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CONTENTS

An overview of Blockchain: Definitions, architecture, versions, applications and future directions

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Abstract. Blockchain technology has been gaining popularity in recent years, with many industries exploring its potential applications. This innovative technology has the potential to revolutionize the way we do business and interact with each other. It has emerged as a revolutionary innovation that promises to transform various industries by enabling secure, transparent, and decentralized transactions. The blockchain is a distributed ledger technology that uses cryptography to ensure the integrity and immutability of data. In this article, we will provide an overview of blockchain, including definitions, architecture, security, applications, and future directions.

Keywords: Blockchain (BC) technology; Security; Consensus; Distributed ledger technology (DLT).

1. INTRODUCTION

Blockchain technology is a revolutionary and innovative way of recording transactions and managing data. It has gained popularity in recent years, with many industries exploring its potential applications. Blockchain is a decentralized system that allows for the creation of a shared database that can be accessed by multiple parties, ensuring transparency and security. Blockchain technology has become a revolutionary innovation in recent years, providing a secure, transparent, and decentralized way of recording transactions and managing data. The concept of blockchain was first introduced in 2008 by an anonymous person or group of people known as Satoshi Nakamoto in a paper titled "Bitcoin: A Peer-to-Peer Electronic Cash System [1]." The first implementation of blockchain technology was the Bitcoin network, which went live in 2009[2]. Since then, blockchain technology has evolved significantly, with new use cases and applications emerging in various industries. Some of the industries that have been impacted by blockchain include finance, healthcare, and supply chain management [3]. As the technology continues to evolve, we can expect to see further development and innovation in the field of blockchain [4].

This paper is arranged as follows. Section 2 provides Blockchain Versions and Types, Section 3 investigates in Blockchain Architecture, Section 4 demonstrates Attacks and Solutions in Blockchain, Section 5 provides Applications of Blockchain, Section 6 includes the paper with Future Directions.

2. BLOCKCHAIN VERSIONS AND TYPES

a. Blockchain Versions

Blockchain 1.0 refers to the original version of blockchain technology, which was introduced with the creation of Bitcoin in 2009. It was designed to facilitate peer-to-peer transactions without the need for intermediaries such as banks or financial institutions [5]. The Bitcoin blockchain uses a proof-of-work consensus algorithm to validate transactions and maintain the integrity of the network.

Blockchain 2.0, also known as smart contract blockchain, was introduced with the creation of Ethereum in 2015[6]. This version of blockchain technology added the ability to execute smart contracts, which are self-executing contracts with the terms of the agreement written into code. Smart contracts allow for the creation of decentralized applications (DApps) that can automate complex transactions and processes.

Blockchain 3.0 is the latest version of blockchain technology, which focuses on improving scalability, privacy, and security [7]. This version of blockchain technology includes features such as sharding, which allows for parallel processing of transactions to improve scalability, and privacy-preserving technologies such as zero-knowledge proofs and secure multi-party computation (MPC). Blockchain 3.0 also includes the use of consensus algorithms such as proof-of-stake (PoS) and delegated proof-of-stake (DPoS) to reduce energy consumption and increase efficiency.

Blockchain 4.0 is a term used to describe the integration of blockchain technology with other emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data. This version of blockchain technology aims to create a more interconnected and intelligent network that can facilitate complex transactions and processes [8].

Blockchain 5.0 is a term that is still in its early stages of development, but it is expected to focus on creating a more decentralized and democratic internet. This version of blockchain technology aims to give users more control over their data and online identity, while also addressing issues such as censorship and net neutrality [9].

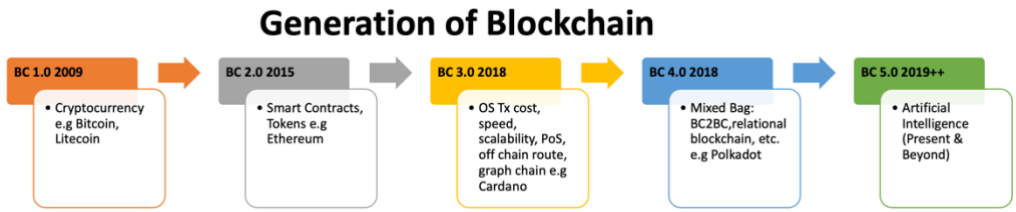

Fig. 1. Generations of Blockchain

Overall, each version of blockchain technology has unique features and use cases that make it suitable for different industries and applications. As blockchain technology continues to evolve, we can expect to see further innovation and development in this space.

Blockchain technology has evolved over the years, with different versions being developed to cater to different needs. Blockchain 1.0 was the first version of blockchain technology, which focused on creating a decentralized ledger for financial transactions. Blockchain 2.0, also known as smart contracts, introduced the concept of programmable contracts and decentralized applications (dApps). Blockchain 3.0, also known as the blockchain of things (BoT), aimed to integrate blockchain technology with IoT devices to create a more secure and efficient network. Blockchain

4.0 is the latest version of blockchain technology, which integrates blockchain with emerging technologies such as AI and big data to create a more interconnected and intelligent network. There is also talk of Blockchain 5.0, which aims to create a more decentralized and democratic internet.

b. Blockchain Types

There are three main types of blockchains: public, private, and hybrid. Each type has its own unique features and benefits. In this Section, we will explore the differences between these types of blockchains and their use cases.

Public Blockchain: A public blockchain is a decentralized network that anyone can join and participate in [10]. These blockchains are open to the public, meaning that anyone can read, write, and verify transactions on the network. Public blockchains are often associated with cryptocurrencies like Bitcoin, Ethereum, and Litecoin.

Public blockchains are highly secure because they use complex algorithms to validate transactions. They also have a high level of transparency because all transactions are publicly visible on the network. This makes public blockchains ideal for use cases where transparency and security are critical, such as financial transactions or voting systems.

Private Blockchain: A private blockchain is a closed network that only authorized users can access. These blockchains are often used by businesses and organizations to share sensitive information securely [11]. Private blockchains are not open to the public, meaning that only authorized users can read, write, and verify transactions on the network.

Private blockchains are highly secure because they use cryptography to validate transactions. They also have a high level of privacy because all transactions are only visible to authorized users on the network. This makes private blockchains ideal for use cases where privacy and security are critical, such as supply chain management or medical records**.**

Hybrid Blockchain: A hybrid blockchain is a combination of both public and private blockchains [12]. These blockchains allow for the benefits of both public and private blockchains, making them ideal for use cases where both transparency and privacy are critical.

Hybrid blockchains are often used by governments and financial institutions to securely share information with authorized parties while still maintaining a high level of transparency. For example, a government might use a hybrid blockchain to securely share citizen data with authorized agencies while still maintaining the privacy of its citizens.

There are three main types of blockchains: public, private, and hybrid. Each type has its own unique features and benefits, and they are all suitable for different use cases [13]. Public blockchains are ideal for use cases where transparency and security are critical, private blockchains are ideal for use cases where privacy and security are critical, and hybrid blockchains are ideal for use cases where both transparency and privacy are critical [14].

3. BLOCKCHAIN ARCHITECTURE

Blockchain technology is a distributed ledger system that allows for secure, transparent and tamper-proof transactions. It is the underlying technology behind cryptocurrencies such as Bitcoin and Ethereum, but its applications extend beyond financial transactions. In this Section, we will explore the architecture of blockchain and its different components.

The blockchain architecture consists of three main components:

1) Distributed Network

2) Consensus Protocol

3) Data Structure

1) Distributed Network

A blockchain network is a distributed network of computers that work together to maintain the blockchain ledger [15]. Each computer in the network is called a node. Nodes communicate with each other to validate transactions and update the blockchain ledger. The distributed nature of the network makes it resilient to attacks and ensures that no single entity controls the network.

2) Consensus Protocol

Consensus protocol is an essential component of blockchain technology that ensures that all nodes in the network agree on the state of the ledger. Consensus protocols are responsible for validating transactions, adding new blocks to the blockchain, and maintaining the integrity of the network [16]. There are different types of consensus protocols used in blockchain networks, including Proof-of-Work (PoW), Proof-of-Stake (PoS), and Delegated Proof-of-Stake (DPoS). In this paragraph, we will explore these consensus protocols and their differences.

Proof-of-Work (PoW): PoW is the most widely used consensus protocol in blockchain networks, including Bitcoin and Ethereum. In a PoW system, nodes in the network compete to solve a complex mathematical puzzle to add a new block to the blockchain [17]. The first node to solve the puzzle is rewarded with newly minted cryptocurrency. This process is known as mining.

The PoW protocol has several advantages, including its security and decentralization. However, it also has some drawbacks, such as its high energy consumption and slow transaction processing times.

Proof-of-Stake (PoS): PoS is a newer consensus protocol that aims to address some of the drawbacks of PoW. In a PoS system, nodes are chosen to validate transactions based on the amount of cryptocurrency they hold [18]. The more cryptocurrency a node holds, the more likely it is to be chosen to validate transactions and add new blocks to the blockchain.

The PoS protocol has several advantages over PoW, including its energy efficiency and faster transaction processing times. However, it also has some drawbacks, such as its potential for centralization and security risks.

Delegated Proof-of-Stake (DPoS):DPoS is a modified version of PoS that aims to address some of its drawbacks. In a DPoS system, nodes are chosen to validate transactions based on the number of votes they receive from other nodes in the network[19]. The more votes a node receives, the more likely it is to be chosen to validate transactions and add new blocks to the blockchain.

The DPoS protocol has several advantages over PoS, including its faster transaction processing times and reduced potential for centralization. However, it also has some drawbacks, such as its potential for vote buying and security risks.

3) Data Structure

The data structure of a blockchain is a linked list of blocks. Each block contains a set of transactions and a reference to the previous block[20]. This creates an immutable chain of blocks that cannot be altered once they are added to the chain.

The data structure also includes a cryptographic hash function that ensures the integrity of the data in each block.

4. ATTACKS AND SOLUTIONS IN BLOCKCHAIN

a. Blockchain Attacks

Blockchain technology has been touted as a secure and tamper-proof way of storing data and conducting transactions. However, like any technology, it is not immune to attacks. Here are some common attacks on blockchain systems and how they can be prevented:

1. 51% Attack: This is when a single entity or group controls more than 50% of the network's computing power, allowing them to control the blockchain and potentially double-spend coins[21]. This attack is rare and difficult to execute on larger blockchains like Bitcoin, but smaller blockchains are vulnerable.

2. Sybil Attack: This is when an attacker creates multiple fake identities to gain control of the network[22]. This can be prevented by implementing a proof-of-work or proof-of-stake consensus algorithm that requires users to prove their identity.

3. Smart Contract Vulnerabilities: Smart contracts are self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code[23]. However, if there are vulnerabilities in the code, attackers can exploit them to steal funds or disrupt the network.

4. Distributed Denial of Service (DDoS) Attacks: This is when an attacker floods the network with traffic to overwhelm it and disrupt its operation[22]. This can be prevented by implementing a robust network architecture that can handle high volumes of traffic.

While blockchain technology is relatively secure, it is not invulnerable to attacks. It is important for blockchain developers and users to be aware of these attacks and take steps to prevent them.

b. Blockchain Solutions

Blockchain technology has been touted as a secure and tamper-proof way of storing data and conducting transactions. However, like any technology, it is not immune to attacks. Here are some solutions to common attacks on blockchain systems:

1. 51% Attack: This attack can be prevented by implementing a proof-of-work or proof-of-stake consensus algorithm that makes it difficult for any one entity to control more than 50% of the network's computing power.

2. Sybil Attack: This attack can be prevented by implementing a proof-of-work or proof-of-stake consensus algorithm that requires users to prove their identity. Additionally, network participants can use reputation systems to identify and exclude bad actors.

3. Smart Contract Vulnerabilities: To prevent smart contract vulnerabilities, developers should thoroughly test their code and use formal verification techniques to ensure that the code is correct. Additionally, developers can use bug bounty programs to incentivize security researchers to find and report vulnerabilities.

4. Distributed Denial of Service (DDoS) Attacks: To prevent DDoS attacks, blockchain networks can implement distributed denial of service protection services, such as Cloudflare or Akamai. Additionally, networks can use rate limiting and IP blocking to prevent attackers from overwhelming the network.

5. APPLICATIONS OF BLOCKCHAIN

Blockchain technology has been gaining traction in various industries, including finance, healthcare, and supply chain management. Here are some examples of how blockchain is being used in these industries and the benefits it provides:

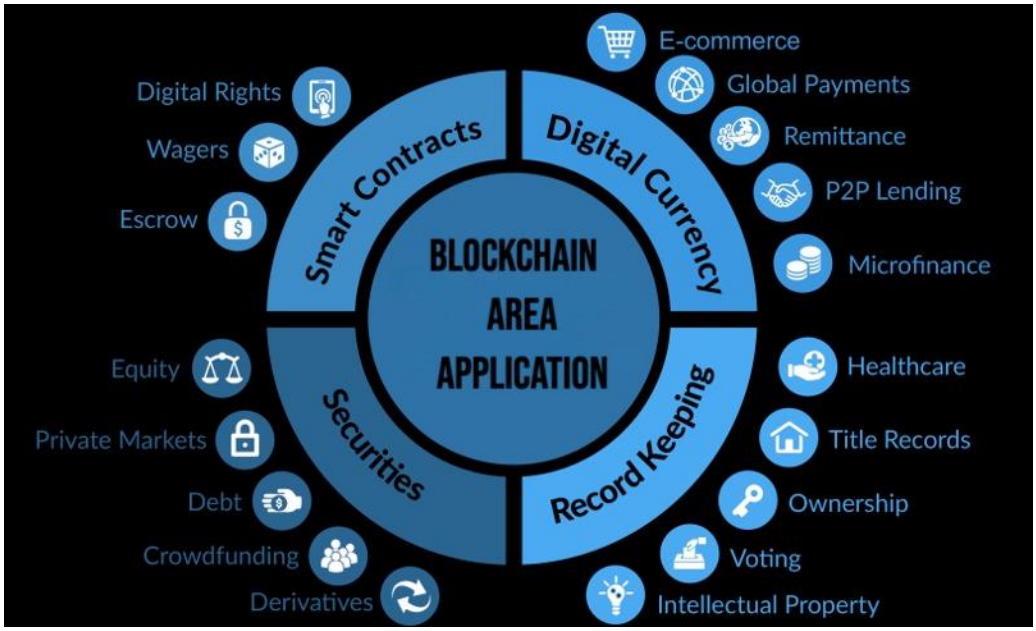

Fig. 2. Areas of blockchain technology application, source: researchgate

1. **Finance:** Blockchain technology is being used in finance for various purposes, such as cross-border payments, trade finance, and asset management. For instance, Ripple's blockchain-based payment network enables faster and cheaper cross-border payments by eliminating intermediaries [24]. Similarly, TradeIX's blockchain platform digitizes trade finance processes, reducing paperwork and increasing transparency. Blockchain technology also enables asset managers to create and manage digital assets, such as cryptocurrencies and security tokens, with greater efficiency and security.

Benefits: By using blockchain technology, financial institutions can reduce costs, increase speed and security, and improve transparency and trust among stakeholders.

2. **Healthcare:** Blockchain technology is being used in healthcare for various purposes, such as medical record management, clinical trials, and drug supply chain management. For instance, MedRec is a blockchain-based medical record management system that enables patients to control their health data and share it securely with healthcare providers[25]. Similarly, ClinicalTrials.gov is a blockchain-based platform that enables researchers to manage clinical trial data securely and transparently. Blockchain technology also enables drug manufacturers to track the supply chain of drugs from production to distribution, reducing the risk of counterfeit drugs.

Benefits: By using blockchain technology, healthcare providers can improve patient outcomes, reduce costs, increase efficiency, and enhance data security and privacy.

3. **Supply Chain Management:** Blockchain technology is being used in supply chain management for various purposes, such as traceability, provenance, and quality control. For instance, Walmart's blockchain-based food traceability system enables the company to track the origin and journey of food products from farm to store, reducing the risk of foodborne illnesses and increasing consumer trust [26]. Similarly, De Beers' blockchain-based diamond traceability system enables the company to track the origin and journey of diamonds from mine to store, reducing the risk of conflict diamonds.

