Secured 6G Communication for Consumer Electronics with Advanced Artificial Intelligence Algorithms

Shitharth Selvarajan[1*], Hariprasath Manoharan[2], Adil O. Khadidos[3], Alaa O. Khadidos[4],Abdulrhman M.Alshareef [5],Aisha Alsobhi [6]

***Abstract*—In this paper advanced features of 6G networks by examining security of consumer electronic products are discussed. With rapid growth of consumer electronic products the network features are updated thus providing fast response to end users but security of transmission remains a major concern. Hence a collaborative framework is formulated in proposed method that solves all uncertainties in consumer electronic products if it is recommended to provide operation using 6G networks.The major significance of proposed method is to identify all problems that occurs in consumer electronic products that operated with advanced technological networks such as 6G and advanced 6G communications. Hence foremost importance is provided to identify all problems by using advanced artificial intelligence algorithm where electronic products can be identified by using natural language processors to convert machine language to identifiable ones thereby expert solutions are achieved. The above mentioned integrated model is tested in real time with four major parametric cases that includes latency, security with both crypto keys and encryption, error minimization where in each case the objective functions are optimized with maximized security of 87data transmission for every consumer electronic products in 6G is reduced below 1%.**

***Index Terms*—6G networks ; Advanced Artificial Intelligence; Consumer Electronics; Security**

I. Introduction

THE job of establishing successful connection with consumer electronic items poses a significant challenge within contemporary communication networks. However, it is worth noting that many electronic goods have not undergone changes in their specifications, which means that it is feasible to utilize the same communication spectrum for the entirety of their operation. The examination of data allotment in specific channels is necessary in order to fully harness the benefits of 6G communication for electronic items. This is particularly important as consumer electronics in the future will rely only on updated communication features.

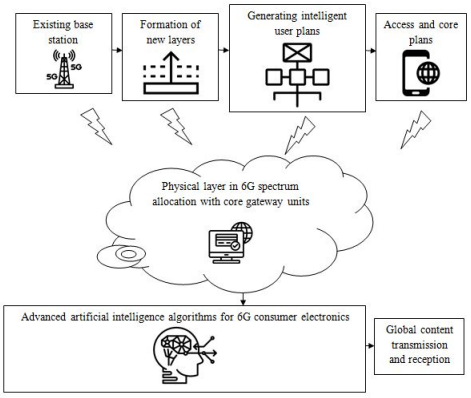

Fig. 1. Block diagram connectivity for 6G in consumer electronics

In addition to the allocation and specifications of the spectrum, it is crucial to assess the security circumstances that impact the stability of data operations. In the context of ensuring security, it is imperative to thoroughly assess the many vulnerabilities that may arise inside system functionalities. Furthermore, it is crucial to include sophisticated algorithmic features in order to effectively safeguard consumer electronic products against a wide range of potential attacks. The implementation of powerful artificial intelligence algorithms has enabled the protection of consumer electronic items against a wide range of assaults, hence enhancing the security of data transmissions. It is imperative to thoroughly examine each device and its associated features, as the application of modern artificial intelligence algorithms is contingent upon the presence of up-to-date network features. Additionally, certain features may need to be incorporated into existing operating systems. In order to ensure the optimal utilization of resources, it is imperative to verify and protect not only consumer electronic products that function with 6G communications, but also other conventional techniques like as sensing and cloud connectivity. Therefore, the suggested approach involves the development of a collaboration channel specifically tailored for consumer electronic devices that function using 6G technology. Furthermore, the system model

First Author is with the School of Built Environment, Engineering and Computing, Leeds Beckett University, LS1 3HE Leeds, U.K.(Email: s.selvarajan@leedsbeckett.ac.uk) Second Author is with the Department of Electronics and Communication Engineering, Panimalar Engineering College, Poonamallee, Chennai. (Email: hari13prasath@gmail.com) Third Author is with the Department of Information Technology, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia. (Email: akhadidos@kau.edu.sa) Fourth Author is with the Department of Information Systems, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia. (Email: aokhadidos@kau.edu.sa) Director, Artificial Intelligent and Data Analysis Centre, King Abdulaziz University, Jeddah, Saudi Arabia - 21589 Fifth Author is with the Department of Information Systems, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia(Email: amralshareef@kau.edu.sa) Sixth Author is with the Department of Information Systems, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia(Email: ayalsobhi@kau.edu.sa)

.

is subjected to natural language processing techniques and expert systems, wherein the solutions are derived solely from the user's expertise. Figure 1 is a block diagram that showcases the connectivity representations for 6G networks.In the proposed method type of security that is allocated during data processing (both classification and collection) is provided by using crypto and encryption keys where after data collection it is essential to increase the security of consumer electronic products. In addition for industrial process some of the sensors which increases the security of electronic products are integrated to provide exact status and in case of failure it can be identified and reported to control centre. Hence this type of security for consumer electronic products is indicated before and after data processing where consumer electronic product remains feasible at all operating points.

A. Background and related works

This section provides a comprehensive analysis of the available literature pertaining to consumer electronic product representations in the context of 6G communications. The analysis of the impact of 6G networks is of great importance, as it involves the examination of diverse parameters and the implementation of various algorithms to address them. However, certain information obtained from current methodologies has presented a novel strategy for constructing a platform for the suggested method in comparison to existing approaches. In this study, a heterogeneous mode of operation is implemented, involving the utilization of various layers. This approach facilitates the connection of a greater number of edge computing devices through the utilization of 6G networks [1]. The implementation of numerous layers in a cloud-centric strategy enhances the performance of each device significantly. Additionally, the inclusion of medium access control levels leads to a reduction in transmission latency. In a conventional manner, medium access control consistently facilitates a data transmission methodology that enables the connection of unreliable networks, consequently posing challenges to the security of consumer electronic transmission systems. Furthermore, the implementation of an offloading approach allows for the transmission of all information without the need for a central controller [2]. In the majority of offloading solutions, the allocated resource stays unutilized, resulting in insufficient bandwidth provision that adversely impacts all core tasks within 6G networks. The inability to utilize the strongest channel in 6G networks due to external factors hinders the attainment of proportionality rates. In contrast, this paper examines the supplementary methodologies that address the prerequisites and diverse obstacles encountered in the implementation phase of 6G networks for consumer electronics [3]. Upon further analysis, it becomes evident that the primary obstacle encountered in consumer electrical goods stems from the integration of several signals, resulting in the provision of low power latencies. Furthermore, the utilization of various signals in electronic devices leads to a state of failure, rendering it impractical to build three-dimensional perspectives in highly congested areas. On the other hand, it is important to build a resource control strategy in the event that 6G networks are expanded for consumer electronic operations [4]. During the process of extending the cases, a pre-coding strategy is incorporated, which allows for the training of all information related to 6G allocations using a minimal number of data sets. The implementation of extension technology leads to the transformation of 6G networks into resilient networks, characterized by a decrease in interference among interconnected nodes. Furthermore, an alternative approach to direct allocation is the utilization of a scheduling scheme, such as the zero force technique. However, it is important to note that in real-time applications, the 6G networks are susceptible to various forms of interference due to the absence of consideration for electronic specifications during the design process. One of the measuring strategies employed in vehicular applications is the utilization of edge computing, similar to other offloading techniques [5]. This strategy incorporates a policy gradient approach to effectively monitor all relevant cars without requiring subtask assignments. In the context of policy gradient implementations, a graph-based approach is described, which facilitates rapid convergence compared to alternative network processes. However, a graph-based method has the capability to offer viable answers to all existing control problems, hence rendering the offloading study ineffective in comparison to analyses conducted using cloud computing approaches. The job model with a completion time period is optimized by minimizing waiting time periods, even after the establishment of three fundamental models. A lightweight communication strategy has been developed for 6G networks, which serves as an alternative method for offloading analysis. This technology incorporates high data encryption features [6]. It has been noticed that in order to build effective communication approaches, it is necessary to incorporate a visible light communication spectrum that possesses significant data transmission capabilities. The establishment of an asymmetric mode of operation with optimal length characteristic features is made feasible by the utilization of diverse encryption standards. Subsequently, all signals utilized for the operation of consumer electrical items can exclusively be facilitated inside the light spectrum regions.In addition, the subsequent iteration of advanced networks, referred to as consumer electronics 2.0, incorporates industrial processes and signal transfer techniques that are executed with minimal interference [7]. The conversion of edge processing systems into service representation units is anticipated as a result of the proliferation of advanced electronic systems. This transformation is expected to address the increasing demands in 6G networks by providing greater resources within each unit. If a greater amount of resources are allocated, it will result in the creation of an additional layer positioned above the physical layer. This presents a significant challenge in managing such a layer within hostile situations.In order to mitigate such occurrences, it is imperative that all 6G networks are devoid of any supplementary resource allocation, hence necessitating a reduction in transmission rates through the utilization of intelligent surface units. Therefore, it is imperative to tailor 6G networks through the utilization of a collaborative entity that facilitates modifications within each production unit, while minimizing any external influences

