system is vulnerable to attacks like hypervisor and data will be leak from VM image and snapshots, side channel attacks and dos attacks. There are many critical **research gap** in virtualization like weak VM isolation present isolation is not strong as much needed to prevent inter VM attacks. High resources can be consumed by security, limited research on multi clouds system. Hypervisor vulnerability in which hypervisor is single point of failure and lack of protection. Absence of standard security frame works there are not accepted frame work for security,less use of AI and automation to detect error and for security. These are the gap in research which need improvement for good work or as a solution. The main **Objectives** (goal) of research is to check the security issues in system and vulnerabilities in virtualization. Review a different types of virtualization and effects on systems. The major **importance** to study is that virtualization is generally used in cloud computing, data sharing, IOT&edge computing, to understand the challenges. Researchers improved the security day by day organization improve security, developer deign more efficient platform, policy maker build standardized framework for cloud computing. To introduce an advanced techniques like Ai base detection, secure hypervisor and good isolation methods. The future must be focus on security, efficient and scalable virtualization environment.

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Literature review:

Virtualization is very important part of modern computing. It was **introduced** in 1960sand developed in 1970s. It is extensively available in belated 1990s, and become popular in 2000s in the growth of cloud computing. virtualization allow multiple virtual machine to run on single physical system with hypervisor, virtual machine monitor. Which helps in to improve flexibility, resource sharing, assess, and scalability, backup and live migration which also help in cost, also utilization of hardware which is used to support technologies like container, NFV, cloud computing etc. There are different type of virtualization like para, full, hardware and hardware assisted. There are also network, desktop and operating system virtualization. In this there is also include some technologies like Xen, VMware, KVM, Docker and hypervisor platform. with the **benefits** it's also caused many challenges in security, the threats are hypervisor attacks ,VM escape, malware attacks , rootkits, data leakage, weak isolation, denial of service and multitenancy attacks. Containers are light weight and good but it provide weaker isolation not like traditional which provide stronger isolation .virtualization environments also caused VM image attacks where malicious spreads malware in systems .container also introduce many problem of security like sharing of same kernel. Weak kernel allow attacks to run vulnerabilities, In cloud computing there are some issues like privacy, unauthorized access, authentication is weak, and security risks. The finding in literature review find multiple **research gaps** like weak hypervisor, trust issues, single point failure, not availability in of standardized frameworks, encryption is weak, limited protection against the attacks, policies across the virtualization platform, intelligent thread detector. existing models have high complexity and poor scalabilities. The solutions also may cause some problems like high complexity, overhead of performance, lack of APIs, and lack of integration. The main research gaps are VM migration, snapshot management and encryption communication, secure sharing systems and protection of cybersecurity. For the **future work** the main work is to develop a lightweight or secure hypervisor, strong VM, techniques like container isolation. The main work needed in future is integrated of AI detecting tools, IDS/IPS tools, VM migration is secure, strong privacy control in cloud. Advance framework, real time detection of attacks, merge with modern technologies like edge computing, NFV, SDN, and IOT also important for future enhancements. In Future virtualization security the major role is Artificial intelligence and machine learnings and AI based ids/ips, detection of anomaly also advance cloud security models like zero trust architecture, block chain based and automatic access control. Block chain control or improve transparency, immutability and secure authentication. **Researcher suggest** integration of virtualization with modern technologies like SDN, NFV, edge computing IoT and multi cloud framework, scalable network and virtualization are important for direction of future.

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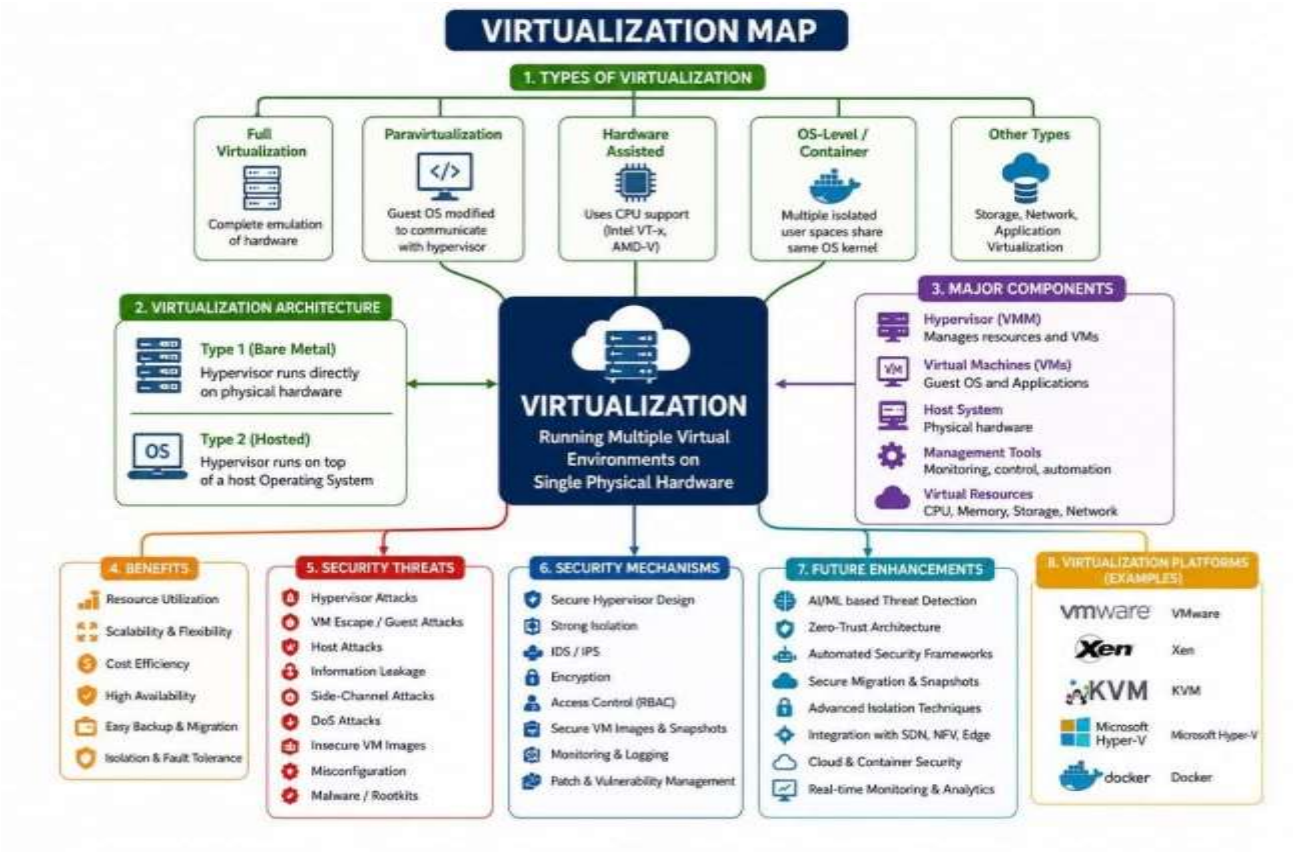