Benefits: By using blockchain technology, supply chain managers can increase transparency, traceability, and trust among stakeholders, reduce costs, and improve efficiency.

Blockchain technology is being used in various industries for different purposes, providing benefits such as increased transparency, efficiency, and security. As the technology matures and more use cases emerge, we can expect to see further adoption of blockchain in different industries.

6. Future Directions

Blockchain technology has been gaining momentum in recent years, with various industries exploring its potential applications. However, despite the progress made so far, there is still room for further development and innovation in this field. In this section, we will discuss the potential for further growth and some of the challenges that need to be addressed. Additionally, we will explore the potential impact of blockchain on society and the economy in the future.

a. *Potential for Further Development and Innovation*

Blockchain technology has shown promise in various industries, including finance, healthcare, and supply chain management. However, there is still significant potential for further development and innovation in this field[27]. For instance, blockchain technology can be applied to voting systems, identity verification, and energy trading.

One area where blockchain technology can be further developed is scalability. Currently, most blockchain networks can only handle a limited number of transactions per second, which limits their usefulness in high-volume applications. To address this challenge, researchers are exploring various solutions such as sharding, sidechains, and off-chain transactions.

Another area where blockchain technology can be further developed is interoperability. Currently, there are several blockchain networks that operate independently of each other, which limits their usefulness in cross-border applications[28]. To address this challenge, researchers are exploring various solutions such as atomic swaps, cross-chain communication protocols, and interoperability standards.

b. *Potential Impact of Blockchain on Society and the Economy*

Blockchain technology has the potential to transform various aspects of society and the economy [29]. For instance, blockchain-based systems can increase transparency, accountability, and trust in various industries. Additionally, blockchain technology can enable new business models and revenue streams, such as tokenization and decentralized finance.

One potential impact of blockchain technology is on the financial sector. Blockchain-based systems can enable faster and cheaper cross-border payments,

reduce fraud and money laundering, and increase financial inclusion[30]. Additionally, blockchain technology can enable new financial products and services, such as peer-to-peer lending and crowdfunding.

Another potential impact of blockchain technology is on the healthcare sector. Blockchain-based systems can enable secure and transparent sharing of medical records, improve clinical trial data management, and reduce the risk of counterfeit drugs[31]. Additionally, blockchain technology can enable new healthcare models and services, such as telemedicine and personalized medicine.

Blockchain technology has the potential to transform various industries and aspects of society and the economy. However, there are still challenges that need to be addressed, such as scalability and interoperability [32]. As blockchain technology continues to mature and more use cases emerge, we can expect to see further development and innovation in this field. Additionally, we can expect blockchain technology to have a significant impact on society and the economy in the future.

7. CONCLUSION

In conclusion, blockchain technology has proven to be a revolutionary innovation with the potential to transform various industries. Its decentralized nature, immutability, and transparency provide a secure and efficient way of conducting transactions. This article has provided a comprehensive overview of blockchain technology, from its definition and architecture to the different versions and applications across various industries.

The first generation of blockchain technology paved the way for the current third generation, which addresses scalability, interoperability, and sustainability challenges. With the increasing adoption of blockchain technology, there is a potential for new business models and the disruption of traditional industries.

However, blockchain technology still faces challenges such as scalability, interoperability, and regulatory issues. These challenges need to be addressed for widespread adoption of blockchain technology.

Despite these challenges, the future of blockchain technology looks promising. It has the potential to transform various industries by improving efficiency, reducing costs, and enhancing security. As more organizations and governments adopt blockchain technology, we can expect to see more innovative use cases and applications in the future.

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Error Correction Using Quantum Computation

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Abstract. Quantum Error Correction (QEC) is an important technique for protecting quantum information against decoherence and errors. This involves the design and implementation of algorithms and techniques to minimize error rates and increase thestability of quantum circuits. One of the key parameters in QEC is the distance of the error- correcting code, which determines the number of errors that can be corrected. Another important parameter is the error probability, which quantifies the likelihood of errors occurring in the quantum system. In this context, the goal of a simulation sweeps like the one performed in the code is to study the performance of the QEC codefor different values of the distance and error probability, and to optimize the code for maximum accuracy. By varying these parametersand observing the performance of the code, researchers can gain insights into how to design better codes and improve the reliability ofquantum computing systems. We also discuss thechallenges that need to be addressed for quantum computing to realize its potential in solving practical Error-correction problems.

Keywords: quantum, error corection, decoherence, algoritm.

1. INTRODUCTION

The methods and techniques used in this paperinvolve both classical and quantum computing.Quantum computers are expected to revolutionizecomputing by solving problems that are intractablefor classical computers. However, the major challenge for building practical quantum computers is their susceptibility to de-coherence and errors. To address this challenge, quantum error correction (QEC) techniques such as surface codes have beendeveloped. Surface codes are a promising class of QEC codes that can be implemented in variousquantum hardware platforms, includingsuper conducting qubits, ion traps, and topologicalqubits.

In this paper, we aim to contrast your research on depolarizing algorithms with the potential of quantum computing for error correction protocols. We provide a review of the existing literature in this field, highlighting the advancements and limitations of current approaches. we examine various quantum algorithms proposed for error correction, including those based on amplitude amplification and other innovative techniques. These algorithms offer promising avenues for improving the efficiency and effectiveness of error correction in quantum systems.

Throughout the paper, we critically analyze the strengths and weaknesses of these quantum error correction approaches, contrasting them with the depolarizing algorithms that you have researched. We highlight the potential advantages and limitations of each method, considering factors such as computational complexity, resource requirements, and scalability.

Quantum error correction algorithms use the principles of quantum mechanics to protect quantum information from the effects of noise and errors. These algorithms rely on the fact that quantum systems can exist in a superposition of multiple states and that entanglement allows for the transfer of information between qubits.

Surface code -based algorithms, it relies on a two- dimensional array of physical qubits to protect quantum information from errors. The surface code uses a set of measurement-based error correction techniques to detect and correct errors that occur during quantum computation. To evaluate the performance of these algorithms, we use various metrics such as time complexity, space complexity, and the number of quantum gates required.

We offer a critique of the current quantum algorithms and point out the difficulties that must be solved to make quantum error- correction algorithms practical for real-world applications. The main challenge in developing practical quantum error correction algorithms is the limited number of qubits and the high error rates of current quantum hardware. Moreover, developingquantum algorithms that can handle real-world situations like dynamic graphs and many constraints are still difficult to solve.

In conclusion, this paper provides a comprehensive review of the state-of-the-art quantum based Error correction algorithms and highlights the potential of quantum computing for solving combinatorial optimization problems. While there are still many challenges to be overcome, we believe that quantum computing has the potential to revolutionize the field of optimization and provide new solutions to some of the most challenging problems in computer science.

2. RELATED WORK

The problem of finding the Error and Correct it in a graph is a well-studied problem in computer science, and various classical algorithms have been developed for this purpose. The most well- known and widely used classical algorithm for distance Monte Carlo simulation, Which was first proposed by Stanislaw Ulam and Nicholas Metropolis in the 1940s. It is a statistical technique used to estimate the probability of an event occurring by running a large number of simulations. In the context of quantum error- correcting codes, Monte Carlo simulation can be used to estimate the number of steps until logical bit failure for each distance and probability.

However, the space complexity and time complexity of Monte Carlo simulation are generally considered to be reasonable, given the accuracy and flexibility of the technique. Monte Carlo simulation is a widely used simulation technique in many fields, and it has been used to solve a wide range of complex problems.

Recently, Quantum error correction was proposed independently of Monte Carlo simulation. Quantum error correction was first proposed by Peter Shor in 1995, who developed the concept of quantum error-correcting codes as a way to protect quantum information from decoherence and other types of errors. Shor's work was based on the idea of encoding quantum information in a larger system of qubits, so that errors in individual qubits could be detected and corrected.

While Quantum algorithms have shown impressive potential in terms of theoretical time complexity but implementing them in practice on existing quantum hardware poses several challenges. These challenges include the Qubit noise, Overhead, Complexity, Error threshold, Fault tolerance, short coherence time of qubits, the high error rates of quantum gates, and the absence of reliable fault-tolerant quantum hardware. Despite these challenges, researchers are making rapid progress in QEC, quantum error correction is a critical component of quantum computing and is essential for realizing the full potential of quantum technologies.

Ongoing research is focused on developing new and more efficient codes, as well as on improving the overall reliability and robustness of quantum error correction.

3. CURRENT STATE AND ADOPTION

Since quantum computing technology is still in its early stages of development, it is still difficult to find functional quantum computers that can deal with everyday problems. The development of quantum computing hardware and software, however, is being supported by a number of businesses and academic institutions, and significant advancement has been made in recent years.

Quantum error correction (QEC) is a field of research in quantum information theory that deals with methods for protecting quantum systems from the effects of noise and errors. QEC is essential for the development of practical quantum computing technologies, as it allows quantum computations to be performed with a high degree of accuracy even in the presence of noise and errors. The current state of adoption of QEC is still in its early stages, as practical quantum computers are still in their infancy and have yet to achieve the level of fault tolerance required for large-scale computations. However, significant progress has been made in recent years in both the theoretical and experimental aspects of QEC, and there is optimism that the field will continue to advance rapidly.

Despite its current limitations, quantum computing has the potential to tackle challenging issues in a variety of industries, including cryptography, machine learning, and optimisation. Cloud-based quantum computing services have already been introduced by a number of businesses, including IBM, Google, and Microsoft, enabling experimentation with quantum algorithms and applications by researchers and developers.

While the use of quantum computing is still in its infancy, a number of sectors, including banking, pharmaceuticals, and materials science, have already begun investigating its potential to address challenging issues that are insurmountable using conventional computer techniques. In the future years, we may anticipate a greater uptake of quantum computing across a variety of sectors as technology develops and more potent quantum computers become available.

4. METHODS AND TECHNOLOGY USED

COBYLA algorithm: By employing the COBYLA algorithm in quantum error correction, researchers can optimize and fine-tune various aspects of the error correction process to enhance the resilience of quantum systems against errors and noise. The algorithm aids in finding solutions that can improve the overall performance and reliability of quantum computation and communication systems.

Aer Simulator: The Aer simulator, available in the Qiskit library, is utilized to simulate the noisy quantum circuit. It provides a platform for executing quantum circuits on a classical computer and obtaining measurement outcomes in the presence of noise.

Measurement Calibration (CMC) algorithm: to mitigate errors in the measurement results obtained from executing a quantum circuit. This algorithm helps to improve the accuracy of the measurement outcomes by mitigating the effects of noise and errors in the quantum system.

Quantum Computing: In Quantum computing, data is processed using the principles of quantum physics. Qubits are used in quantum computers in place of traditional bits to represent data. Quantum computers can do some tasks faster than classical computers because qubits can exist in a superposition of states.

Qiskit: Qiskit is an open-source framework for programming quantum computers. It provides a set of tools for building and executing quantum programs, including simulators and hardware interfaces. Qiskit is built on top of Python and is designed to be accessible to both quantum and classical programmers.

IBM Quantum Experience: IBM Quantum Experience is a cloud-based service that gives users access to actual quantum simulators and hardware. It offers tools for visualising the quantum state and analysing the results as well as the ability for users to build and run quantum programmes using Qiskit.

Monte Carlo simulation: It is a statistical technique used to estimate the probability of an event occurring by running a large number of simulations. In the context of quantum error-correcting codes, Monte Carlo simulation can be used to estimate the number of steps until logical bit failure for each distance and probability.

Python: Python is a programming language used for a range of purposes, such as data processing and scientific computing. For building quantum programmes utilising Qiskit and other quantum libraries, it is widely used in the quantum computing field.

Matplotlib: Matplotlib is a plotting library for Python. It offers tools for making line graphs, scatter plots, and histograms, among other types of plots. In the scientific community, it is frequently used to visualise data and outcomes.

The main method used in this paper is the implementation of the quantum version of COBYLA algorithm. The COBYLA algorithm, or Constrained Optimization by Linear Approximations, is a classical optimization algorithm commonly used in the context of quantum error correction. It is employed to optimize specific aspects of quantum error correction codes, such as the arrangement of qubits, gate sequences, or error correction protocols. The algorithm is implemented using the Qiskit framework, which is an open-source software development kit for quantum computing developed by IBM. The implementation of quantum error correction also incorporates classical techniques to optimize the quantum circuit and obtain the final error- corrected solution.

In this papper quantum error correction, the COBYLA algorithm is utilized to optimize the parameters and operations of the error correction circuit. It operates in a gradient-free manner, meaning it does not rely on gradient information, making it suitable for optimizing quantum circuits where gradients might be difficult to compute.

Quantum error correction techniques are evaluated by comparing them to classical error correction methods in terms of time complexity and the number of quantum gates used. Time complexity is assessed using big-O notation to understand how the algorithm scales with input size. The number of quantum gates used directly affects the resource requirements of the quantum circuit. Scalability analysis considers the algorithm's ability to handle larger-scale quantum systems, such as increasing the number of qubits or complexity of error patterns. This evaluation helps assess the efficiency of error correction methods.

The code utilizes the Qiskit library to implement a quantum error correction circuit for addressing error correction in quantum computing. Quantum error correction techniques are applied to mitigate the impact of noise and errors on quantum systems. The circuit is designed to detect and correct errors that may arise during quantum computations. The algorithm incorporates error-detection codes and error-correction codes, leveraging the principles of quantum error correction to identify and rectify errors caused by the quantum hardware or external factors. This ensures the integrity and reliability of the quantum information.

To construct the quantum error correction circuit, the code utilizes the Quantum Register and Classical Register classes to define the quantum and classical registers, respectively. It then uses the Quantum Circuit class to create the circuit by applying error- detection and error-correction codes to the qubits. These codes help detect and

correct errors introduced during quantum computations, ensuring the integrity and reliability of the quantum information and most commonly used controlled gates in quantum error correction include controlled-X (CNOT) gates and controlled-Z (CZ) gates. These gates are used to perform controlled operations on qubits to correct errors based on the syndrome measurements obtained from the error-detection codes.

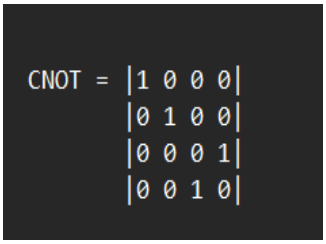

Fig. 1 a

Fig. 1 b

The CNOT gate (Fig. 1a) acts on a two-qubit system, where the control qubit is the first qubit and the target qubit is the second qubit and it defined as on Fig.1 b. This means that if the control qubit is $|0\rangle$, the target qubit remains unchanged, and if the control qubit is $|1\rangle$, the target qubit is flipped. The CNOT gate is widely used in quantum computation and quantum error correction protocols.

For the the syndrome measurement step CZ gate is used where the controlled-Z (CZ) gate is a two- qubit gate that applies a phase-flip operation (Z gate) on the target qubit if and only if the control qubit is in the state $|1\rangle$. The CZ gate can be represented by the following matrix (Fig. 1c).

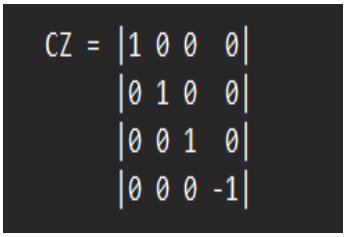

Fig. 1 c

Fig. 1 d

The CZ gate acts on a two-qubit system, where the control qubit is the first qubit and the target qubit is the second qubit. It can be defined as on Fig. 1d. This means that if both the control and target qubits are in the state $|1\rangle$, a phase-flip (-1) operation is applied to the target qubit. Otherwise, no operation is applied. The CZ gate is commonly used in quantum computing for entangling qubits and implementing quantum gates such as the Toffoli gate and the controlled phase gate. To simulate the quantum error correction circuit, the code can utilize the Aer simulator, which allows for the execution of quantum circuits on a classical computer. The execute function is used to run the circuit on the simulator and obtain the counts of the measurement outcomes.