TABLE I
PROPOSED VS. EXISTING

References	Main Characteristics	Objectives			
		A	B	C	D
[11]	Expert system prediction for medical electronics	✓		✓	
[12]	Multi keyword search for 6G networks		✓		✓
[13]	Loss estimation in transportation systems using 6G	✓			✓
[14]	Hybrid radio frequency systems for 6G			✓	✓
[15]	Multiple input and output for 6G mobile broadband	✓	✓		
[16]	Millimeter wave prediction with increased security		✓	✓	
[17]	Blockchain integrated medical things for medical electronic products	✓			✓
[18]	Nonviolent biometric authentication with data acquisition and feature extraction for consumer electronics		✓		✓
[19]	Consumer load electronics monitoring using artificial bee colony algorithm	✓		✓	
[20]	Multichannel consumer electronic recognition using artifical neural network	✓	✓		
Proposed	**Advanced artificial intelligence for consumer electronics with 6G**	✓	✓	✓	✓
A: Latency and command effects; B: Establishment of crypto keys;C: Security encryption; D: Errors and Energy consumption					

[8]. During the customizing phase, the presence of effective computing services in all terminal applications may lead to a reduction in automated transmission schemes. Additionally, it is feasible to implement a dynamic edge computing procedure that offers security offloading to 6G devices with enabled capabilities. This approach enhances the likelihood of successful transitions while maintaining equal synchronization [9,10]. Table 1 presents a comparative analysis between the proposed method and the existing method, considering well-established objective functions.

B. Research gap and motivation

The current body of literature examining the impact of 6G communications on consumer gadgets lacks a comprehensive analysis of the implementation of security mechanisms inside the network. Several researchers have successfully implemented 6G communication using millimeter waves. However, their focus has primarily been on estimating losses, neglecting other crucial parameter determinations. Furthermore, the fundamental disparity arises from the absence of incorporation of 6G language processing system in algorithmic patterns, without the utilization of expert judgments. Therefore, it is important to address certain inquiries in order to ascertain a precise resolution for bridging the current gaps.

- RG1: Can the 6G consumer electronic model be established with collaborative features to overcome latencies in communication?
- RG2: Whether crypto keys can be added with encryption features thereby achieving expert solutions?
- RG3: Is it possible to reduce the amount of energy to electronic products where errors in processing units are minimized.

C. Major contributions

In order to develop a system model that provides solutions to above mentioned gaps proposed method is implemented with advanced artificial intelligence algorithms where consumer electronic product parameters are designed with following objectives.

- To design a collaborative 6G model to reduce the amount of waiting time period for considered consumer electronic products.
- To create crypto key features with increased encryption of data for taking expert decision based on user knowledge.
- To minimize the errors in 6G communications at minimized energy rate of each consumer electronic products.

II. INTERRELATED SYSTEM MODEL FOR 6G

In the allocation of 6G network to consumer electronic items, it is imperative to accurately identify the wave in accordance with architectural and mathematical definitions. Nevertheless, altering the architectural depiction of waves, even in the context of millimeter wavelengths, is unfeasible. However, it is plausible to modify the characteristics that facilitate the construction of a system model that enables efficient communication. The suggested method incorporates a system model to address security concerns associated with data transmission during the establishment of 6G communications. This model integrates many techniques like edge computing and wireless sensor networks.

A. Collaborative electronic model

Prior to data transmission, it is essential to verify the channel model in order to effectively utilize the allocated sub-channels inside the system. Let $SC_1 + .. + SC_i$ represent the total count of sub channels that have been assigned for transmission, considering the power factor $PF_1 + .. + PF_i$ Therefore, the utilization of Equation (1) can offer a collaborative framework for ensuring the secure transmission of data.

$$CEM_i = \sum_{i=1}^{n} [(SC_1 + .. + SC_i) * (PF_1 + .. + PF_i)] + \delta_i \quad (1)$$

δ_i represents bandwidth of operation
Equation (1) represents the requirement for defining bandwidth ranges for each subchannel in order to construct a secured channel for data transmission between a transmitter and receiver in consumer electronic products. This enables the establishment of correct secured spectrum ranges.

B. Consumer electronic latencies

The subchannels that function within specific bandwidth ranges exhibit a high level of security. However, certain electronic equipment may have difficulties in transmitting data securely inside the relevant bandwidth ranges. Insufficient bandwidth allocation in 6G networks for consumer electronic items might result in latency, hence compromising the security of data transmission. Therefore, Equation (2) is derived in order to minimize delay in the transmission process.

$$latency_i = min \sum_{i=1}^{n} (ED_i + WT_i) \tag{2}$$

ED_i denotes latencies that are present in product execution
WT_i indicates waiting time period of each product
According to Equation (2), the absence of implementation of consumer products in 6G networks indicates that a given product lacks the capability to adequately cater to end consumers, thereby compromising the security of adjacent products.

The control operations pertaining to 6G networks in the context of consumer electronic items are executed through the utilization of a text command procedure, resulting in the establishment of a cryptanalytic architecture that employs binary values, as denoted by Equation (3).

$$command_i = min \sum_{i=1}^{n} (I_s(i) + \sum_{i=1}^{n} (pulse_b(i)) \tag{3}$$

I_s represents 6G signal strength
$pulse_b$ denotes variation of binary pulses
Equation (3) establishes the necessity of executing commands in accordance with the distinct pulse shape associated with each electrical product. Therefore, it is imperative to compute the intensities for every digital pulse in order to facilitate the implementation of a safe transmission technique.