Figure 1 virtualization Map

Methodology:

Research deign:

This research is deign to follow emphasize, detailed and investigate the design to analyzed the security, challenges, and enhancement of features and technology virtualization have in modern computing. This is design to understand the virtualization and their operation like how they operate a system. How the **security vulnerabilities** appear with these environment, and how modern security can enhance the system and protect these in cloud based and their techniques and how it spread in framework. Virtualization is one of the best or important technology in cloud computing initiative framework, network management and modern system.it allow multiple operating system to run at the same time on single physical machine with the use of hypervisor and virtual machine technologies. **Virtualization improve** flexibility, scalabilities and resource sharing. In this it also introduce a lot of security issues, risks and attacks like hypervisor and virtual machine avoidances and attacks like side channel, denial of service, malware and data leakage. Thus, the **main reason** of research design is to analyze logically to these issues and techniques of security to enhance a system and to secure the environment of system. The study assume a **descriptive research** methodology because the main work of the research is theoretical analysis or understanding. Clearness, interpretation and relative evaluation of past published papers related to virtualization security. Instead of numerical study

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it main focus is on theoretical studies of security frame work, architecture of hypervisor, monitoring the system, analysis threats and techniques of isolation and ai based detection tools and the main existing technology of virtualization. The **subjective approach** help in understanding the relationship between virtualization technologies and security challenges of virtualization. It support the different frameworks, architecture and model discuss in past studies. It also follow the descriptive research deign because it also describe the characteristics, structure, function, and security mechanisms of virtual systems. This research also adopts survey based and analytical approach because data is collected from a wide range of articles. This study also identify the weaknesses of system and enhancement of future that help to improve the security of virtualization.it also include **analogous methodology** to analysis and different technology and platform to understand their strength, limitation and security capabilities it also include the comparison virtual machine and container, Xen and VMware or KVM, Bare metal vs hosted hypervisor, traditional and cloud base virtualization, hardware and software virtualization. These comparison analyze assess of isolation capabilities, resource utilization, good monitoring, security performance, flexibilities and scalabilities also threats mechanisms. This study analyze the implementation of security in cloud computing and where multiple user share same data through multitenancy. In this there are risk like VM escape attacks, side channel attacks, data leakage, and unauthorized access, compromise in hypervisor and exhaust resources attacks are more critical. Although, research design asses the frame work in cloud base security and virtualization models. This research paper specially focus on major areas of virtualization security enhancement like: **Hypervisor design** which have important role in control layer of virtual system. Hypervisor manage communication between hardware and virtual machine they are major attacks it assess techniques hypervisor and secure architecture of hypervisor and control access system also protection methods. **Isolation techniques** are the most important security technique in virtualization in which, name space isolation, process of isolation, file system isolation and network isolation and sandboxing techniques like java and chroot sandboxing. **Intrusion detection** and monitoring design which include analysis of intrusion of detection system, intrusion prevention of system and real time threat analysis detecting tools and monitoring tools for detection like rootkits, malware and hidden communication channels also unauthorized access attempts. **Artificial intelligence** and automation modern virtualization depend on ai based system to analyze anomaly ai detecting tool, threat analyzer, automatic security management, monitoring frameworks. AI techniques improve prediction of threats, automatic detection, and intelligent monitoring tools. This also discuss **containerization technology** like Dower and Kubernetes because it widely use in cloud environment, it is lightweight, efficient, but it improve weak isolation compared to virtual machine. This research also compared the VM security and container security models to check their advantages. Network virtualization like VLAN,VPN, network function virtualization and software design, to check the how network can be secured for attacks and unauthorized access. The **integrity** in virtual system investigate block chain integration, role based access, next generation firewall and secure vm snapshots and encryption of storage. The **overall research design** consist of theoretical analysis, detail of virtualization architecture and framework,

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security analysis of mechanisms, research gap, limitation, comparison of security tools and future enhancement and recommendation. This research paper provide a good understanding of history ,security, challenges, threats, technologies, present ,past, future work and future enchantment, weakness in current environment, secure and more scalable virtual security system can explained in it.

1. Data collection:

In this we discuss the **data collection** methodology in virtualization system, and it use a **secondary data collection** to collect the information of virtualization technologies, cloud computing, hypervisor architecture, protection of virtual machine, and advance tools to detect systems. As virtualization is developing research area so secondary data collection provide access to large quantity of existing technologies, security framework and past tested virtualization models. The **goal** of data collection is to collect reliable, relevant and quality information which help to analysis architecture of virtualization, hypervisor security, isolation of virtual machine, container security, network virtualization or threat detecting tool. The **main purpose** of research is truest on **qualitative secondary data** in which information removed, reviewed, compared and analyze from past published papers, and other technical resources. This purpose is good because virtualization security already have material theoretical and technical both that can analyzed it systematically without need of physical experiments. **Source** of data collection this data is collected by multiple industrial, academic and technical sources to assure reliabilities and variety of information. The main data sources are IEEE research paper which is a primary source that used in this and provide information of peer reviewed, analysis security framework, architecture of hypervisor, cloud computing models and virtualization experimental techniques, it help to analysis attacks like VM, hypervisor vulnerabilities, intrusion detection system, resource scheduling methods and framework monitoring. Journals who reviewed the virtualization and several cybersecurity are modern trends of virtualization, attacks like malware and rootkits, security threats like container and real time monitoring system. These **journal** also gave data about advance protocols of security, AI based security and integration of block chain in cloud environment. Report of cloud computing in which cloud security and virtualization were analyze multi-tenant cloud, resource challenges, security risks and VM migration or security of storage. It also help to assess the issues in scalability, distributed virtualization and techniques to monitoring cloud**.. Existing virtualization** frame work or documentation are used to analyze CPU, GPU virtualization, hardware virtualization, virtual network setups and real time monitoring tools. Frame work also provide understanding of VMware ESXi, Xen hypervisor, architecture of KVM and Docker containers. Data collection cover the research areas the main focus are on major domains which is related to virtualization security enhancement. **Hypervisor security** control communication between hardware and virtual machine it focused on hypervisor attacks, vulnerabilities and hyper jacking threats and secure design of hypervisor. **Rootkits and malware detection** in which malware analysis, sandboxing techniques VM isolation and rootkit monitoring system. The main focus is on **java sandboxing** and **chroot isolation.** Namespace isolation and container security such as Docker,

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kubernetes which is lightweight but weaker isolation compared to other it analyze namespace, process, and network and file system isolation. Network virtualization collect information of virtual LAN, virtual private network, and network function virtualization and SDN (software defined networking) it also analyze secure communication of virtual, traffic isolation, sharing sources and prevention of network attacks. AI base security of virtualization modern virtual are mainly focus on AI integration system in data collection it include **AI threat detection**, predictive analysis of security, automatic system of monitoring, and intelligent resource scheduling and AI help to improve real time detection of attacks, automatic response mechanisms and accuracy in threat prediction. Resource scheduling analyzed CPU scheduling, resource balancing, VM migration, context switching and frame work monitoring. This research also assess the large scale cloud system, real time monitoring in virtualization and overhead performance by security mechanisms. Data source platforms from the data is collect are IEEE Xplore, Google scholar, research gate, cloud computing and cybersecurity, virtualization frame work or reposts. These **platform i**s used because they have reliable research of peer reviewed, update studies of security and technical implementation also industrial practices of virtualization. The collected data mainly focused on qualitative secondary data, a good observation of technical data, comparisons of security frame work, repots of threats, assess of monitoring system, and security in hypervisor. The collected data arrange types such as hypervisor attacks, VM attacks, side channel attacks, AI based security system, and models for security like container. The data collection play very **important role** to identify or analyze weaknesses of virtualization environment, security limitations in hypervisor and gaps in current monitoring system and future enhancement by using AI and automation.