Quantum error correction involves the use of unitary operations to detect and correct errors in quantum systems. Controlled-X (CNOT) gates, along with other gate

operations, are utilized to perform error detection and correction operations. These gates enable entanglement and transformations necessary for error correction in the quantum circuit.

This code implements a quantum error correction routine using the stabilizer formalism. The error correction is performed on a square lattice of qubits, where each qubit can be in either the state |0⟩ or |1⟩. The lattice size is defined by the variables n_rows and n_columns.

The stabilizer formalism is based on the measurement of stabilizer operators, which are products of Pauli operators (X, Y, Z) that commute with each other. In this code, the stabilizers are created as follows:

X-Stabilizers (Plaquettes): For each qubit in the lattice, except those on the last row and last column, four X-stabilizers are created. These stabilizers are defined by the product of X operators applied to neighboring qubits. The stabilizer generators are given by:

$$Sx_{i,j} = X_{i,j} * X_{i,j+1} * X_{i+1,j} * X_{i+1,j+1}$$

where i and j are the indices of the qubit in the lattice. Z-Stabilizers (Vertices): For each qubit in the lattice, Z-stabilizers are created. These stabilizers are defined by applying an H (Hadamard) gate to each qubit. The stabilizer generators are given by:

$$Sz_{i,j} = H_{i,j} * Z_{i,j}$$

After creating the stabilizer generators, the code performs stabilizer measurements. Each qubit is measured in the computational basis (Z-basis) to obtain the syndrome information. The measurement results are stored in the counts variable.

Next, the code could implement an error correction logic to correct the errors based on the syndrome information. This part is currently commented out, so the specific error correction steps are not shown in the code. The error correction logic typically involves analyzing the syndrome patterns and applying appropriate recovery operations to correct the errors.

Finally, the measurement results are printed using the print(counts) statement, which displays the number of occurrences of each possible measurement outcome. It's worth noting that the code uses the Qiskit library for quantum computing, specifically the QuantumCircuit class for circuit construction and the Aer module for defining the backend and executing the circuit. This code demonstrates how to simulate a noisy quantum circuit using the Qiskit library and visualize the results using a bar plot. Let's break down the code step by step:

matplotlib.pyplot is imported as plt to create the bar plot.

QuantumCircuit, transpile, A_{er}, and execute are imported from qiskit to define and simulate quantum circuits.

NoiseModel, depolarizing_error are imported from qiskit.providers.aer.noise to create a noise model and define depolarizing errors.

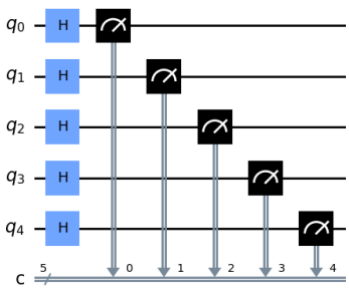

Fig. 2a

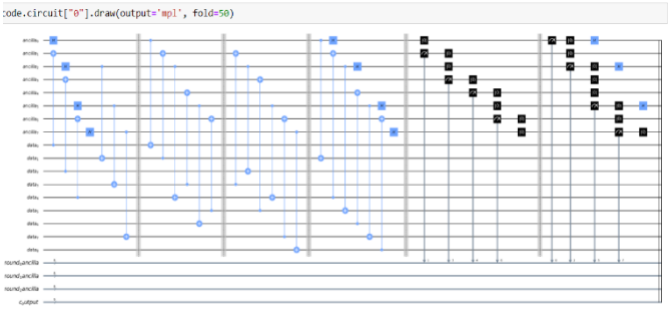

Fig. 2b

Defining the number of qubits and the error rate: n_qubits is set to 5, indicating the number of qubits in the circuit.

error_rate is set to 0.05, representing the probability of an error occurring on each qubit during simulation.

Creating the noise model:

A NoiseModel object named noise_model is created. A for loop is used to iterate over each qubit.

Inside the loop, depolarizing_error is used to generate a depolarizing error object with the specified error_rate and a single-qubit gate error model.

The depolarizing error is added to the noise model for each qubit, targeting the corresponding qubit using

['u%d' % i] and adding it to the qubit list [i]. Creating the quantum circuit:

A QuantumCircuit object named circuit is created with n_qubits qubits and n_qubits classical bits.

The Hadamard gate (h) is applied to all qubits using circuit.h(range(n_qubits)).

A measurement operation is added to each qubit, mapping qubit indices to classical bit indices using circuit.measure(range(n_qubits), range(n_qubits)). Transpiling the circuit for the noisy simulation:

The transpile function is used to optimize the circuit for the target backend, considering the basis gates defined in the noise model (noise_model.basis_gates).

Simulating the noisy circuit:

The A_{er} simulator backend is chosen with Aer.get_backend('qasm_simulator').

The execute function is called to run the transpiled_circuit on the backend.

The noise_model is passed as an argument to consider the defined noise during the simulation.

Theresult of the simulation is obtained with noisy_job.result().get_counts(transpiled_circuit), which returns the measurement counts.

Plotting the noisy counts (Fig. 3 a, b). A bar plot is created using plt.bar with the keys (measurement outcomes) and values (counts) from noisy_counts. Axes labels and a title are added to the plot using plt.xlabel, plt.ylabel, and plt.title. Finally, plt.show() is called to display the plot.

In summary, this code sets up a quantum circuit with a specified number of qubits, introduces depolarizing errors to simulate noise using a defined error rate,

executes the circuit on a simulator, and plots the measurement counts obtained from the noisy simulation.

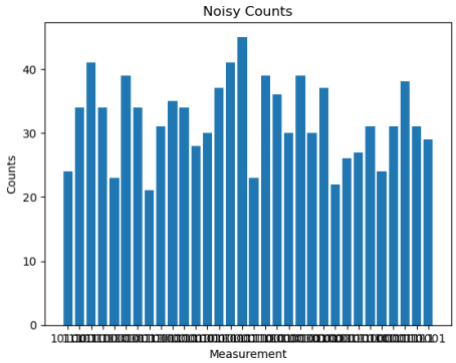

Fig. 3a

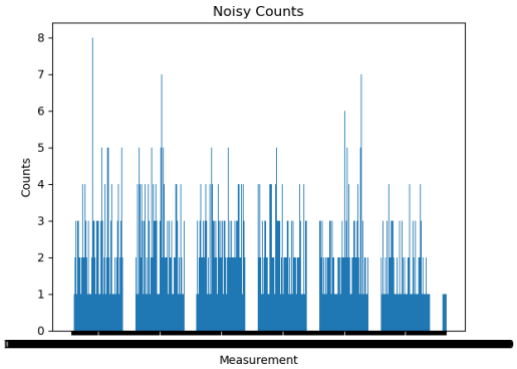

Fig. 3b

5. RESULT AND DISCUSSION

Classical error correction involves encoding and decoding information using classical bits and error- correcting codes. It has polynomial time complexity O(n^k) but requires additional storage and transmission overhead.

Quantum error correction aims to protect quantum information from errors and uses quantum error- correcting codes based on entanglement and superposition. It often has exponential time complexity and requires more qubits and gates as the system size increases. Efficiency Comparison:

1. Error Correction Capability: Quantum error correction can handle arbitrary errors on multiple qubits, while classical error correction is limited to detecting and correcting specific error patterns.

2. Scalability: Quantum error correction is crucial for scaling up quantum systems, while classical error correction methods may become impractical as the system size increases.

3. Error Threshold: Quantum error correction has an error threshold, beyond which errors cannot be effectively corrected, while classical error correction can achieve lower error rates without such a strict threshold.

4. Overhead: Quantum error correction incurs significant overhead in terms of qubits, gates, and resources, while classical error correction has a comparatively lower overhead.

By visualizing the measurement counts in this bar graph, you can gain insights into the distribution of measurement outcomes and assess the impact of noise on the quantum circuit. It provides a way to analyze the effectiveness of error correction techniques and the stability of the simulated quantum system. Overall, quantum error correction provides the potential for reliable error mitigation in large-scale quantum computations, although it is more resource-intensive and faces challenges in scalability and time complexity.

Classical error correction is more efficient but lacks the ability to protect against arbitrary errors on multiple qubits.

Ongoing research focuses on developing better error-correcting codes, fault-tolerant architectures, and noise-resilient algorithms to enhance the efficiency of quantum error correction and improve the scalability and reliability of quantum computing systems.

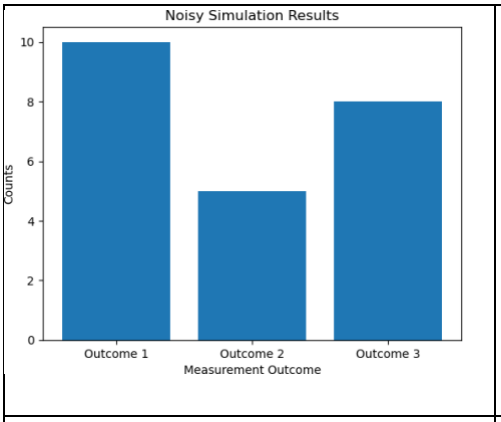

Fig. 4a

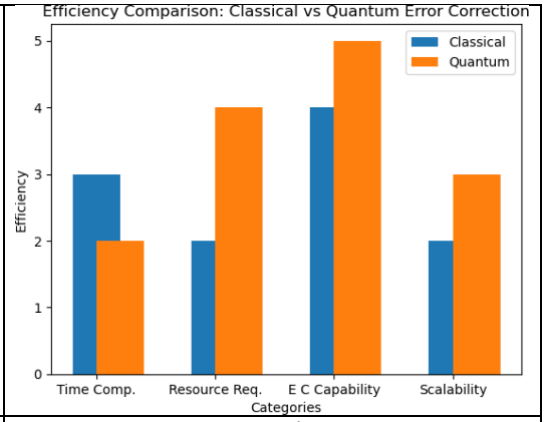

Fig. 4b

The graph provides a concise summary of the time complexity comparison between classical and quantum error correction methods, allowing for easy understanding and interpretation of the information.

5. CHALLENGES

Two of the main challenges in using quantum computing for quantum error correction problems Exponential resource requirements: Quantum error correction typically involves encoding quantum information in a larger number of physical qubits, which increases the resource requirements of the system exponentially. This can be a significant challenge in terms of hardware limitations and computational resources needed for error correction.

Noisy and error-prone environment: Quantum systems are highly susceptible to noise and errors due to various factors such as decoherence, imperfect gates, and environmental interactions. Designing error correction techniques that can effectively handle and correct errors in such noisy environments is a major challenge.

6. LIMITATIONS

1. Complexity of error correction codes: Quantum error correction codes can be complex and challenging to implement, especially as the size of the quantum system increases. Understanding and implementing advanced error correction codes may require significant computational resources and expertise.

2. Hardware limitations: The effectiveness of quantum error correction techniques is dependent on the capabilities and limitations of the underlying quantum hardware. Current quantum hardware may have constraints such as limited qubit coherence times, high error rates, and imperfect gate operations, which can impact the performance and efficiency of error correction.

3. Resource requirements: Quantum error correction typically requires a significant number of physical qubits to encode and protect a smaller number of logical qubits. This can impose resource constraints, including the need for large- scale quantum systems and computational resources, which may not be readily available.

7. FUTURE SCOPE

The future of quantum error correction holds great promise as researchers strive to advance algorithms, hardware, and software tools. On exciting direction for future research involves the exploration of hybrid classical-quantum algorithms. These algorithms aim to harness the advantages of classical and quantum computing together, potentially enabling more efficient solutions for problems like shortest-path calculations. Additionally, there is ongoing interest in developing novel error-correcting techniques tailored specifically for quantum computing. These advancements could pave the way for fault-tolerant quantum shortest-path algorithms, further enhancing the capabilities of quantum computing in solving complex problems.

8. CONCLUSION

In this paper, we have presented a novel approach for Error Correction path using quantum computing the research focuses on the implementation of quantum error correction techniques, incorporating classical methods to optimize the quantum circuit. The COBYLA algorithm is utilized for optimizing the parameters and operations of the error correction circuit. The performance of quantum error correction is evaluated by comparing it with classical error correction methods in terms of time complexity and the number of quantum gates used. The analysis includes assessing the scalability of the algorithm with increasing input size, such as the number of qubits or the complexity of error patterns. The research employs the Qiskit library to implement a quantum error correction circuit, leveraging error-detection and error-correction codes to ensure the reliability of quantum information. The circuit utilizes controlled-X (CNOT) and controlled-Z (CZ) gates for error detection and correction operations. Additionally, the research demonstrates the simulation of noisy quantum circuits using Qiskit and visualizes the results using bar plots, highlighting the effects of depolarizing errors on measurement outcomes.

The graph visually conveys the key takeaway that classical error correction techniques typically have polynomial time complexity, while quantum error correction techniques exhibit exponential time complexity. This difference in time complexity highlights one of the challenges faced in quantum error correction, as the computational resources required for error correction operations grow exponentially with the number of qubits or system size.

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Machine Maintenance Policies in Local Sugar Manufacturing: A Case Study of Madukismo, Indonesia

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Abstract. This study aimed to analyze the factors that cause un-optimal on a maintenance of machinery in P.G Madukismo. An engine maintenance which was carried out by P.G Madukismo for 6 months, had not been able to suppress an engine stop time. In 2016 the planned engine stop time in P.G Madukismo was on 88.8 hours, but in reality the P.G Madukismo engine stopped clock reached on 179.44 hours during a milling season.

By exploring a case study approach, data collection was examined by interviews, observation and documentation. The data collected was analyzed using the reduction, data presentation and concluding withdrawal stages. The results of this study indicated that the main factors that caused engine maintenance had not been optimal because the useful life of the machine had been exhausted and preventive maintenance that was carried out cannot replaced all engine components that were damaged or worn. In addition, P.G Madukismo also did not have a SOP related to machine maintenance. Efforts that had been made to optimize machine maintenance were preventive maintenance, which was carried out not only outside the milling season but also during the milling season and provided training to employees to improve employee capabilities.

Keywords: machine maintenance, stop time.

1. BACKGROUND

A decrease amount of sugar production in Indonesia was pushed by an imported sugar policy. Some common influencing factors on the domestic sugar production are weather conditions, a decreasing amount of sugar cane land and a decreasing production capacity of sugar mills in Indonesia. The production capacity can be improved by revitalizing machines and, then, by maintaining a production number toward optimal one [1].

Madukismo Sugar Factory (P.G Madukismo) is a sugar mill owned by PT Madubaru as one of state owned corporation. The production of Madukismo in 2016 was only reached at 32,326 tons from the production target of 37,233 tons (krjogja.com 2016). One of the factors that affect the productivity of Madukismo was that it related to the decrease in yield. Alternative improvements were first, a preventing the decline in yield and second, an increasing the effectiveness of machine maintenance [2].

The maintenance system applied by Madukismo is consisted of a preventive maintenance and a maintenance after breakdown. A preventive maintenance is a maintenance activity carried out to prevent an unexpected breakdown. A maintenance breakdown is an activity of maintenance that is carried out after some facilities' breakdown.

The maintenance of machines that were carried out from November to April had not been able to press the engine stop clock. The planned engine stop clock was 88.8 hours, but, in fact, the 2016's engine stop time reached 179.44 hours. An increase of some engine stop hours had increased of an engine maintenance cost around 6%. A

budgeted maintenance cost up to December 2016 was Rp. 11,009,094,003, but its' realization of maintenance cost reached Rp. 11,658,424,879.

Based on the problems mentioned above, some purposes of this study can be defined as: first, to identify un-optimal maintenance activity in P.G Madukismo. Second, to analyze a solution on optimizing a machine maintenance of P.G. Madukismo.

2. TERMINOLOGY

2.1 Maintenance

A maintenance is all related activities to maintain all equipment to keep working properly. According to [3], a purpose of asset maintenance is to extend an useful life of assets, to ensure an equipment availability and operational readiness of equipment and equipment installed for production activities, to reduce maintenance costs as low as possible by carrying out maintenance activities effectively and efficiently, meeting product needs and production plans timely, and, to improve employee safety and health.