C. Product crypto keys

In the context of 6G communication, the establishment of cryptographic keys becomes imperative for ensuring advanced security measures while accessing consumer electronic products. These keys are specifically required to be established for various digital pulse shapes. Let $\alpha_1 + .. + \alpha_i$ denote a collection of unbounded key authentication mechanisms intended for public utilization, while $\beta_1 + .. + \beta_i$ represents a specific key subject to usage limitations. Therefore The formulation of Equation (4) incorporates cryptographic keys that correspond to distinct digital pulse forms

$$CK_i = max \sum_{i=1}^{n} ((\beta_1 + .. + \beta_i) * pulse_b(t)) \tag{4}$$

$pulse_b(t)$ indicates digital pulse at corresponding time periods. According to Equation (4), it is necessary to utilize restricted keys exclusively for the modulation of pulses that occur at distinct time intervals. The utilization of unconstrained keys in 6G technology results in data transmission remaining in a condition of low security, consequently compromising the protection of information in electronic items.

D. 6G electronic product encryption

Once the keys are recommended for electrical goods, it is imperative that all keys are encrypted, ensuring that the digital signal pulse is transmitted with an appropriate signal decoding mechanism. Therefore Equation (5) is derived to describe the process of encrypting electronic devices by utilizing power variations.

$$encrypt_i = max \sum_{i=1}^{n} \vartheta_i * r_c(i) + \phi_i \tag{5}$$

ϑ_i denotes product text representations
r_c represents recovered text patterns from electronic products
ϕ_i indicates consumer product recommendations
According to Equation (5), the recovery of text patterns from 6G systems is necessary in the event that any cryptanalytic features are compromised. Therefore, in 6G systems, an encryption key is provided for each recovered pattern, resulting in the minimum of route loss.

E. Product energy consumption

In the context of 6G processing systems, it is important to process information pertaining to electronic products through offloading activities, while simultaneously minimizing energy consumption across all edges of 6G devices. Let $E_1 + .. + E_i$ represent the total energy consumption of a set of electronic devices, where $QT_1 + .. + QT_i$ signifies the corresponding quantity of these devices. The energy consumption of 6G networks can be mathematically expressed using Equation (6), taking into account the appropriate number of electronic products

$$energy_i = min \sum_{i=1}^{n} \frac{((cycle_1 + .. + cycle_i) * PD_i)}{QT_1 + ..QTi} \tag{6}$$

$cycle_1 + .. + cycle_i$ denotes 6G energy consumption cycle PD_i represents number of recommended devices
Equation (6) establishes that an energy-saving method is implemented for each piece of information regarding electronic products, in accordance with the corresponding number of determinations. If the amount of electronic items increases significantly, it can lead to a reduction in energy savings within 6G edge server compute systems.

F. Product errors

In the context of offloading analysis, it is seen that a significant number of 6G networks exhibit channel fluctuation, leading to the presence of errors in data processing channels. This occurrence arises due to the collaborative nature of data processing, wherein each data element undergoes processing. Product faults primarily occur as a result of the relocation of consumer products, wherein certain external factors may be present due to deteriorating conditions. Therefore, any discrepancies found in existing products are indicated and represented by Equation (7) in the following manner.

$$Errors_i = min \sum_{i=1}^{n} \rho_i * (1 - f_i) \tag{7}$$

ρ_i denotes errors in each channel
f_i indicates total failure probabilities

G. Objective functions

The interdependent variables pertaining to 6G networks are formulated as multi-objective functions to facilitate connectivity with diverse parameters specific to consumer electronic devices. Therefore, Equation (8) and (9) can be expressed as coupled parametric representations in the following manner.

$$obj_1 = min \sum_{i=1}^{n} (latency_i, command_i, energy_i, errors_i, RJ_i) \tag{8}$$

$$obj_2 = max \sum_{i=1}^{n} (CK_i, encrypt_i) \tag{9}$$

The above mentioned objective functions are processed with advanced artificial intelligence algorithm where high security features for 6G networks are provided with consumer electronic energy saving process. A comprehensive exposition of sophisticated intelligent algorithms is presented in Section 3.

III. Advanced artificial intelligence

The machine handling process is executed using an intelligent algorithm that transforms all smart electrical components into intelligent units. Therefore, the proposed model utilizes sophisticated artificial intelligence algorithms that employ natural language processors to analyze encrypted communications. In order to enable the integration of smart devices with 6G networks, a novel expert system model has been proposed. This model has separate incentive functions to facilitate the conversion process.In contrast to conventional artificial intelligence algorithms, advanced algorithms prioritize the attainment of robust security measures for concealing transmitted content from individual recipients [21,22].One significant benefit of selecting advanced artificial intelligence algorithms is their ability to adapt to changes in data and the corresponding environmental model in order to accommodate consumer traffic.

This necessitates the utilization of advanced algorithms to effectively address the evolving environmental conditions. Furthermore, it is worth noting that all consumer electronic items in the sixth generation (6G) possess the ability to offer enhanced capabilities and sensing solutions, hence augmenting the security of transmission. It has been widely recognized that in order to make informed decisions, it is necessary to assess the provided data using sophisticated expert systems. This process enables the development of a comprehensive framework for executing autonomous operations in the context of 6G technology. Given that 6G operations are not feasible for an entity, the execution of data integration operations can be achieved through the utilization of electronic language processing units within cloud services. Moreover, it is imperative for modern artificial intelligence systems that offer expert system solutions to incorporate security measures at the highest level of the physical layer. Consequently, any electronic devices containing sensitive information must ensure the presence of a coordinating function. In the process of establishing coordination function entities within the physical layers, the integration of software modules enables 6G networks to exhibit enhanced flexibility.

A. Natural language processing

Given the dynamic nature of 6G communication requirements over time, it is imperative to explore the implementation of a natural language processing system to enhance the performance of encrypted data transmission in consumer electronic products, particularly in light of the variations that may arise. One of the primary justifications for selecting natural language processing as a sophisticated artificial intelligence technology is its ability to effectively manage large volumes of data through the amalgamation of many electrical components. The potential for enhancing the efficiency of consumer electronic devices can be achieved through the utilization of natural language processing systems. These systems are recognized as automated tools capable of effectively interpreting data, so enabling the processing of a substantial volume of data units to mitigate any potential ambiguity among interconnected systems.

One significant benefit of including natural language processing in the suggested system model is the enhanced capability for data analysis. This is primarily attributed to the improved accuracy in the interaction between different users, which effectively mitigates errors in the receiving pathways. The implementation of natural language processing in the context of 6G technology enables the establishment of a streamlined data processing system, leading to enhanced efficiency and cost reduction for all individuals involved. Given that intelligent software units facilitate the transmission of data, it becomes feasible to comprehend natural languages across diverse communication channels. Consequently, in 6G communications, exclusively authorized users possess the capability to extract text and other data formats. Natural language processing (NLP) plays a significant role in handling the retraction of sensitive data, as it offers a distinct framework for organizing unstructured data associated with consumer electronic items. Furthermore, the storage requirements for natural language processing are significantly reduced as a result of the utilization of pre-processing approaches that are executed alongside training units.

