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NGWN - Next Generation of Wireless Networks based on Industry 5.0 in Computational Intelligence

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Abstract: Systems that are aware of their context can automatically adjust and monitor how they operate based on the execution context in which they are introduced. Nevertheless, the goal necessitates combining the cyber-physical worlds by leveraging Industry 5.0 technology enablers. This survey-based tutorial aims to address how the next generation of wireless networks (NGWNs) and the emerging computational intelligence (CI) paradigm can come together to meet the demanding computational and communication needs of the Industry 5.0 vision's technological enablers. In this article, we look at and evaluate the most recent advancements in ideas and technologies, including software service architectures, open radio access networks, CI tools and structures, network-in-box design, and potential enabling services. These developments are essential for developing CINGWN objectives that satisfy the demands of the Industry 5.0 vision. It is recommended that future research concentrate on creating transparent, reliable, and quantifiable technologies that offer a fulfilling work environment motivated by practical requirements.

Keywords: *computational intelligence, next generation of wireless networks, Industry 5.0*

1. Introduction

The goal of NextG wireless networks, also known as intelligent, robust, and dependable networks, is to serve as a technology enabler for Industry 5.0 applications and services by fulfilling the various communications and computing needs that have as their foundation the three key components of the human-centric industry, sustainability, and resilience. Increased industrial output at the same time as fewer disruptions and crises is referred to as resilience [1]. Efficiency in energy consumption and resource reuse are two of the environmental aspects that sustainability primarily addresses. Human wants and interests are central to the production process under the human-centric approach, which also incorporates computer interaction and personalization.

1.1. Next-Generation Wireless Networks

With the recent introduction of 5G networks, a great deal of research is being done to envision next-generation wireless networks, or 6G wireless systems, which will allow for extremely flexible knowledgeable end-to-end networking construction by deeply integrating ubiquitous AI into all facets of network infrastructure. The three main objectives are as follows: 1) high-performance networks for processing and data transmission; 2) assistance with human-centered, self-governing, and intelligent systems; and 3) AI-native service-oriented design is able to provide hybrid 6G services because it possesses the inherent properties of improved and flexible service-based architecture. In this way, CI integration can be very important to achieving the 6G goal.

The Computational Intelligence paradigm leverages advanced computational methods such as deep neural networks, fuzzy systems, swarm AI, and evolutionary AI to provide intelligent interaction, calculations, and operational storage capabilities to a wide range of applications. 1) Hyperconverged computing infrastructure (HCI), which includes public data lakes, on-site private data centers, cloud/edge computing infrastructure, and 2) facilitating communication methods, such as B5G/6G wireless systems, cognitive CPS systems, and NG-IoT and IIoT.

Future industries must be equipped to address pressing societal issues, such as 1) protecting the planet, its resources, and climate change; 2) developing circular production models; 3) emergence of facilitating IT technology; and 4) updating energy use guidelines to ensure that natural resources are used effectively in the event of external shocks, like as the Covid-19 epidemic (resilience); and 3) digital hyper-connectivity and developing digital skills for social stability and individual empowerment (human-centric value). The industrial 5.0 vision components depend on achieving and enabling the 17 Sustainable Development Goals, sometimes referred to as Global Goals, as outlined in the United Nations' Agenda 2030.

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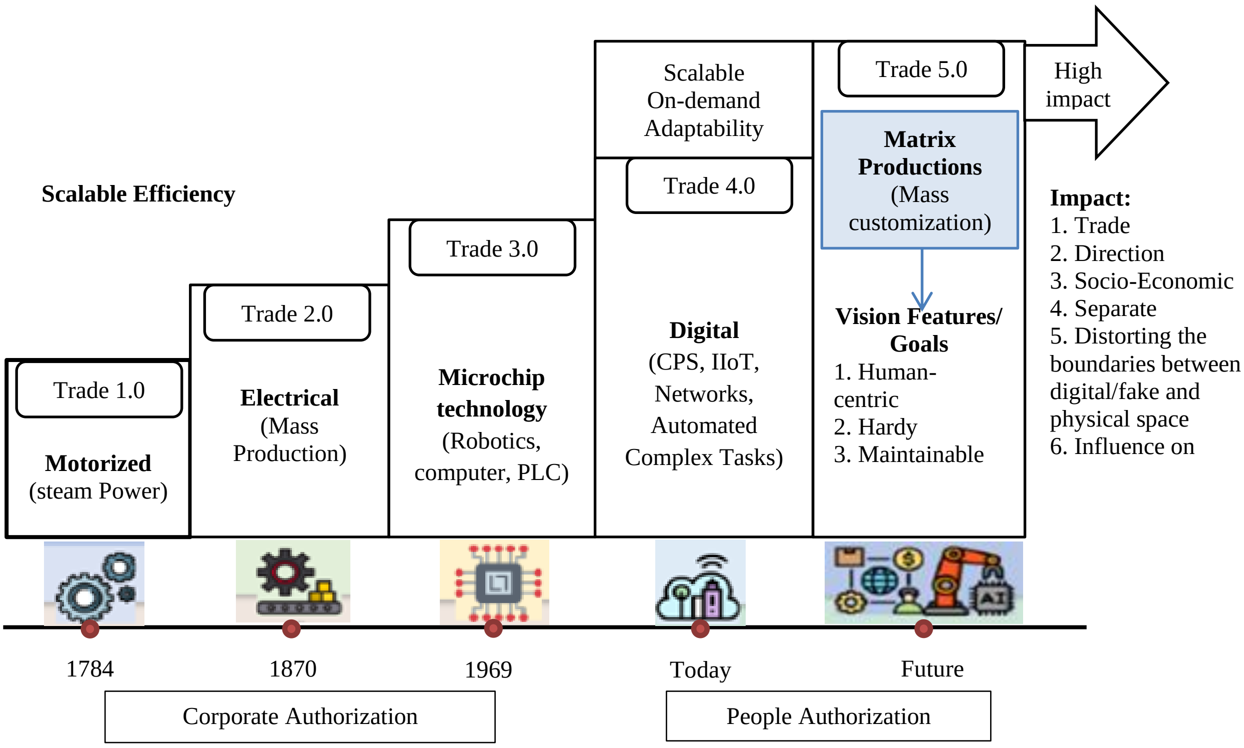