2.2. Value Stream

Value streams are describing all activities carried out to create value for customers. Value streams are created into an image called value stream mapping (VSM).

Value stream mapping is an instrument for analysing some financial benefits obtained from a lean manufacturing. The benefits of lean manufacturing can be made into a box score. The box score is a framework for evaluating some operational and some financial impacts of Lean. In the box score, there are three categories as follows.

1) Operational

The components in operational are related to the performance measurement of the value stream. The performance measurement of the value stream aims to continuously improve some activities in the value stream. The performance measurement component of the value stream is as follows.

a) Dock to dock days is the time needed from received raw materials until the goods are delivered to the customer.
b) First time through is the units percentage that are processed perfectly and in accordance with quality standards during the first process without any improvement, rework, retesting, or re-adjustment.
c) On time shipment is the percentage of orders that sent to customers on time.
d) Sales per person is sales that is done by one person then it measured through created values from value stream productivity. Measurement of sales per person must be known by the number of sales and the people involved.
e) Average Cost Per Unit is the total cost of activities in the value stream in a period and divided by the amount of production.

2) Resources Capacity

A capacity is a level of ability to produce optimally from a facility which is usually expressed in the amount of output. The capacity that referred in the box score is the capacity of the number of people, machines and time available in a period. The capacity used is divided into three categories as follows.

a) Productive is the time of labor or machinery that spent to produce products.

b) Non productive is all the time used, including non-value added activities, the time spent reworking.
c) Available is the remaining machine or labor after calculating productive and non-productive time.

3) Finance Information

Financial information contained in the box score are items that become the attention of both accounting and finance in the company. These items are income, inventory, raw material costs, costs incurred in the value stream process, and profit from the value stream.

2.3. Factors that Cause Maintenance

The factors that cause machine maintenance problems will be analyzed using the 7M principle. According to [4], the source of the quality problems found is based on 7M principles:

1) Manpower (labor), related to lack of knowledge, lack of basic skills related to mental and physical, fatigue, stress and ignorance.
2) Machine and equipment, related to no preventive maintenance system for production machinery, including other facilities and other equipment that are not in accordance with the specifications of the task, not calibrated, too complicated.
3) Methods (work methods), related to the absence of proper work procedures and methods, the absence of an explanation regarding the work method, the existing work method does not match to the system being applied.
4) Material (raw materials and auxiliary materials), related to the absence of quality specifications of raw materials and auxiliary materials used.
5) Media, relating to work place and time that does not pay attention to aspects of cleanliness, occupational health and safety and a conducive work environment.
6) Motivation, related to the absence of a correct and professional work attitude caused by reward that is unfair to the labor.
7) Money (finance), related to the lack of support to improve the quality.

3. PREVIOUS CASES

The results of [5, 6] showed that in the last 5 years PT PLN Ranting Pekanbaru has faced problems, namely the high gas engine damage and engine maintenance costs which are increasing every year. The causes of these problems are (1) lack of planning, implementation and supervision by the company; (2) the policy has not been implemented in evaluating maintenance costs; (3) the price of spare parts is increasing; and (4) lack of expertise owned by maintenance personnel.

While [7] stated that the company has not made many new investments or replacements in a number of equipment whose useful life has expired. The company has not made replacements for equipment but has only carried out preventive maintenance on a number of equioments supporting facilities that they have so far. The results of this study indicate that the application of internal control components applied by PT Sawokembar Galeria was inadequate. However, overall it is not in accordance with COSO because there were still risks that have not been minimized by the company.

For example, a record error was made by the warehouse administration officer in recording spare parts, limited administrative officer who was only one person so that the task carried out could not be completed properly and on time and the absence of a company data security system including equipment data outside the company.

Based on previous case studies, a case approach was selected. An interview, an observation and a critical review of documents are examined in collecting relevant data. A type of semi-structured interview was implemented for finding some insights from the head of the installation department, human resources staff, financial staff, manufacturing supervisors in the field section. An observation was conducted for some periodical information of maintaining a machinery process between November to April. Finally, a critical review of some documents owned by the company was carried for the company's work plan and budget (RKAP) in 2016, 2016 financial statements, 2016 performance report, 2016 asset list report, 2016 milling daily report and the machine's Standard Operational Procedure (SOP) used in Madukismo PG.

In a stage of data analysis, a tabulation technique by [8] was implemented on interview transcripts, observation transcripts and documents' critical review working paper. on a critical review. Some steps, such as a data reduction, a data reorganizing, and a scheme of research finding based on data relationship. So, a triangulation technique in this study can be a testing instrument for a data credibility by checking data obtained through several sources [9].

4. SYMPTOMS

An engine maintenance carried out every year for 6 months had not been able to suppress the engine stop time. The 2016's engine stop time reached 179.44 hours. The engine stop time planned for 2016 was only 88.8 hours. An increasing of engine stop hours caused 6% increased of engine maintenance costs. A higher production cost affected a decreasing of company's profit in 2016 compared to a 66% decreased in 2015.

The machine used by Madukismo has a capacity of 3,500 tons of sugar cane per day. At the beginning of its establishment, P.G Madukismo could only grind sugarcane for 1,500 tons of sugar cane per day. P.G Madukismo has not been able to use the engine capacity optimally. Based on the results of the analysis in Table 1, P.G Madukismo can only use a machine of 94.1% of the existing engine capacity. The optimal engine capacity used is only 87.4%. The use of engine capacity that has not been optimal results in higher production costs which were also higher in the cost of sugar per kg. The high cost of production also makde the price of sugar produced by P. Madukismo cannot competed with imported sugar. In addition, P.G Madukismo has not been able to make efficiency on production costs. The increase in production costs was not proportional to the increase in the amount of production. This was based on the 2016 financial report, some production costs increased by 91% but the amount of production produced by P.G Madukismo only increased by around 2% compared to 2015.

Table 1. Box score

Operational	Dock to dock days	6 hours 10 minutes
	First Time Through	80%
	On time Shipment	92%
	Cost per kg	Rp 6452
Machine Capacity	Productive	87,4%
	Non Productive	6,7%
	Available	5,9%
Finance	Sale	Rp 240 182 562 430
	Production Cost	Rp 208 939 199 182
	Value Stream Profit	Rp 31 243 363 248

Source: Observation.

4.1. Machine Maintenace in P.G Madukismo

P.G Madukismo applied preventive maintenance and maintenance breakdown. Preventive maintenance was done by checking all the equipment used during production. This aimed to prevent the occurrence of damage during production and suppress the milling stop hours that were below 2.5% of the milling time during the production period. While maintenance breakdown was maintenance that carried out when the engine was damaged. If there was engine damage or symptoms of season engine damage, the damage was reported to the installation section. It aimed to minimize the stopping hours of the engine and the production process continues smoothly.

Based on the milling daily report in 2016, much damage occurred at the boiler station. The boiler station is a station that generates steam to drive turbines and electricity producers that will be used to operate production machinery in P.G Madukismo. The engine stop time caused by damage to the boiler station was 121.85 hours from the total stop time of 179.44 hours. This engine stop clock shows the time needed to repair the engine when there is damage.

4.2. Factors Causing Machine Maintenance Is Not Optimal

1. Man power (Labor)

Manpower is a factor that is related to the knowledge and skills of the labor. Employees who worked during machine maintenance consist of wholesale employees and permanent employees. Wholesale employees are non-permanent employees who usually work during production. Employees who worked in P.G Madukismo especially for machine maintenance when recruited had technical skills such as welding or graduating from Vocational High Schools (SMK).

In addition to the qualifications of each employee, P.G Madukismo also enhanced the ability of employees by providing training in the form of in-house training and other training conducted with third party collaboration. In-house training attended by all employees including certain time-working employees (KKWT) who only worked during the milling season. In addition, P.G Madukismo also provided training to permanent employees held at LPP Yogyakarta. Manufacturing and installation employees usually followed this training.

2. Machine

Machine are factors related to engine age and preventive maintenance of the engine used. Based on the analysis of the 2016 asset report document, 71% of the assets used for the production process of the book value were Rp. 0,-. In addition, based on observations, P.G Madukismo still used one of the rounds that have been in place since the mill was operated. This round served to separate sugar from the solution after going through the crystallization process.

P.G Madukismo applied preventive maintenance to prevent damage to production machinery during the milling season. Preventive maintenance was carried out not only outside the milling season but also during milling season. When outside the milling season, preventive maintenance was carried out by dismantling all production machines to check the engine condition after being used for almost 6 months. Whereas during the production period, preventive measures were carried out, it was checking and monitoring directly for 24 hours. However, preventive maintenance carried out outside the milling season was still unable to press the engine stop time. This was because the company cannot replaced all engine components that were damaged or worn. Before replaced the engine components, the installation part first considered whether the component must be replaced or only repaired. However, considerations were made not to replace the engine components sometimes, which cause engine damage during production.

3. Method

Factors that related to the method are the implementation of the Standard Operating Procedure (SOP) in machine maintenance and explanation of the machines used. The Standard Operating Procedure (SOP) is a guide made to ensure that an activity runs as expected. P.G Madukismo had a SOP related to the production process and the machine operating process. However, P.G Madukismo doid not have a SOP related to maintenance for each machine used. Routine maintenance that carried out every year was based on activities that was done in the previous year and reports of engine failure during the milling season. Routine maintenance that carried out every year has not been made into a document so that maintenance was carried out only based on the knowledge possessed by the employee. This was in accordance with the observations and the documents that carried out by the researchers found that the existing SOPs were only related to the machine operating process.

4. Material

Material is one factor that influences the quality of maintenance. The material referred to in maintenance activities is the availability of spare parts. Spare parts are components of the machine that are reserved for repair or replacement if the engine is damaged. Spare parts prepared by the company only for engine components that are often damaged.

Submission of spare parts to be purchased was proposed by each operator from each machine. Then, the head of the installation department would choose the spare parts components, which must be purchased immediately.

If the spare parts that needed were not available in the warehouse, the operator of the machine would do the engineering of the engine so that the machine continued to operate. Engineering can be done in the form of operating another machine or keep operating the machine that has been damaged but the operation was not optimal.

Engineering of engine that got damage would be done until the required spare parts are available. This engineering requires the expertise of each machine operator.

5. Media (Work Environment)

One of the factors that can affect employee performance is the media. The media in question is related to the time and environment of the workplace. The working environment conditions of P.G Madukismo were conducive. However, there were still some shortcomings such as the presence of puddles in the factory floor and the road that goes through to monitor and check the condition of each machine that has begun to break down so that it requires caution when passing through it. In addition, some employees also did not use safety helmets as long as they were in the factory and there were employees who hang their clothes on the cable next to the machine that was under repair.

6. Motivation

Factor that can affect the quality of maintenance is motivation. The intended motivation is giving employees reward or punishment in improving their performance. Reward and punishment are given based on performance. The performance of each employee is evaluated using a Performance Management System (SMK (*Sistem Manajemen Kinerja*))). Reward can be given in the form of salary increase, bonus or promotion. In addition, punishment is given in the form of reprimands, salary deductions to dismissal.

7. Money

P.G Madukismo cannot approved all parts parts purchase. However, the installation department, which was responsible for maintaining the machine, was given the authority to allocate the funds to another account in the installation section if the purchased parts were not included in the company's RKAP. In addition, if the funds provided for maintenance activities have been expired, the installation department can submit additional budgets to the board of directors with certain considerations.

Engine maintenance that was not optimal caused damage to the engine during the milling period. Damaged engine repairs had resulted in increasing engine stop hours. High engine stop hours can cause a decrease in sugar cane yield so that the amount of production produced also decreases [10].

P.G Madukismo has only focused on machine maintenance by replacing engine parts that have been damaged. Madukismo P.G has difficulty in revitalizing the engine because of the limited funds available and it was difficult to find third party funds loans. This can be seen from the financial ratio of debt to equity in 2016 was 2.17 times. This figure showed that the greater the burden of the company to repay the loan. In addition, the source of debt owned by Madukismo P.G in 2016 only came from PT. Bank Rakyat Indonesia and PT. Rajawali Nusantara Indonesia. Debt from PT. Bank Rakyat Indonesia aims for farmers' working capital for the milling season in 2017. PT. Rajawali Nusantara Indonesia as the shareholder also provides debt for additional working capital.

The P.G Madukismo policy, which was unable to revitalize the production machine, has an impact on the engine stop and production costs have increased. The low capacity of production machinery and the quality of raw materials resulted in decreased sugar production. This has an impact on government policy to export every

year because the amount of sugar production in Indonesia cannot meet the needs of all people [11].

5. EFFORTS THAT CARRIED OUT

Below are the efforts that have been done by P.G Madukismo:

a. The Implementation of preventive maintenance

Preventive maintenance in P.G Madukismo was done for 6 months. This maintenance is usually carried out from November to April. Preventive maintenance was done by checking all engine components used during the production process. In addition to preventive maintenance that carried out outside the milling season, P.G Madukismo also carried out preventive maintenance when the milling season. The action taken was to make improvements to the engine when symptoms arisen that can caused the engine to stop operating.

b. Implementation of maintenance and production processes in accordance with standard operating procedure

The implementation of the standard operating procedure (SOP) aimed to minimize errors in the production process. P.G Madukismo has a SOP related to the operation and condition of the machine used during the production process.

c. Employees Training

In improving the quality of maintenance, P.G Madukismo was not only focused on providing spare parts. However, P.G Madukismo also focused on improving the quality of human resources. This can be seen from the provision of training to installation employees who were tasked with checking and repairing production machines. Every year, P.G Madukismo provided an opportunity for employees to attend training hold by the Yogyakarta Plantation Education Institute (LPP).

6. CONCLUSION

The conclusions of this study refer to the main objective of this study is to identify and analyze the factors that cause maintenance of the machine in the Madukismo P.G has not been optimal and analyze the efforts that have been made P.G Madukismo in optimizing machine maintenance. The conclusions of this study are as follows.

1. Machine maintenance is not optimal due to the useful life of the machine used by P.G Madukismo have been expired. Therefore, P.G Madukismo applies preventive maintenance for 6 months to minimize engine damage during the milling season. However, preventive maintenance has not been able to minimize engine damage during the milling season. Limited spare parts owned by P.G Madukismo cannot replace engine components that have been damaged. In addition, P.G Madukismo also does not have a SOP related to the maintenance of the machines used. The SOP that is owned is limited to the operation of the machine.

Engine maintenance that is not optimal caused damage to the engine during milling. Machine damage can result in a decrease in sugar cane yield because the waiting time for processing sugar cane become longer. The decrease in sugar cane rendement causes the amount of sugar production to decrease. P.G Madukismo step to revitalize production machinery has difficulty due to limited funds and it is difficult to find for third party loans. The Madukismo P.G policy which is unable to revitalize the production machine has an impact on the engine stop and production increased

costs. In addition to the engine stop hours, low production engine capacity and quality of raw materials caused decreased sugar production.

2. Efforts made to make sure optimum engine maintenance that is preventive maintenance measures. It carried out not only outside the milling season but also during the milling season. P.G Madukismo employees monitor and check 24 hours during the milling season. It aims to detect symptoms of engine damage, if there are symptoms of direct damage repairs are made. Furthermore, employees of P.G Madukismo also carry out production processes in accordance with existing SOP to minimize engine damage. In terms of improving the ability or skills of employees, P.G Madukismo also provides training to employees who that held with third parties. Training is usually given to engineers and supervisors from production machines. The training was held in collaboration with the Yogyakarta Educational Institution (LPP) when the season was outside.

7. RECOMENDATIONS

Based on the conclusions that have been explained before, the research recommendation is that P.G Madukismo can make back up funds for the replacement of production machinery. P.G Madukismo can also use general reserve funds for machine replacement. General reserve funds should not only be used to distribute dividends to shareholders but are used for repair and replacement of production machines. Replacement of production machines can be done in stages. The machines that can be mounted first are machines that experience a high level of damage every year, for example the machines that are in the boiler station. Therefore, the problem of high engine stops hours every year, especially the boiler station can be minimized.

