Enhancing Elderly Care: Microservices-Enabled IoT Models for Addressing and Monitoring Needs

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Abstract
Many nations are witnessing a demographic change, with a rising proportion of the population being old. This trend is known as the "aging population" or "silver tsunami." As individuals live longer lives, there is a greater demand for services that address the special health and social requirements of the elderly. On the other note, Microservices' scalability, flexibility, decentralization, and adaptation in the complex and evolving environment of Internet of Things applications may be connected to the exponential development of microservice-enabled IoT systems. The popularity and effectiveness of this combination strategy can be attributed to the synergy between microservices architecture and the special demands of IoT. The integration of microservices into Internet of Things (IoT) applications for geriatric healthcare and home support represents a paradigm shift. This design makes it easier to create scalable and adaptable systems to meet the different demands of geriatric healthcare. Because of the modular architecture, particular health monitoring features may be developed independently, allowing for personalized treatment. Microservices provide real-time data processing at the edge, as well as the smooth integration of diverse IoT devices and fault separation for increased dependability. We examine the elderly common needs and subsequently examine a variety of microservice enabled IoT applications designed to offer the necessary assistance. Furthermore, we look at the problems of developers w.r.t implementation of IoT Systems empowered by microservices and also challenges that must be overcome in order to improve the practicality and dependability of these IoT devices for everyday usage.

Keywords: *Elderly people, Wearable, Sensors, IoT, Microservices,*

Introduction

IoT (Internet of Things) technology, which has applications in everything from smart homes to industrial automation, has completely changed how we connect with and manage objects and data. The significance of IoT stems from its potential to link numerous devices, collect massive quantities of data, and enable improved decision-making, eventually improving efficiency and convenience across several domains. Microservice architecture, however, has emerged as a critical facilitator in the IoT ecosystem. Its importance stems from its ability to meet the issues provided by the complexity and scalability demands of IoT. Microservices provide flexibility, scalability, and fault tolerance, allowing IoT systems to support a wide range of devices and protocols, adapt to changing workloads, and undergo ongoing growth and improvement. Agile, robust, and scalable IoT and microservices are made possible by their combined strength.

A new software design paradigm for systems is called micro-service architecture. It proposes dividing a single huge and complicated application into manageable groups, with each group dealing with the relevant services. Each microservice is dedicated to a particular business function based on its specific business responsibilities. As a result, separate services may be readily deployed and published internally to the production environment in isolation, and changes to services will not impact the entire system. A given service may be readily realized using any suitable technologies and languages [1].

IoT is a massive deployment environment with numerous apps, protocols, servers, and sensors that necessitates more integration between applications, data, and devices. Because Microservices are based on a loosely connected design, this may be accomplished smoothly. Figure 1 depicts a basic IoT architecture based on microservices, in which each service is an independent codebase written in any programming language and maintained by a small team. This team can deploy their service independently, rebuild, and redeploy it without affecting the main application. Unlike previous models, where this is handled by a distinct layer, each independent service is responsible for retaining its data, control, and external states. These services connect using well-defined APIs (REST, HTTP). The most appealing aspect of microservices is that they do not have to share the same technology, programming language, frameworks, or libraries [2].

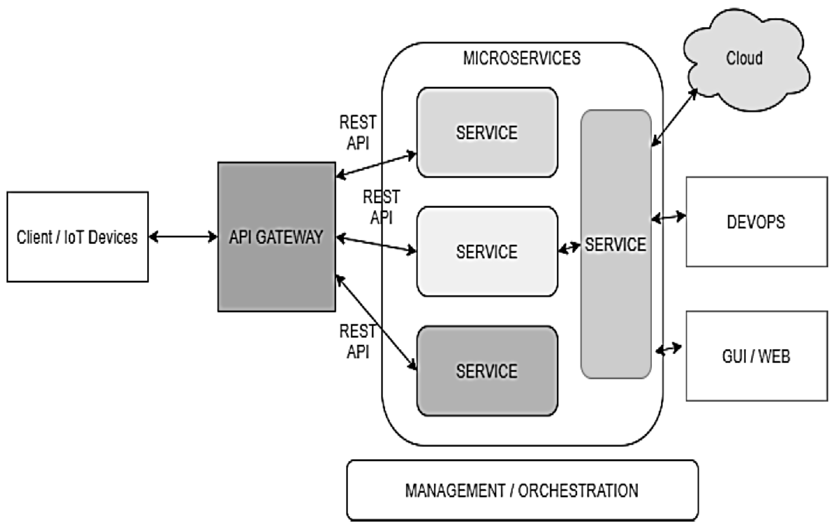

Figure 1. Microservices-based IoT architecture

Within the medical healthcare sector, IoT is at the forefront of innovation, revolutionizing the delivery of care and quality of service. It accomplishes this by providing a range of value-added services. For instance, IoT enables remote medical consultations, allowing patients and healthcare professionals to connect seamlessly regardless of geographic distances. Moreover, it ensures uninterrupted access to essential medical equipment, patient data, and health information, fostering a more efficient and responsive healthcare ecosystem. IoT also automates the collection and analysis of data generated by medical devices, facilitating timely and accurate insights into patient health. Furthermore, it supports continuous monitoring of patients' conditions, allowing for real-time tracking of vital signs and health metrics. In essence, IoT's contributions to medical healthcare extend far beyond mere connectivity, fundamentally improving the quality of care and the overall patient experience [3][4].

Table 1 contains citations for Microservice-enabled IoT and wearable devices, as well as their applications in diverse sectors. This study, on the other hand, outlines current advancements in Microservice-enabled IoT and wearable technologies, with a specific emphasis on their assistance for the elderly.

Table 1: A Survey Research Overview on Microservices-Enhanced IoT Systems from 2017 to 2022.

.No.	'ear	'itle	₹emarks
	018	'Actual Use of Architectural Patterns in Microservices-Based Open-Source Projects' [5]	'This article makes numerous important contributions. For starters, it offers a comprehensive catalog of microservices architectural patterns drawn from academic and industrial literature. Second, it defines a clear link between Quality Attributes (QAs) and these architectural principles for microservices. The article also includes a thorough list of technologies used as frameworks in the creation of microservices-based systems that utilize these architectural principles. Finally, it provides a detailed comparison between Service-Oriented Architecture (SOA) and microservices architectural patterns' [5]
	019	'Open Issues in Scheduling Microservices in the Cloud' [6]	A discussion about microservice serving as the IoT application cloud's catalyst is done. they mentioned IoT applications decompose into several microservices, which are then deployed across actual hardware resources in the cloud and at the network's edge.[6]
	019	'A Microservice-Based Framework for Developing Internet of Things and People Application' [7]	The study provides a thorough assessment of existing research on IoT designs. The emphasis on attaining a high degree of Separation of Concern (SoC) is a major feature of the architectural approach it makes. This is performed by subdividing the application layer into sublayers or subsystems, each with its own set of responsibilities. Furthermore, within the context of the previously indicated concept, the study investigates the implementation of a microservice architecture in combination with serverless elements. It then describes how this architectural notion was realized in an IoT system prototype built for the healthcare sector. [7].
	019	'Microservices and Its Applications: An Overview' [8]	'Reviews the literature and the survey conducted by researchers while taking into account various micro-service features' [8].
	020	'An IoT Platform Based on Microservices and	This paper proposes an IoT-agnostic architecture based on microservices architecture and serverless computing. It

	Serverless Paradigms for Smart Farming Purposes' [9]	discussed a framework known as "Senviro Connect" where a deployment of five IoT devices is used to improve wine output for smart farming [9].
020	'Microservices Architecture for IoT Applications in the Ocean' [10]	'Mentioned the critical challenges of IoT applications and data in the Ocean and also will keep an eye on how microservice architecture plays essential roles in IoT applications' [10].
020	'A Flexible IoT Stream Processing Architecture Based on Microservices' [11]	The researchers have discussed a proposal based on an IoT Platform called as Senseioty stage which is created by FlairBit, the same can be taken as an adaption to any other platforms that match similar technologies.[11]
020	'A Systematic Review on Software Architectures for IoT Systems and Future Direction to the Adoption of Microservices Architecture'[12]	'Provides a simplified understanding of architectural practices and principles to aid academics and practitioners in promoting information-sharing software architectural roles and duties for Internet of Things software' [12].
021	'Microservices in IoT Security: Current Solutions, Research Challenges, and Future Directions'[13]	Review about microservices-based security techniques for IoT applications. This study seeks to give practitioners insights into the ongoing issues in IoT security and to uncover untapped research routes in this domain that have potential. [13].