Fig. 1.1. Principal drivers and objectives of the various industrial revolutions, including Industry 5.0

We have made an effort to provide the first thorough overview of the path towards Industry 5.0 in Figure 1.1, taking into account a wide range of CIGNWNs aspects. Although 5G network development has already begun, there aren't many examples in the literature of how innovative manufacturing businesses have profited financially from this novel technology. There is insufficient evidence, often anecdotal, with notably untested effects due to a lack of reporting. There isn't much published in peer-reviewed academic journals or as working papers on the advantages and disadvantages of companies implementing 5G technologies [2]. Therefore, the following are the study's primary contributions that have an impact:

- Technical Enablers and Needs: This article identifies and discusses several crucial technical enabler needs related to the industry 5.0 goal.
- NBIs and CI-NGWNs: To satisfy the many KPIs of Industrial 5.0's technology enablers, CI-NGWNs' design goals, vision, and NBI architecture have been categorized and examined.
- The paper describes and explores Multi-tenant Soft write Architecture is an industrial control and automation software framework that makes it possible to provide Industry 5.0 applications with intelligent, personalised services in light of the technological shift in automated manufacturing.
- Research problems and Lessons acquired: Drawing from the evaluated research, the community was presented with suggestions and a roadmap for upcoming research problems.

The remaining sections of the article are organised as follows. The prerequisites for the industry 5.0 visions and NIBs' design of CI-NGWNs are covered in section 2. Section 3, which discusses the purpose and requirements of CI techniques in connection to Industry 5.0, comes after Section 4. Section 5 concludes with some final thoughts. It discusses the lessons learned, suggestions, research problems, and potential for the future.

2. Literature Review

Zhou, C. et.al [3] The need for 5G network capacity is fuelled by the rise of bandwidth-demanding apps. The NGWN, which will replace 5G, is anticipated to enable numerous novel applications, including holographic interaction, industry 5.0, virtual reality and augmented reality, and sophisticated autonomous driving. Compared to 5G applications, these new apps have stricter service needs, such as data throughput and latency, and their quality of service (QoS) requirements may vary. The new applications—such as compute-intensive applications—need more network resources than just traditional communication services; these resources include computation and storage capabilities.

Ahmed, R. R. et.al [4] Though Maxwell's discovery of electromagnetic waves in 1867 marked the beginning of the cellular industry's history, the analog system that was introduced in the 1980s was regarded as the first-generation mobile network. The 1G technology, often known as analog methods, was limited to speech transmission during mobile phone conversations. In 1979, Nippon Telephone and Telegraph introduced the first full cellular communication system. In the same year, Sweden and Norway unveiled Nordic Mobile Telephone (NMT), a commercial analogue mobile communication system.

Kumar, R., et.al [5] Four main criteria—data rate, mobility, bandwidth, and coverage—were used to categorize wireless mobile networks during the development of NGN standards. Bandwidth determined data rate, and coverage determined mobility. Thus, networking norms and technologies were split into two categories: standards with lower data rates and more coverage, and standards with higher data rates and less coverage. This division was based on data rate and coverage. It is anticipated that the implementation of NGN and the offering of triple-play products will ultimately boost Internet service provider profits by obtaining a significantly greater profit per subscriber, in addition to providing richer content to Internet consumers.

Manzoor, S., et.al [6] Mobility management is necessary for SD-Wi-Fi in order to distribute the load across IEEE 802.11 users. The seamless movement of devices necessitates the usage of handover protocols. A strategy is presented that provides continuous connectivity by utilising logical access points. The received signal strength indicator is the only significant component to take into account when evaluating parameters for handover selections. At APs, the traffic load is calculated and distributed. Handover decisions based solely on metrics are inefficient since they lead to congested hotspots. In SD-Wifi, load balancing is accomplished through clustering local controllers and flow prioritization. An analytical hierarchical approach is used to prioritize the packets, with the local controllers processing the highest priority packets first.

