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# Leveraging Software-defined Wireless Networks for Intelligent Resource Management in 5G and Beyond Wireless Networks

**Tejinder Kaur[1], M.Samba Siva Reddy[2*], Vinothkumar Kolluru[3], Siddhartha Nuthakki[4], Pradosh Kumar Gantayat [5] and Mukesh Soni[6]**

[1]Department of MMICTBM, Maharishi Markaneshwar (Deemed to be University) Mullana Ambala-Haryana 133207, India

[2]Sr.Assistant Professor, Department of Electronics and Communication Engineering, Lakireddy Bali Reddy College of Engineering (Autonomous), Mylavaram, India

[3]Senior data scientist Department of Data Science, Stevens Institute of Technology, 1Castle Point Terrace, Hoboken, USA

[4]Lead Data Scientist, NeonSoft Inc, USA

[5]Department of Artificial Intelligence and Data Science, Faculty of Science and Technology (IcfaiTech), The ICFAI Foundation for Higher Education, India

[6]Division of Research and Development, Lovely Professional University, Phagwara, India

***Corresponding Author:** M. Samba Siva Reddy, 2Sr.Assistant Professor, Department of Electronics and Communication Engineering, Lakireddy Bali Reddy College of Engineering (Autonomous), Mylavaram, India.

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**Abstract:** The emergence of Software-Defined Networking (SDN) has enabled network operators to build more flexible and programmable networks, leading to significant advancements in the networking industry. Wireless networks have become ubiquitous in our daily lives, enabling seamless communication between devices and supporting a vast array of services. However, wireless networks face several challenges, such as limited spectrum resources, interference, and high network complexity. Software-Defined Wireless Networks (SDWNs) have emerged as a promising solution to address these challenges. SDWNs leverage the principles of Software-Defined Networking (SDN) to provide a more flexible and programmable wireless network architecture. This approach enables network operators to manage network traffic and resources through a centralized controller, providing greater control over the network and allowing for more efficient resource allocation and traffic management. With the proliferation of wireless devices and the increasing demand for mobile data, Software-Defined Wireless Networks (SDWNs) have emerged as a new paradigm for managing wireless networks. This paper provides an overview of SDWNs, including their architecture, benefits, challenges, and current research trends. We also discuss several case studies and use cases of SDWNs and explore their potential impact on future wireless networks.

**Keywords:** Artificial Intelligence, Health, Telemedicine, Medical

## Introduction

How artificial intelligence (AI) can help in medical decisions about telemedicine? Many health care processes, such as inpatient clinical information systems, antibiotic prescriptions, and pressure ulcer risk assessment, are supported by computer-aided decision making (Alampany, An example of this is the AI-based telephone emergency triage assessment system. is AI can support medical decisions, including the decision to use telemedicine. An example is the system developed to facilitate a structured initial medical evaluation process in the emergency department in Germany called the (SMED). A study conducted by the Institute for Social-and Preventive Medicine (ISPM) of the University of Bern analyzed the system and revealed that 91% (153) of the advice given with the system was considered correct, 5% (10) were considered early 4% (7) were considered late. More than 90% of physicians surveyed considered both consultation and time appropriate. The use of the software includes a structured survey based on the 85 most common complaints of the International Classification of Primary Care (ICPC-2) and a thematic list of specific questions that describe the patterns of complaints that the software can handle. The purpose of the first questions is to determine whether there are any signs of urgency; If the answer is yes, the call is immediately forwarded to the emergency telephone number (112). If the urgency procedure is rejected, the questions are focused on the main complaint and are colours according to the level of urgency (red, orange, yellow-green, dark green). There are four levels of emergency care: (1) urgent care, (2) medical treatment as soon as possible, 3) medical treatment within 24 hours, and 4) no treatment within 24 hours, and four levels of care: (1) emergency services (112) , (2) hospital emergency departments, (3) general practitioner/on-call medical services, and 4) medical teleconsultation. The algorithm used by AI systems is based on deep and machine learning (ML), which is based on a neural network structure and allows for an almost infinite number of questions and answers. The level of urgency or care recommended depends on the relative weighting factors of the respective group, so different combinations of complaints and risk factors may lead to different recommendations. In addition, according to Mir (2019), two improvements to SMED have recently been implemented: (a) automating a telephone conversation with a patient to make a recommendation for natural language processing by AI to the healthcare professional; to be communicated. And (b) implementing SMED as a digital self-assessment through a chat bot with another option to find a suitable consultation and make an immediate appointment It is currently being debated whether early ML-based tools can also be effective in managing patients' unnecessary demand (see Schlagman, Greiner, Searle, et al , Wang et al supporting). , they can be used as a helpful tool in deciding whether treatment can be provided remotely (tele consultation). Based on the information provided by patients, the technological system will predict low-risk cases for which remote non-emergency care can be provided, and separate them from cases that are not urgent, but physiological. The growing number of programs evaluating ML (AI) based tools for non-emergency triage is a clear indication for its future use in supporting the decision to use telemedicine [1].