1. Contributions of this research

The work makes the following key research contributions:

- We pinpoint the current challenges and constraints experienced by the aging population.
- We look into the possibilities of Microservices-powered Internet of Things (IoT) technologies to solve these issues and improve the well-being of elderly citizens in their homes.
- We examine the challenges that need to be conquered for the usage of IoT healthcare applications in rural and urban areas of India.
- We scrutinize the obstacles that need to be surmounted for the full implementation of Microservices-enabled IoT healthcare applications, to streamline the lives of the elderly.

The layout of the paper can be described as, Section 3 discusses the independent living demands of India's senior population and provides an outline of conventional assistive technology used to help aging folks. Section 4 is devoted to describing several Microservice-enabled IoT solutions for the senior population needs that have been proposed in recent years. Moving on to Section 5, we identify upcoming issues that must be addressed to construct practical, intelligent, and trustworthy IoT solutions for geriatric healthcare utilizing the Microservice architecture. Section 6, we discuss some of the challenges that need to be highlighted w.r.t the implementation of Microservices-enabled IoT healthcare applications. Finally, in Section 7, we provide our last thoughts.

2. Challenges Faced by the Elderly Population in India

The world population is aging at an alarming rate. As a result of these developments, there is an urgent need to create integrated care methods that are centered on individuals, emphasizing the needs and preferences of older people. Simultaneously, it is critical to ensure access to a variety of age-friendly services that are intimately linked to families and communities. Public health policies should address the various health and functional conditions faced by older people, with the goal of increasing the proportion of those who have good aging trajectories. To achieve integration, macro-level elements such as law and financing must be addressed, as well as meso-level concerns such as developing age-friendly surroundings and micro-level therapeutic treatments [14].

Over the last five decades, India, the world's second-most populated country, has experienced a substantial demographic transition, with the population aged 60 and above nearly doubling. According to projections, the proportion of Indians aged 60 and above would climb from 7.5% in 2010 to 11.1% in 2025, representing significant absolute growth [Government of India, 2011; United Nations Department of Economic and Social Affairs (UNDESA), 2008]. According to UNDESA estimates, India had roughly 91.6 million senior people in 2010, with an annual increase of 2.5 million between 2005 and 2010. The geriatric population is expected to reach 158.7 million by 2025, outnumbering people under the age of 14 by 2050 (Raju, 2006). UNDESA (2008) [15]. The aged population in India is expected to grow at a decadal pace of 41%, with seniors accounting for more than 20% of the overall population by 2050. According to the UNFPA's 2023 India Ageing Report, the country's old population is predicted to outweigh those aged 0 to 15 by 2046 [16].

The global COVID-19 epidemic has highlighted the fragility of the world's ageing population. The ageing population in India is growing as a result of greater life expectancy and lower death rates. The elderly are more vulnerable owing to a variety of characteristics, including education, social position, gender, and living conditions. They are disproportionately impacted by noncommunicable illnesses such as cardiovascular disease, stroke, cancer, respiratory problems, and numerous impairments. Furthermore, the elderly frequently have difficulties with mobility, eyesight, hearing, mental health, and cognitive decline. Addressing the expanding senior population and the issues that come with it need a comprehensive plan. The study proposes combining disparate programs such as social security, pensions, food security, and health benefits. The authors emphasize the importance of a comprehensive approach to geriatric healthcare, arguing for a shift away from the existing fragmented system that concentrates on individual health conditions through disease-based programmers' plan also emphasizes the importance of primary care physicians gaining more geriatric health knowledge, training, and skill development. Recognizing the lack of geriatricians, the authors emphasize the significance of prioritizing geriatric training and research. The essay's holistic approach strives to better meet the ageing population's diverse health and social requirements [17].

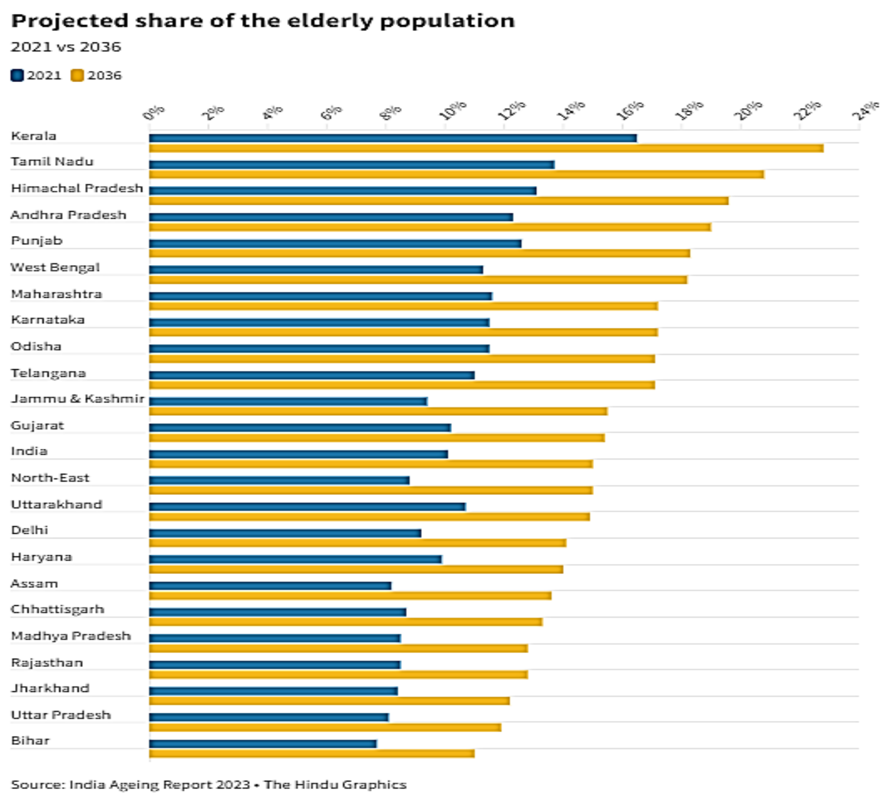

Figure 2. Projected share of the elderly population [16]

[18] The study emphasized five significant impairment problems based on the disability survey done in 2002 (NSS 58th Round, July-December, Report No. 485) as part of research on "morbidity and healthcare." These criteria are as follows:

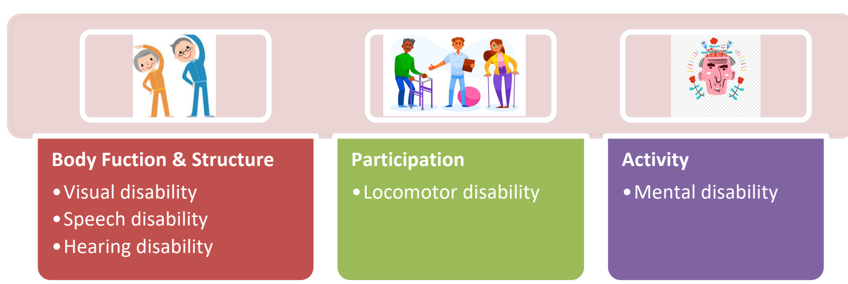

Figure 3. challenged faced by the elderly population

The NSSO's surveys have generally revealed the following four categories of impairments. However, the NSSO has recently added mental impairments, albeit this has not been included here due to comparability difficulties.

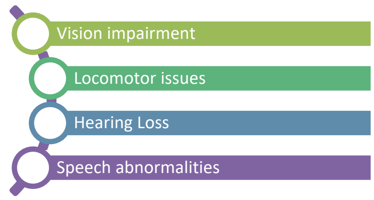

Figure 4. Categories of impairments

Estimates for each of the four impairments described above are reported in the table below for 1995-1996 and 2002.