Matenga, A. E., et.al [7] The next industrial paradigm shift, known as Industry 5.0, aims to build a robust, environmentally friendly, and human-centric environment by combining next-generation technology, developing CI, and NGWN. I4.0 is the forerunner to i5.0, and for highly hyper-connected systems, i5.0 depends on the integration of 14.0 capabilities. Under i4.0, CM is still a relatively young and developing technology, although it has gained recognition by the industrial sector as a crucial and fundamental technology for Industry 5.0. Smart transit solutions are being tailored for i5.0 while taking into account futuristic and intelligent cities. Complex systems may track and monitor assets in real-time by integrating blockchain technology with the industrial IIoT.

Palmieri, F., et.al [8] Security considerations always influence the decision of which devices are admitted onto a network, a feature that network administrators find quite interesting. This is especially more crucial in mobile wireless LAN setups since these networks are frequently set up to provide constant access to the Internet, making them attractive targets for hackers. Furthermore, the owners of many systems and devices that must be connected to these settings are almost entirely uninformed of security precautions like updating operating systems and anti-virus programs.

Aliannejad, F., et.al [9] Among the value-based reinforcement learning techniques, we use the Learning technique to establish appropriate wireless linkages between users and the access point (AP). The Learning technique controls the mosaics' state in an environment that is provided by the SDMs. Q-learning searches for a sequence of actions that maximizes the predicted discounted reward, or an optimal state-action strategy. When choosing an action, an agent typically selects the action that acts randomly with a likelihood of ϵ and has the highest Q-value. This implies that exploration and extraction ought to involve certain trade-offs. The way the agent chooses an action about its state is specified by the optimal policy.

Tahira, S., et.al [10] The primary issue with registrations is that it experiences additional commands/messages, packet loss, and MDT latency. We know from the literature that the registration phase needs to be optimized with the least amount of communication overhead. Additionally, it must support the transfer of IPSec SAs for authorization and authentication. It should be possible to use the generic scheme with any NGMN handovers between LTE and 5G or WiMAX. Cross-layer techniques that shorten the registration delay have only been proposed up to this point, and they only make use of layer 2 or layer 3 procedures.

3. Methods and Materials

Industry 5.0 is the enhanced version of the fourth industrial revolution. This subsection discusses Industry 5.0's new features. Figure 3.2 provides a graphical explanation of some of the possible uses of Industry 5.0, which are covered in this section.

3.1 Applications for Industry 5.0

Observations from many cutting-edge industries indicate that Industry 5.0 is already being applied in a number of fields, such as disaster management, cloud manufacturing, manufacturing, production, healthcare, education, and human cyber-physical systems. Industry 5.0 not only uses machines to integrate cutting-edge technologies like artificial intelligence, the Internet of Things, edge computing, cobots, 6G and beyond, digital twins, big data analytics, etc., but it also makes use of human intelligence in decision-making. That's why Industry 4.0's foundational elements of automation and efficiency are combined with the human element [11]. Industry 5.0's human-robot co-working capacity harnesses human cognition and decision-making to enable unparalleled mass customization across multiple industries through the application of crucial supporting technologies. Industry 5.0 has the immense potential to totally revolutionise a number of different businesses and areas. However, several issues need to be resolved to fully realize its promise. These issues include processing diverse information, managing resources, handling enormous volumes of data, Earlyn, etc.

3.1.1. Technology Enablers

According to the current state of research, Industry 5.0 in Figure 3.1 is crucial to many applications because it embraces enabling technical trends such EC, DT, IoE, big data analytics, cobots, 6G, NS, XR, and XR PMN. When combined with creativity and cognitive abilities, all these technologies that enable can help businesses boost output and provide customized goods faster.