1) 6G data classification : The transmission data found in 6G networks exhibits distinct classification properties pertaining to frequency terms for each electronic device. Therefore, the establishment of data classification through the utilization of natural language processing can be achieved by employing Equation (10) in the following manner [21].

$$CFC_i = \sum_{i=1}^{n} \frac{(\aleph_1 + .. + \aleph_i)}{\aleph_t(i)} \tag{10}$$

$\aleph_1 + .. + \aleph_i$ represents total number of data in each unit
$\aleph_t(i)$ denotes total number of units

2) Language processing time: In order to provide efficient communication in the context of 6G technology, it is important to perform timely natural language processing or

conversion. To this end, a hybrid process can be implemented, which would effectively reduce the required time intervals for such operations. If the hybrid process lacks long-term communication assistance, the attainment of text analytics becomes significantly more challenging. Therefore, Equation (11) is derived to calculate the processing time for each data point [22].

$$PT_i = \sum_{i=1}^{n} (\sigma_1 + .. + \sigma_i) * time_d(i) \tag{11}$$

$\sigma_1 + .. + \sigma_i$ denotes combination of consumer data
$time_d$ indicates total time period of each data

Algorithm 1 Algorithm Natural Language Processing

procedure NLP
Given
$\aleph_1 + \cdots + \aleph_i$: Number of data units
$\aleph_t$: Total number of units
for i=1:n **do**
CFC_i for classifying the data based on number of data units
PT_i for finding the time period that is considered for conversion periods
end for
for all i=1:n **do**
LS_p for arranging the converted data in to sequence with distribution management
end for
end procedure

3) Language sequence: It is imperative to verify the sequence employed during the conversion process, since any alterations in this procedure can have an impact on the dissemination of data to consumer gadgets. Therefore, a meticulous procedure for arranging the sequence is conducted by employing Equation (12) in the following manner [6,19].

$$LS_P = \sum_{i=1}^{n} (dist_{s1} + dist_{si}) \tag{12}$$

$dist_s1 + .. + dist_si$ denotes distributed sequence for consumer products
The flow of natural language processing with proposed system model is deliberated with block representation indications in Figure 2. The electronic products that are identified using natural language processing includes number of data units that must be identified at initial step. Once the number of data units are identified then the type of network can be chosen and with fast mode a conversion process is completed and every information can be converted to human processing language for further processing. After converting the machine language to human language every data will be modified based on external configurations thus a time period representation is made. Conversely the identified data will be distributed across entire network where consumer electronic products are identified and at minimum time period expert decisions are made.

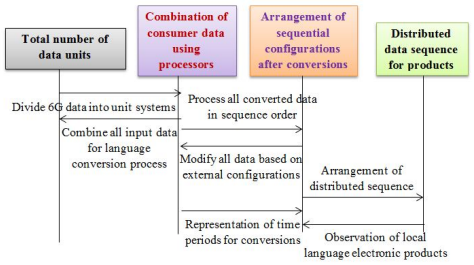

Fig. 2. Natural language processing systems for consumer electronic products

B. Expert system

The utilization of natural language processing complicates the examination of precise operational circumstances across different systems, necessitating the acquisition of external knowledge to comprehend the many behaviors exhibited by 6G signals [23-25].Therefore, the integration of an expert system, which is recognized as a sophisticated artificial intelligence algorithm, with the proposed system model is employed to analyze various consumer electronic devices. The expert system utilizes the fundamental knowledge of users to analyze consumer issues, employing a computational processor to effectively address relevant problems. It is important to establish a 6G forward chain procedure in order to provide accurate decision-making for all transmitted signals in electronic devices, as per the user's understanding. If precise decisions are not made, users are granted flexible alterations that enable a backward chain by manipulating the binary pulses at the output unit.
Moreover, the integration of expert systems into decision-making systems can facilitate the establishment of green communication over 6G networks, thereby enhancing the security of consumer electronic items. The implementation of expert systems in the 6G network enables the conversion of non-clustering units for efficient data transmission. As a result, both the activation and assurance of security in receiving units of consumer electronic items at the user end are ensured. One of the main benefits of incorporating expert systems into 6G communication is the capacity to enhance decision-making processes for consumer electronic products. By leveraging expert knowledge, these systems may give more accurate and informed decisions. Additionally, the integration of expert systems can contribute to improving the reliability of 6G networks by utilizing expert knowledge to address various challenges and complexities. This approach enables the attainment of predetermined solutions based on the analysis of gathered data. In addition, the expense associated with expert systems is diminished due to the fact that each solution is attained within the designated 6G limits, hence minimizing the likelihood of errors.

1) Expert system sensitivity: The amalgamation of knowledge obtained from many users will be utilized to determine the optimal representation values. However, in addition to machine intelligence, which can be relied upon to a certain degree, choices based on user expertise are also very susceptible to even little alterations in the system.Hence, the representation of the sensitivity of 6G in consumer electronics

with expert judgements can be expressed by Equation (13) in the following manner [9,15].

$$sensitivity_i = \sum_{i=1}^{n} \frac{PT_e(i)}{OD_e i} \tag{13}$$

PT_e indicates positive expert solutions
OD_e denotes over signal diagnosis errors
The flow of expert system in 6G with proposed system model is deliberated with block representation indications in Figure 3.

Algorithm 2 Algorithm Expert Systems

procedure ES
Given
PT_e : Number of positive expert solutions
o_τ : Outliers of each data
for i=1:n **do**
$sensitivity_i$ for calculating the sensitive data before achieving expert solutions
$sensitivity_i$ for selecting the signals with low sensitive ranges
end for
for all i=1:n **do**
RJ_i for rejecting expert solutions that are not present in the boundary regions
end for
end procedure

2) Expert selectivity: The selection of a specific signal for transmission in a network operation can be determined based on the features of signal sensitivity. Therefore, it is imperative to carefully choose the proper signals that facilitate an effective identification procedure prior to transmitting them to consumer electronic items.The representation of signal selectivity in 6G networks can be expressed mathematically using Equation (14) in the following manner [10,14].

$$selectivity_i = \sum_{i=1}^{n} \frac{RTN_i}{TFP_i} \tag{14}$$

RTN_i denotes removal of true signal negative states
TFP_i indicates removal of true false positive rates

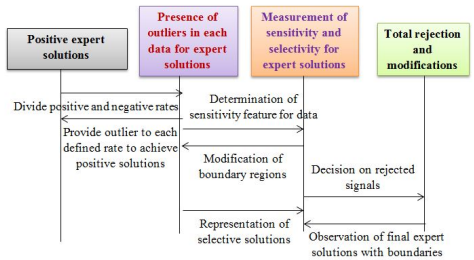

Fig. 3. Expert systems in 6G for consumer electronic products

3) Expert rejections: By employing a comprehensive decision-making process that takes into account the entirety of user knowledge, it becomes feasible to eliminate superfluous conversions in electronic products. Therefore, it is expected that 6G signal processing units will be equipped with significant rejection capabilities.The rate of rejections can be determined using Equation (15) in the following manner [22].

$$RJ_i = min \sum_{i=1}^{n} \frac{\tau_r(i)}{o_\tau} \tag{15}$$

τ_r denotes total number of rejected expert solutions
o_τ indicates outliers of each rejected data
Table 2 provides information on variables and its corresponding representations.