	Visual	Hearing	Speech	Locomotor	Hearing & Speech
NSSO 52nd Round (1995-96)					
Male	24.38	13.32	3.14	10.08	
Female	28.44	15.07	3.69	11.06	
Persons	26.43	14.20	3.42	10.57	
NSSO 58th Round (2002)					
Male	18.70	1.51	0.23	3.10	0.14
Female	26.25	1.51	0.17	2.60	0.13
Persons	22.40	1.51	0.20	2.80	0.13

Source: NSSO 1998 and 2003.

Figure 5. Percentage of elderly reporting different types of disabilities, 1995-96 and 2002

The authors emphasized the need of health planners tailoring healthcare programs to address the unique requirements of older people, taking into consideration issues such as illiteracy and economic reliance [18]. They advocated establishing a healthcare initiative similar to the Rashtriya Swasthy Bima Yojana (RSBY) for National Old Age Pension Scheme recipients. They also recommended for the implementation of a 'old age health card' aimed at disadvantaged and neglected older people [18]. The authors also emphasized the paucity of data on the health state of elderly people, particularly those with impairments. This lack of knowledge stymies future study attempts [18]. Furthermore, the authors emphasized the need of health planners addressing the elderly's special healthcare demands, including long-term care and the funding of such services [18].

2.1. *Chronic diseases faced by the elderly in India*

Chronic illnesses are the leading causes of disability and early death among the elderly in India. Using data from the 75th round of the NSSO survey, this study studied the prevalence and determinants of chronic diseases in the population aged 60 and above in India. According to reports, around 21% of the elderly in India suffer from at least one chronic illness. Chronic illness affects 17% of the elderly in rural regions, but 29% of the elderly in metropolitan areas. Diabetes and hypertension account for approximately 68% of all chronic diseases. The largest frequency of chronic illnesses is seen in Kerala (54%), followed by Andhra Pradesh (43%), West Bengal (36%), and Goa (32%).

Higher educational attainment, urban residency, economic dependency, living alone or without a spouse and children, and affluent origins all associated with a higher probability of having chronic illnesses. When compared to their rural counterparts, urban inhabitants are 1.15 times more likely to suffer chronic illnesses. In rural places, older women outnumber males in terms of their chance of developing chronic diseases. Unmarried, widowed, or divorced elderly women in cities are significantly more vulnerable to chronic illnesses than married senior males. Disparities in education, social class, and caste all contribute considerably to these variances. Recognizing the considerable incidence of chronic diseases among various segments of the aged population is critical, identifying it as a serious public health concern [19].

2.2. Mobility Impairments

Physical mobility issues affect around 5% of the elderly in India. The country's ageing environment has become a gender-centric issue, not only because of the rising number of women reaching old age, but also because of their fragility and disadvantages across several dimensions. Women are frequently the primary carers for elderly and handicapped family members. With roughly four million people believed to be dealing with mental health concerns, India's old population is at a higher risk of different morbidities. Furthermore, around 12 million individuals in India are classified as "handicapped," yet there is a scarcity of knowledge about the issues that these demographic faces as they age. Despite the recent establishment of the National Policy on Elderly Persons, which aims to improve the quality of life for millions of elderly Indians, the issues faced by elderly people with disabilities, as well as those who become disabled later in life, continue to be addressed separately in policy and practice [20].

2.3. Complications with Cognitive Function and Mental Health in the Elderly

Cognitive function and mental health complications in the elderly are a developing problem in India. Higher systolic blood pressure (SBP) and lower diastolic blood pressure (DBP) have been linked to worse cognitive performance in older persons in India [21]. Elderly women, in particular, experience more health issues and are more prone to suffer from chronic illnesses, which can cause physical and emotional difficulties [22]. Mental illnesses are estimated to affect roughly 15% of the elderly in India [23]. Furthermore, cognitive impairment is substantially higher in rural old people than in urban senior people, with females experiencing more difficulties with cognitive function [24]. The lack of a comprehensive healthcare delivery system, as well as socio-cultural changes, further erode older Indians' quality of life, leading to physical morbidity, psychological discomfort, and mental health disorders [25].

According to the authors of [26], 7.14% of older men and 20.03% of older women had cognitive impairment. Cognitive impairment was more likely in illiterate older men and women, as well as older men and women in the lowest wealth quintile. Surprisingly, older women with no present or recent employment experience have lower risks of cognitive impairment than their labor-force counterparts. While non-working older males have a greater risk of cognitive deterioration, this link is not statistically significant. The probabilities of cognitive impairment in older males with one, two, or three risk factors were 5.34, 7.14, and 13.05 times greater, respectively than in those with no risk exposure. A similar tendency was reported for women, albeit with lower chances.

2.4. Sensory Perception and Communication/Vocalization Problems in India's Elderly

Sensory perception and communication/vocalization issues are common among India's elderly. The rise in dual sensory impairment (hearing and vision) among the elderly is cause for worry, with a prevalence ranging from 17.7% to 32.6% depending on the method utilized [27]. This disability presents unique rehabilitation issues and necessitates a collaborative approach at the primary healthcare level for diagnosis and rehabilitation [28]. Furthermore, in India, the changing lifestyle and move from joint to nuclear families has resulted in older people experiencing challenges inside their families, including loss of social life and social security [29]. The perceptions of older people towards their family members are being researched, notably in Haryana [30]. Overall, India's aged population requires special care and attention and changing socioeconomic dynamics demand addressing the issues they confront [31].

According to research, vision and hearing loss in elderly people may be risk factors for the development of depressive symptoms. However, there has been little study on the relationship between dual sensory loss (DSL), which includes both visual and hearing impairment, and depressive symptoms. The purpose of this study is to look at the link between DSL and depression symptoms in people aged 45 in India. Using data from the first nationally representative population survey, which was performed between 2017 and 2019, the researchers used Poisson models to examine the relationship between self-reported visual and hearing loss and depressive symptoms. Age, gender, education, economic position, marital status, urbanicity, area of residence, diabetes, heart disease, hypertension, stroke, and smoking were all considered in the study.

According to the findings, both vision and hearing loss were linked to a higher prevalence of depression sym ptoms. Notably, DSL was associated with a 46% greater probability of developing depressive symptoms. These data show that decreased vision and/orhearing loss may be risk factors for depressive symptoms in old er Indians, emphasizing the need for more investigation into this association [32]. Even in good health, a considerable proportion of older people report changes in their voice that might impede effective communication. Although vocal alterations are prevalent in the elderly, many do not seek diagnosis or treatment for perceived vocal problems. These vocal abnormalities have a significant influence on social relationships, as they can hinder communication and general quality of life in older persons [33].
The authors of [34] examined the audiological findings of 151 geriatric patients with hearing loss who had complained of a gradual loss of hearing during the previous ten years. The degree of hearing loss (52% of the time) corresponds to moderately severe sensory-neural hearing loss. The most often related disorders were cardiovascular diseases, such as high blood pressure (42%), and diabetes (17%). 34% said there were no known causes of their hearing loss. The most prevalent symptoms were difficulty comprehending conversational speech (54%), tinnitus (49%), vertigo (25%), and sensitivity to loud noises (15%). The most common audiogram shape (45%) is related to a steeply sloping pattern. Males showed a steeply sloping high-frequency hearing loss (52%), whereas females (60%) had a flat or gradually sloping audiogram (10%). A dismal 14% follow-up rate was observed, with most persons reporting inadequate benefit from hearing aids, particularly in loud circumstances. The causes of hearing loss seen in these people are among the well-known causes of old age hearing loss. Hearing loss is tolerated by the Indian populace until it interferes with daily conversation.