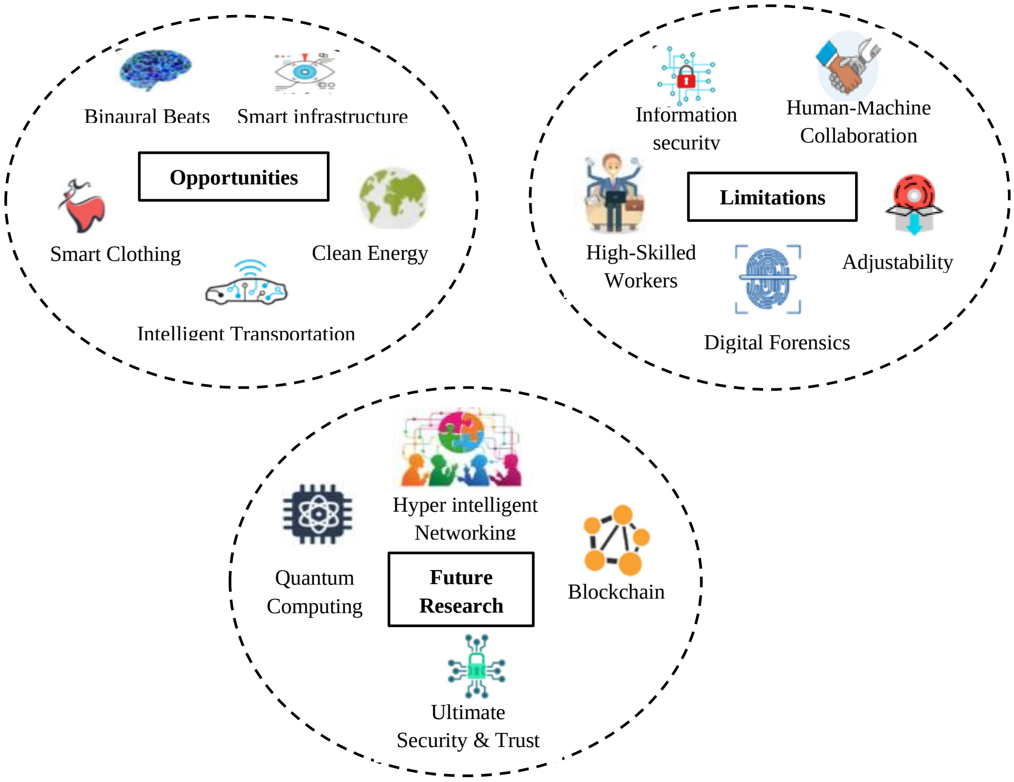

Fig. 3.1. 4 Industries 5.0: Prospects, Restrictions, and Upcoming Studies

- Industry 5.0 is now able to improve overall data quality, minimize latency, and decrease network traffic security and privacy, and speed up transactions that are slowed down by connectivity problems thanks to EC's improvements. Through the use of common hardware and software, EC enables Industry 5.0 to share information about its industrial sectors.
- By identifying things that can be altered or renewed depending on their productivity, forecasting future errors, preventing significant financial losses, and producing more accurate projections, the DT assists Industry 5.0 in overcoming technical issues.
- Cobots are employed in Industry 5.0 to boost output and strengthen the new bond between people and robots. Cobots increase productivity growth and enhance security and efficiency in Industry 5.0 applications, giving human workers more engaging tasks to complete.
- Industry 5.0's adoption of IoE presents an opportunity to reduce operating costs by removing communication channel obstacles, decreasing latency, cutting waste in the supply network, and streamlining production procedures.
- Industry 5.0 mass customization procedures benefit from big data analytics' zero-fail connectivity with available resources. Manufacturers are able to generate and handle vast volumes of data with the help of real-time analytical data shared with smart systems and data centers.
- 6G networks should be able to provide ultra-high data rates, ultra-low latency, ultra-high reliability, incredibly efficient energy utilisation, traffic capacity, and other necessary features by the intelligent digital economy for Industry 5.0 apps.
- NS offers several virtualized networks at an affordable price with the best possible use of network resources for IIoT network monitoring. XR is utilized in Industry 5.0 applications including maintenance, driver/pilot training, indoor and localized outdoor navigation, health education, remote healthcare, assembly line monitoring, remote support, and drone/UAV pilot training. PMNs are utilised in numerous Industry 5.0 settings, including as industries, hospitals, schools, and colleges, to offer customised, use case-specific network services that provide location-specific connectivity solutions.

3.2 Issues Facing Industry 5.0

After Industry 5.0, it is easier to overlook the potential problems. In order for the company to benefit from industry 5.0 innovations, the problems must be identified and resolved.

- As human workers interact with increasingly sophisticated robots, they must acquire the competency skills necessary to collaborate with both the robot maker and the smart machine. Technical skill acquisition is a challenge for human workers in addition to the soft skills needed. The new professions that require a high level of technological abilities are challenging, such as managing translation and programming to the manufacturing robot.
- More time and effort must be invested by human workers in adopting advanced technologies. Industry adoption of collaborative robots, artificial intelligence, current data, internet of things, customized software-connected factories, and artificial intelligence is required. Version 5.0.
- Investments in cutting-edge technologies are necessary. UR Cobot is not inexpensive. Investing in the training of human labourers for new positions is costly. Companies are finding it challenging to modernise their production operations in preparation for Industry 5.0. Adopting Industry 5.0 is costly since it calls for highly trained workers and intelligent machinery to boost efficiency and production.

o Industry 5.0 has security challenges since ecosystem trust is built on security. The industry uses authentication on a large scale to communicate with different devices and defend against upcoming quantum computing applications that aim to deploy Internet of Things nodes. Industry 5.0 uses automation and artificial intelligence, which puts the organisation at danger. For this reason, dependable security is essential. Tight security regulations are required to prevent security problems because Industry 5.0 applications are mostly reliant on ICT systems.