Tools and technologies:

Multiple tools and technologies, virtualization platform, frame work for security and monitoring tools or systems are used **generally** in modern cloud computing and virtualized structure. These tools and technologies are very **important** for security, monitoring system, and threat detection with virtual conditions. The reason of using these tools are to analyze or understand how virtualization operate and how hypervisor manage virtual machine or how vulnerabilities security occur. How protection and monitoring enhance security in virtualization. **Platform** of virtualization are the technologies that is used to manage, monitor or crate the system in virtual machines. It analyze multiple platform to compare the system to check the security, management capacity and isolation techniques. Platform which are available are **VMware ESXi:** is the commonly used types in which type 1 is bare metal which is run directly without any host needed. VMware used because it gave strong platform to virtualization, good resource scheduling, secure management of VM, concept of hardware and monitoring in real time. **Xen hypervisor:** is a open source platform for virtualization which is commonly used in cloud computing which helps in Para virtualization, hardware virtualization, and VM secure isolation and multi-tenant cloud system. **Kernel based virtual machine** is a Linux virtualized system that assess in to kernel. It convert Linux system into hypervisor which has capabilities to run multiple virtual machines. KVM also analyze some terms like overhead of

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security, performance in VM and monitoring in real time. **Docker Containers** is an important technology of containerization, not like virtual machine it share hosted system kernel with the lightweight, more faster and efficient resource sharing. In this Docker evaluate lifecycle management of container, namespace isolation, process isolation, file system isolation and internal and external attacks of containers. It also explain coordination of container an image security in **Programming languages** that link with virtualization and manage the system also implementation of security with the help of these are **Python** one of the commonly used language in security of virtualization or cloud computing. It introduce some common used of it like AI detecting tools, monitoring system, automatic system and analysis of security and integration of machine. **Java** programming language is to assess techniques of sandboxing, security of application level and virtual frame work. Sandboxing include process isolation, execution will be restrict and secure management of application. It also analyze the mechanism security to protect system which are running in virtualized environment. **C and C++** are low level language which is mainly used in development of hypervisor, virtual machine system and operating system kernels. **Linux virtualization platform** it is important because it operate a system of Xen and KVM of Linux also support a secure containerization and most of the cloud depend on Linux servers. The system also assess the multi-tenant, cloud system and virtualization resource allocation. **Security tools or techniques** it evaluate multiple tools and frame work to protect the environment of virtualization. **IDS (intrusion detection system)** that monitor the traffic of VM, behavior of system and network also suspicious or unwanted activities it also help to detect malware, rootkits or unauthorized access. **IPS (intrusion prevention system)** it provide automatic system to prevent mechanisms against the attacks of VM, intrusion network and hypervisor attacks attempts. **NGFW (next generation firewalls)** which is used to assess traffic filtering, deep packet checking or secure the monitoring of communication. **RBAC (role based access control)** used for restrict unauthorized access, use of privilege and improve the security. **Sandboxing and chroot isolation** are assess for testing of malware, secure execution and application isolation. **AI technology or tool** in which modern virtualization relay on it, in this we review detection through AI, security analysis with prediction, anomaly detection automatic, efficient monitoring systems. These tools improve attack detection which happened in real time, response of threats, and accuracy in monitoring system.it will also evaluate automatic system in large scale of environment, resource scheduling and predictive maintenance frame work. **Network technologies** in cloud virtualization is important for secure communication with virtual system. **VLAN (virtual local area network)** are used to evaluate traffic segmentation, secure isolation in network and separation in network. **VPN (virtual private network)** provide system to secure encryption of communication, remote access and confidentiality in data. **NFV (network function virtualization)** in which it convert hardware into software base virtual system, it assess for scalabilities, secure flexibilities and optimization. **Software networking** which separate the network control and data forwarding systems. It help to improve management of centralized system also monitoring system and dynamic security policy in networking context, handling of interrupt, efficient resource scheduling and CPU cycle utilization in technologies.

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Data preprocessing:

Data processing play very **important role** in management and analyzing or filtering and arranging the collected data from research papers, journals, reports of virtualization. Although research papers is **primary founded** on literature review, methodology so preprocessing is important to convert raw or unorganized into organized or meaningful data that suitable for analysis. The data can be collect from different sources like IEEE paper, Google scholar, virtualization framework, journals of security, technical whitepapers, and documentation of hypervisor also AI base security. This **origins** have large amount of information related to architecture of virtualization, vulnerabilities security, technologies like hypervisor, threat detection tools, monitoring framework, virtualization in network, and resource scheduling system. The gathered information is highly varied and distributed on different studies. Preprocessing include removed irrelevant data or duplicated data, organized the information, classify security threats, comparison of technologies of virtualization and find research gap or future enhancement options. It **help in** accuracy of research, consistent data, analysis or quality of find data also reliability of findings. **Classification of virtualization techniques** when the duplicated data will be removed the collected data will be clarified according to different virtualization architecture. The **research steps** of virtualization are full, para or hardware virtualized, operating virtualization container based or network based virtualization and storage virtualization. Each virtualization are analyze to understand the utilization of resources, mechanisms isolation, capabilities in security or techniques of monitoring. The **categorized process** help in comparing of tradition virtualization, modern cloud virtualization also lightweight containerization system. The grouped data support to analyze CPU/GPU, hypervisor or VM lifecycle management. **Classified of attacks and vulnerabilities** virtualization face different types of security threats and vulnerabilities. Thus, preprocessing participating sorted attacks in groups for easier analysis. These attacks are hypervisor attacks, VM (virtual machine) attacks, VM escape attacks, Side channel attacks, Rootkits or malware attacks, container or hidden communication attacks, DOS(denial of service) attacks, network base or resource base attacks. Each attack types help to analysis attack behavior, impacts of security, threats levels, and problem in detection and existing techniques of protection. The classification help to identify crucial vulnerabilities in virtual system, weaknesses of monitoring system, limitation of security frame works. It improve in understanding of internal and external threats or multitenant risks also hypervisor techniques. **Filtering unrelated studies** so the virtualization is linked with many computing domains, collected studies information unrelated to research. Filtering process prevent security of virtualization, no cloud computing or analysis of hypervisor and threat detection system also container security. It helps to improve research, topic significance of topic and main focus on analytical. **Organization Research gap and future enhancement** is a important task of preprocessing that include extraction and organization of research gap, limitation or future enhancement. **Data Organization** after collecting of data it will be organized into different research organization. The major types are **virtualization architecture** were group into two types of virtualization architecture (type1 bare metal: That run directly on hardware) and (type2 hosted: run on top of OS) and hardware virtualization, cloud virtualization