2.5. Pathogens and Emerging Infectious Diseases
Emerging infectious illnesses and pathogens in the elderly are a major issue. Because of age-related variables that influence their immune system, older persons are more prone to infectious infections [35]. The advent of novel viral illnesses, such as COVID-19 caused by SARS-CoV-2, has emphasized the age-dependent weakened physiological response to stress and decreased immunity in older individuals [36] [35]. In elderly people, especially those with underlying chronic illnesses and impaired immune systems, these diseases can cause severe consequences and increased morbidity and death [37][38]. Because of vague presentations and age-related variables, infections in the elderly might be difficult to diagnose. It is critical to thoroughly analyze clinical symptoms, patient history, and risk factors to ensure that suitable antimicrobials are administered on time while avoiding needless antibiotics.
Antibiotic abuse and misuse are important causes of adverse medication events and future infections, such as those caused by Clostridium difficile and antibiotic-resistant bacteria, in long-term care facilities (LTCFs). Antibiotic stewardship programs (ASPs) are being established in healthcare settings, including long-term care facilities (LTCFs), to track patterns of antibiotic usage and outcomes and to improve prescribing practices. This study focuses on the difficulties of identifying, treating, and preventing infectious illnesses among older persons living in long-term care facilities (LTCFs), with a specific emphasis on antibiotic stewardship. The

authors examine the clinical significance, presentation, diagnosis, medication, and prevention of a variety of infectious disorders, such as skin and soft tissue infections, infectious diarrhea, bacterial pneumonia, and urinary tract infections [39].

2.6. *Elderly Safety, Wellness, and Entertainment in India*

Safety, wellness, and amusement are all essential considerations for India's older population. In India, the elderly confront issues such as loneliness, desertion, and a lack of personal family care, all of which might jeopardize their safety and well-being [40]. To address these concerns, projects have been launched to create home-based monitoring systems that give constant monitoring and support to the elderly, including tracking their mobility and detecting falls [41]. Furthermore, trustworthy and valid tools to assess the wellness of the senior population are needed, such as the Perceived Wellness Survey (PWS), which has been shown to be useful in measuring health in community-based older adults [42]. The increased number of seniors living alone has resulted in the growth of the Geriatric Care Industry in India, with government and private sector providers making efforts to safeguard the well-being of the aged [43]. Overall, addressing the elderly's safety, well-being, and entertainment requirements in India necessitates a holistic approach that involves monitoring systems, evaluation tools, and support from both the government and the private sector [44].

Population aging is a global problem since the number of older people is quickly growing, with India classified as a "aging nation" with 8.6% of the aging population (aged 60 and over) according to the 2011 Census. Due to diminishing physical and mental health in old age, older adults are vulnerable to a variety of physical and psychological morbidities. The senior population in India has a variety of issues, ranging from inadequate social security coverage to rising healthcare costs. In India, there is an insufficient number of geriatric health clinics and carers to care for the elderly [45].

The aging population is a key feature of the twenty-first century, with increased life expectancy due to advances in healthcare. physical functions decline with age, resulting in changes in physical structure and an increase in fat. Physical inactivity among India's elderly has a negative influence on their health. The study's goal is to provide a design-based solution to encourage regular physical activity among the elderly for good aging. Personal and telephone interviews were used to obtain data from 29 old people living in seven different places across India. Participants reported lower physical activity levels due to a lack of motivation, loneliness, and social isolation. Using a user-centered design approach and the Octalysis framework, an exergaming solution was created [46].

2.7. *Microservice enabled IoT Systems Enabling Independence in Elderly and Disabled Populations*

Statistics reported in the preceding sections show that as the world population ages, the elderly confront significant health issues, resulting in a reduction in both their physical well-being and independence. This scenario presents mental and physical obstacles in many aspects of modern life. Looking ahead, the demographic changes will not only impact the availability of a younger workforce in the professional healthcare sector but also affect the pool of potential caregivers. Without technological interventions, healthcare costs may surge due to an increasing number of elderly and disabled individuals requiring services, compounded by a shortage of healthcare professionals, inadequate infrastructure, and limited-service accessibility.

The incorporation of microservices is a substantial improvement for the present and future development of the RO-Smart Ageing system, giving scalability and flexibility benefits. Microservices enable reuse across multiple healthcare domains while also maintaining dependability by implementing fault tolerance and allowing the system to continue operating even if one service fails. These characteristics are critical for a

Remote Health Monitoring System (RHMS), especially in cases involving trigger alerts or continuous geriatric monitoring. Furthermore, the system can adjust not only to an older person's unique health issues, but also to the developing nature of age-related illnesses. The Edge/Fog layer handles functions like scheduling, storing, and monitoring data from IoT devices and wearables, lowering the computational load on the Cloud Layer. The Cloud Layer is the most efficient for jobs needing extensive processing and storage capabilities, such as in-depth analytics. The RO-Smart Ageing system's six-layer design permits the integration of multiple technologies to construct both the smart environment and microservices with specialized functionality. Fault isolation, fine-grained access control to improve healthcare data security, and loosely linked components all contribute to the system's agility [47].

3. Microservices-based IoT products for the elderly

Microservices-based Internet of Things (IoT) solutions are a breakthrough way to leverage the potential of the IoT by combining the agility of microservices architecture with the complicated demands of IoT ecosystems. The design of these novel systems divides IoT features into independent, self-contained services, each with a defined role. This modularity provides exceptional flexibility and scalability, enabling seamless adaptability to the dynamic nature of IoT contexts. Microservices provide a bridge for interoperability, allowing disparate devices operating on different protocols to interact in unison. This strategy optimizes resource utilization, which is especially important in IoT, where devices frequently have limited processing capabilities. Furthermore, microservices-based IoT devices excel in real-time data processing, allowing for quick decision-making, and they enable continuous integration, allowing for rapid modifications. With specialized microservices for analytics and machine learning, these products also unlock the potential for data-driven insights, predictive maintenance, and advanced functionalities. In essence, these systems are versatile, secure, and efficient, poised to revolutionize industries ranging from healthcare to manufacturing, heralding a new era of IoT innovation.

The healthcare domain utilizes a wide range of devices to diagnose, treat, monitor, and manage various medical conditions. These devices play a crucial role in improving patient care and outcomes. Here are some types of devices commonly used in the healthcare domain:

Table 2: Types of devices commonly used in the Healthcare

Type of device	Device Details
Diagnostic Devices	X-ray machines: Used for imaging bones and tissues.
	Ultrasound machines: Utilized for imaging soft tissues and monitoring fetal development.
	MRI (Magnetic Resonance Imaging): Provides detailed images of internal structures.
	CT (Computed Tomography) scanners: Combines X-rays with computer technology for cross-sectional images.
	Blood glucose meters: Measure blood sugar levels for diabetes management.
	Blood pressure monitors: Used to measure blood pressure.
Therapeutic Devices	Ventilators: Assist patients with breathing difficulties.
	Defibrillators: Used to restore normal heart rhythms during cardiac emergencies.
	Infusion pumps: Deliver controlled doses of medication or fluids.

	Pacemakers: Regulate and normalize heart rhythms.
	Dialysis machines: Filter and clean blood for patients with kidney disease.
	Radiation therapy machines: Used in cancer treatment
Monitoring Devices	EKG/ECG (Electrocardiogram) monitors: Record electrical activity of the heart.
	Holter monitors: Continuously monitor heart activity over an extended period.
	Pulse oximeters: Measure oxygen saturation in the blood.
	Continuous glucose monitors (CGMs): Track glucose levels in real-time.
	Blood pressure cuffs: Monitor blood pressure over time.
Surgical Instruments	Scalpels, forceps, and surgical scissors: Used in various surgical procedures.
	Laparoscopes: Enable minimally invasive surgeries.
	Robot-assisted surgical systems: Aid surgeons in performing precise procedures.
Wearable Health Devices	Smartwatches and fitness trackers: Monitor activity, heart rate, and sleep patterns.
	Wearable ECG monitors: Record heart activity continuously.
	Smart clothing: Measure various health parameters like posture, muscle activity, and temperature.
Assistive Devices	Hearing aids: Improve hearing for individuals with hearing loss.
	Wheelchairs and mobility aids: Assist people with mobility impairments.
	Prosthetic limbs: Replace missing or amputated body parts.
	Communication devices: Help individuals with speech or communication difficulties.
Telehealth Devices	Videoconferencing equipment: Used for remote medical consultations.
	Telemedicine carts: Equipped with cameras and medical peripherals for remote examinations.
Laboratory Equipment	Microscopes: Used for examining tissues and pathogens
	Centrifuges: Separate substances in blood and other bodily fluids.
	Analyzers (e.g., blood analyzers, chemistry analyzers): Perform various diagnostic tests.
Implantable Devices	Pacemakers and implantable cardioverter-defibrillators (ICDs): Monitor and regulate heart rhythms.
	Neurostimulators: Manage chronic pain and neurological disorders.
Home-Health Monitoring Devices	Home blood pressure monitors: Allow patients to track their blood pressure at home.
	Digital thermometers: Measure body temperature.
	Home pregnancy tests: Detect pregnancy at home.