3.3 NGWN's Expanded Capability

AI and big data analytics enable network operators to anticipate data more accurately, hence increasing their capacity. The usual approaches are unsuccessful in these conditions. For example, the mobile network provider can require fixes to deal with the issues. Big data analytics will therefore be able to compile all the data in one place, enabling error detection and resolution in the shortest amount of time [12]. Big data analytics can be used to analyze and forecast data from the standpoint of the users and the network. Subscription or user-perspective data will comprise user affordability, device data, policy, service quality, and behavioral data. To maximize results in terms of raising customer happiness, centering decision-making on the user will be made possible by the analysis of their data.

The data from the network perspective will encompass all the procedures, such as organising, supervising, and assessing the procedures; setting prices; handling intricate circumstances; and resolving network operating system problems. For next-generation wireless networks, there are various approaches to enhance the communication process. The growing most efficient techniques that the next-generation networks can use are described in detail below.

1. It is feasible to enhance the communication process for future generations with the use of an appropriate resource allocation method. Future generations may benefit greatly from the right allocation of resources through the use of big data analytics, according to reports. In order to ensure that customers receive effective services; through the application of data analytics, network operators can, for example, schedule and manage their resources according to customer demand. This will be advantageous for future wireless systems.
2. Giving consumers a high-quality experience is crucial, and it can only be done with big data's assistance. This is because the data will make it possible to choose the best solutions based on the preferences and types of applications that people use.
3. Large-scale traffic surges can be handled by network operators with the use of artificial intelligence and big data. System managers are able to make informed decisions about which smartphone or small device to connect to the networks based on user profiles and affordability by employing data-driven technologies and algorithms.
4. Network administrators can boost the network's capacity and efficiency by strategically placing small cells, but it might be challenging for them to determine which area is ideal for small cell installation. However, because it can make the greatest predictions even at unfamiliar sites, big data analytics and ML might be the most helpful in this regard.
5. The quality of services offered to users has been adversely affected by "Radio Access Network Congestion Control," which can be attributed to the increasing demands of users on networks and the restricted resources of network operators. If network operators utilise the traditional approach and provide additional resources, the system will get more intricate and the quality of the output will worsen. Artificial intelligence and big data analytics are consequently regarded as the most beneficial instruments for network operators in these kinds of circumstances.
6. Every gadget or cell phone has a unique traffic profile, which led to the formation of unique information and trends for every cell. There is a rise in load on one cell when some subscribers disconnect from a certain cell and reconnect to another, which disrupts traffic patterns. In the near future, network operators will need to be able to effectively operate the next generation wireless network predictive analysis using data analytics will prove helpful in locating the overload.
7. Beamforming is an integrated technology component that plays a key role in providing data speeds and network service coverage in "next generation wireless systems." The most important techniques for increasing data and coverage rate by determining the best location and orientation for the antenna are ML, big data analysis, artificial intelligence load estimation and suggesting the optimal course of action to resolve the problem.