**Why use artificial intelligence in telemedicine decision-making** [2]

The implementation of telemedicine has not reached its full potential in most European countries. Indeed, there is a significant tendency to encourage the development of telemedicine in key functions, such as the use of teleconsultation or telemonitoring among specialists, which harms the implementation of the highest emergencies, such as remote treatment Telemedicine is currently limited to simpler terms as an adjunct to conventional medical consultation and treatment [2]. The question we ask is why? A physician's judgment about when to provide telemedicine care is complex and therefore difficult to implement [2].
For example, countries such as Germany have specifically adopted telemedicine in certain circumstances. The Deutschland antigen Ärztinnen und Ärzte (MBO-Ä) or the professional code of medical practice, specifically provides for the use of telemedicine "in individual cases where this is medically appropriate and permitted" for case management purposes. Which provide criteria for interpretation in simulated cases [3].

For example, the German Medicines Marketing Act on human clinical trials provides criteria for determining when there is a therapeutic justification and when this status is granted. Potential human risks and benefits" are understood by the recipient (interested party) and the immediate importance of the medicinal product outweighs the disadvantages. On a balance of what is best for the patient, taking into account the possibility of use in emergency situations, only remote cases will also be evaluated on an individual basis even in cases where the physician evaluates the risk/benefit ratio based on the patient's clinical picture and situation. In other words, remote medicine can only be used in situations where there is little risk of its use, as we are dealing with minor illnesses (e.g., cold, flu) [4]. The challenge then is to distinguish clinically from low-risk or illnesses requiring immediate healthcare. How to identify cases where treatment is only available remotely? As we discuss below, intelligence plays an important role in answering this question [5].

**Artificial intelligence systems as decision support for remote treatment in telemedicine: liability in case of errors**

AI software is used for medical triage under the new European AI framework

The use of ML-based AI systems as medical decision support tools to improve the quality of patient care raises the legal question of who is responsible for the harm caused by the decision. Clearly, prioritization of care requires a preliminary assessment of the patient and a definitive diagnosis [5].This part of the paper considers whether a claim for liability in the event of an error of an AI system can be based on the proposals of two previous directives: the proposal on a Directive of the European Parliament and of the Council – Contracts on artificial intelligence Civil liability of -M202K-602 Final Regulation, and Proposal for a Directive on Liability for Defective Products [COM (2022) 493 final]. We first analyze how the AI system works with these propositions [6].

AI software used for medical triage is considered a high-risk intelligent system (according to art.3, 6 of the Intelligence law proposal) Footnote2 means confirmation of compliance with the requirements of Chapter III Law on Artificial Intelligence It must be evaluated in order to AI software used in medical triage is also considered a medical device (Art. 2.1. EU Regulation 2017/745 on Medical Devices or Medical Device Regulation or MDR (DOUE L 117/1)) meaning that the European Union market As with other AI software medical devices, the software must be CE marked and undergo a conformity assessment process to obtain the CE mark. Finally, once all evaluation processes are developed and all requirements are met, the technical robustness of high-risk AI systems reduces the risk of systemic errors. In the following section, we discuss how the liability claim directive in this case can be based on two recently approved proposals related to damages caused by artificial intelligence (AI) systems in the home. Aspects are dealt with [6].

Is a physician liable for damages caused by clinical advice generated by an AI system?
In the case of non-contractual liability for harm caused by a high-risk AI system, the proposed AI Liability Directive provides for a presumption of causation between the defendant's fault and the result produced by the AI system or the failure of the AI. . To produce system output (Article 4 of the AI Responsibilities Directive) [7].