The following general architecture of microservice-based IoT systems in Fig. 3 can be observed which comprises three layers: Edge, Fog, and Cloud. The Edge layer represents IoT devices, while the Fog layer handles device-level adaptations and lightweight data processing. The Cloud layer is responsible for heavyweight computations and consists of microservice, management, adaptation, and application infrastructure layers.
In the Edge and Fog layers, IoT devices, such as sensors, send data to the Fog layer and periodically transmit QoS data like battery level and memory consumption. The Fog Layer performs lightweight computations and architectural adaptations based on QoS data, leveraging machine learning models. It communicates with the Cloud Layer through a Message Broker.

The Cloud Layer consists of multiple layers. The Microservice Layer manages microservices and monitors QoS parameters. The Management Infrastructure Layer handles service discovery, management, and architectural adaptations. The Adaptation Infrastructure Layer collects data and employs machine learning models to predict QoS for IoT devices and microservices. The Context Analyzer identifies adaptation needs, and the Decision Maker selects the best adaptation technique. The Application Infrastructure Layer executes application-level adaptations based on user goals, using microservice compositions. This architecture leverages various technologies like Apache Kafka, Istio, Kubernetes, Docker, Apache Zookeeper, Elasticsearch, Grafana, and Keras with Python for machine learning models.

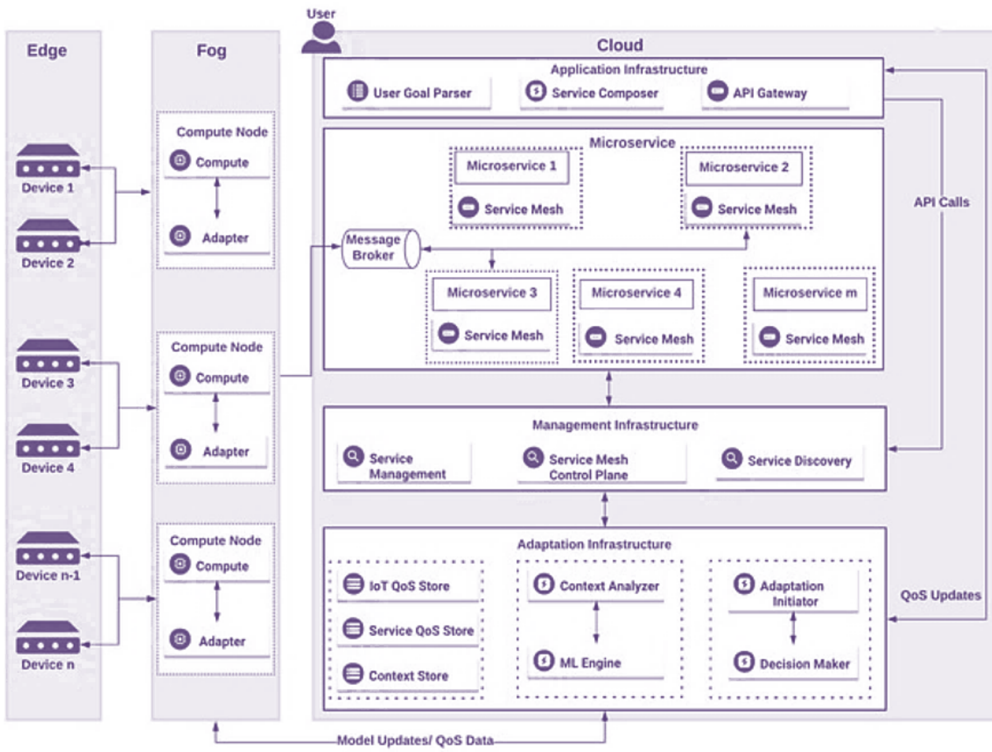

Figure. 6. Adaptable Plan Design for IoT Systems Considering Microservices [48].

In This section, for elderly People various IoT Systems can be included, that can smartphones with apps or other wearables like smartwatches and other gadgets, as they do the data collection for processing automatically with some manual intervention. On the other hand, Elderly citizens can also use them for any medical facilities or contact a caregiver/healthcare professional. Some Monitoring apps collect data using information from the smartphone like tracking depression. But in both cases, they have to be connected to the Internet (either continually or event-based/delay-tolerant). While some scholars may disagree that some mobile applications are part of IoT, it is worth noting that in the International Telecommunication Union's 2005 study, the definition and number of IoT devices presented (as of 2005) in this report listed smartphones as IoT devices [49].

In India, the registration, regulation, and quality control of medical equipment, pharmaceuticals, and cosmetics is done by the Central Drugs Standard Control Organization (CDSCO) a regulatory entity in charge of medical devices and pharmaceuticals. It is managed by the Directorate General of Health Services of the Government of India's Ministry of Health and Family Welfare. To conduct regulatory tasks and maintain compliance, CDSCO has a headquarters in New Delhi and various zonal offices, sub-zonal offices, port offices, and laboratories around India. Medical devices that are used for in vitro diagnostics, surgical supplies (such as dressings, bandages, staples, sutures, and ligatures), and blood and blood component collection bags with or without anticoagulants are among the notified medical devices. Substances such as mechanical contraceptives (such as condoms and intrauterine devices), disinfectants, and pesticides are also regulated [51].

Several techniques and applications have been designed to assure compliance with the regulatory framework for medical devices. These include obtaining a Certificate of Registration for Notified Bodies to audit Class A and Class B medical devices, acquiring medical device import licenses, acquiring licenses or loan licenses for manufacturing Class C or Class D devices for sale or distribution, and receiving test licenses for manufacturing and importing medical devices for clinical investigations and evaluation. Permissions are also required for government hospitals or medical institutions to import investigational medical devices, conduct clinical investigations for investigational medical devices, evaluate the clinical performance of new in vitro diagnostic medical devices, and manufacture or import medical devices without a predicate device. Other activities include the registration of medical device testing laboratories, the development of guidance and FAQs on key regulatory processes, the processing of applications for the issuance of Free Sale Certificates and Market Standing Certificates, and the resolution of complaints and issues relating to substandard quality medical devices. Managing post-approval changes for medical devices, forming expert committees in the field of medical devices, inspecting manufacturing sites for quality compliance, capacity-building initiatives for technical management, responding to parliamentary questions, requests for information (RTIs), clarifications, NOCs (No Objection Certificates), and port office queries, and providing clarifications to applicants on the regulatory status of their products are integral components of the regulatory system for medical devices in India [49][50][51].

3.1. *Microservices-Driven IoT Solutions for Managing Chronic Health Conditions*

Microservice-based Chronic illness IoT models provide a modern and efficient strategy for managing and monitoring long-term health issues. Chronic illnesses need ongoing monitoring and personalized care, and IoT technologies paired with microservices architecture may deliver scalable, adaptable, and reliable solutions.

3.1.1. *microservices-based IoT solutions for monitoring high cholesterol levels*

Digital Twin (DT) technology in the healthcare arena, especially on heart health. authors presented the Heart DT, a system that has physical sensors that can collect and analyze data. This Heart DT, which is deployed as microservices in a Kubernetes environment, analyses real-time data from smartwatches, demonstrating excellent classification accuracy for ECG signals associated with heart diseases. The second component of the paper presents a higher-level framework for managing complicated illnesses employing distributed DTs. They propose the notion of pathological DTs, which indicate the unique illnesses of a patient. While there are certain limitations, such as the PDMP platform's idealization and the need to enlarge the dataset, future work hopes to expand the platform to cover more organs, illnesses, and conditions [53].

3.1.2. *Internet of Things (IoT) solutions empowered by microservices for the monitoring of elevated blood pressure*

Hypertension, defined as a blood pressure of more than 130/90, is a serious health problem. The primary focus of IoT solutions for hypertension treatment is on monitoring and identifying the disease. Non-invasive methods restrict the brachial artery momentarily with an inflated cuff on the left arm, gradually releasing pressure in a regulated manner. These devices display blood pressure values when connected to a sphygmomanometer. Traditional manual blood pressure testing methods include a skilled individual listening for certain Korotkow sounds using a stethoscope. In manual IoT systems, either the user or a third party must measure and enter data into a smartphone application [54].