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and container virtualization. **Security issues and vulnerabilities** are those who related to security vulnerabilities in hypervisor, VM communication risks, data leakage or malware attacks also a Rootkits attacks and unauthorized access issues, which is used to analysis risks, weak authentication, and failure monitoring and control the access weaknesses. **Threat models** which are based on organization into models also threats are internal/external attacks, multi-tenant attacks, VM to VM attacks and so on. It help in analysis of attack surfaces, factor of risks and security levels. **Existing solution of security** to organize existing protection tools are IDS, IPS, NGFW (next generation firewalls, RBAC (role based access control), sandboxing techniques or chroot isolation. This include a data of AI monitoring tools predictive framework or block chain model and techniques like encryption.

proposed Model/Algorithm:

The proposed model and algorithm are **mainly focus** on working on developed or secure system, scalable virtualization frame work which is capable to protect the virtualization structure and against the cyber threats of advanced time. The **proposed methodology** combine multiple security technologies and monitoring system to protect virtual machine, hypervisor, container and network virtualization is for improvement in security**. Modern virtualization** are extreme dynamic which is the reason of the vulnerable attacks like hypervisor, virtual machine, Rootkits and malware, side channel ,data leakage and a lot of attacks. **Traditional security** are incapable to detect modern attacks because many threats can avoid static security rules which manipulate weaknesses in virtualization system. The **aim** of proposed to give strong isolation in VM, Continuously monitoring, threat detection will be automatic, good prediction of attacks, Secure system of monitoring and enhanced cloud framework. The framework help to improve security, scalability, performance and automation and management of resources in virtualization environment. The **proposed security architecture** consist of multiple combination of layers to work together and protect the virtualization structure. The proposed model combine the protection layer of hypervisor, monitoring layer of virtual machine, detection layer of AI anomaly, prevention system or intrusion detection, and secure control on access and secure image of VM, and real time monitoring. Each layers have responsibilities of security task with virtual environment. **Hypervisor protection** is important steps of virtualization system because it manage the communication between physical and hardware virtual machine. **Hypervisor operate** the high privilege level the compromise in the hypervisor can affected the all virtual environment. The proposed introduce a secure hypervisor protection of frame work like hypervisor security, restrict privilege, resource isolation, and secure communication of VM, and implementation of access control. The proposed layer monitors CPU usage, Memory location, switching context or handling in interrupt or interaction with VM. The **frame work** help to reduce the attacks surface by disable unnecessary services or limited unauthorized access and applying secure hypervisor classification. And proposed protect the hyper jacking attacks, VM vulnerabilities is reduce or improve the trust within cloud structure. **Virtual machine monitoring system** which include advance virtual machine monitoring which responsibilities are observing the behavior if virtual machine or check their suspicious activities. The **monitoring framework** to

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analyze are VM communication, use resource, behavior of network traffic, execution of activities, and modification of unauthorized file. The VM help in to protect malware infection or attacks and rootkits behavior or communication which are hidden and shady VM migration activities. This **monitoring** also tracks cycle of CPU, usage of memory, Disk access and changes in VM state. Real time monitoring improve visibilities of threats and attacks detection in early or reliability in system and efficient response on incidents. **AI based quirk detection** is also essence component of proposed model. In which traditional security system depend on predefined statistic rules. Which are not efficient in unknown zero day attacks. The proposed frame work merged AI detection to identify intelligent and abnormal behaviors of attacks. The **detection system** identify processing of unusual stuff, abnormal systems and attempts of unauthorized access or unusual communication between VMs. AI is use to improves detection abilities in real time, prevention from attacks, good response of system, accuracy in threat prediction. Machine learning integration unified the proposed security frame work for automatic detection of threats or for analysis of behavior. The proposed methodology is include in detection system of machine learning, recognition system and predictive models of security and behavioral system. The ML is **skilled** using attacks of historical, malware behavior, records of VM traffic and secure event. The **procedure** of it to analyze the system is behavior of network, activities of users, utilization and interaction of hypervisor. Machine learning help to **improve** accuracy of detection, positive detection, flexible learning of capabilities and analysis of security in large scale. **Intrusion detection system and Prevention system** (IDS/IPS) frame work unified the IDS/IPS which help to monitor network packets, VM communication and access attempts to hypervisor also activities of container. IDS/IPS help in detection of malware, unauthorized access and attacks like VM, behavior of Rootkits or Denial of service. The layer of prevention automatically prevent the system from the malicious traffic and infected isolation VMs also generate an alarms to safe the data. Security **Access control frame work** is an important component of virtualization security because the entire cloud environment are negotiation of unauthorized access. The proposed execute in role base access control, authentication of multi factor, separation of privilege. **Secure VM image verification** in which virtual machine images include malware, backdoors, and hidden malicious code. **Namespace isolation** divide processes, file system, network or user with virtual system. It prevent attacks of container to container, communication of unauthorized or interface of resources. **Sandboxing security** build an environment in which malware can be execute without damaging the host system. Which improve analysis of malware, threats or protection of system. In this proposed use java sandboxing, chroot and secure environment. **Rootkits detection** are infected system because it hide malicious activities in virtual system. And it improve visibilities of threats, identification of malware and protection of hypervisor.

System Architecture

System architecture is a **design** to give a secure, scalable and intelligent or efficient virtualization of frame work of modern cloud computing and divide structures. The **architecture unify** the virtualization platform or frame work security also AI