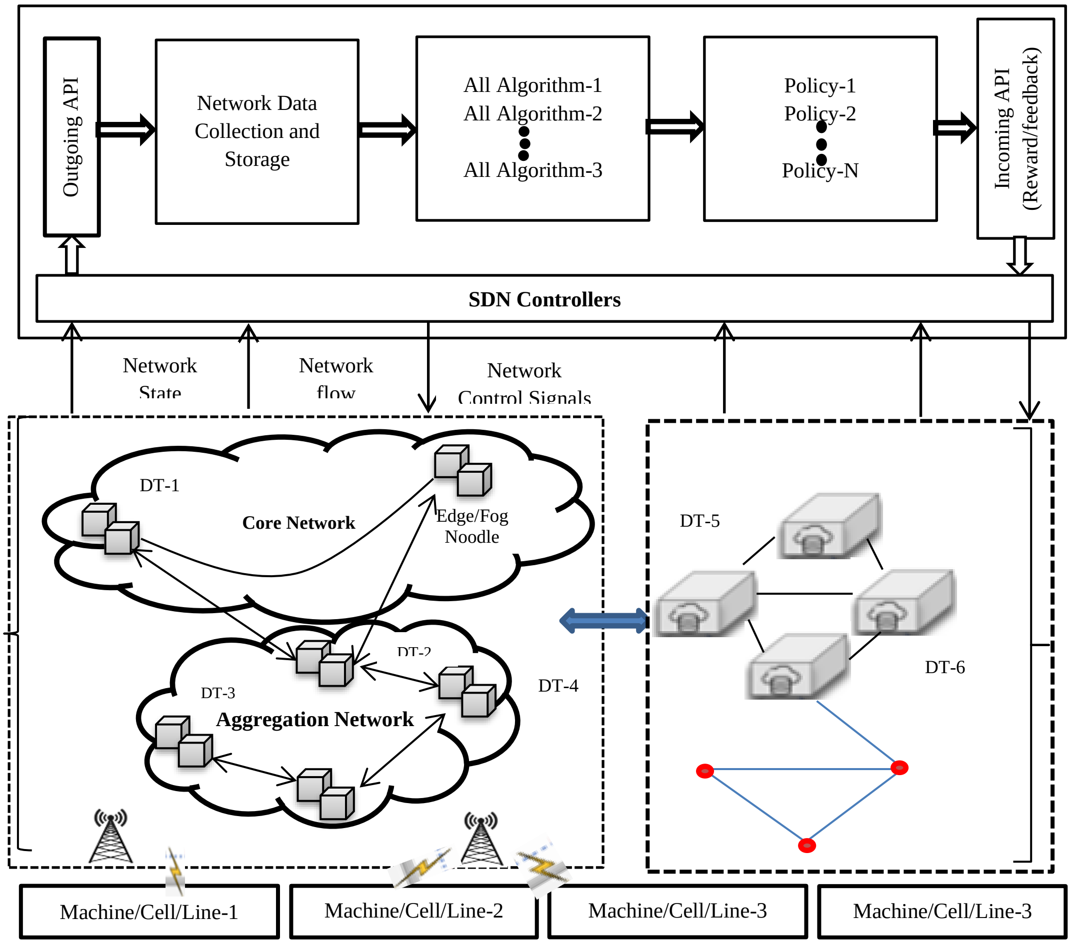

Fig. 3.2. Enabled zero-touch hybrid NBIs architecture of CI-NGWNs with softwarized communication between deployed digital twins and physical twins

For instance, the TSN-enabled hybrid NIBs infrastructure shown in Figure 4.2 combines the backhaul hyper converged industrial network with the CI-NGWNs infrastructure to provide dependable and secure computer services and communication to the interconnected machine cells on the actual manufacturing floor.

4. Implementation and Experimental Results

4.1 Conditions for Simulation

We have worked through several MOOUI instances in the simulation, all varying in difficulty. Table 1 displays the values for M, N, and P for each of the ten MOOUI instances. The GA algorithm that I have previously defined to address these issues is listed below.

Table 1. Principal Attribute of the Issues Addressed

Complications	Managers	N	N1	N2	Kinds	P	P1	P2	Kinds
1.	11	4	4	2	1	4	2	2	2
2.	21	6	4	3	5	5	2	2	3
3.	31	7	4	4	5	5	4	3	4
4.	41	11	4	5	5	6	4	4	4
5.	51	16	7	6	5	6	4	4	4
6.	61	16	11	7	5	11	6	6	5
7.	71	21	9	8	5	11	7	5	5
8.	81	26	11	9	5	16	11	6	6
9.	91	40	16	10	5	16	9	8	7
10.	151	41	21	11	12	21	11	11	8

4.2 Quantitative Evaluation

In order to maximise capacity expansion with many objectives, we assess the effectiveness of my algorithms. The experiment was carried out on a real Intel® Dual Core 3.0 GHz processor with two gigabytes of RAM, the C language to execute the experiment GA algorithm. The objective function values of the initial and optimal solutions are compared in Figure 4.1, which depicts a population size of 500, POP POP X Y and a termination condition of 100 generations [13]. Figure 4.2 illustrates how long it takes to handle MOOUI instances.

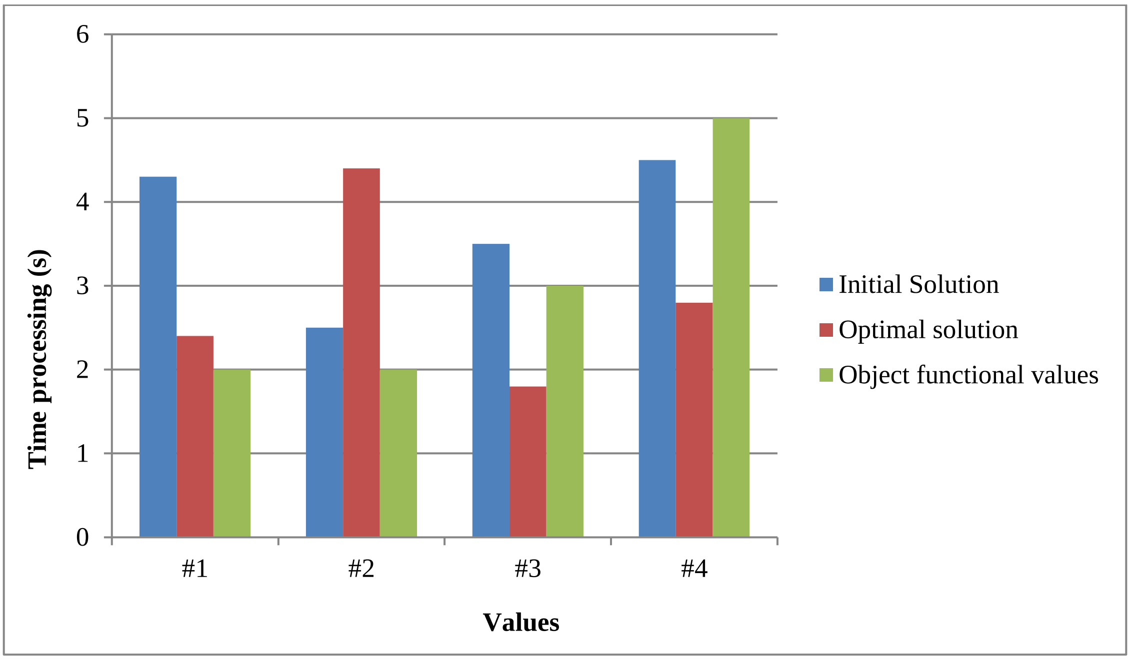

Fig. 4.1. The MOOUI instances' time processing and value comparison of capacity growth are Addressed