Coming to Microservices, in [55] the author proposed an architectural design that includes a patient, a physician, identity and notification services, and an SDI proxy. Each of these components has its database, connects to the central Kafka cluster, and runs in its own Docker container. In Another paper [56], the author describes the design and development of a health data platform designed for home-based senior care, utilizing AAL (Ambient Assisted Living) technology. It describes the platform's technical framework and key features, with the goal of improving the quality of home-based elderly care using AAL technology, addressing the complexities posed by an aging society, and ultimately improving the well-being of elderly people receiving care at home.

On the other hand, there are some IoT models that are discussed in [57][58][59] where they have proposed Digital sphygmomanometers, which involve inflating and deflating a cuff in a regulated manner. Blood pressure is measured in these devices by monitoring deformable membranes or utilizing piezo resistance technology built into the device. The device's microcontroller then processes the changes in capacitance or resistance during cuff deflation to determine blood pressure. Notably, this strategy removes the requirement for external measuring staff. While the majority of automatic digital sphygmomanometers use cuff-based oscillometric measurement, there are creative alternatives such as Photoplethysmography (PPG) sensors that may be placed on various body areas such as the finger, wrist, forehead, or toe. Furthermore, as proposed by Chandrasekhar et al., the use of an iPhone's screen pressure sensor and Charged-Coupled Device (CCD) camera sensor to detect blood pressure is a new innovation. These innovative techniques have the benefit of not requiring external blood pressure monitors.

3.1.3. Heart Disease Monitoring and Management Enhanced with IoT-Enabled Microservices

Microservice-enabled IoT devices for monitoring and managing cardiac disease provide a cutting-edge approach to healthcare. These devices use microservices architecture to build a highly adaptable and modular system capable of monitoring and treating cardiac problems in real-time. They capture and interpret crucial data, such as heart rate and ECG measures, by seamlessly integrating into the Internet of Things, providing a dynamic and personalized approach to patient care. The real-time analytics and decision-making capabilities of this technology, together with robust alerting systems in crises, give essential information to patients and healthcare professionals, supporting early intervention and successful management of cardiac problems. Some of the papers are mentioned below for reference that proposed IoT Systems based on Microservices.

Table 3: A Research Overview of IoT Systems based on Microservices

IoT system	***Implementation Details***
'A Framework for Real-time Remote ECG Monitoring and Diagnoses' [59]	In this paper, an elaborate Remote Patient Monitoring (RPM) platform designed for real-time telehealth operations in this research. Scalable data monitoring, real-time data analysis and decision-making, thorough data accessibility, and robust emergency notifications for urgent health conditions are all part of the system. Their key focus is on establishing the overarching framework architecture, allowing technology integration, different system-level integrations, and viable deployment options. They also provided a practical use case demonstrating the utilization of real-time electrocardiogram (ECG) monitoring for patients with chronic cardiac problems.
'Intelligent Sleep Monitoring System Based on Microservices and Event-Driven Architecture'[60]	The article describes a contactless or wearable sleep monitoring system, an event-driven and microservice architecture, and an Internet-of-Things (IoT) platform. The system uses electrocardiogram (ECG) data, which is processed using the weighted extreme learning machine (WELM) algorithm, particle swarm optimization's (PSO), and fuzzy logic, to accurately quantify sleep quality and identify sleep phases
'Lightweight and Context-aware Modeling of Microservice-based Internet of Things' [61]	This work provides a number of important contributions. To begin, it presents a context classification schema that divides context information into four separate groups based on the source of the context data and its link to the connected devices. Second, it introduces a context-aware service description technique based on microservice architecture, providing a simplified and complete service description framework for delineating IoT context, service, and interface properties. Finally, the paper demonstrates the approach's practicality and efficacy through a case study using a smart senior care system, emphasizing its real-world relevance and beneficial effects.

3.1.4. IoT-Infused Microservices for Diabetes Management"

Researchers presented a device based on IoT for monitoring blood glucose in [62]. It uses a Raspberry Pi Zero (RPi) camera to record photos of the user's fingertip, which are then analyzed by a neural network built using TensorFlow libraries within a Flask microservice to perform non-invasive monitoring. The estimated glucose readings that arise may be accessed by a variety of end devices, including smartphones, increasing its adaptability for a wide range of monitoring and other applications.

The authors of [63] described an architecture for monitoring the health of elderly patients in a closedloop IoT healthcare setting using an intelligent job mapping method.This technology uses data from biological sensor s to detect emerging health risks and swiftly alert the appropriate authorities.This is accomplished through th e use of a combination of thresholdbased and machine learning algorithms that detect and report irregularitie s for faster and more proactive reactions.In addition, the scientists developed a criteria for detecting anomalie s in blood glucose level data.Type 2 diabetes is a chronic illness characterised by increased insulin resistance that most commonly affects middleaged and older people, although it can also occur in obese children and te ens. Type 1 diabetes, on the other hand, is a chronic disease caused by insulin insufficiency that is predominantly caused by inherited causes and may be altered by specific viral factors. Symptoms of type 1 diabetes most commonly emerge during infancy or adolescence, although they can also appear in adults. Unfortunately, there is no known cure for Type 1 diabetes, and therapy focuses mostly on controlling blood glucose levels with insulin, dietary changes, and lifestyle changes.

3.1.5. Cancer Care and Monitoring with IoT-Powered Microservices

Cancer is often identified after an examination of the patient's clinical history, medical indicators, and reported symptoms. The doctor will next suggest specific diagnostic procedures, such as radiological imaging and other criteria, to confirm the diagnosis.In the recommended microservice design for survival analysis, the physician uploads diagnostic data, which includes clinical information and CT/PET imaging scans, over the API Gateway. This API Gateway acts as a reverse proxy, accepting all application programming interface (API) requests, consolidating the services required to satisfy them, and then returning the applicable results to the physician [64].

In [65], a web-based system, a microservices cloud with a programming interface and a database built with NodeJS and MongoDB which were packaged and deployed using Docker and Docker Compose. The process begins with the data consolidation into the cancer population registry database and followed by cross-validation using ASEDAT software. The specialists will then interfere to verify correctness. Following that, A R Shiny framework which performs data visualization and report production to help in decision-making. Currently, the analytics are based on demographic factors such as age, gender, and cancer type. Additionally, it can also generate geographical heat maps illustrating cancer incidence at the regional level, line plots for visualizing temporal trends, and standard risk factor plots.

3.1.6. IoT Emphasizing for Steady Kidney Infection Through Microservices

Chronic kidney disease (CKD) therapy is currently benefiting from Microservice architecture combined with IoT. This design allows for the adoption of many IoT-enabled devices while also providing scalability and improved interoperability [66]. This architecture is built on a layered framework and uses a device template method to enable adaptive integration of microservices with IoT devices [67]. In addition, a service aggregation technique has been incorporated to reduce latency and encourage microservice reuse [68]. Performance is improved by moving data processing closer to the source by utilizing microservices within the Fog/Edge computing layer [69]. This architectural framework not only enables continuous monitoring of patients' health via various IoT devices, but it also provides carers with remote access to patient data [70]. Tele nephrology made possible by telecommunications technology, holds significant potential to improve CKD outcomes, especially in low to middle-income countries.

3.1.7. IoT-powered microservices to treat depression and mental health

Globally, depression (DD) is a common health problem. The World Health Organization projects that by 2020, depression will account for the largest portion of healthcare spending for both the public and private sectors. Reducing the length of depression is an important objective for mental health professionals, and using Cognitive Behavioral Therapy (CBT) is one way to do this [71]. In [70], researchers proposed a WoO (World of Opportunities)-based IoT platform that uses a Microservices Model that includes support for depressive disorders. A Real-World Knowledge (RWK) model is also included, which captures user situations and emotions. The authors presented an IoT Cognitive Behavioral Therapy (CBT) system that is powered by the Web of Objects (WoO) in an effort to reduce costs and save time. The main objectives of this system are to gather, represent, and help people who are experiencing depression. Additionally, semantically interoperable microservices were used to track the symptoms of depression in an IoT environment [72].