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Print ISSN 3007-3189

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monitoring system and resource scheduling, and detection of threats in multiple layers, which are able to protect a virtualization system for advance cyber threats. **Modern virtualization** are high in interplay because it support multiple virtual machines, shared hardware resources and structure of multi-tenant cloud, application of containerize. Virtualization help to **improve** scalabilities, resources and flexibilities but it also describe multiple security threats like hypervisor, VM, malware, data leakage, unauthorized access, side channel or Denial of service attack. To **handle** these issues proposed architecture combining the management of hypervisor, threat detection of AI, Role based access control, Real time frame work monitoring, and secure virtualization. The architecture is use to layer framework because layer improve threat isolation, control the access, efficient monitoring, and management in resources also prevention of attacks. **Work flow of the system** the architecture follow the flow of work or steps for consisting the structure with layers like input layer, virtualization layer, security layer, processing layer or output layer. Each layer of virtualization are used to enhance the management. **Input layer** the first layer of the architecture are like entry point to enter in the system for all request, communication and for interaction of data with virtual environment. It receive the input layer for user requests, traffic of virtual machine, network into packets, request into cloud services and request of storage access. The input layer collected the authentic user information or control access and communication VM logs. **Virtualization layer** is a important layer of architecture because it handle the virtual resources, virtual machines or containerized system. In this layer it also include Hypervisor (Xen, VMware, KVM), Docker containers, scheduling of resources system and VM frame work or Virtual network system. These layers built detachment between physical hardware, virtual machine, application or cloud services. These layers allow multiple system to run the system and share physical structure. **Hypervisor system** add different hypervisor like Xen hypervisor, VM ESXi, KVM kernel base. It help to manage location of CPU, memory of virtualization, storage virtualization, communication between networks, and resource scheduling. These layers help to execute context switching, handling of interruption, VM management, and Migration support of VM .It also provide hypervisor between isolation and VMs, hardware generalization, and optimization of performance. **Container virtualization** in which architecture merge technologies of container like Docker, Kubernetes system. Container is lightweight virtualization which share the host operating system of kernel. Container also support in fast arrangement, architecture of micro services, application of cloud native, efficient resource virtualization. It also monitor systems like container, name space isolation, communication process, images verification of container, container help to improve flexibility, scalabilities but with advance security are needed because container have weak isolation in the comparison of other. These scheduling system forcefully distribute the resources between virtual machine or containers consistent with workload, levels of priority, policies of security and it improve the efficiency of performance, scalabilities, reliability and energy. **Security layer** are the important layer of architecture because it protect the environment of virtualization away from threats and unauthorized access. The security layer contains intrusion detection system, intrusion prevention system, next generation firewalls, Role base access, encryption system and merge of block chain. The frameworks of ips\ids improve the

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http://amresearchreview.com/index.php/Journal/about
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Online ISSN 3007-3197
Print ISSN 3007-3189
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visibility of threats, automatic capability of response and awareness of security. **AI monitoring tools** applied the security layer to improve threat detection. It is used to analyze patterns behavior, usage of VM resources, irregularities of network traffic, activity of hypervisor, The AI layer help to produce predictive analysis of threats, automatic detection, and attacks categorization. It help AI to enhance accuracy of detection, monitoring in real time, capabilities to predict the threats, and automatic security. **Next generation firewalls** helps to give the inspection of deep packs, filtering the traffic, application security by levels, and monitoring the secure communication. It helps to protect firewalls of VM traffic, channel of cloud communication, application of container. **Role base access control** it provide a strict access control by user's roles and with privileges. It help to improve authentication of users, security of administrative and management of access. **Processing layer** which help to perform the operations and function like analytical of the architecture. It also include the analysis system of threats. Resource **allocation**, management of isolation frame work, monitoring system of isolation and processing event of security. It help to process the threats analysis like alerts in security, threats harshness and vulnerabilities of systems. **Allotment of Resources** the processing layer forcefully manage the CPU resources, usage of memory, traffic of networks, distribution of storage, it help to improve efficient balancing of workflow, reduce overhead of performance and improvement in scalability. **Isolation management** protect the virtual machine and container from unauthorized interaction, which include the isolation of name space, process of isolation, file system and network isolation. It also help to prevent isolation of VM to VM attacks, escape of container attacks, and sharing the vulnerabilities of resources. **Output layer** help to portray the final architecture in which monitoring results, processed information and decision of security will be generated. The output also help to administrators to monitor the system security, analyze the threats or attacks and improve the management.

Implementation process:

The implementation method is important to provide detail understanding of virtualization challenges, assessment of different frame work, and analysis of modern protection and identify the research gap. These implementation steps divide it into many different phases like collection of literature, identification of threats, analysis of frame work, and evaluation of security and incorporation in AI monitoring also analysis of result. **Literature collection** the first step of implementation is to process the relevant data from research paper, journals, reports, and frame work of virtualization or cloud security related to enhancement of virtualization security. The literature review is important because it include the architecture of multiple papers, security mechanism complexity, different hypervisor and varied cloud structure. The collected literature have IEEE papers, journals virtualization security, reposts of cloud computing, technical white papers, documentation of hypervisor and AI base cybersecurity study. These **papers** is selected by the reasons of relevant data of virtualization security, analysis of hypervisor, security container security, protection of cloud structure, intrusion detection system and monitoring of AI threats. The **collected information** have main focus on attacks of hypervisor, isolation of VM, detection of rootkits and malware, network virtualization and scheduling resource

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system and real time monitoring system. The collected data have **stages** of virtualization architecture of comparable analysis, history of virtualization, analyzing of security frame work. These steps help to build a theoretical background, objectives of research, and existing limitation of virtual security. These collected data arrange according to virtual technology, models of threats, security framework, techniques of monitoring, AI merging system. **Threat identification** is a second step to identify and analyzed the security threats which affect the virtual environment. it introduce multiple threats or attack surfaces because multiple VMs share the same hardware, located the resource dynamically, operate the system kernels of container. These multiple security threats include, **VMM** (virtual machine monitor) attacks point the hypervisor for responsible managing virtual machine, hypervisor control all VM operations it can handle the all structure of it. The VMM introduce hypervisor techniques, attacks like hyper jacking, unauthorized privilege also manipulation of VM control. **Rootkits Attacks** which hide the malicious designed to neglect the detection or gaining the unauthorized access to system. This implementation step help to analyze hypervisor rookits, VM based malware, hidden kernel and attacks techniques. It also help in identification of monitoring week systems, detect the limitation also vulnerabilities of security in virtual layers. **Malware attacks** are virtual system in which vulnerable to malware distribution because of resources sharing or communication of VM which can spread malicious code. It also include analysis of Trojanized VM images, distribution of Worms and Ransomware attacks also infected virtual network. This implementation assess the detection of malware, sandboxing system and intrusion prevention systems. **Hidden communication channels** are the unauthorized communication of paths in between virtual machine or containers. It help to analyze conversion of communication, side channel attacks, unauthorized interaction of VM also resource sharing. In this it also identify the weakness of isolation, limitation in monitoring and communication flaws of hypervisor. **VM attacks** build when attackers avoid from virtual machine or gain the access to host systems. This implementation assess failure of isolation, vulnerabilities hypervisor also shared resources and container attacks. **Denial of service** in which attacks overhead the system resources and distribute the services of virtualization. This implementation analyze the resource attacks, flooding of attacks, overload CPU attacks, Cloud base dos vulnerabilities. This stage help to improve scalabilities of system, scheduling weakness and inefficient monitoring. **Frame work analysis** which help after the threats identification or different virtualization frameworks, technologies which are analyze to assess the architecture their performances and scalabilities of security mechanisms. It also include analysis of VMware, Xen hypervisor, KVM kernel based virtual machine and Docker containers and NFV network function virtualization systems. VM analysis the evaluation of hypervisor protection, scheduling of resources, isolation of VM, live migration or performance efficiency. **Xen hypervisor analysis** is used to analyze the para virtualization, hardware assisted virtualization and multi-tenant and resource balancing. It also help to improve the scalabilities performance and VM migration of security. **Security review** has four steps to evaluate or review the security mechanisms in virtual environments. **Isolation techniques** which is used to analyze the efficiency of VMs and container and how they are separate from another. **Hypervisor security** help to

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review the hardness of hypervisor techniques and access control system also the privilege mechanisms and secure configuration. **Monitoring systems** help to analyze the real time threats detection, VM activity, usage of resources and security of logging. **Comparative Testing** is use to perform the review the efficiency of performance security in different virtual systems. Which is also compare the virtual performance and good work of container and utilization of resources. **Result analysis** is the final implementation to focus on collect data to find or analysis or find the conclusion of it. It also help to identify the weakness of security, hypervisor vulnerabilities, and failure of isolation. It also study on research gaps, future enhancement and integration of ai also advance monitoring systems. Implementation are very **important** because in virtual environment everything is very complex so a structured data help to reduce the complexity of it.