The replacement of production machines to be more modern can also reduce production costs as has been done by PT Gunung Madu Plantations. The milling capacity when it began operating in 1978 was 4,000 TCD but currently it has reached 16,000 TCD. The use of advanced production machines and technology both at the factory and when planting sugar can increase sugar production which reaches 190,000 tons per year with production costs only around Rp. 488,000,000 [12].

Furthermore, P.G Madukismo can make a Standard Operational Procedure (SOP) related to machine maintenance. Activities carried out related to machine maintenance such as dismantling machines are made into a SOP document. The making of this SOP is aimed at the steps that are carried out related to machine maintenance in accordance with predetermined standards, not only based on certain employee information.

8. RESEARCH LIMITATIONS

1. This research is only limited to the whole maintenance of production machines in P.G Madukismo, not on the maintenance activities of each machine used.
2. Researchers cannot observe during the milling season to see the effectiveness of the use of production machines. This is because, the P.G Madukismo milling season in 2017 ends in October 2017.

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Influence of Personality on Technology Readiness and Intention to Use Online Vehicle Taxes Payment in Surabaya, Indonesia

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Abstract. The purpose of this study is to ascertain the relationship between personality and technology readiness and the intention to use online vehicle taxes payment (SIGNAL application) in Surabaya, Indonesia. This study used a quantitative research methodology. The structural equation modeling (SEM) data analysis method was used in this investigation. Simple random sampling methodology and probability sampling to determine the sample. There are 100 respondents served as the sample. There were six hypotheses tested in this study. The findings demonstrated a favorable and substantial relationship between personality traits such as agreeableness, conscientiousness, extraversion, and a chance to experience and technological readiness for motor vehicle tax payment using the SIGNAL application. However, personality neuroticism has a detrimental impact on a person's ability to use technology when paying motor vehicle taxes using the SIGNAL application. Furthermore, technology readiness positively and significantly impacts the intention to use the SIGNAL application to pay motor vehicle taxes.

Keywords: Online Vehicle Tax, Technology Readiness, Personality, Intention to Use.

1. INTRODUCTION

Society is currently living in a time where everything is quick, automated, online, and connected [1]. All community activities that previously operated traditionally have been redirected to shift towards digitalization due to the rapid development of technology toward digital [2]. Today's humans can accomplish things that were never thought possible in the past thanks to information and communication technology research as well [3]. With the development of this contemporary digital era, more individuals are using the internet [4]. In practically every element of people's life, the advancement of digital technology is significant, notably for the economy [5]. In the era of the Fourth Industrial Revolution, players in the market, both public and private, are competing with one another in their business operations by utilizing the benefits provided by technology and information systems, and directing manufacturing technology toward trends in automation and data exchange.

Electronic Government, also known as E-Government, is a growing trend in government circles for providing public services online. E-Government defines as a

system of governance that has been created using the power of digital technology. Public services provided by e-government can be accessible whenever, from anywhere, and 24 hours a day [6]. The community will be able to save more time and money by introducing an online system [7]. The use of E-Government is proof of the effective application of information technology in government organizations and plays a significant part in satisfying the government's objective to improve public administration services [8]. E-government has started to take off in Indonesia, where it is employed, among other things, in connection with a tax payment system that offers web-based services. State revenue has a significant impact, one of which comes from taxes [9]. According to Law No. 16 of 2009, taxes are coercively owing mandatory contributions to the state by people or entities, and the benefits received are not used directly for the benefit of the people but rather for the state's requirements.

Table 1. State Revenue Realization

Sources of Revenue-Finance	**State Revenue Realization (Billion Rupiah)**		
	2021	**2022**	**2023**
Tax Revenue	2 006 334,00	2 435 867,10	2 443 182,70
Non-Tax Revenue	458 493,00	510 929,60	426 259,10

The total state revenue from taxes is higher than the non-tax revenue, according to data from the Central Statistics Agency for the years 2021–2023. This demonstrates that the taxes industry is the source of governmental income. As a result, the government of Indonesia places a high priority on tax collection. The Ministry of Finance reported that during the past 20 years, the number of Indonesians who are registered as taxpayers has increased 20-fold. 2.59 million people were enrolled as taxpayers in 2002. By 2020, that number had increased to 46.83 million, and by 2021, it had risen once more to 49.82 million.

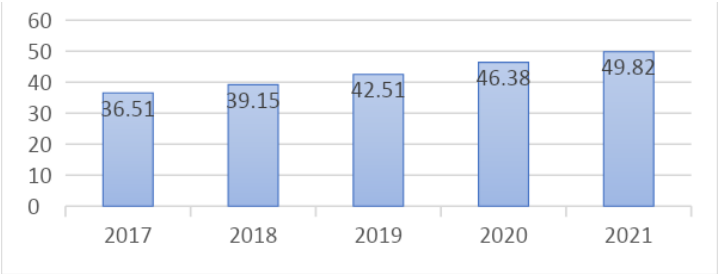

Fig. 1. Number of Taxpayers in Indonesia

There were an additional 3.85 million new taxpayers between January and September 2022, according to the Ministry of Finance's Directorate General of Taxes. Given that there are more taxpayers in Indonesia than ever the increase in tax revenue, the Directorate General of Taxes has made new changes to the country's tax code to better serve taxpayers and make it simpler for them to fulfill their tax-related obligations. Application-system is one way to modernize tax payments through the use of information technology.

The SIGNAL (National Digital Samsat) program is one type of e-system for collecting taxes. Using the National Police motor vehicle database, the population

master database, the Ministry of Home Affairs, and each provincial motor vehicle tax information system, a platform known as SIGNAL is used to digitally validate annual STNK, Payment of Motor Vehicle Tax, and Payment of Road Traffic Funds [10]. It is possible to think of the National Digital Samsat (SIGNAL) as an application that makes it easier for taxpayers to securely pay their yearly motorized vehicle tax [11].

Due to the current challenges, the community is thinking of digitizing this system. Here, the researcher conducted a pre-research survey for responses from Surabaya locals about their use of the SIGNAL application by using a Google form. The findings indicate that a large number of people have still not paid their motor vehicle taxes using the SIGNAL application. The community still faces some challenges because so many people do not yet know about the SIGNAL application.

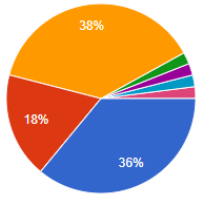

Fig. 2. Pre-Research Survey Results (Barriers to using the SIGNAL application)

In addition, a lot of people find the SIGNAL application confusing and unsatisfactory. This implies that another barrier to using the SIGNAL application is one's level of technological preparedness. Even though the system is online and makes paying taxes relatively simple at any time, many continue to put off doing so, as seen by the surrounding phenomena.

To accomplish effective and contemporary tax administration, the digitization of the system in the SIGNAL application needs the support of all parties to continue to boost taxpayer services and compliance [12]. Because a technology's significance for human interests ultimately depends on the function or contribution of its utility, readiness assessment is vital. A person's propensity to use and apply new technology in reaching their goals in both daily life and the workplace is referred to as their level of technological readiness [13]. The purpose that each person utilizes is a key component of this technology. Personality also contributes to the current technological advancement as the second internal component [14]. A very small number of qualities serve as indicators of personality, and the majority of these traits are influenced by environmental, social, and behavioral factors [15]. This claim explains how people vary depending on the kind of tool they employ [16]. According to The Big Five Theory, there are five different types of personality: agreeableness, openness to new experiences, extraversion, neuroticism, and awareness [17]. According to definitions, agreeableness is a personality attribute that has altruistic, gentle, and trustworthy characteristics and is prosocially oriented toward other people. Openness to new experiences is characterized as a personality trait with high creativity, mental complexity, daring to try a novel, unconventional things, and high levels of imagination and originality. Extraversion is a personality trait that is energetic toward the material and social environment, has a friendly disposition, is forceful and active, and exhibits pleasant emotions. A personality that exhibits negative emotions, such as anger, sadness, anxiety, and depression, is said to have neuroticism. Conscientiousness is described as a personality trait with impulse control that supports goal-oriented actions including planning, according to rules and standards, being organized, and setting priorities for work. People's feelings, thoughts, and behaviors are all influenced by their personality qualities, thus it stands to reason that personality traits will also be useful in understanding how someone plans to use new

technology. As a result, it's critical to discuss how personality affects the acceptance and use of new technology [18].

Intention to Use in taxation has been the subject of a significant amount of research. Studies have looked at technology readiness as a predictor of intention to use. The impact of technology readiness on intention to use was both considerable and not significant, according to the researchers. According to the research, technology readiness significantly affects taxpayer desire in using electronic filing [19]. According to studies, technology readiness does not significantly influence the desire in adopting mobile payment applications [20]. Technology readiness influences the desire to use the SIGNAL application. Technology readiness is also determined by a person's psychology. In addition to the intention to use, technology readiness is also influenced by internal factors from a person, namely from the side of his personality. This is considered important because everyone has different characteristics of their personality that can predict the readiness of their technology.

The authors revisited this subject by including personality as a new variable and reexamining the impact of technological readiness on intention to use in light of the aforementioned research gap.

Adopting technological advancements does not always result in success because some variables can affect how well it goes. Of course, there are still a number some technologically unprepared components in this upgrade that prevent paying this tax. The researcher is interested in researching the impact of personality on technology readiness and the intention to use the SIGNAL application to pay motor vehicle taxes in the city of Surabaya based on the context that has been presented.

2. LITERATURE REVIEW

2.1. Theory Acceptance Model (TAM)

Technology acceptance is the act of a person voluntarily embracing new technology. User willingness is a crucial component for the effective deployment and exploitation of technology [21]. Researchers have created several models to comprehend the characteristics of technology acceptability among people during the past few decades. For many information technology-based applications, the effectiveness of this strategy has been repeatedly tested. The most well-established and significant foundation for technology acceptance, however, is Davis' TAM technology acceptance model [22]. Davis created the Technology Acceptance Model (TAM) as a research model in 1989; by incorporating TRA, it has become a potent theoretical model [23]. This TAM model analyzes the adoption of information technology using a behavioral theory approach [24]. The goal of TAM is to be able to understand user behavior and the broad factors that influence technology acceptance [25]. One of the top research models for analyzing and explaining the uptake of various technologies, such as SIGNAL applications, is the TAM model. Perceived usefulness and perceived ease of use are the two halves of the TAM model. A person's perception of the utility of adopting new information systems and technologies to enhance user performance is known as perceived usefulness, or PU. perceived ease of use (measures how much consumers are believed to benefit from adopting new technologies [26].

The degree to which a person thinks utilizing technology will save him or her effort is measured by perceived ease of usage. One of the criteria used to assess behavioral intention to use technology is perceived ease of use. People will be interested in using technology if they believe it is simple to use. On the other hand, if a piece of technology is challenging to operate, no one will utilize it. The more people

that are highly tech-ready, as is the case with SIGNAL application usage, the better equipped they will be to use this application.

2.2. Intention to Use

An action made by someone motivated by something is known as having the intention to use it. One of the many reasons why someone chooses to use technology is because he thinks it is helpful, simple to use, secure, and comfortable to use. A person's decision to adopt technology is also influenced by their social environment. The intention to use is a behavioral inclination of consumers to keep utilizing a technology [27]. Intensity and usability have a direct impact on this construct. The user's attitude and degree of confidence that using this online method will boost the efficiency of paying motor vehicle taxes will determine how well they utilize the SIGNAL application. These consumers' interest prompts them to utilize the SIGNAL application, which is regarded as offering advantages in the simplicity of use and tax payment process.

2.3. Technology Readiness

A person's propensity to use and apply new technology in reaching their goals in both daily life and the workplace is referred to as their level of technological readiness. Technology Readiness is a characteristic or individual difference variable that measures people's general receptivity to new technology. Technology readiness has four components: optimism, innovation, discomfort, and insecurity. Taxpayers who are ready for new technology advancements as well as those who are high on optimism and innovation as well as those who feel some unease and uncertainty [28].

2.4. The Big Five Personality

Psychologists utilize the Big Five Personality method to evaluate or observe a person's personality. Initially, Lewis Goldberg presented this theory in 1981. However, who employed Allport and Odbert's multidimensional personality structure model, are credited with developing the big five ideas. The five-factor model is what Costa and McCrae refer to as the big five personality theory [29].

Human personality has five dimensions, or traits. The five components that make up the Five-Factor Model (FFM), which was based on the McCrae and Costa personality theory are as follows:

1. The intensity of a person's negative emotions is referred to as neuroticism. The tendency to exhibit negative emotions is evident in this personality trait. People with this personality are known for being excessively scared, nervous, and nervous.
2. Extraversion is a personality characteristic that has to do with sentiments of emotion and enjoyment toward oneself and the environment as well as one's level of comfort when interacting with other people.
3. The quality of openness to experience shows a willingness to try new things. The depth of interest in knowledge is the kind that is open to experience. This personality type has unique traits or traits that are indicative of it, like intelligence and a broad intellect.
4. The ability to effortlessly agree or get along with others is known as agreeableness. The degree of conformity to personal norms determines the type of this friendliness. The pleasant, accepting, and friendly traits of this personality stand out.
5. Being conscientious is the quality of being cautious or conscious. This personality is constantly focused on reaching objectives. Achievement, discipline,

obedience, and orientation are the distinctive traits of someone with this personality [30].

2.5. Vehicle Tax

Due to the enormous number of motorized vehicles that increases significantly each year, the motorized vehicle tax is one of the prospective taxes [31]. The motor vehicle tax plays a significant role in local tax revenue. Whoever owns a motor vehicle, whether an individual or an organization, is subject to the motor vehicle tax. Ownership of motorized vehicles is the goal of the motorized vehicle tax.

2.6. SIGNAL Application

The SIGNAL application uses the motorized vehicle database owned by the National Police, the population for which there is a master database at the Directorate General of Population and Registration Civil Engineering, the Ministry of Home Affairs, and the motor vehicle tax information system are managed to validate the Annual STNK Payment for Motorized Vehicle Tax and Payment of Road Traffic Funds digitally Associated parties without skipping over the National Police's primary duty of overseeing Ranmor operations. The tutorial may be found at https://samsatdigital.id/tutorial and the Signal app can be downloaded from the Play Store. The training website walks users through each step of using the Signal program, from signing up to adding vehicle information and paying taxes to issue E-TBPKP, E-Approval, and E-KD.

A framework for thinking about the influence of personality on technological readiness and the intention to use the SIGNAL application for paying motor vehicle tax in the city of Surabaya may be constructed based on the findings of the explanation of the variables and theories that have been discussed.

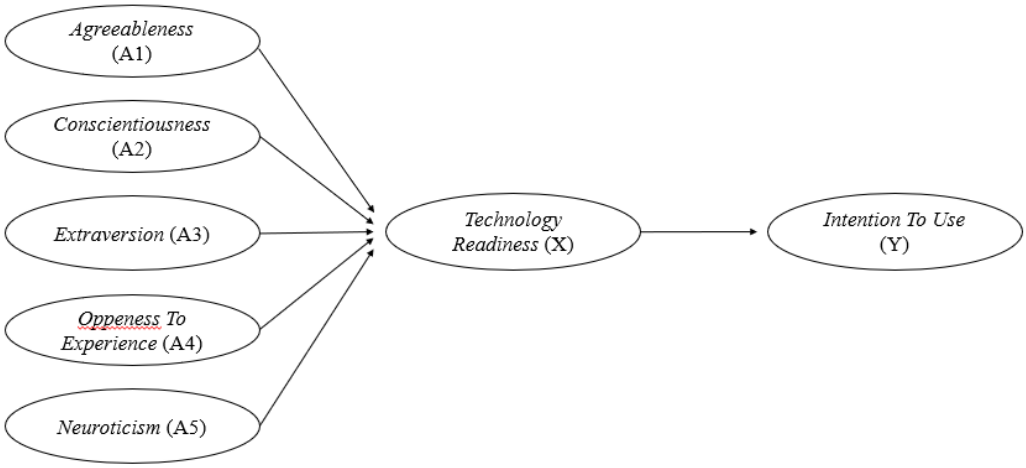

Fig. 3. Thinking Framework

H1: Agreeableness has a significant effect on technology readiness
H2: Conscientiousness has a significant effect on technology readiness
H3: Extraversion has a significant effect on technology readiness
H4: Openness To Experience has a significant effect on technology readiness
H5: Neuroticism has a significant effect on technology readiness
H6: Technology Readiness has a significant effect on the intention to use the SIGNAL application.