3.1.8. IoT-enabled microservices for dementia or Alzheimer's care

A set of robotic behaviors intended for monitoring and interacting with elderly Alzheimer's patients are presented in this study. These behaviors are based on microservices running on a local server and are meant to be used with an inexpensive robotic device. Microservices are independent, self-contained parts that divide the operations needed to accomplish particular robot behaviors. These actions include monitoring, interacting, and navigating. Event-based communication amongst system components manages patient requests and signals, improving the dependability of service composition. The system is currently being used in a private home where an elderly couple resides [73].

In [74], Researchers proposed Sammen Om Demens (SOD), a mobile application designed to assist individuals with dementia who may wander and become lost. This application engages caregivers, family members, and volunteers from the community in real-time location tracking of dementia patients. The system transfers location data frequently from the patient's smartphone to a backend system, where it undergoes intensive data processing using artificial intelligence techniques to detect unusual behavior. To meet the demanding performance and architectural requirements, the backend employs microservices and serverless services for efficiency and scalability. The study demonstrates the effectiveness of this approach by deploying the SOD backend on a public cloud and subjecting it to simulated load tests.

In [75], "Together about Dementia," a mobile health app designed to help people with dementia who get lost or confused. The app detects these kinds of circumstances and sends out an alert, inviting volunteers and family members to assist. A backend system using serverless and microservices architecture makes this feasible. The app that is installed on the user's portable device collects location data, and the backend uses artificial intelligence techniques to identify anomalies in that data.

3.2. IoT solutions powered by microservices for those with mobility issues

Age-related changes in mobility can impair an individual's mobility, potentially leading to movement issues such as falling or difficulties sitting and standing. Muscle weakness, joint difficulties, pain, diseases, and neurological abnormalities (affecting the brain and nerve system) are common ailments that can limit movement in the elderly. When many mild disorders coexist, they might considerably impede movement. In 2011, India had 5,376,205 impaired old persons, resulting in a disability rate of 5178 per 100,000 elderly people. Movement and visual impairments accounted for 25% of all disabilities, while hearing impairments accounted for 19%. Seventeen Indian states and union territories have disability rates that were higher than the national average. Disability rates rose as people aged, reaching at 8409 per 100,000 for those aged 80 and more. Males had greater rates of disability than females (5314 vs. 5045 per 100,000), and there was a significant difference between rural and urban regions (5593 vs. 4181 per 100,000). Disability rates were lower in the working and married populations during the period [76].

Ambient Assisted Living (AAL) is an environment designed to support independent living for senior citizens residing in smart homes. A middleware that unifies different technologies to create the intelligent living environment forms the foundation of the system. The fundamental strength of the system is its modular architecture, which is based on microservices and assigns distinct functionalities to individual code bundles. Because of its design, it is possible to replace outdated features and add new ones without causing any problems or needing to make significant changes. Additionally, the benefits of insulation and resilience provided by the microservice architecture allow new components to be developed without affecting existing applications in the event of a component failure, update requirement, or obsolescence, guaranteeing uninterrupted operation [77].

Researchers in a cited study [78] presented a system with a microservices architecture that collects sensory data while older adults perform Basic Activities of Daily Living (BADLs) and Instrumental Activities of Daily Living (IADLs). Intellectual, administrative and social components are included in IADLs. An assessment of frailty status was achieved using a machine learning model that utilized this sensory data; The model outperformed previous approaches that exclusively used BADLs. Healthcare professionals may find this model useful to automatically detect frailty as it is highly accurate, adaptive, environmentally friendly and non-intrusive.

This paper [79] introduces the health Guardian platform, a project created by IBM's Digital Health team with the goal of swiftly converting AI research into cloud-based microservices. This platform has the ability to collect health-related data from numerous mobile and wearable digital devices. As a result of its adaptable architecture, which supports microservices that can handle a variety of data types, including text, audio, and video, comprehensive health assessments are made possible by recording voice, facial, and motion data. three particular microservices were focused, each tailored to different input data types, such as wearable-based for functional mobility assessment, video-based for assessing mobility, and text-based for assessing depression. The Clinical Task Manager (CTM) is also covered as a tool for establishing clinical studies. The health Guardian platform is actively being used in cooperation with research partners to accelerate digital health applications and streamline the development of AI models.

The RO-Smart Aging system is discussed in [80] which was created as a component of the Romanian research project "Non-invasive monitoring and assessment of the health of older people in a smart environment. The Mild Cognitive Impairment (MCI) patients who will be monitored by this system will have their health evaluated, predicted, and tracked remotely. It combines non-intrusive IoT devices for tracking health-related metrics, motion sensors for gathering health and lifestyle information, and a cloud platform for data storage, advanced analysis, and AI-based disease prediction.

3.3. *IoT solutions with microservices for infectious diseases*

In India, the elderly population is growing, posing significant problems for the country's healthcare system. On the one hand, the prevalence of NCDs among the elderly in India is rising; on the other hand, the elderly in India are also concerned about CDs. Although preventing the spread of communicable diseases (CDs) remained a top priority, non-communicable diseases (NCDs) are unavoidably straining the health and social security systems [81].

a microservices-based architecture was developed and put into use for telemonitoring and clinical diagnosis of infectious diseases in elderly patients. Every day, nurses use biosensor kits to collect vital signs, which are then continuously updated in a cloud-hosted medical database. This system supports high-performance applications, in particular for the pre-diagnosis of infectious diseases in the elderly, by using a flexible microservices architecture that integrates edge and cloud computing paradigms. This e-health system's viability and innovation are shown by the analysis of the usability of the equipment, architectural performance, and service concept. It is also budget-friendly and geared toward helping those living in underprivileged areas [82].

In this study [83], a useful tool for predicting the onset of infectious diseases is introduced for use by nursing home medical staff. Acute respiratory, urinary tract, and skin and soft tissue infections are the three types that are specifically discussed. The project involved creating a unique biosensor system that tracked residents' daily vital signs and sent the information to a cloud-based database using a trial-and-error data collection method. Classifiers were used to find patterns in the spatial domain processing of the data that was gathered. Because they can change in response to pathophysiological adaptations brought on by infectious diseases, vital signs were chosen as a measure of health. These modifications could impact body temperature, electrodermal activity, oxygen saturation, heart rate, and blood pressure as a result of things like infection-related inflammation, stress-induced sympathetic nervous system activation, and changes in the functions of the nuclei that control heart and lung activity.

3.4. *Microservice-based Internet of Things home safety solutions*

Smart home security makes use of an assortment of Internet of Things (IoT) enabled products to enable users to remotely monitor and control their home's security. In addition to controlling who has access to the doors if they have smart locks, these systems can control the surveillance both inside and outside the house. In addition to alerting homeowners to strange activity or unforeseen attempts to enter the house through the windows or doors, smart home security systems enable users to remotely monitor and manage their properties in real time. Even when disarmed, smart security systems continue to monitor and send alerts, in contrast to traditional home security systems. In addition to alerting users when someone is at the door, smart doorbells enable users to recognize and speak with strangers before opening the door. Another feature of smart home security systems is their ability to detect motion and provide remote access for smart security cameras. In this section, an overview of these smart home systems for human safety is provided.

[84] introduces a novel architecture for smart homes that is meant to be more scalable, dependable, and agnostic than current options. Machine learning applications written in different programming languages become more interoperable and reusable thanks to the use of microservices operating on a distributed cluster of five nodes. This architecture also replaces the central computing unit to reduce single points of failure and boost reliability, integrating seamlessly with the majority of smart home setups. Adding more hardware and software resources enables it to provide better scalability. The system's high availability and resilience were highlighted by experiments that showed it could continue to function even in the event of a complete node failure or a power surge.