The findings demonstrate that the method produces roughly optimal outcomes quickly with little interactions for difficulties with small numbers of M, N, and P, such as #1, #2, #3, #4, and #5. On the other hand, huge problems—like problems #6, #7, #8, #9, and #10—may yield optimal solutions more slowly. The distribution of the parameter data affects the convergence speed, which varies. Problem #3's first assignment is depicted in Figure 4.2.

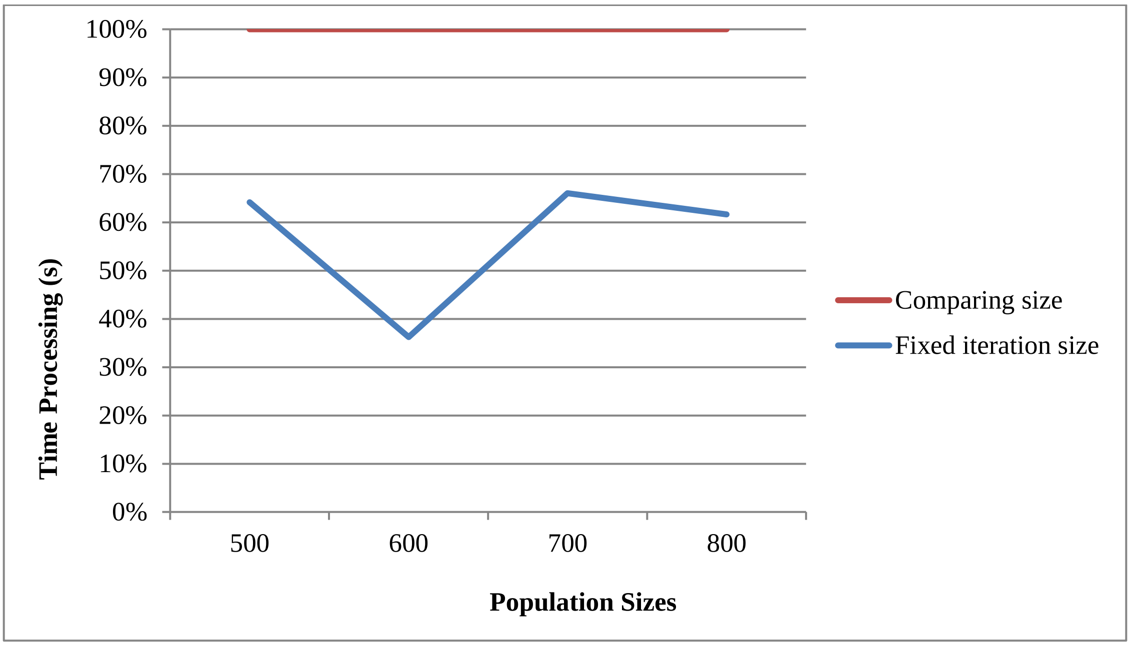

Fig. 4.2. Comparing the Amount of time needed to solve Problem #3 with varying population sizes and Interaction Counts

The results of the comparison between case #3, where Figure 4.3 shows the fixed iteration size of 100 and the population size that can vary from 500 to 1000.