TABLE II
VARIABLE REPRESENTATIONS

Variables	Representation
δ_i	Bandwidth of operation
ED_i	Latencies that are present in product execution
WT_i	Waiting time period of each product
I_s	6G signal strength
$Pulse_b$	Variation of binary pulses
$pulse_b(t)$	Digital pulse at corresponding time periods
ϑ_i	Product text representations
r_c	Recovered text patterns from electronic products
ϕ_i	Consumer product recommendations
$cycle_1 + ... + cycle_i$	6G energy consumption cycle
PD_i	Number of recommended devices
ρ_i	Errors in each channel
f_i	Total failure probabilities
$\aleph_1 + .. + \aleph_i$	Total number of data in each unit
$\aleph_t(i)$	Total failure probabilities
$\sigma_1 + ..\sigma_i$	Combination of consumer data
$time_d$	Total time period of each data
$dist_{s1} + .. + dist_{si}$	Distributed sequence for consumer products
PT_e	Positive expert solutions
OD_e	Over signal diagnosis errors
RTN_i	Removal of true signal negative states
TFP_i	Removal of true false positive rates
τ_r	Total number of rejected expert solutions
O_τ	Outliers of each rejected data

IV. RESULTS

In this paper advanced features of 6G networks by examining security of consumer electronic products are discussed. With rapid growth of consumer electronic products the network features are updated thus providing fast response to end users but security of transmission remains a major concern. Hence a collaborative framework is formulated in proposed method that solves all uncertainties in consumer electronic products if it is recommended to provide operation using 6G networks.The major significance of proposed method is to identify all problems that occurs in consumer electronic

products that operated with advanced technological networks such as 6G and advanced 6G communications. Hence foremost importance is provided to identify all problems by using advanced artificial intelligence algorithm where electronic products can be identified by using natural language processors to convert machine language to identifiable ones thereby expert solutions are achieved. The above mentioned integrated model is tested in real time with four major parametric cases that includes latency, security with both crypto keys and encryption, error minimization where in each case the objective functions are optimized with maximized security of 87The significance of these parametric cases is outlined in Table 3.

- Case 1: 6G latency and consumer commands
- Case 2: Formation of crypto keys
- Case 3: 6G data encryption
- Case 4: Data errors and energy rates

TABLE III
SIGNIFICANCE OF PARAMETRIC CASES

Case studies	Importance
6G latency and consumer commands	To examine the effect of delay and to use individual commands for data processing
Formation of crypto keys	To allocate separate keys for processing each consumer electronic data
6G data encryption	To secure the 6G system for processing text signals before attack
Data errors and energy rates	To minimize the energy and errors in signal transmission system using 6G

A. Discussions

The observation of all designed cases will be conducted in real time using a network simulation tool. This is necessary in order to establish a comparison with the existing method and determine the enhanced results that can be achieved with the suggested method. Greater emphasis is placed on scenario 2 and 3 due to the imperative necessity to enhance the security measures of consumer gadgets in the context of 6G communication networks. Furthermore, the desired results are attained through the utilization of one transmitting unit and one receiving unit, with the objective of maximizing the transmission rate to 1024 bits per second.The simulation parameters pertaining to the suggested technique are presented in Table 4. The gathered dataset will be integrated with a sophisticated artificial intelligence system, which will segment signals inside the communication network. This will enable the utilization of the collaborative model that has been established, incorporating individual bandwidth selection. Furthermore, the inclusion of a soft prediction unit in electronic devices allows for precise estimation, hence enhancing the security of data operations. The following is a comprehensive account of the designed cases, including a complete description for each.

1) ***Case 1: 6G latency and consumer commands****:* In this scenario, the delay associated with the 6G communication time period is noted to vary among consumer electronic items due to their distinct specifications. Consequently, the process of language conversion during interaction experiences a certain amount of delay. However, it is crucial to prevent the latencies induced by independent sources in consumer electronics to ensure that only valuable communication signals are sent throughout the full spectrum. In the established collaborative model, latencies arise as a result of the incorporation or inclusion of specific electrical devices inside the spectrum. Moreover, the latencies are aggregated by incorporating the signal waiting duration, as both the transmission and receiving processes introduce delays in each measurement procedure. Therefore, a command processing system is implemented by manipulating binary pulses, resulting in enhanced signal strength in the full spectrum of 6G communications. Figure 4 depicts the comparative analysis of delay % and signal strength magnitude in the context of signal processing inside the 6G spectrum. The analysis encompasses both the suggested approach and the existing approach.

TABLE IV
SIMULATION ENVIRONMENTS

Bounds	Requirements
Operating systems	Windows 8 and above
Platform	MATLAB and Slicing network simulator tool
Version (MATLAB)	2015 and above
Version (Network simulator tool)	1.1 and above
Applications	All consumer electronic products
Implemented data sets	Advanced artificial intelligence model with expert solutions based on collected data knowledge after training

The data presented in Figure 4 clearly demonstrates that the latencies observed in the proposed collaborative model are significantly lower when compared to the latencies observed in the previous method. The suggested technique involves the connection of 6G command processing units with source units, wherein the signal intensity for each consumer product is determined. Consumer electrical gadgets typically avoid signals with low signal intensities due to the recognition of such signals. The controlling procedure results in the conversion of every signal into binary pulses, wherein digital operations offer precise and rapid responses in comparison to conventional operating signals. In order to substantiate this case, the waiting time intervals for each signal have been observed to be 60, 120, 180, 240, and 360 seconds. It has been noted that the consumer electronic products exhibit the highest signal strength percentages within these waiting periods. Consequently, the proposed method demonstrates a reduction in latency percentage below 10%, whereas the existing approach exhibits a latency percentage above 12% in relation to the waiting time period. Therefore, the implemented collaborative model for consumer electronic devices operates efficiently with prompt responsiveness in comparison to the current approach. The user's text is already academic and does not require any rewriting.

2) ***Case 2: Formation of crypto keys****:* Given the integration of various bandwidths within certain spectrum ranges, it is imperative to ensure the protection of each data segment in

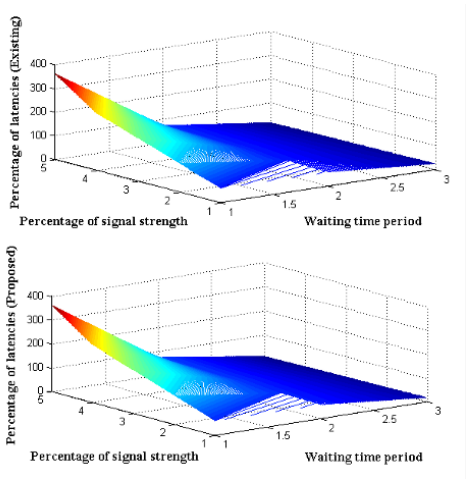

Fig. 4. Latencies in 6G transmission for consumer electronic products

consumer electronic devices. The suggested method includes a cryptographic key construction that distinguishes itself from the existing approach by representing each peak using binary pulses. In 6G data processing units, cryptographic keys are commonly employed to ensure robust security for information signals. This is achieved through the utilization of digital signatures for each user, thereby safeguarding the identity of consumer electronic devices. The aforementioned safeguards are made available to users upon request, as cryptographic keys are subject to limitations and are issued for a specified duration in the proposed approach. Consequently, once the cryptographic keys are employed for a specific transaction, they are afterwards eliminated from all system units. As a result, inside the designated 6G spectrum, consumer electronic items persist within a safeguarded domain. Figure 5 illustrates the cryptographic key generation process for both the proposed and existing approaches. According to the findings presented