3. DATA AND METHODOLOGY

This study used a quantitative research methodology. The 1,886,790 motor vehicle taxpayers in the city of Surabaya make up the study's population. The probability sampling method and a straightforward random sampling strategy were used to determine the sample. A sample of 100 motor vehicle taxpayers is obtained by applying the Slovin formula to the sample with a precision of 10%. Both primary and secondary data are used in this investigation. A collection of questions from the Google Form *questionnaire* was used to collect primary data.

The secondary data used in this study is literature-based data that the authors gathered through studies originating from scientific journals, reference books, articles, and researchers conducting literature studies using publish or perish and VoS Viewer to compile prior studies [32] in order to form a solid research foundation. Utilizing Google Forms, questionnaires were distributed to respondents as part of the data collection process. Using SmartPLS 3.0.4, the structural equation modeling (SEM) data analysis method was used in this investigation. Data analysis from the outer model test and the inner model test are used in hypothesis testing.

4. RESULTS

4.1. Convergent Validity Test

The convergent validity test aims to compare each item's score to the construct score, yielding a loading factor value as the outcome. When the correlation is greater than 0.70, it is said that the loading factor value is high. However, a value of 0.5–0.6 is adequate for the initial stages of the study. Using a loading factor value greater than 0.70 in this investigation. The following outcomes are provided by the SmartPLS output for the loading factor:

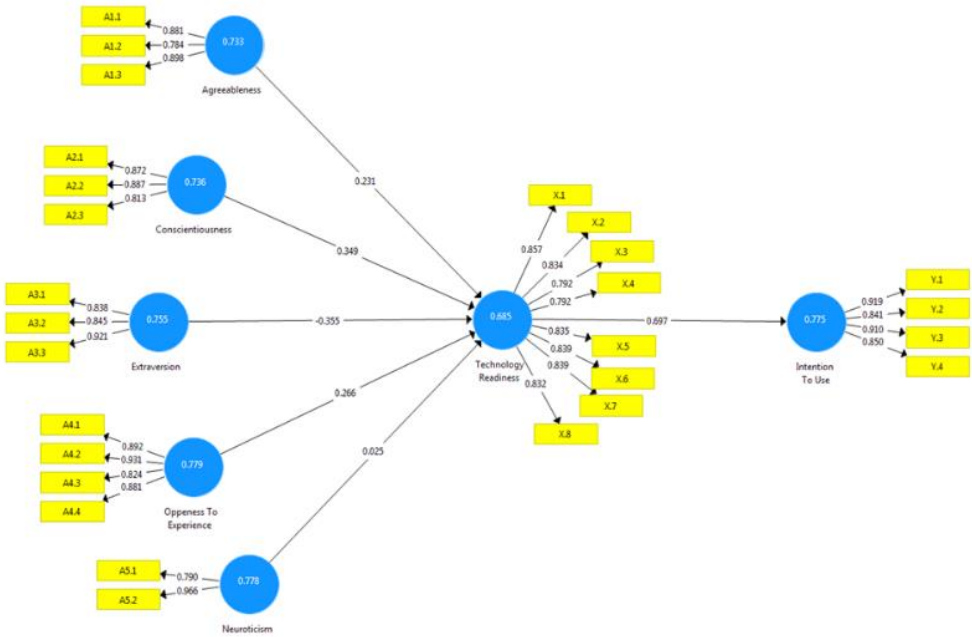

Fig. 4. Outer Model Testing

Based on the preceding image, it can be deduced that the outer loading value above 0.70 indicates that the indicators of agreeableness, conscientiousness, extraversion, openness to experience, neuroticism, technological readiness, and intention to use have satisfied the criteria. With these findings, all variables show convergent validity, which satisfies the requirements, making the indicators in this test legitimate and usable for further study.

4.2. Discriminant Validity Test

There are two ways to conduct this test. First, consider the importance of cross-loading. This indicator achieves discriminant validity if the correlation between constructs and indicators is larger than the correlation with indicators from other constructs. The cross-loading value for each indicator shows in Table 2.

Table 2. Cross-Loading Value

Indicator	*Agreeableness*	*Conscientiousness*	*Extraversion*	*Openness To Experience*	*Neuroticism*	*Technology Readiness*	*Intention To Use*
A1.1	**0.881**	0.698	0.205	0.494	-0.018	0.507	0.605
A1.2	**0.784**	0.410	-0.044	0.231	0.081	0.374	0.462
A1.3	**0.898**	0.578	0.127	0.526	0.040	0.527	0.547
A2.1	0.549	**0.872**	0.280	0.551	-0.101	0.503	0.418
A2.2	0.606	**0.887**	0.191	0.526	-0.121	0.494	0.553
A2.3	0.568	**0.813**	0.260	0.585	0.207	0.483	0.522
A3.1	0.187	0.364	**0.838**	0.280	-0.042	-0.090	0.036
A3.2	0.098	0.224	**0.845**	0.282	-0.043	-0.114	0.031
A3.3	0.084	0.211	**0.921**	0.154	-0.086	-0.184	-0.056
A4.1	0.476	0.582	0.279	**0.892**	-0.018	0.485	0.383
A4.2	0.467	0.564	0.276	**0.931**	0.007	0.462	0.377
A4.3	0.439	0.532	0.076	**0.824**	0.138	0.417	0.398
A4.4	0.404	0.599	0.238	**0.881**	0.048	0.472	0.385
A5.1	0.058	0.003	-0.015	0.099	**0.790**	0.032	-0.046
A5.2	0.021	-0.013	-0.087	0.018	**0.966**	0.075	0.015
X.1	0.561	0.506	-0.128	0.447	-0.102	**0.857**	0.730
X.2	0.561	0.583	-0.072	0.443	-0.023	**0.834**	0.696
X.3	0.478	0.442	-0.053	0.448	-0.053	**0.792**	0.588
X.4	0.401	0.515	-0.088	0.431	0.028	**0.792**	0.569
X.5	0.470	0.462	-0.206	0.425	0.194	**0.835**	0.482
X.6	0.387	0.408	-0.202	0.420	0.146	**0.839**	0.494
X.7	0.404	0.460	-0.105	0.452	0.139	**0.839**	0.501
X.8	0.368	0.396	-0.238	0.379	0.189	**0.832**	0.486
Y.1	0.593	0.554	-0.049	0.396	-0.003	0.655	**0.919**
Y.2	0.545	0.558	0.146	0.390	-0.072	0.508	**0.841**
Y.3	0.604	0.563	-0.008	0.451	-0.022	0.675	**0.910**
Y.4	0.483	0.368	-0.098	0.297	0.077	0.596	**0.850**

The model is considered to have superior discriminant validity in a second method, in addition to considering the cross-loading value, if the square root of the average variance extracted (AVE) for each construct is higher than the latent variables in the same column. The average extracted variance (AVE) squared value for each variable is shown in Table 3. Based on the calculation results in Table 3, it can be concluded that all variables have an AVE value of more than 0.50 so the variables in this study are declared valid.

Table 3. Quadratic Value *Average Variance Extracted* (AVE)

	Average Variance Extracted (AVE)
Agreeableness	0.733
Conscientiousness	0.736
Extraversion	0.755
Openness To Experience	0.779
Neuroticism	0.778
Technology_Readiness	0.685
Intention_To Use	0.755

4.3. Reliability Test

The reliability test evaluates an instrument's consistency and dependability in measuring a concept or variable under investigation. The reliability score of a concept can be used to determine the dependability criterion. If the composite reliability score is greater than 0.70 and the Cronbach's alpha value is less than 0.60, the construct is deemed reliable. The values for each variable's composite reliability and Cronbach's alpha are listed below:

Table 4. Reliability Measurement Results

	Cronbach's Alpha	Composite Reliability
Agreeableness	0.818	0.891
Conscientiousness	0.820	0.893
Extraversion	0.846	0.902
Openness To Experience	0.905	0.934
Neuroticism	0.752	0.874
Technology Readiness	0.934	0.946
Intention To Use	0.903	0.932

Based on Table 4, it can be concluded that all variables have a reliability value of Cronbach's alpha of more than 0.60 and more than composite reliability of 0.70. So it can be concluded that all variables in this study have fulfilled the requirements or can be declared reliable.

4.4. Coefficient of Determination

The amount of variation in the dependent variable that is completely explained by the independent variables is presented using the coefficient of determination, also known as the R-Square. The R-Square value ranges from 0 to 1, and it is divided into three categories: strong (value of 0.67), moderate (0.33), and weak (0.19). The following table shows the findings of the R-Square measures used in this study:

Table 5. Measurement Results *R-Square*

Variable	R Square	R Square Adjusted
Technology Readiness	0.527	0.502
Intention To Use	0.486	0.481

Based on the R-Square value above, the coefficient of determination of intention to use is 0.486 (48.6%) where this value is in the moderate category because it is > 0.33 but < 0.67. The R-Square value of 0.486 indicates that the intention to use can be explained or influenced by technology readiness by 0.486 or 48.6%, while the remaining 0.514 or 51.4% is explained by other variables outside

the analysis model. Meanwhile, the coefficient of determination for technology readiness is 0.527 or (52.7%) which is also included in the moderate category because it is > 0.33 but < 0.67. The R-Square value of 0.527 indicates that technology readiness can be explained or influenced by intention to use by 0.527 or 52.7%, while the remaining 0.473 or 47.3% is explained by other variables outside the analysis model.

4.5. Hypothesis Testing

This model's structural stage seeks to ascertain whether there is interdependence between variables. The t-test is used for testing. If the significant value of the t statistic is less than 0.05, the variable is said to have an influence. The following figure (Fig.5) displays the computation's findings.

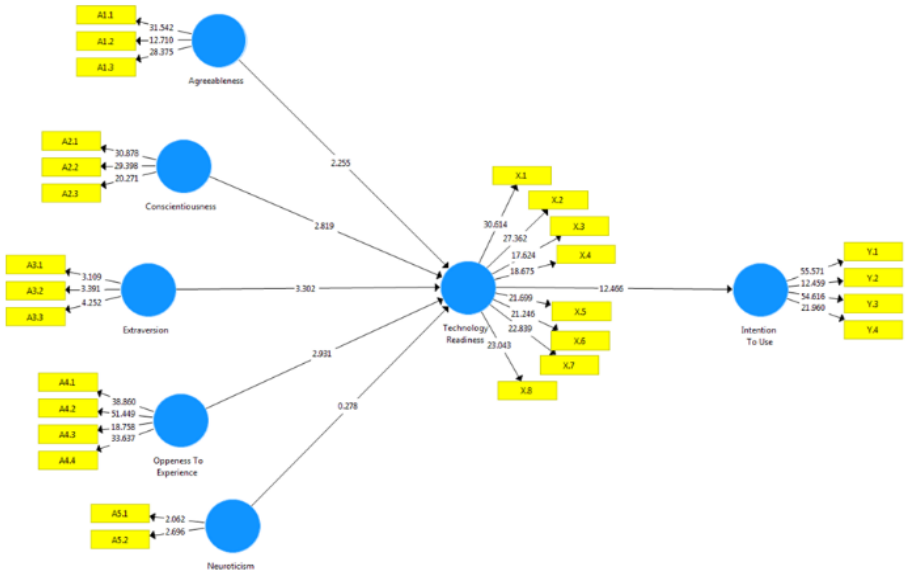

Fig. 5. Testing *Inner Model*

The following is the estimated value of each relationship between research variables:

Table 6. Value *Path Coefficient*

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Agreeableness -> Technology_Readiness	0.231	0.247	0.103	2.255	0.025
Conscientiousness -> Technology_Readiness	0.349	0.325	0.124	2.819	0.005
Extraversion -> Technology_Readiness	-0.355	-0.327	0.107	3.302	0.001
Neuroticism -> Technology_Readiness	0.025	0.034	0.090	0.278	0.781
Openness To_Experience -> Technology_Readiness	0.266	0.260	0.091	2.931	0.004
Technology_Readiness -> Intention_To Use	0.697	0.703	0.056	12.466	0.000

5. DISCUSSION

That H1 is accepted in light of the findings of the hypothesis testing that has been done. This hypothesis is supported because the relationship between agreeableness and technological readiness is consistent with Lewis Goldberg's (1981) Big Five Personality Theory. Friendly, accommodating, and inclined to readily accept any explanations are traits of someone with an agreeable disposition. They will be more able to adopt new technology without considering any potential minor hazards. The results of this study are supported by previous research conducted by Simanullang (2021) which shows that personality attitudes, especially the personality of the Big Five Personality Model, namely Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism greatly affect ASN performance in carrying out their work.

It is also well known that H2 is acceptable. According to Lewis Goldberg's (1981) Big Five Personality Theory, the conscientiousness variable has an impact on technological preparedness, which supports the validity of this concept. An individual with this conscientious personality style usually prefers to complete tasks quickly. New tools that make it simpler to accomplish tasks, like the SIGNAL app, which allows users to execute motor vehicle tax payments from any location at any time, will make people with this personality happier. The results of this study are supported by previous research conducted by Obrenovic et al. (2022) showing that conscientiousness personality traits have a positive impact on knowledge-sharing behavior.

Also acceptable is H3. According to Lewis Goldberg's (1981) Big Five Personality Theory, the extraversion variable's impact on technological preparedness is what led to this hypothesis' adoption. A person with an extraversion personality is outgoing, energetic, aggressive, and emotional. This type of disposition tends to make people more open to embracing new technologies. The findings of this study are corroborated by earlier research by Nikbin et al. (2021) that found a substantial relationship between Facebook addiction and the Big Five personality traits of conscientiousness, openness to experience, extraversion, and neuroticism.

Similar to H4, it is acceptable. The Big Five Personality theory proposed by Lewis Goldberg (1981) and its relationship to the variable openness to experience on technological preparedness account for the acceptance of this concept. A person who is open to new experiences tends to be receptive to them. If a person has this personality trait, new applications—like those connected to the SIGNAL application—will tend to make them more adaptable or more likely to accept these technological advancements. The results of this study are supported by previous research conducted by Watjatrakul (2020) showing that neuroticism and an opportunity to experience are two personality traits that moderate the relationship between perceived value for money and the intention to learn online courses.

H5 is rejected. This claim is disproved since, in accordance with Lewis Goldberg's Big Five Personality theory, the neuroticism variable has no bearing on technological preparedness. This neuroticism personality type is characterized by excessive worry. As a result, people with this neuroticism tend to detest using novel applications like the SIGNAL application. The findings of this study are corroborated by earlier research by Giovanna Priscilla & Febriyanti Salim (2023) that found no correlation between the Big Five personality traits and employee engagement. Because it has poor emotional regulation and is sensitive, neuroticism is a quality that has little bearing on employee engagement.

Last but not least, H6 is known to be accepted. According to the TAM theory proposed by (Davis, 1989), which deals with a person's perception of usability and convenience in using and utilizing new technology, the acceptance of this hypothesis

is due to the effect of the technology readiness variable on the intention to use the SIGNAL application. In this situation, a person with a high level of technological readiness is more likely to be open to using or experimenting with new technologies, such as the SIGNAL application. The findings of this study are corroborated by earlier research Nurul Afifah & Retno Pratiwi (2019), which shows that technical preparedness significantly affects taxpayer interest in using e-filling.

6. CONCLUSION

The purpose of this study is to ascertain the relationship between personality traits (agreeableness, conscientiousness, extraversion, opportunity to experience, and neuroticism) and technology readiness as well as the intention to use the SIGNAL application to pay motor vehicle taxes in the Indonesian city of Surabaya, Indonesia. This study's methodology was quantitative, with simple random sampling utilized to choose the sample and structural equation modeling (SEM) for data analysis. The researcher can conclude that personality agreeableness, conscientiousness, extraversion, and opportunity to experience have a positive and significant effect on technology readiness in paying motor vehicle taxes through the SIGNAL application based on the findings of the analysis and testing of the hypotheses that have been conducted. Neuroticism, on the other hand, has a detrimental impact on a person's readiness for technology. Furthermore, the intention to use the SIGNAL application to pay motor vehicle taxes is positively and significantly impacted by technology readiness.