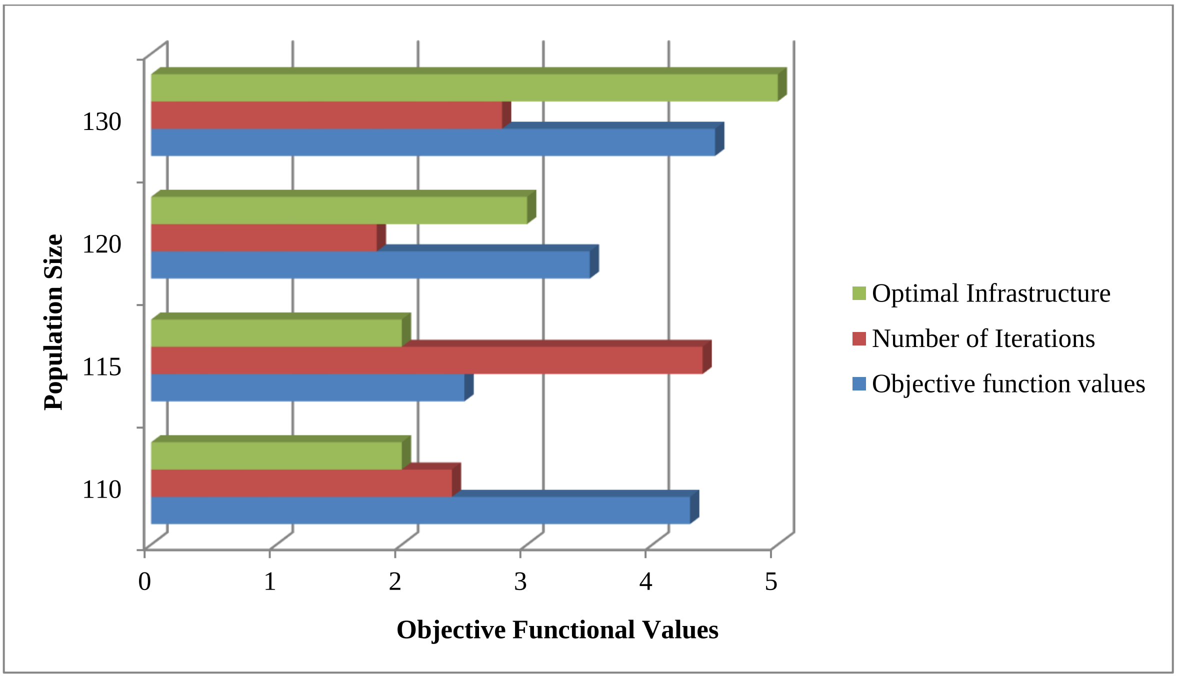

Fig. 4.3. Comparing the objective function values for issue #3 with varying interaction counts and population sizes

4.3 Utilized in the development of Haiphong City's infrastructure upgrades for the telecommunications networks

According to the Department of Information Communication's Strategies to Develop Post and Telecommunications in City Haiphong from 2010 to 2021, system switchboards switched channels are used for local voice traffic switching in most of Haiphong's switching networks. Moreover, NGWN is implementing convergent voice, combining data from mobile and landline networks into a single network and offering new NGN-based services to city subscribers. There are six mobile suppliers networking in the Haiphong city region.

- GPC Construction and Management is the business behind the Vinaphone network of communications services [14, 15]. 120 mobile stations and a mobile switchboard are part of the current network, which was mostly set up using shared infrastructure and management with Telecommunications Institute Haiphong stations.
- The Mobile Information Center's fifth generation Mobi Fone network is presently being built and managed, with 95 stations broadcasting mobile content installed primarily at postal regions, telecom stations, and individual organizations within the city.
- Viettel Telecom's Viettel Mobile Network constructs, oversees, and arranges the city's commercial operations. The 270 stations that make up the current network broadcast mobile income; these stations are primarily situated at the city's businesses and homes.
- The Information Power Company and Communications eMobile Network is designed and operated by them. The current network broadcasts on mobile cities through 89 stations.
- Built and managed by ST telecom is the SFone Network. There are 43 stations in the current network that transmit on mobile cities installed at other local businesses or people as well as post office districts.
- Development and administration of Hanoi Information Joint Stock Company is the provider of HT-Mobile networks. Across the city, Network operates eighteen mobile stations which are situated in post offices and other nearby businesses and residences. Vietnam Mobile is the new name for HT-Mobile, which is now transitioning from CDMA to GSM technology.

Presently, there are very few home stations throughout the city and a shared infrastructure mobile network. Local payment only roughly fifty points less than the overall usage of the network structures between mobile businesses (primarily Vinaphone and Mobile phone, placed in the central postal districts and telecommunication stations). Four firms and service providers, including Viettel, EVN, FPT, and VNPT Haiphong Telecommunication, built the internet in Haiphong city.

5. Conclusion

This article evaluated the Industry 5.0 vision as well as the vision requirements for creative uses in Industry 5.0, with a major focus on the role of CI integration using NGWNs' CI-native NIBs architecture—as a technological enabler to meet the vision's fundamental requirements. This paper addresses the multi-objective optimization infrastructure upgrade problem in NGWN by introducing a novel genetic method based on an array of two populations. Based stations and base station controllers are concentrators in my two-level network architecture model, whereas mobile users are sources. The goal of the model is to minimize the costs associated with connecting sources to concentrators. This strategy is suitable and successful, according to the experimental findings.

Furthermore, the technologies and services within the NIB architecture that could be utilized by CI-NGWNs to achieve Industry 5.0 were deliberated. Upon concluding, we analyzed the results of our study and offered perspectives, suggestions, and future paths for investigating Industry 5.0 and how CI and NGWN influence it. Particularly, the primary obstacles in Industry 5.0 are meeting the demands of more and more human-machine interactions to deliver human-centric solutions. Scalable and flexible continuous integration technology is needed at the software network interface bus architecture level of NGNs for hybrid and unified service deployments.

The discussion and evidence above suggest that the most promising technologies for meeting the demands of the next generation are those related to artificial intelligence, machine learning, and data analytics of network operators. By raising the network's capacity without raising its price, these technologies enable network operators to more efficiently regulate, manage, and enhance its performance, hence improving customer satisfaction.

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