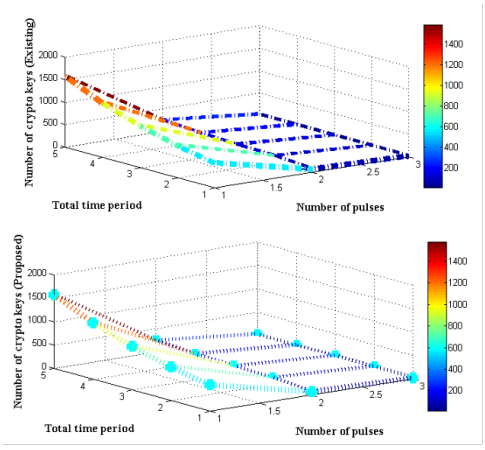

Fig. 5. Crypto key for binary pulses at different time periods

in Figure 5, it can be observed that the utilization of crypto keys with limitations, namely private keys, leads to an augmentation in the magnitude of binary pulses within a specified temporal interval. In 6G networks, the alteration of pulses results in a complete modification of data, so introducing a random possession for the purpose of managing persistence. Furthermore, the generation of cryptographic keys aligns the address with consumer electronic items, so ensuring the protection of other information contained within these products. In order to demonstrate the significance of cryptographic keys, a series of pulse counts were examined, specifically 560,720,930,1210, and 1580. The entire time period for processing of all defined binary pulses is denoted as 70, 130, 150, 180, and 240 seconds, respectively, without taking into account any waiting time periods. Therefore, in the previously given binary pulses, the existing approach yields a total of 8, 10, 11, 14, and 16 cryptographic keys. However, in the suggested method, the total number of cryptographic keys is 15, 17, 20, 22, and 25. Therefore, the proposed system operates with enhanced security even when utilizing a greater quantity of binary pulses in comparison to the current approach. The user's text is already academic and does not require any rewriting.

*3) **Case 3: 6G data encryption**:* In order to ensure stability within the overall system, it is imperative that consumer electronic goods incorporate encryption processes to safeguard the established private keys, should 6G networks be created with cryptographic keys. In this encryption method, the entire system effectively mitigates any potential instability conditions by incorporating user-end recommendations for each product. The encryption procedure serves to impede unauthorized access by external users to the data processing units. This is achieved by assigning distinct identities to each consumer electronic goods. In the event of encountering any data gaps, consumers will be notified to employ encryption techniques on their keys, along with other suggestions for analyzing textual material using natural language processors. One of the advantages of consumer electronic items in the context of 6G is the ability to retrieve all text patterns, which may not be easily recalled by other users, pertaining to information allocated to these products. Figure 6 illustrates the process of encryption, accompanied by a suggestion for both the proposed and existing approaches. Based on the analysis

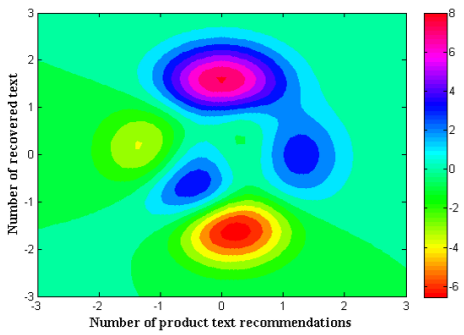

Fig. 6. Three dimensional representation for encrypted and recovered text

shown in Figure 6, it can be inferred that the suggested method offers a significantly higher level of encryption compared to the existing approach. The existence of a larger number of illegal users in the planned collaborative model results in the recovery of a significant portion of text patterns for consumer

electronic items. Therefore, by utilizing all retrieved textual patterns, encryption is employed to replicate 6G signals, while also incorporating product recommendations. In order to substantiate this argument, a range of text recommendations, specifically 100, 200, 300, 400, and 500, were examined. The corresponding recovered text patterns were found to be 24, 26, 27, 29, and 30, respectively. The encryption given by the previous approach for the aforementioned recommendations is limited to less than 70%, however in the collaborative recommendation system, the encryption exceeds 80%. The examination of this phenomenon can be conducted using a maximum text recommendation pattern of 500. In the collaborative model, 87% of the encryption is given, while the present approach only encrypts 67% of the text units.

*4) **Case 4: Data errors and energy rates**:* In the context of consumer electronics in 6G networks, it is important to conduct an analysis of data mistakes under different energy rates during data transmissions. During the error identification procedure, the reference ranges for consumer electrical products are observed. If the communicated value exceeds the specified ranges, it will be flagged as an error. Furthermore, a significant proportion of errors can be attributed to specification issues, including the lack of coordination between 6G networks and other communication units. Furthermore, the mistakes seen in each cycle indicate that the quantity of energy supplied to consumer electronic products will be significantly reduced. However, in certain instances, errors may also arise as a result of inefficiencies in energy usage, even after the appropriate consumer electronic devices have been recommended. On the other hand, the energy representations are generated by a cyclic energy consumption process, which is subsequently replicated using suggested products, as depicted in Figure 7.

The analysis of Figure 7 reveals that the total number of faults in all consumer electrical items is significantly reduced as compared to the current approach. Energy is provided to each consumer electronic equipment in alternating cycles, allowing for the utilization of low energy levels during specific time periods. If consumer electronic items transition to the next cycle, it is possible to achieve significant energy consumption without encountering any wastage issues. Hence, each product has the capability to function well at both the transmitting and receiving ends, resulting in few faults. Consequently, this facilitates the process of endorsing these products to the ultimate consumers. In order to substantiate this particular situation, we examine a range of suggested items spanning from 400 to 1200, with variations of 200. The reference probabilities of error associated with each of these recommended products are 94, 126, 155, 171, and 196. As a result, the utilization of the aforementioned recommended goods leads to a reduction in the occurrence of errors to 2% and 0.7% for the present and proposed approaches, respectively.

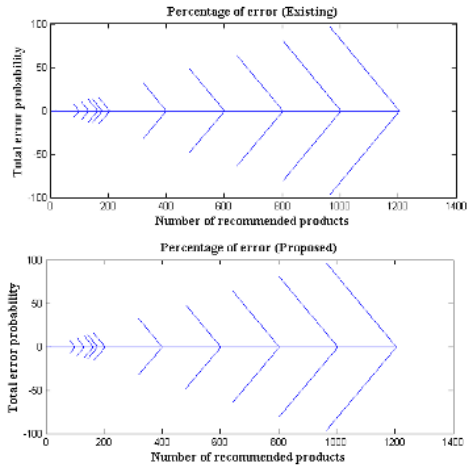

Fig. 7. Energy and error representations for recommended products

B. Computational complexity

In the proposed method computational complexity determines the maximum storage process of data where it is essential to store commands and other collected data from electronic products. Hence it is essential to evaluate the performance of computational complexity with respect to varying iteration periods thereby changes with respect to processing time and sequence can be changed. This type of performance metric evaluations are made for advanced artificial intelligence algorithm thereby expert system solution can be achieved at short periods of time. In consumer electronic products, specifications must be identified in such a way to prevent incorrect classifications where product errors can be reduced at this state. In addition to specifications of electronic products the data must be secured with specially defined storage type thereafter reducing the computational complexity that augments the working of collaborative model. Figure 8 depicts the computational complexity of proposed and existing approach. From Figure 8 it is obvious that