However, the proposed directive applies to fully automated decisions and does not cover liability claims arising out of human action or non-injury, even if the AI system has only provided information or advice that was generated by a human actor. had gone According to the proposed directive (Article 15), clinical judgment in emergency situations, or a model of medical care based on the prediction of an AI system, is considered a human judgment. The initial assessment of a patient is one of the first medical decisions a physician makes. Although the AI system only serves as a medical decision support, it does not replace the role of the decision-making physician and therefore may differ from the recommendations of the AI system. Therefore, tort claims for harm caused by clinical triage decisions based on AI system predictions are excluded from application of the AI Liability Directive. The question arises whether an automated solution can exist without human intervention, because an automated solution can always be interpreted, implemented or processed by a human However, if a doctor follows the advice of artificial intelligence and injuries occur, the question of liability for medical procedures must be resolved according to the personal liability rules of the Member States. In this case, whether the obligation is contractual or contractual, each Member State must consider what duty of care the doctor owes: whether lexartis ad hoc compliance decisions require clinical monitoring and how to pay the patient. Such a high duty of care cannot be required, taking into account the following aspects: 1o) the need for human supervision at all times necessarily precludes the implementation of artificial intelligence systems for clinical decision support; 2o) such a rule would be difficult to enforce because artificial intelligence systems can make unbiased decisions; 3o) If the AI system is properly designed and properly used by the physician, error in the AI system is a risk beyond the physician's control (unless there is an obvious error). For example, in Germany in Sect. 630 h BGB (1): It is considered that the error was committed by a doctor who, in the case of general medical care, had complete control over it and would have harmed the life, limb or health of the patient. Patient "Since the error of the AI system is a risk beyond the control of the doctor, the concept of error does not apply (Schmidt). The complexity of ML systems is a challenge. In the field of medicine, it is especially important to understand artificial intelligence systems. It is important to trust the decisions of doctors and artificial intelligence systems, so in practice - data-based models that guide decision-making, treatment recommendations, and diagnoses (with the help of the final decision-making expert). From), provide an explanation of disease used in medical informatics. For image analysis, for example, using magnetic resonance imaging to detect certain types of cancer [8].

Predictive AI systems as composite products [8].
The question is whether a victim (a person) can claim damages under the strict liability regime of the proposed Product Directive against the "farm operators" involved in the production chain of the AI system. Applying this proposal raises the following issues: [8].

1. The qualification of an AI system as a product is recognised in Art. 4 footnote 3 of the Directive on defective products. In this case, we will be interested in software used for medical purposes that qualifies as a medical device under the MDR (footnote C-329/16, Snitem. However, the proposal uses the generic term 'software', thus raising doubts about the applicability of machine learning AI systems [9]. However, Article 12 of the proposed Directive clarifies that software includes "operating systems, software, computer programmes, applications or artificial intelligence systems" [9].

2. Another question is whether we can regard a machine learning AI system as a defective product that can make incorrect recommendations and consequently harm human health. In this case, the risk of the product lies in the incorrect prediction, therefore constituting an intelligent function, but the prediction depends on the parameters because the AI system changes according to its own learning, so we match the prediction generated by the

independently eat AI system. Contrary to S-65/20 VI v. Krone, footnote 5, there is a fundamental difference in our case that may justify a different qualification in the product liability context for software and printed information. In our case, the software not only transfers information but also forms an entity that can be used for the purpose for which it was designed. The incorrect medical assessment or prediction/knowledge provided by the AI system is itself an inherent element of the purpose-built system and is therefore latent in its use and can therefore be considered a defective product [10].

On the other hand, paragraph 6(c) of the Proposal clearly defines the concept of a defect affecting any ability to continue learning after implementation in the product in relation to machine learning AI systems and recognition. Furthermore, in this case, the unavailability of goods may be considered under Sections. 8 and 9.4 of the Proposed Directive, given the technical complexity of the evidence, the respondents refer to footnote 6.

3. The second question is who can claim damages under the Proposed Directive. It applies to any person (Article 5) who suffers an injury as a result of a defective product (the "customer"). Additionally, the consistent factor in defining "injured person" in the product liability context is that the person has suffered an injury as a result of the defective product. In simple terms, the term refers to both the purchaser of the product and the consumer of the product, or a completely unrelated third party (country) (Junker, 2021). Another problem is that the proposal only covers victims by natural persons (Article 1) and does not cover legal persons, companies and institutions (for example, hospitals) that suffer injuries as a result of defects in their products [10].