In the context of Active Assisted Living (AAL), the concept of "SAVE – SAfety of elderly people and Vicinity Ensuring" is presented in [85]. This is an integrated system intended for home and personal security. The goal of SAVE is to keep seniors connected to their care takers and allow them to stay in their comfortable homes. Using a top-down Universal Modeling Language (UML) service orientation, the system enables a unified co-design of communication between humans and machines. With an integrated subscription mechanism for both people and devices, it boasts a multi-tier user structure along with a central-local distributed processing approach (Cloud-Edge). By taking usability and cognitive age-related factors into account, the SAVE demonstrator places a strong emphasis on end-user perspectives. Locator-Identity Separation Protocol (LISP) and other contemporary techniques are used by Location-Based Services (LBS) to manage data from Geographic Information Systems (GIS). With the help of actigraphy and eHealth services, this system combines "orientation" features like localization and real-time tracking with emergency notifications and well-being restoration. For flexible and programmable communication, a bottom-up strategy is also used, leveraging wearables, smartphones, smartwatches, and micro-services.

Secure authentication and authorization mechanisms are necessary for remote access in a Smart-Home architecture, regardless of whether it uses a trusted cloud to prevent unauthorized actions. In [86], a command authorization system based on a smartphone and a Secure Cloud platform comprise the proposed Smart-Home security framework [87]. The user can regulate the commands that the IoT device receives by using the smartphone authorization mechanism, and the Secure Cloud serves as a middleman between the IoT devices and a third-party cloud vendor [88].

4. The Difficulties of Using Microservice-Enabled IoT for the Elderly

An analysis of microservice-enabled IoT solutions meant to improve the quality of life for the aged and disabled, particularly those living independently without caretaker help, was undertaken at the start of the investigation. Over the last decade, research has improved the creation of microservice-enabled IoT systems in a variety of fields, including remote healthcare, home support, mental or physical handicap management, and assuring timely drug ingestion. Sensors, wearable devices, and voice instructions are used in these systems [89]. The integration of microservice-enabled IoT applications has the potential to considerably aid elders and disabled people in their everyday lives, potentially replacing human carers [90]. Despite their creativity, these models and prototypes have inherent flaws and obstacles that must be addressed before microservice-enabled IoT devices can really simplify the lives of the elderly or crippled, some of them are mentioned below:

- ***Interactive User Interface with Native/Regional Language options:***

The employment of interactive user interfaces with the English language offers several issues for India's elderly. The language barrier is a big barrier, since many older people may not be fluent in English and prefer to communicate in regional languages. Limited English proficiency among the elderly, particularly those with little formal schooling in the language, can make it difficult to understand menu selections, instructions, and navigate inside IoT device interfaces. This language difficulty is exacerbated by cognitive deficits typical in the elderly, such as memory problems and learning difficulties involved with adjusting to new activities. Furthermore, technical apprehension and a lack of localization choices impede the adoption of interactive interfaces.

Resistance to change, particularly in terms of technology and language preferences, may potentially stymie acceptance of English-centric interfaces, since senior people are frequently more at ease with conventional communication techniques in their original tongue. Designing inclusive interfaces in IoT Devices that cater to a wide range of language ability is a huge problem that necessitates cultural sensitivity and user-friendly techniques. Furthermore, the elderly's inadequate training and help to adjust to English-based interactive interfaces adds to the difficulty. To ensure the effective adoption of interactive technology by the elderly in India, a complete approach encompassing language variety, cognitive concerns, and culturally sensitive design is required.

- ***Withstanding to Power Outages while using the IoT Devices/Systems at Home/ Rural Areas***

Power outages have a substantial impact on IoT systems and devices, particularly those linked to healthcare and home care for the elderly. In the context of health monitoring and support, constant power is critical for the functioning of equipment like as wearables, remote health monitoring systems, and smart home technology designed for the elderly. Power outages can jeopardize important health monitoring operations, jeopardize real-time data collecting, and delay the prompt delivery of aid or alarms in the event of an emergency. Wearable health gadgets that check vital signs or provide medicine reminders, for example, may lose functioning during power outages, thus jeopardizing the well-being of older people who rely on this technology. Furthermore, in rural locations where power outages are more prevalent, the efficiency of IoT-based healthcare and aged support might be greatly impacted, restricting access to important services. To address this challenge, innovative power management solutions are required, such as the development of energy-efficient devices, alternative power sources, and reliable backup systems to ensure the continuous and reliable operation of IoT systems designed for elderly care and home assistance, even in the face of power disruptions.

- ***Maintenance and Support issues while using the IoT Systems for Long Time***.

When older people utilize IoT equipment at home for a lengthy period of time, especially in the context of healthcare, maintenance and support difficulties offer substantial hurdles. To guarantee optimal functioning, IoT devices may require frequent maintenance, upgrades, and troubleshooting over time. Navigating these maintenance activities might be difficult for the elderly, who may have little technological ability. Software upgrades, compatibility with newer technologies, and hardware problems may occur, requiring continuing maintenance.

Furthermore, because IoT devices in healthcare are frequently manufactured by different firms, providing interoperability and smooth integration is critical. The lack of standardized protocols may result in device compatibility concerns, compounding maintenance challenges. Long-term support is critical for addressing developing security risks, upgrading software to meet evolving healthcare standards, and ensuring that devices continue to perform as intended in terms of health monitoring and assistance.

Elderly people may have difficulty obtaining timely assistance for technical concerns, thus disrupting their healthcare regimens. Adequate training programs, user-friendly interfaces, and easily available support channels are required to provide the elderly with the skills needed to solve maintenance issues. Collaboration between device makers, healthcare providers, and support services is critical for establishing long-term, user-centric solutions that ease the deployment of IoT systems for geriatric healthcare at home.

5. Challenges in the implementation of IoT systems empowered by Microservices

When building IoT systems driven by microservices, developers and software firms face a variety of obstacles. One significant barrier is the complexity of integrating microservices, particularly in the context of multiple devices and protocols across IoT networks. Ensuring smooth communication and interoperability across these microservices necessitates careful planning. Another major worry is security, since the microservices design brings complications in protecting each service, creating effective authentication mechanisms, and assuring data encryption to prevent vulnerabilities and data breaches.

Scalability and performance are continuing difficulties that need good management of individual microservice scaling while also guaranteeing uniform performance throughout the overall IoT system. Data management and storage become critical factors, necessitating techniques for dealing with the wide range of data types created by IoT devices. Obtaining interoperability across microservices, particularly with third-party services and older systems, adds new problems for developers.

Real-time data processing is frequently required in IoT applications for rapid decision-making, adding complexity to the design of microservices capable of handling massive amounts of data. Monitoring and debugging distributed microservices provide unique difficulties, needing appropriate tools and tactics for tracking performance throughout the IoT system.

Continuous deployment and upgrades, which the microservices design encourages, necessitate careful coordination to minimize disruptions in the IoT ecosystem. Efficient resource management across distributed microservices, taking into account elements like memory and processing capacity, is critical for optimal performance. Maintaining data integrity in a distributed system is difficult, requiring developers to use solutions such as event-driven architectures. Addressing these issues would need a combination of technical skills, careful design considerations, and constant collaboration among developers, engineers, and stakeholders. Because of the dynamic nature of both IoT and microservices, overcoming these issues and creating durable, scalable, and secure IoT systems requires a flexible and adaptable strategy.

6. Conclusion

In the framework of the research, a thorough examination was conducted on numerous IoT solutions introduced in recent years. The primary focus was on investigating innovations geared at improving convenience and support for the elderly in their homes. Both older people and developers have significant problems when it comes to microservice-enabled IoT systems at home. Issues like difficulties adjusting to user interfaces, possible security and privacy problems, and the need on constant power sources offer substantial challenges for the elderly. The older population's linguistic and cognitive variety challenges the adoption of these systems even more. Simultaneously, developers must deal with the difficulties that arise from the integration of disparate microservices, as well as provide adequate security measures and manage scalability and performance. Addressing these difficulties necessitates a comprehensive strategy that incorporates user-centric design principles, constant support mechanisms, and adaptive technical solutions to build a smooth and inclusive microservice-enabled IoT environment at home for the elderly.

Declaration of Competing Interest

The authors declare that there were no identifiable competing financial interests or personal ties that may have been construed to influence the outcomes provided in this study article.

Data availability

The data used in this study came from publicly available sources, primarily Indian government organizations and several other nations. References to these sources are meticulously referenced in their respective parts, assuring transparency and dependability.

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