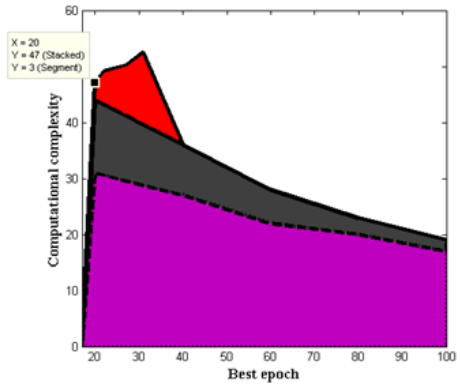

Fig. 8. Performance metrics with computational complexity at best epoch periods

computational complexity is reduced in proposed method as compared to existing approach due to precise separation and identification of electronic products. In the proposed method the storage space is allotted for crypto keys, encryption codes and information about consumer electronic products. For all the above mentioned data storage a separate sequence

is provided where classification mechanism is followed with expert solutions. Since advanced artificial intelligence algorithms are capable of processing more amount of data an automated recognition process is necessary in all circumstances thereby preventing the increasing complexities for all consumer electronic products. To prove the outcome of the considered performance metrics iterations are changed from 10 to 100 where only best epoch periods are considered with step variations of 20. For the indicated best epoch changes the proposed method provides low complexities of 13,9,6,3 and 2% whereas existing approach provides more complexity with 31,27,2220 and 17% respectively.

V. Conclusions

The process of transmitting necessary signals to consumer electronic products with 6G networks is increasing in current generation process. Whenever 5G networks are sliced then every consumer electronic products suffers with major drawback on ensuring security to all information units. Hence in the proposed method a collaborative network model is formulated that interrelates necessary bandwidth at various channels without any external effect. During the process of collaborative data transmission at different bandwidths there will be presence of latencies at all channels that needs to be prevented. Therefore in proposed method network latencies are minimized to 6% by reducing the waiting period at each channel thereafter security of data transmissions are increased. With addition to latency minimization the signal strength of 6G networks that uses binary pulse for representations are analyzed with commanding process thus providing exact contour in three dimensional representations. Moreover the security of consumer electronic products with 6G data transmission networks are ensued by using crypto keys and it is maximized to 25% in proposed method. If crypto keys are used then data encryption must be provided to all data in 6G networks by using separate text patterns thus it is increased to 87% which indicates that all data remains at secured state. After increasing the security of data transmissions highly secured products are recommended to operate at low energy states and by supplying minimized energy rates the collaborative channels reduces the error to 0.7% whereas in existing approach the error rates remains at 2%. Further more due to integration of advanced machine learning algorithms it is possible to achieve optimized solutions that provides low sensitivity measurements in 6G networks.

A. Limitations and future work

The advantage of proposed method is to identify the consumer electronic products with a commanding process where a collaborative electronic model is designed. With the use of collaborative model various latencies that are present in a product is identified and security of data transmission is increased by using crypto keys and individual encryption codes. Further the errors are identified by converting machine language to human language therefore a precise decision making system which provides expert solutions are associated. However the limitations of proposed method is that network flexibility is not guaranteed as the demand for consumer electronic products are much higher then economic analysis cannot be made equal. Hence in future the proposed work on examination of consumer electronics can be extended with different advanced algorithms and several parametric indications can be examined with 6G network flexibility.

B. Policy implications

The fault identification and security improvements in consumer electronic products is highly helpful for all smart industries (Industry 5.0) where every electronic products are operated with automated monitoring units. Hence with the help of natural language processing tool every products are identified in such a way with precise decisions and as a result of expert decisions it is possible to provide balance between product and price thereafter avoiding demand of each product. Consequently after identify consumer electronic faults a secured data transfer with classification procedures are followed hence authorization of each electronic product are registered separately.

References

[1] Y. Zhang, B. Di, P. Wang, J. Lin, and L. Song, "HetMEC: Heterogeneous Multi-Layer Mobile Edge Computing in the 6 G Era",*IEEE Trans. Veh. Technol.*, vol. 69, no. 4, pp. 4388–4400, 2020, doi: 10.1109/TVT.2020.2975559.

[2] S. U. Jamil, M. Arif Khan, and S. U. Rehman, "Resource Allocation and Task Off-Loading for 6G Enabled Smart Edge Environments"*IEEE Access, vol. 10, no. August, pp. 93542–93563, 2022, doi: 10.1109/ACCESS.2022.3203711.*

[3] M. Banafaaet al., "6G Mobile Communication Technology: Requirements, Targets, Applications, Challenges, Advantages, and Opportunities", Alexandria Eng. J., vol. 64, pp. 245–274, 2023, doi: 10.1016/j.aej.2022.08.017.

[4] A. Taneja, N. Alqahtani, and A. Alqahtani ,"Interference Aware Resource Control for 6G-Enabled Expanded IoT Networks," Sensors, vol. 23, no. 12, p. 5649, 2023, doi: 10.3390/s23125649.

[5] G. Liu, F. Dai, B. Huang, Z. Qiang, S. Wang, and L. Li, "A collaborative computation and dependency-aware task offloading method for vehicular edge computing: a reinforcement learning approach", J. Cloud Comput., vol. 11, no. 1, 2022, doi: 10.1186/s13677-022-00340-3.

[6] Y. U. Lee, "Secure visible light communication technique based on asymmetric data encryption for 6G communication service," ,Electron., vol. 9, no. 11, pp. 1–16, 2020, doi: 10.3390/electronics9111847.

[7] S. J. Nawaz, S. K. Sharma, M. N. Patwary, and M. Asaduzzaman, "Next-Generation Consumer Electronics for 6G Wireless Era",IEEE Access, vol. 9, pp. 143198–143211, 2021, doi: 10.1109/ACCESS.2021.3121037.

[8] H. Zhou, Y. Xiang, H. F. Li, and R. Yuan, "Task Offloading Strategy of 6G Heterogeneous Edge-Cloud Computing Model considering Mass Customization Mode

Collaborative Manufacturing Environment",Math. Probl. Eng., vol. 2020, 2020, doi: 10.1155/2020/1059524.

[9] E. Gyamfi and A. Jurcut, "A Robust Security Task Offloading in Industrial IoT-Enabled Distributed Multi-Access Edge Computing" ,Front. Signal Process., vol. 2, no. April, pp. 1–13, 2022, doi: 10.3389/frsip.2022.788943.

[10] N. Vashistha, M. M. Hossain, M. R. Shahriar, F. Farahmandi, F. Rahman, and M. M. Tehranipoor, "EChain: A Blockchain-Enabled Ecosystem for Electronic Device Authenticity Verification," , IEEE Trans. Consum. Electron., vol. 68, no. 1, pp. 23–37, 2022, doi: 10.1109/TCE.2021.3139090.

[11] M. A. Ivanchuk, V. V. Maksimyuk, and I. V. Malyk, "Mathematical Modeling of the Expert System Predicting the Severity of Acute Pancreatitis" ,J. Comput. Med., vol. 2014, pp. 1–4, 2014, doi: 10.1155/2014/532453.