The advantages attained by researchers in this study include the ability to apply the SIGNAL application on target, increasing the effectiveness of tax payment. Additionally, one of the study's drawbacks was the difficulty the researchers had in finding respondents over the age of 50 because people in that age group typically found it challenging to complete surveys using Google Forms. In order to boost literacy in future talks, the researcher can make one final recommendation for additional research: it is anticipated that it will be possible to include other elements that can influence the intention to use the SIGNAL application to make motorized vehicle tax payments. Second, it is hoped that prospective researchers will broaden their population coverage in subsequent studies so they are not confined to a single city.

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Formation of information space of knowledge learning foreign language

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Abstract. Modern trends in digitalization of education lead to the expansion of methods and means of teaching foreign language. This article is devoted to identifying the main components necessary for the formation of information space of knowledge in classes in foreign language, using advantages of training applications, as well as drawing up rules for the effective study of foreign language. It should be noted that the main way to obtain information in the modern world is Internet technology. By teaching foreign language, information technology helps to shape the skills and abilities of spoken language, as well as teach vocabulary and grammar, providing genuine interest and therefore efficiency. Moreover, learning applications develop skills that are important not only for foreign language. The task of teachers of modern digital education is to find the opportunity to use all sources and means of training in the educational process.

Keywords: foreign language, information space of knowledge, learning application, level of language proficiency, digitalization.

1. INTRODUCTION

Currently, Russian education is undergoing significant changes: the transition from traditional forms of teaching to advanced, from outdated teaching methods to innovative, from passive learning content to active. This fact is due not only to the social and economic transformation of society, but also to Russia's entry into the space of international communication. Modernization of modern Russian education is associated with the strengthening of the humanitarian component - the communicative competence of future graduates as the basis for self-realization after graduation [1].

In order to develop the information society, the state creates conditions for formation of knowledge space and providing access to it, improving the mechanisms for dissemination of knowledge, their application in practice in the interests of the individual, society and state [2].

The digital society makes its own adjustments to the implementation of educational activities of any educational organizations of both pre-university and university training. The modern image of the student is increasingly associated with the introduction of information and education to digital platforms. It is difficult to imagine a teenager or an adult who does not own modern Internet technologies, communication systems that can also be used as a source of knowledge.

Modern trends in digitalization of education lead to the expansion of methods and means of education. Many modern teachers in their practice apply innovative teaching methods in collaboration with new technical means in practical classes. Since

classes are held outside the country of the language being studied: its culture, customs, forms and ways of communication, modern technologies such as interactive textbooks and publications, smart boards, Internet resources, mobile applications help create a favorable learning environment.

The purpose of this work is to identify the main components necessary for the formation of the information space of knowledge in foreign language classes, using the advantages of training applications, as well as drawing up rules for the effective study of foreign language. The practical value is in the fact that the materials of this paper can be used by teachers of foreign language in educational process to form an information space of knowledge.

According to the Decree of the President of the Russian Federation from May 9, 2017 No. 203, the pace of technology development, creation, processing and dissemination of information significantly exceeded the capabilities of most people in the development and application of knowledge. The shift of emphasis in the perception of surrounding world, especially on the Internet, from scientific, educational and cultural to entertainment and informational has formed a new model of perception - so-called clip thinking, a characteristic feature of which is the mass superficial perception of information [2].

Thereafter, teacher of foreign language needs to take into account this trend (clip thinking) and most correctly choose the methods and means of training in order to form an information space of knowledge.

2. LITERATURE REVIEW

A review of some methods of teaching foreign languages will help the teacher to navigate more freely in the choice of teaching methods, rationally combine them in his work, consciously and creatively apply them.

Representatives of the natural method of teaching foreign languages noted that it is necessary to create the same conditions and apply the same method as with natural acquisition of native language by a child. The main goal of learning with natural method is to teach students to speak foreign language.

Supporters of direct methods of teaching foreign language sought to associate words of foreign language and its grammatical forms directly (immediately) with their meaning, bypassing the native language of students.

English Methodists, developers of direct teaching method, noted the positive results due to the rationalization of educational material, the intensive teaching process, the use of visual aids and active teaching methods. The plus of direct method is the creation of base for study of living Western European languages; development of oral speech skills based on correct sound design; creating a system of monologue oral exercises; development of various techniques and means of activating the educational process.

Representatives of the audiovisual method note that the ultimate goal of learning foreign language is its use as a means of communication in everyday life. The most rational in the audiovisual method are techniques for the development of auditory perception and auditory memory, active development of strictly selected models, training of intonation speech samples.

The suggestive method (suggestion method) is a modification of direct method. This is a method of accelerated learning of foreign language, designed for three months. Much attention is paid to the connection of educational process with personal interests and motives of students.

Nowadays in education, there is an increased interest in research and development aimed at exploiting the benefits and potential of new modern digital technologies to improve and intensify the learning process. There was a whole range

of works devoted to the analysis of the essence and features of learning using information and infocommunication technologies (Okolelov O.P. [3], Babushkina L. E and Safonov V.I.[4]). A number of publications are devoted to e-learning (Stepanek, J., Simkova, M. [5]), gamification (Kacetl, J., klímová, B. [6]), smart learning (Ignatieva, N., Zhdankina, I., Bykova, D., Sysoeva, Yu. [7]). Digital technologies have become an important part of the educational process in learning foreign languages. These issues are discussed in works of such scientist like Karsenti T., Kozarenko O., Skakunova V. [8], Belyasova J., Teleshova R. [9], Bykova D., Zhdankina I., Ignatieva N. etc. [1].

Obdalova O. A. writes that modern methodology for teaching foreign languages seeks to take into account new trends and model the educational information space, taking into account the specifics of the subject and practical learning tasks [10].

In digital time, modern teachers combine all available techniques and teaching methods in order to correctly and accurately form the information space of knowledge learning foreign language.

3. DATA AND METHODOLOGY

The purposes of formation of knowledge-based information space are to ensure the rights of citizens to objective, reliable, secure information and create conditions for meeting their needs for constant development, obtaining high-quality and reliable information, new competencies, and expanding horizons [2].

To form the information space of knowledge, it is necessary:

- to use and develop various educational technologies, including distance learning, e-learning in the implementation of educational programs;
- to develop and implement partner programs of educational institutions of higher education and Russian high-tech organizations, including the improvement of educational programs [2].

The choice of digital technologies used for educational activities is expanding: adaptive learning, International open educational courses (IOEC), gamification, coloborative learning. Social networks and opportunities for teachers to work with students online form a new area of digital educational environment. Many teachers of advanced universities are working to activate the activities of students during training by creating communities in social networks such as VK, Telegram and others.

Foreign language as a discipline studied by students of higher education organizations is no exception. Language is a public phenomenon; the formation of language competence requires a language environment. We consider the use of modern information and communication technologies (ICT) in the process of teaching foreign languages to be an excellent means of creating a language environment, since their use expands the amount of information received as well as introduces a situational character into the learning process.

Currently, various kinds of applications used to work out certain skills of speaking, writing, lexical and grammatical knowledge have become quite widespread. Among the installed applications for learning foreign language are such as Uchi languages with Memrise, Duolingo, Lingualeo, Polyglot, EWA, Parla, Ling and others. Most diverse interactive training applications for learning foreign languages are aimed at self-study of phonetic and grammatical aspects and bringing them to automatism in use. Features of these programs are interactive dialogs, speech recognition and pronunciation visualization systems, video content, exercises for developing all speech skills, as well as displaying individual language learning results.

Such diversity greatly facilitates the study of foreign language by both students of pre-university educational institutions and higher education organizations. Various sources of information, an expanded range of exercises of lexical and grammatical

nature are the main positive features of using applications for learning foreign language. However, among the positive features, negative ones are also observed. Among them a significant negative feature is the lack of feedback and the ability to evaluate such types of speech activities as monologue and dialogic speech.

Among the main advantages of learning foreign language using the above-mentioned means, we can highlight the following:

1. Flexibility in time. Learning English online allows you to arrange your time according to your personal and professional obligations and responsibilities. You can choose the amount of time you want to learn, depending on your goals.

2. Learn at your own pace. Virtual English lessons are tailored to your needs, so you can set your own pace. You have more freedom to decide whether to spend less time on a specific item you've already mastered, or need to focus more on other areas.

3. Economy. Staying at home you will save money you would otherwise spend on transport, books, photocopies and projects. These resources can help you embark on the journey you've always dreamed of, or fulfill your childhood dream.

4. More time for you. Attending face-to-face classes means you spend time on the way to work, which brings nothing into your life and is also stressful. You can spend that time on activities you like, or just relax. Remember that your physical and mental well-being is also important.

Despite this, applications and Internet platforms for learning English have a reputation for being ineffective. We've all met someone who has been using language apps every day for months but is still barely able to say a word or build a sentence when talking. There are ways to avoid this trap.

Successful students draw up a curriculum that helps them practice all necessary English skills. Apps can certainly be part of that.

The authors of this paper conducted a survey among students of Nizhny Novgorod State Engineering and Economic University on the necessity and importance of forming an information educational space using modern training applications. The following questions were proposed.

1. How do you assess your level of language proficiency?

a) Zero;

b) Initial (understand several familiar expressions; you can talk about yourself and ask basic questions, participate in simple conversation);

c) Elementary (you can communicate on basic topics (family, shops, work, etc.), participate in everyday communication);

d) Pre-Intermediate (you can communicate in most situations of everyday life and travel, compose simple texts, describe events and your interests);

e) Intermediate (understand the meaning of a complex text; you can communicate on abstract topics, including in the field of your specialty; you can safely communicate with native speakers, defend your point of view in a dispute);

f) Upper-Intermediate (you understand complex texts; you can freely express all your thoughts and emotions, use language in all areas: social, professional, academic).

2. What do you think is the most appropriate way to learn foreign language?

a) Language courses in Russia;

b) Language courses and internships abroad;

c) Individual tutoring;

d) Online programs;

e) Specialized centre;

f) Self-education.

3. Are you interested in the possibility of learning foreign language using distance education and modern learning apps?

a) Yes;
b) No;
c) I find it difficult to answer.
4. Do you use English learning apps?
a) Yes;
b) No.
5. Would you like to know which mobile apps can help you to learn English?
a) Yes;
b) No.
6. Distribute according to the degree of importance for you, the following characteristics of learning apps on 5-point scale (1 is the most important, 5 is the least important)

Characteristics	Point
1. Availability	
2. Interactivity	
3. Constant updating of information	
4. The opportunity to study at individual pace	
5. Saving time	

Having analyzed the results of the survey, we came to the conclusion that 40% of respondents have Pre-Intermediate language proficiency, 45% - Intermediate and only 10% of respondents have Upper-Intermediate level. The most appropriate ways to learn foreign language are language courses and internships abroad, online programs and individual tutoring (Fig. 1).

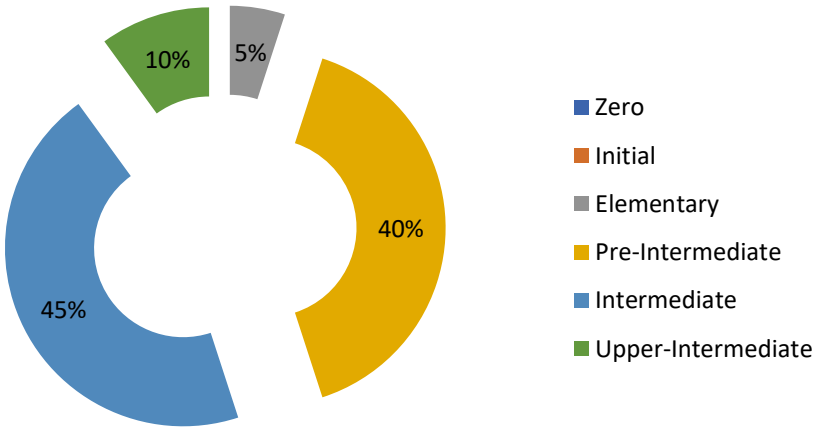

Fig. 1. Students' level of language proficiency
Source: compiled by the authors

However, 45 % of respondents are interested in the possibility of learning foreign language using distance education and modern learning apps and 30% uses English learning apps. 63% of respondents would like to know mobile apps which can

help them to learn English, because it gives them opportunities to study English language at individual pace and save time (Fig. 2).

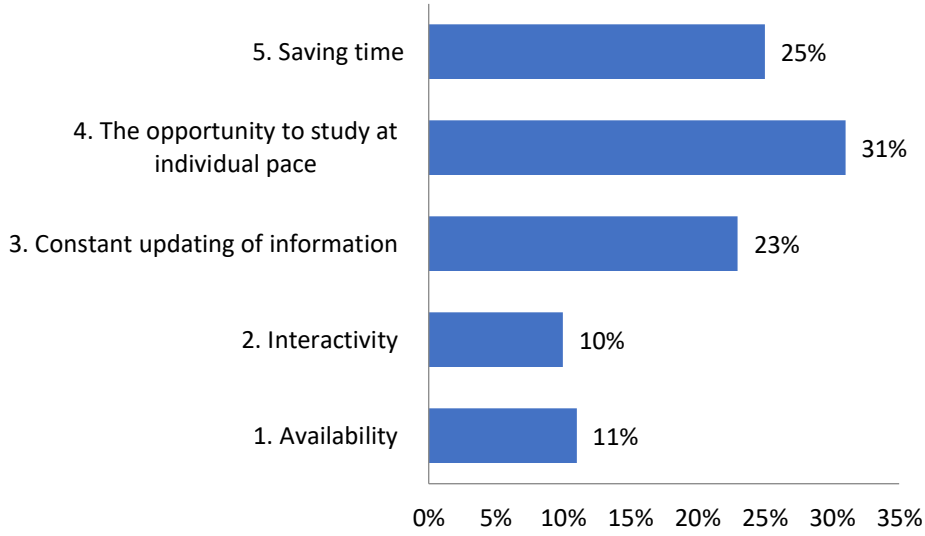

Fig. 2. The degree of importance of characteristics of learning apps according to respondents' opinions
Source: compiled by the authors

4. RESULTS

We highlight several rules for effectively learning foreign language using training applications:

1. Combine applications (and other methods, if possible).

There is (not yet) a single application that perfectly teaches all language skills. Everyone has strengths and weaknesses, and you can combine them while trying to learn a new language. Try balancing your time between apps that develop different skills. Memrise [11], for example, helps you quickly learn a new vocabulary, but does not help you link these words into sentences. To do this, you may need an application focused on developing your grammar skills, such as The British Council Learn English Grammar [12], or an application that shows words in their context, such as FluentU [13]. Many apps send reminders to students to use them every day "to see progress."

Applications are most effective when combined with other training methods. If you can afford it, combine app-based learning with language classes, whether online with a service like Preply [14] or in traditional classroom.

2. Focus on the areas where you are experiencing the most difficulties.

There is a wide range of apps to choose from, each with its own benefits. Don't overload yourself by splitting your study time between them all. Select one or two English skills you are struggling with and download apps designed to develop them. For example, if you really need a conversational practice, try Busuu [15] or Monthly [16]; if you need help writing texts in English, try Tandem [17] and Grammarly [18].

3. Give preference to conversational practice.

As a rule, many English language learning apps can quite easily elevate your vocabulary, reading and spelling skills to new heights. Some of them are even useful for developing your understanding of grammar. But without a decent practice in talking to native English speaker, you risk never learning how to combine new skills.

The modern picture of the world dictates more and more new trends towards the digitalization of almost all spheres of human life. Learning languages is one of the most striking examples of the use of modern Internet technologies, communication tools in learning. The task of teachers of modern digital education is to find the opportunity to use all sources and means of training in the educational process.