Evaluation Metrics:

It play important role in virtualization security because it help in measuring and analyzing of the efficiency, reliability, scalability and security capabilities of virtualization systems. As modern virtualization framework consist of multiple interconnected systems like hypervisor, virtual machine, container, cloud platforms, network virtual and Artificial Intelligence base monitoring systems and it is important assess of the systems. Virtualizations is most important technologies in cloud computing that enable efficient sharing source, isolation workload, scalabilities or flexibilities of structure management, Yet in spites of its advantages, introduction of virtualization many challenges of security like hypervisor, VM attacks, malware and side channel attacks also access to unauthorized users and resource sharing vulnerabilities. The virtualization security will be evaluate by using evaluation metrics. The process of evaluation in research are focused on analyzing these features, such as security efficiency of security, capabilities of threats, utilization of resources efficiency, optimization of performance and responsive monitoring tools and reliability or scalability. The matrices help to decide if the proposed virtualization security frame work can productively detect the cyberattacks, protect the hypervisor and virtual machines, and reduce vulnerabilities, improve the frame work performance in cloud, maintain stability and support the scalable operation of cloud. The evaluation methodology allow the comparison between security traditional mechanisms or AI base security, bare metal or hosted hypervisor, virtual machine and container also the different monitoring and resource scheduling, good threat detection and intrusion detection systems. The evaluation metrics divided into four classification. Security metrics, performance Metrics, AI evaluation Metrics, Reliability metrics. **Security Metrics** are used to evaluate how efficient virtualization work can protect the cloud frame work, hypervisor, virtual machine, and container or communication against the threats like cyber and unauthorized activities. Virtualization system host multiple users and workload to shared hardware resources, strong security are important to prevent from attacks and maintain the integrity. These are used to analyze important security frameworks like rate of attack detection, capability of malware detection, efficient isolation, and control access. Attack detection rate measure the capabilities of the virtualization security framework to identify the activities like malicious activities or threats like cyber and how

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Online ISSN 3007-3197
Print ISSN 3007-3189

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increasingly it spread on system. **Malware detection capability** is used to measure how efficient virtualization system identify the malicious software inside the Virtual machine, container, and hypervisor. Malware is most dangerous threats of cloud frame work it speedily spread in virtual resources. The research evaluate mechanism to detect against the several types like Trojanized VM images, Rootkits, Worms, Ransomware attacks and hidden execution of malware. The malware detect by multiple techniques like signature base detection, AI based detection, sandboxing or infection prevention. Virtualization system provide protection techniques like sand boxing and isolation. Sand boxing allow activities like suspicious to execute in controlled environment without damaging the primary framework. **Isolation productivity** measure the efficiency of virtual system which separate the virtual machines, container, process and network resources from another. Isolation is one of the most important security principal of virtualization because multiple users share the same physical hardware, weak isolation allow attackers to manipulate vulnerabilities which perform VM to VM attacks , container attacks, resource sharing attacks or unauthorized communication. This research assess the isolation of name space, process isolation, file system, network isolation, in which metrics determine protection of VM strength, reliability of isolation, communication security an separation of resources. **Access control potency** measure the authentication of systems, polices of authorization and privilege of administrative which protect the framework. **Performance metrics** evaluate the efficiency of operations in virtualization systems and mechanisms of security. Virtualization environment maintain a balance between security or scalabilities and performance of system. This may increase the overhead processing and reduce the overall systems which help metrics to analyze the tradeoff between implementation of security. Resource utilization and efficiency of operation. This metrics perform serval types like utilization of CPU, overhead of context switching, interrupt handling and latency of networks also usage of resources. **CPU usage** measure the efficiency of resources and locate it also consumed by hypervisor, virtual machines and containers also monitoring systems. It also evaluate scheduling of CPU, allotment of hypervisor resources, overhead of AI monitoring, multi VM processing performance. **AI evaluation Metrics** play important role in proposed virtualization security frame work. AI base are capable of detecting unknown attacks, analyze the behavior of it also predict the future threats. **Accuracy** help to measure the correct the AI system threats, malware and suspicious activities operation. **Precision** measure the ratio of correct identification of threats compared to the tootle number of detect error. **Recall** measure the effective AI detect systems and actual attacks of malicious activities. High recall include strong detection of error. **Reliability Metrics** assess the stability, continuity of operation or fault of management with virtual environment. it also help to check whether the security framework can maintain performance under workloads.

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Online ISSN 3007-3197
Print ISSN 3007-3189

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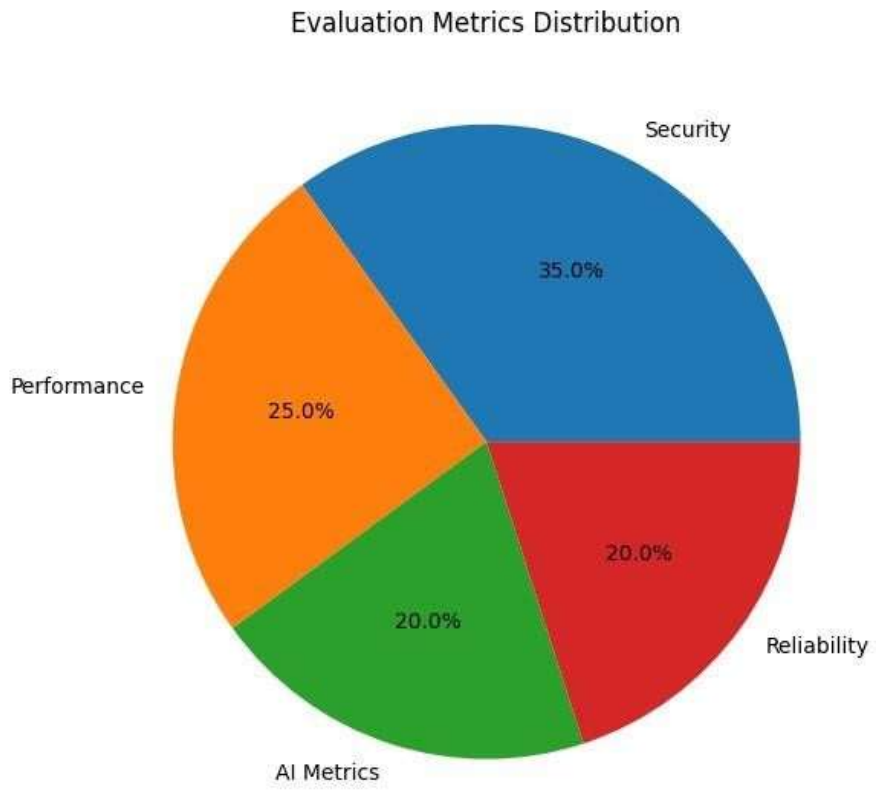