[12] D. Bakkiam David and F. Al-Turjman, "Synonym-based multi-keyword ranked search with secure k-NN in 6G network", IET Networks, 2022, doi: 10.1049/ntw2.12050.

[13] S. Pattanaik, A. L. Imoize, C. T. Li, S. A. J. Francis, C. C. Lee, and D. S. Roy, {"Data-Driven Diffraction Loss Estimation for Future Intelligent Transportation Systems in 6G Networks" ,Mathematics, vol. 11, no. 13, pp. 1–20, 2023, doi: 10.3390/math11133004.

[14] S. Nath, S. P. Singh, and S. Sengar, "Interference and noise analysis for hybrid FSO/RF-based 6G mobile backhaul" ,ETRI J., vol. 44, no. 6, pp. 966–976, 2022, doi: 10.4218/etrij.2022-0213.

[15] A. K. Yerrapragada and B. Kelley,"On the application of k-user mimo for 6g enhanced mobile broadband" ,Sensors (Switzerland), vol. 20, no. 21, pp. 1–16, 2020, doi: 10.3390/s20216252.

[16] F. O. Catak, M. Kuzlu, E. Catak, U. Cali, and D. Unal, "Security concerns on machine learning solutions for 6G networks in mmWave beam prediction" ,Phys. Commun., vol. 52, p. 101626, 2022, doi: 10.1016/j.phycom.2022.101626.

[17] L. Rachakonda, A. K. Bapatla, S. P. Mohanty, and E. Kougianos,"SaYoPillow: Blockchain-Integrated Privacy-Assured IoMT Framework for Stress Management Considering Sleeping Habits", IEEE Trans. Consum. Electron., vol. 67, no. 1, pp. 20–29, 2021, doi: 10.1109/TCE.2020.3043683.

[18] S. K. Behera, P. Kumar, D. P. Dogra, and P. P. Roy,"A Robust Biometric Authentication System for Handheld Electronic Devices by Intelligently Combining 3D Finger Motions and Cerebral Responses", IEEE Trans. Consum. Electron., vol. 67, no. 1, pp. 58–67, 2021, doi: 10.1109/TCE.2021.3055419.

[19] S. Ghosh and D. Chatterjee,"Artificial Bee Colony Optimization Based Non-Intrusive Appliances Load Monitoring Technique in a Smart Home",IEEE Trans. Consum. Electron., vol. 67, no. 1, pp. 77–86, 2021, doi: 10.1109/TCE.2021.3051164.

[20] G. A. Prabhakar, B. Basel, A. Dutta, and C. V. Rama Rao,"Multichannel CNN-BLSTM Architecture for Speech Emotion Recognition System by Fusion of Magnitude and Phase Spectral Features Using DCCA for Consumer Applications",IEEE Trans. Consum. Electron., vol. 69, no. 2, pp. 226–235, 2023, doi: 10.1109/TCE.2023.3236972.

[21] T. B. Ahammed, R. Patgiri, and S. Nayak,"A vision on the artificial intelligence for 6G communication", ICT Express, vol. 9, no. 2, pp. 197–210, 2023, doi: 10.1016/j.icte.2022.05.005.

[22] A. Rawal, J. McCoy, D. B. Rawat, B. M. Sadler, and R. S. Amant, "Recent Advances in Trustworthy Explainable Artificial Intelligence: Status, Challenges, and Perspectives,", IEEE Trans. Artif. Intell., vol. 3, no. 6, pp. 852–866, 2022, doi: 10.1109/TAI.2021.3133846.

[23] T. Hai, J. Zhou, Y. Lu, D. N. A. Jawawi, D. Wang, and S. Selvarajan, "An archetypal determination of mobile cloud computing for emergency applications using decision tree algorithm,", 2023, doi: 10.1186/s13677-023-00449-z.

[24] S. Shitharth, F. S. Alotaibi, H. Manoharan, A. O. Khadidos, K. H. Alyoubi, and A. M. Alshareef, "Reconnoitering the significance of securty using multiple cloud environments for conveyance applications with blowfish algorithm,",J. Cloud Comput., vol. 11, no. 1, 2022, doi: 10.1186/s13677-022-00351-0.

[25] S. Selvarajan, H. Manoharan, C. Iwendi, and T. Alshehari, "SCBC: Smart city monitoring with blockchain using Internet of Things for and neuro fuzzy procedures,", vol. 20, no. November, pp. 20828–20851, 2023, doi: 10.3934/mbe.2023922.

Dr S. Shitharth completed his PhD in the Department of Computers Science Engineering, Anna University. He is currently pursuing his Postdoc (Visiting) at The University of Essex. He has worked in various institutions with a teaching experience of seven years. Now, he is working as an Associate Professor at Kebri Dehar University, Ethiopia. He has published in more than 51 International Journals and 20 International National conferences. He is also an active member of IEEE Computer Society and five more professional bodies. He is also a member of the International Blockchain organization. He is a certified hyperledger expert and certified blockchain developer.

Dr. Hariprasath Manoharan is working as Assistant Professor in the Department of Electronics and Communication Engineering, Panimalar Institute of Technlogy, Poonamallee, Chennai, Tamil Nadu, India. His areas of Research include Wireless Sensor Networks, Data Communications and Testing of Communication devices. He has published 13 research articles which includes SCI, SCIE, ESCI, SCOPUS indexed articles and has presented articles in 6 International Conferences. He has also published a book entitled 'Computer Aided State Estimation for Electric Power Networks' which provides a complete guide to all Research Scholars in the field of Electronics and Communication Engineering.

Dr. Adil Khadidos received the B.Sc. degree in Computer Science from King Abdulaziz University, Jeddah, Saudi Arabia, in 2006, and the M.Sc. degree in Internet Software Systems from the University of Birmingham, Birmingham, United Kingdom, in 2011, and the Ph.D. degree in Computer Science from the University of Southampton, Southampton, United Kingdom, in 2017. He is currently an Assistant Professor at the Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia. His main research interests include the areas of computer swarm robotics, entomology behavior, machine learning, self-distributed systems, and embedded systems.

Dr. Alaa Khadidos received the B.Sc. degree from King Abdulaziz University, Jeddah, Saudi Arabia, in 2006, and the M.Sc. degree from the University of Birmingham, Birmingham, United Kingdom, in 2011, and the Ph.D. degree from the University of Warwick, Coventry, United Kingdom, in 2017, all in computer science. He is currently an Assistant Professor with the Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia. His main research interests include the areas of computer vision, machine learning, optimization, and medical image analysis.

Abdulrhman M Alshareef received the Ph.D degree in computer sicnese from the University of Ottawa, where he is an Assistant Professor with the Information System Department, King Abdulaziz University, Jeddah, Saudi Arabia. His research interests include recommender systems, social media mining, data sciences, information assurance artificial intelligence, e-business technologies. He is an active reviewer in multiple Q1 journals.

Dr.Aisha Y. Alsobhi is an Assistant Professor at the Faculty of Computing and Information Technology at KAU. She received her Ph.D. in Computer Information System from Middlesex University, UK. Her research interests include semantic web, adaptive technology, ande-learning