5. CONCLUSION

Achieving a positive effect in the educational process using modern educational technologies is one of the conditions for increasing the level of professional competence of the teacher at the current stage of educational development. Knowledge of foreign language in the modern world is an integral criterion for assessing the competence of future specialist [19].

Modern students are interested in figuratively emotional education, when only emotionally significant information is absorbed. The modern student uses a fragmentary-clip consciousness formed under the influence of a large flow of information, which leads a person to the need to use unified, simplified thinking schemes that are largely based on the sphere of the unconscious [20]. The main way to obtain information in modern world is Internet technology. Visualization becomes an integral part of the learning process.

In any educational process, individual characteristics of students should be taken into account, and in accordance with this principle, when including training applications in the learning process, it is necessary to conduct a test to determine the level of language proficiency at the initial stage [21].

By teaching foreign language, information technology helps to shape the abilities and skills of spoken language, as well as teach vocabulary and grammar, providing genuine interest and therefore efficiency. Moreover, learning applications develop skills that are important not only for foreign language. This is primarily related to mental operations: analysis, synthesis, abstraction, identification, comparison, juxtaposition, verbal and semantic forecasting and deflection, etc.

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Health Digital Indicators' Juxtaposition

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Abstract. A study is discussed the comparison of main health performance indicators in two different countries: New Zealand and Republic of Cyprus, and globally by approaches from the particular to the general, and multi-dimensional measures of global health indication. The objective was to establish the content validity, the reliability and sensitivity, and the validity of rank order comparisons. This study analyzed 2021-2023 annual reports World Health Organization, European Union Commission, and NZ government. The finding of this work is synopsis of Health Digital Indicators. The result of synopsis has shown that there are so many different kinds of Health Indicators that unite by digital technology to collect data for them. Author juxtaposed regional (European and Pacific) and global health indicators counted for health goals.

Keywords: health, indicators, assessing, adequacy, juxtaposition, evaluation, measurement.

1. INTRODUCTION

For the last two years, the COVID-19 pandemic has triggered a global health crisis that has put healthcare systems across the world under unprecedented pressure. It has put health systems in the spotlight, exposing and exacerbating existing weaknesses. At the same time, the pandemic has also led to remarkable innovation and advancements. For example, digital technologies were employed to actively monitor COVID-19 patients with mild symptoms at home. Also, using of telehealth services to tackle the decrease in face-to-face consultations while protecting patients and workers from infection. These developments triggered by the unprecedented challenge of the COVID-19 pandemic indicate that healthcare systems can adopt new technologies and care delivery modes at incredible pace and scale. [1].

The virus has not only affected our health and health systems directly through rising cases, hospitalisations and deaths. If we look ahead to the coming years, the consequences of having to postpone essential treatment for chronic and non-communicable diseases during the pandemic, the long-term symptoms that many people unfortunately continue to experience following their recovery from infection, and the negative impact of the crisis on mental health and wellbeing will continue to affect health systems long into the future. [1]

World Health Organization (WHO) states that measures to ensure the safety, security and functionality of health infrastructure are needed at both national and community levels. Countries and communities need to prioritize the protection of new and existing hospitals and other health facilities from identified hazards and should ensure the physical integrity of buildings, equipment and critical hospital systems. More and more attention has been paid to creating comfortable and functional hospital environments, where the patients can feel good and at ease maintaining the same efficiency of medical activities. In addition, flexibility has been particularly considered because hospital facilities must adapt to the continuous needs of change. [2-6]

In principle, having identified an optimal set of KPIs, it is feasible to develop a model for evaluating Health System performance by applying an appropriate method to determine the KPIs' importance. [11]. In addition, measurement set could help most hospitals improve their mission achievement. In this measurement set were included asset turnover, cash flow, mortality, complications, county-of-location, and cost per case [12].

This paper considers the nowadays model of KPI system related to two countries hospitals: NZ and Cyprus in COVID-19 era bearing in mind the digital view on COVID-19 Impact [13] and county-of-location characteristics.

2. DATA AND METHODOLOGY

The evaluation of the performance of the health systems represents an intensely debated topic at the level of international organizations, the governments and the population, as it has direct implications on each citizen. Although it is very difficult to measure accurately, the efficiency of health systems can be assessed in terms of the input-output relationship. Starting from this, overall, the results of our analysis show that there are a multitude of factors that influence the efficiency of health systems, which are not only associated with health issues, but also with economic, social, governmental aspects. [11, 12].

For this study author has chosen two countries that have similar characteristics such territory area, population, climate, etc. In addition, author has resided similar period of time in these countries and has had the opportunity to become acquainted with the health care systems of these countries.

The data was obtained from WHO and EU statistical reports of health care in New Zealand (NZ) (https://www.adhb.health.nz) and Cyprus (https://shso.org.cy/en/hospital/geniko-nosokomeio-lefkosias/) for time period 2021 – 2023 with once-a-year frequency of the data observations and calculation. Experts were involved in the working groups with different purposes according to the development phase of the methodology. Key points of these measures' approaches were considered in previous author's publications [8-10, 13].

3. RESULTS

First of all, it should be noted that by evaluation Health services we must take into account COVID-19 impact and consequences. For example, the analysis from the Country Health Profiles 2021 shows how both across and within European countries, differences in health status mirror to a large extent the unequal distribution of its main socio-economic, behavioural and environmental determinants. This generates significant health disparities across the population that, in turn, reduce the capacity of the most disadvantaged groups to access healthcare services and maintain good health (https://health.ec.europa.eu/system/files/2022-02/2021_companion_en.pdf).

3.1. NZ Health Performance Indicators

NZ Health System Indicators framework is a new approach to measuring the performance of the health system. The framework is premised on shared accountability. The Government sets high-level goals for the system, the Ministry and Te Tāhū Hauora develop high-level indicators for those goals with input from the health sector, and local providers work with input from local consumers to agree what local actions are needed to contribute to the high-level goals.

Work to implement the framework is underway. Full implementation involves areas developing local solutions to local problems, with an emphasis on continuous improvement at a local level to lift the overall performance of the health system. This early in the development of the framework, and before full implementation of the local actions, the results should be interpreted with caution.

In New Zealand (NZ) the first update of the Health System Indicators framework was added in December 2021, and updates are added each quarter. These show change from baseline for most of the high-level indicators (Table 1) and include

district health board (DHB) results. The baseline for improvement for most indicators is December 2019, as more recent data has been significantly affected by the COVID-19 response so is not appropriate to use as a baseline.

Table 1. The high-level Health Performance Indicators in NZ

Government priority	High-level indicator	Description
Improving child wellbeing	Immunisation rates for children at 24 months	Percentage of children who have all their age-appropriate schedule vaccinations by the time they are two years old
	Ambulatory sensitive hospitalisations for children (age range 0–4)	Rate of hospital admissions for children under five for an illness that might have been prevented or better managed in the community
Improving mental wellbeing	Under 25s able to access specialist mental health services within three weeks of referral	Percentage of child and youth (under 25) accessing mental health services within three weeks of referral
	Access to primary mental health and addiction services	In development
Improving wellbeing through prevention	Ambulatory sensitive hospitalisations for adults (age range 45-64)	Rate of hospital admissions for people aged 45–64 for an illness that might have been prevented or better managed in the community
	Participation in the bowel screening programme	In development
Strong and equitable public health system	Acute hospital bed day rate	Number of days spent in hospital for unplanned care including emergencies
	Access to planned care	People who had surgery or care that was planned in advance, as a percentage of the agreed number of events in the delivery plan
Better primary health care	People report they can get primary care when they need it	Percentage of people who say they can get primary care from a GP or nurse when they need it
	People report being involved in the decisions about their care and treatment	Percentage of people who say they felt involved in their own care and treatment with their GP or nurse
Financially sustainable health system	Annual surplus/deficit at financial year end	Net surplus/deficit as a percentage of total revenue
	Variance between planned budget and year end actuals	Budget versus actuals variance as a percentage of budget

Source: URL https://www.health.govt.nz/new-zealand-health-system/health-system-indicators-framework].

3.1. Cyprus Health Performance Indicators

Overall, the Cypriot population is among the healthiest in the EU. One important goal of recent extensive health system reforms to introduce universal coverage is to reduce what was the highest level of out-of-pocket spending in Cyprus by improving financial protection [15].

Below is a list of the most effective indicators in the European Union (Cyprus is EU Member State), according to the survey. Table 2 below presents an overview of the indicators reported by countries to assess efficiency of hospital care. For each level (national, regional etc.), each survey respondent presented the key set of indicators used to assess efficiency of care in their country. [14]. For each indicator listed, almost all survey respondents reported hospitals as the setting where their country's efficiency of care measurement and assessment activity are most consolidated, also partially thanks to the relatively greater availability of data about activities and processes taking place in the hospital setting compared to other health care system areas. [16-21].

Table 2. EU Key efficiency / appropriateness indicators reported by survey respondents (in ascending order of priority)

Indicator Name	**Priority**
% of inpatient stays with a 'short' pre-operative LOS (specific procedures)	1
ALOS for normal vaginal delivery	1
Average time of utilisation of operation theatres over 24 hours	1
Life expenctancy / health expenditure as % of GDP	1
Number of bed-days	1
Number of doctors per patient	1
Productivity of doctors (activity based on DRG-rates divided by number of doctors)	1
Share of labour costs due to overtime / contracted working hours / total HR costs	1
Share of laparoscopic cholecystectomies with post-operative LOS < 3 days	1
Cancer screening outside of target group	1
Overuse of diagnostic imaging: medical radiation exposure (mSv/capita/year)	1
Percentage of patients prescribed treatment w/antidepressants for less than 3 months	1
Ratio hospitalizations attributed to DRG at high risk of inappropriateness / DRG at low risk	1
Hospitalisation rate for diagnostic services	1
Share of medium-high priority services provided in the maximum time foreseen	1
Share of C- sections over total number deliveries (%)	1
Retention rate of phyisically ill employees in the workforce	1
Generic / low-cost medication prescribing rates	2
Pharmaceutical costs per patient	2
Share of pharmaceutical costs on total healthcare costs	2
Share of procedures performed in settings with a minimum volume threshold per year	2
Patient-experienced satisfaction	2
Unexplained geographic variation in volumes of knee arthroscopy and catheterisation	2
Pressure ulcers (2-4) in hospitalized patients	2
Preventable admissions rate for 65+ patients	2
Share of CT-scans and MRIs performed in compliance with current clinical guidelines	2
Average length of stay (ALOS) patients ready for discharge	3
Cost per bed / doctor	3
Number of cases per health care worker / FTE	3
Share of cholecystectomies conducted laparoscopically	3
Various financial ratios (e.g. debt-to-equity)	3
Children vaccination rate	3
Prevalence of potentially inadequate medication (PIM) in the elderly	3
Hospital-acquired infections	3
% of patients 50+ who underwent cancer screening within established timeframe	3

n-day hospital readmission rates	5
Bed occupancy rate	5
Hospital discharge rates	6
Hospital admissions for ambulatory-sensitive conditions	7
DRG-based cost per patient (by disease cat.)	7
Hospital productivity (activity based on DRG-rates divided by operating costs)	8
Share of day surgery for selected procedures	15
Average length of stay (ALOS)	17

Source: author's compilation from [14].

Table 2 above presents an overview of the indicators reported by survey respondents to assess the efficiency of health care. The most frequently reported indicator is the Average length of stay (ALOS), and the most rarely - % of inpatient stays with a 'short' pre-operative LOS (specific procedures).

But all of above listed particular European indicators were designed before COVID-19 pandemic that has had a tremendous impact on the health care system as a whole globally. Taking an approach from the particular to the general, let's consider global indicators.

3.3. Global Health Indicators

Good health is essential to sustainable development of humanity and third Sustainable Development Goal (SDG) states by United Nation (UN). Achieving this Goal 3 SDG means ensuring universal health coverage, including financial risk protection, access to quality essential health services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all, including the following [https://www.undp.org/sustainable-development-goals/good-health]:

Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all;

Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination;

Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate;

Support the research and development of vaccines and medicines for the communicable and noncommunicable diseases, and, in particular, provide access to medicines for all;

Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries;

Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.

Goal 3 SDG means of implementation for the targets: Tobacco control; Medicines and vaccines; Health financing and workforce; Emergency preparedness; Universal health coverage.

To monitor achieving of these UN goals and targets, WHO defined and calculated global health-related indicators. The statistics shown below in Table 3 represent official WHO statistics for selected global health-related Sustainable Development Goal (SDG) indicators [5-7]. Summary measures of health, such as total population, is included to provide a general indication of the current situation. Comparable estimates are subject to considerable uncertainty, especially for countries where the availability and quality of the underlying primary data are limited. Year means WHO reports data. For example, in row 2021 shown data from WHO Statistics 2021, based on evidence available in early 2021.

Using Delphi method author defined that indicators chosen below might be enough to analyze the difference between Health system of two small countries. Data obtained from 2021-2023 WHO Statistics reports are given in Table 3.

Table 3. WHO statistics for health-related indicators for Sustainable Development Goals

Indicator Name		Total population in thousands	Density of medical doctors, per 10 000 population	Total alcohol per capita (≥ 15 years of age) consumption (litres of pure alcohol)	Domestic general government health expenditure as percentage of general government expenditure (%)	Suicide mortality rate, per 100 000 population	Road traffic mortality rate, per 100 000 population	Mortality rate attributed to exposure to unsafe WASH services, per 100 000 population	COVID-19 cumulative total deaths, per 100 000 population
Country / Data type	Year		Comparable estimates	Comparable estimates	Comparable estimates	Comparable estimates	Comparable estimates	Comparable estimates	Comparable estimates
Cyprus	2021	1199	10.8	10.8	6.6	3.6	0.3	0.3	
	2022	1207	10,8	10,8	9,9	3,6	0,3	0,3	
	2023	1244	8.1	8.1	14.1	3,6	1.6	1.6	153,6
NZ	2021	4783	10.7	10.7	19.3	11.0	0.1	0.1	
	2022	4822	10,7	10,7	18,7	11.0	0,1	0,1	
	2023	5130	9.9	9.9	18.7	11.0	2.1	2.1	63,81

Source: Author' s compilation from [4-6], https://covid19.who.int/table.

As shown in Table 3, as of 24.06.2023, COVID-19 mortality is the highest compared to all-cause mortality according to WHO. With similar density of physicians per 10,000 population as in NZ, the cumulative total COVID-19 deaths per 100,000 population in Cyprus are 2.4 times higher than in NZ. This is likely because domestic public health expenditures as three-year average percentage of total public expenditures are 1.9 times higher in NZ than in Cyprus.

4. CONCLUSION

The finding of this work is synopsis of Health Digital Indicators. The result of synopsis has shown that there are so many different kinds of Health Indicators that unite by digital technology to collect data for them. Author juxtapose regional (European and Pacific) and global health indicators counted for health goals.

This research had some limitation due to digital data representation. WHO states that Only 50% of countries have included data disaggregation in their published national health statistics reports [https://www.who.int/data/inequality-monitor]. Also, it is important to note that in global statistics report are absent some of the most important indicators such general mortality rate by country, mortality rate related to patients' deaths in Hospitals, etc.

Taking into account the number of deaths from COVID-19 per 100,000 population [https://covid19.who.int/table], the health care system is not coping with the COVID-19 virus that has suddenly descended upon humanity. In consequence, it is not the system of indicators needs to be revised, but the system of health care. The future research can investigate preferences of Health system's financing without mediators like Medical Insurance Funds.

The aim to create a more flexible and agile workforce which can be used for surge capacity needs to be embedded in workforce planning, together with skill-mix innovations and investments in a sustained expansion of the health workforce [1].

The overview is finalized to modernization and to outline how to increase the physical environment contribution to the restructure of the entire health care system by drawing a new strategy for Health care activity to ensure high standard care and effective using of given resources. The customization has concerned objectives of the assessment, main aspects, algorithms, metrics, and outcomes representation. Aspects with reference to specific established goals and they are based on a hierarchy of main indicators which assign greater importance to safety and functionality. In addition, the algorithms take into account the relationships between the hospital services, considering them as complex systems of result-oriented health care [9].

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Aims and Objectives

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