Figure 28.Evaluation Metrics

Limitation:

Virtualization provide a detailed review of virtualization security, hypervisor protection, AI base monitoring framework, cloud virtualization technologies, different types of limitation which is in research methodology and implement the process. The range of implement, scalabilities and real world applicably processed the security frame work. Virtualization or cloud computing are developing the modern threats of cyber security and it became more complex, due to these technologies changes it contain some difficulties of analyze completely with a single research study. The limitation divide into several types like data limitation, technical limitation, scope limitation and practical limitation. **Data limitation** it is the major limitation of research which mainly depend on secondary data. Instead of primary data. This review include research papers, journals, reports of virtualization, cloud computing review and frame work of security. These review provide valuable information which is not completely represent the real time cloud systems, developing of threats cyber and operation of frameworks, different papers include testing methodology, datasets and virtualization environments. These virtualization shortage available datasets include hypervisor attacks, VM attacks, and container vulnerabilities and AI based virtualization security. These research face some challenges like standardized cloud

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security data sets, accessing virtualization environments and obtaining malware behavior in hypervisor. **Technical limitation** proposed security frameworks that merge advanced technologies like Artificial Intelligence, real monitoring, intrusion detecting systems and hypervisor security frameworks. Implementing these technologies introduce many different types of security challenges.AI base security systems needs high resources, large training datasets, and continuous capabilities of monitoring. Machine learning expand CPU resources, GPU processing and capacity of memory, which increase the overhead of systems, consumption of resources and cost of framework. Another limitation is advance security machine to reduce the performance of virtualization. **Scope Limitation** have the main focus on security virtualization, protection of hypervisor, cloud computing environment and security of container frameworks. These systems are important do study cause of covering the all technologies which is related of modern computing environments. These provided limitation analysis the edge of computing environment, IoT system, fog architecture computing. Iot and edges introduce some challenges like limited process power, lightweight requirements of security and real time communication .These technologies required special frameworks. It main focus is one VM ware, Xen, Docker and other platform of organization which are not analyze in it. **Practical limitations** are proposed some security solution are review in it by conceptual, simulation and theoretical which are implement in real world on large scale of advanced virtualization security frameworks which need initiative level frame works, high performance of hardware, committed cloud environment. Such frame works is difficult to access for academic purpose. In practical limitation there is lack of testing in large scale, experimental deployment of cloud and industrial virtualization systems. Testing advance security in real world cloud systems can affect the performance of systems, interrupt their services, increase risks in operational, because of these challenges there are some solution to assess these are comparative analysis, existing services and frame work of theoretical system. Instead of fully scale testing of deployment. Practical implementation of high frame work cost, secure the testing by restricted system. **Future direction limitation** which provide options to future research for development. It main focus is to study experimental of real world in virtual environment, light weight, Edges and IoT virtualization. It also help to improve protection of hypervisor, automatic protection of threats and AI predictions.

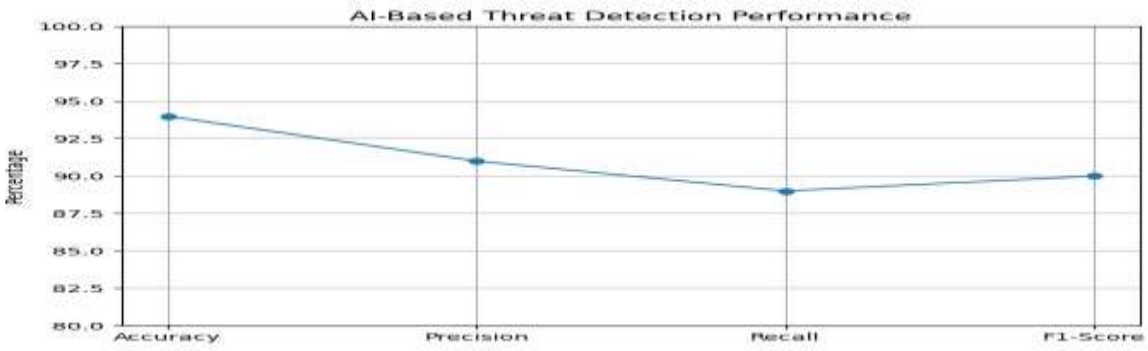

Figure 3 AI based threat detection

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Online ISSN 3007-3197
Print ISSN 3007-3189

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Result and analysis:

The result and analysis part assess the effectiveness of virtualization security, AI based monitoring systems, protection of hypervisor techniques, intrusion detections frameworks in modern virtualized system. The analysis focus on performance of security, capability of attack detection, utilization of resources, scalabilities, efficiency of isolation, and comparison of traditional and modern security of virtualization.

Experimental Result show that AI provide better threat detection and monitoring performance compared to other.

Result:

Security tools	Detection rate	Speed	Accuracy
Traditional IDS	78%	medium	Ordinary
Signature detection	82%	medium	Good
AI based detection	95%	Fast	High
Hybrid ids	97%	Very fast	Very high

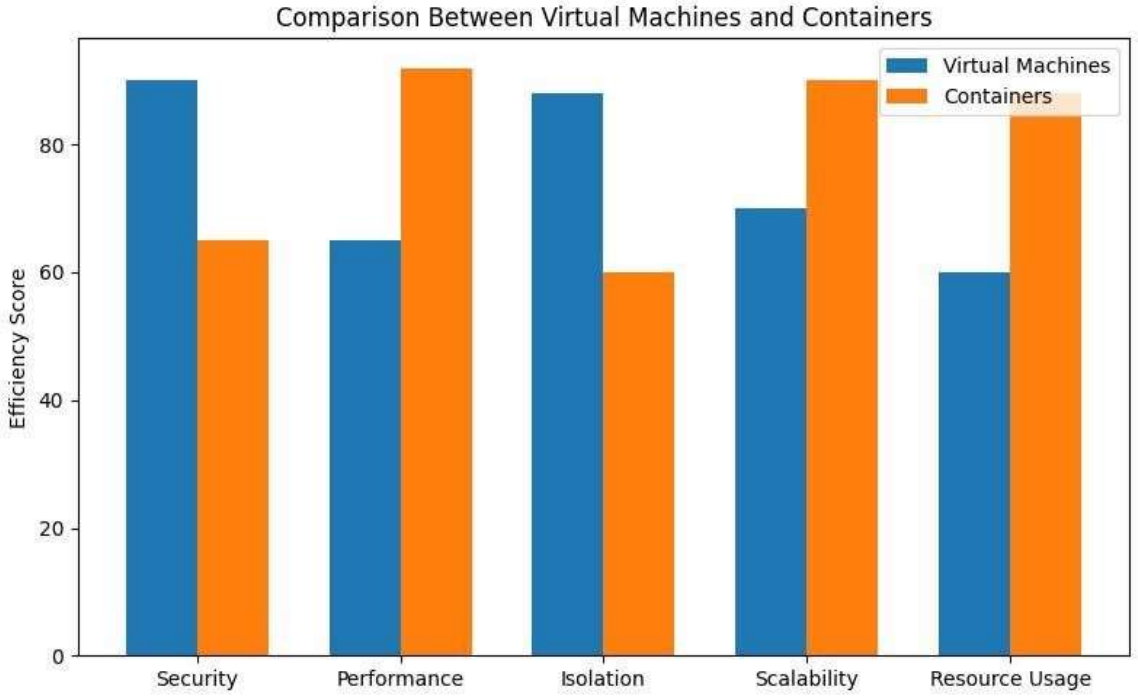

Figure 4 Comparision

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Resource utilization result:

Technology	CPU usage	Memory efficiency	Scalability
VMware ESXi	Medium	High	High
Xen hypervisor	Low	High	Very high
KVM	Medium	Medium	High
Docker container	Very low	Very high	Very high

Performance analysis:

Assess how security effect virtualization scalabilities, efficiency and how monitoring performance work. **Hypervisor security platform** help in implementation of secure hypervisor, reduce unauthorized VM communication, improve protection against hypervisor attacks. Advanced system of monitoring increased CPU overhead and memory. **AI monitoring performance** help to improve threat detection**,** malware detection, prediction of activities, and automatic response of mechanism. **Container security analysis** improve performance of speed, resource efficiency but with weaker isolation and it increase the security risks. With compared to tradition virtual machine. **Network virtualization analysis** like virtual LAN, VLAN, VPN and software network (SDN).

Comparison of existing systems:

Features	Traditional security system	Proposed AI base virtualization framework
Threat detection	Limited	Advanced
Zero day attack	weak	Strong
Real time monitoring	medium	High
VM isolation	Standard	Enhanced
Hypervisor protection	Basic	Advanced
Scalabilities	Moderate	High

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Automation	Limited	Intelligent automation
Malware detection	Signature base	AI detection

Discussion:

The discussion section provides an interpretation and explanation of the research results, and the advantages, disadvantages and feasibility of the suggested framework are analyzed against the results. **Interpretation of Findings** the results show that VEs can be very susceptible to todays. the ability to respond in realtime and the prediction of suspicious behavior. The research further revealed that hypervisor architecture with security, namespace isolation and sandboxing methods, and intrusion detection systems enhance the security of a virtualization platform. But more robust security could result in more resource consumption and system complexity. Containerization technologies like Docker and Kubernetes offer enhanced scalability and resource utilization compared to traditional virtual machines yet offer less isolation. **Strengths and Weaknesses** strengths extensive examination of virtualization security issues. In-depth study of virtualization security issues. The study compares VMware, Xen, KVM and Docker. **Weaknesses** the analysis is mostly theoretical and literature based few applications in the real world or limited practical testing – limited applicability in real-world settings it takes a considerable amount of data and computing power to train AI systems. **Real-world Impact** the research is practically relevant for cloud computing providers, cyber security researchers, virtualization developers and organizations employing virtual infrastructures. **Cloud Computing** The proposed framework enhances security for framework and Platform Service of and distributed systems with multiple users using the same resources. **Cybersecurity Industry** Real-time threat detection and automated monitoring systems can enhance threat detection using AI and mitigate cyberattack risks. **Enterprise Virtualization** to enhance system protection, organizations can adopt secure hypervisor configurations, RBAC policies, AI monitoring, and VM isolation techniques when leveraging VMware, KVM, Xen, and Docker.

Conclusion

Virtualization has become one of the most important pieces of technology within the modern computing world as it allows for cloud computing, resource sharing, scalability, flexibility and distributed systems. Virtualization environments, however, pose some security issues such as hypervisor vulnerabilities, VM escape attacks, malware propagation, side-channel attacks, and unauthorized access and container isolation weaknesses. This research work presents a detailed study on the evolution of virtualization security enhancement through discussions on the virtualization technology history, architecture, threats, virtualization monitoring systems and virtualization protection mechanisms. The study tested several virtualization technologies, such as VMware ESXi, Xen Hypervisor, KVM, and Docker containers,

Online ISSN 3007-3197
Print ISSN 3007-3189

to gain insights into the different security features and vulnerabilities of each. The research revealed significant gaps, including insufficient VM isolation, ineffective IDS, absence of standardized security framework, and limited AI integration, among other issues, as well as vulnerabilities in cloud based multi-tenant systems. Current security solutions such as IDS/IPS frameworks, secure hypervisors, AI-based monitoring, sandboxing, namespace isolation, and RBAC and block chain-based integrity were also being investigated. The research was successful in meeting the goals of identifying vulnerabilities within virtualization environments, examining the current protection mechanisms, and offering a secure virtualization framework with AI. The proposed framework enhances the attack detection, monitoring efficiency, real-time response and virtualization security by applying the intelligent automation and machine learning techniques. Finally, intelligent security, automatic monitoring, robust isolation methods, secure cloud communication, and flexible security strategies are crucial for safeguarding contemporary cloud-based systems against sophisticated cyber-attacks on future virtualization environments.

Future work and recommendations

Suggested Improvements Enhance the security of hypervisors with lightweight, secure architectures Improve VM / container isolation techniques Minimize CPU & memory burden of security monitoring systems Enhance live IDS intelligence and detection Improve the security in Multi-tenant Cloud architectures. Enhance secure VM migration and encrypted storage systems Future Enhancements in AI. The integration of AI and Machine Learning. Advancement in AI behavior and analysis and predictive security systems to automatically detect and respond to attacks in future systems. **Future work options** AI attack detection zero day enable virtualization on quantum computing environments Combining VM and container security solutions Secure, energy efficient virtualization security systems Secure Software Defined Networking (SDN) frameworks Intelligent orchestration of cloud resources and automated scheduling/optimization of resources. Deep learning real-time malware prediction system. Ensure Virtualization in 5G and future communication networks.

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Krishna Sai Ketha*, Guanqun Song*, Ting Zhu* *Department of Computer Science and Engineering, The Ohio State University, Columbus, USA Email: ketha.2@buckeyemail.osu.edu, song.2107@osu.edu, zhu.3445@osu.edu

Fatma Bazargan, Chan Yeob Yeun, Mohamed Jamal Zemerly Electrical and Computer Engineering Department, Khalifa University of Science, Technology and Research, PO Box 573, Sharjah, United Arab Emirates.

OHR International Journal of Intelligent Instrumentation and Computing 2021, Vol. 1, No. 1, pp. 34–38 https://doi.org/10.54646/bijiiac.006 www.bohrpub.com.

National University of Defense Technology College of Electronic Science and Technology Changsha, China *corresponding author's email: 18299927375@163.com.

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