4. According to Article 7 of the proposal, responsibility lies with the manufacturer of the product and the manufacturer of its components However, in machine learning-based AI systems, diagnostic advice was provided by the AI system autonomously, raising the question of whether the manufacturer is liable. Since continuous learning is an integral part of system development, it can be assumed that any operation of the system is attributed to the manufacturer.

## How AI Support Decision Making

diagnosis and prognosis [10]

AI algorithms can analyze electronic health records (EHR) from wearable devices. And remote consultation to identify patterns and provide clinical advice Machine learning model tele monitors analyzes large datasets of patient records. To help diagnose heart disease in diabetic patients, Cancer and other diseases are spreading rapidly

Personalized Treatment Plan

AI –based DSS in telehealth can tailor treatment recommendations based on individual patient profiles. For example, AI can recommend medication adjustments based on real-time patient data. This reduces unwanted effects. Natural language processing (NLP) tools can analyze patient interactions .This helps doctors make more informed decision during virtual consultations.

Remote monitoring and control

In the field of telehealth, AI systems can continuously monitor patients with chronic diseases. It uses data from wearable devices and sensors to detect abnormalities in vital signs

Automatic reminders or suggestions for medication adjustments, lifestyle changes or urgent care can be initiated to ensure timely intervention

Triage and Virtual assistants

An AI-based triad system can help determine the severity of a patient's condition during a telehealth session. It advises health professionals in prioritizing

**Technological Frameworks of AI-Based DSS in Telehealth** AI-driven decision support systems in telehealth are built using a variety of advanced technologies, including:

Machine Learning (ML):

ML models are designed to learn from large datasets and improve their performance over time. In telehealth, ML is often used for diagnostic tools, predictive analytics, and automated decision-making. For example, models can predict patient deterioration or the onset of chronic conditions based on historical data from remote monitoring devices.

Natural Language Processing (NLP):

NLP enables AI systems to interpret and process human language, making it possible to analyze patient interactions, extract medical information, and provide automated responses. NLP-driven AI can assist in analyzing unstructured data from doctor-patient conversations, electronic health records, and patient queries

Computer Vision:

In telehealth, computer vision is often applied for image recognition in fields like radiology, dermatology, and ophthalmology. AI-based systems can analyze medical images from remote locations, assisting doctors with diagnosis and treatment recommendations. For instance, AI algorithms can detect abnormalities in X-rays, CT scans, or retinal images during telehealth consultations.

Robotic Process Automation (RPA):

RPA can automate repetitive tasks in telehealth, such as appointment scheduling, patient follow-ups, and routine data entry. This enhances operational efficiency, allowing healthcare providers to focus more on clinical decision-making

## Application of AI-Based DSS in Telehealth

Remote diagnosis and diagnosis:
AI-powered DSS can help doctors diagnose diseases during tele consultation by analyzing patient data, symptoms and medical history in real time. Artificial intelligence tools have shown successful diagnostic accuracy and early detection for remote diagnosis of common diseases such as diabetes, heart disease or skin lesions.

Management of Chronic Diseases: AI systems can track patient data on conditions like hypertension, diabetes, asthma and COPD, identify risk factors and recommend interventions. These systems can notify both patients and physicians when deviations from expected health parameters occur. AI-based predictive models make it possible to predict disease progression and adjust treatment plans accordingly

Behavioural health and mental health support: AI-powered platforms can assist mental health professionals by monitoring patient interactions (tone of voice, emotion analysis, etc.) during telehealth sessions, providing insights that can inform treatment decisions. Chat bots and AI consultants can provide initial psychological support, assess patients' emotional well-being and recommend appropriate interventions or referrals for more severe cases

Virtual Health Assistant:
Artificial intelligence-powered virtual assistants (eg, chat bots, voice-activated assistants) are commonly used in telehealth to help patients manage their health care needs. They can answer medical questions, provide appointment reminders and help manage medications. These virtual assistants can also serve as early triage tools, asking patients about their symptoms and providing initial advice before contacting a healthcare provider.

Remote care of elderly:
AI-based DSS is particularly valuable in monitoring elderly patients with multiple chronic conditions. Remote monitoring systems equipped with artificial intelligence can detect subtle changes in a patient's health, allowing for early intervention and reducing the number of hospital admissions. AI can also facilitate medication management and decline detection through wearable devices and smart home devices

Tele-ICU and Remote Critical Care:
AI-based DSS can be used in remote critical care scenarios where real-time decision support is critical. Artificial intelligence algorithms can help manage ICU patients remotely by analyzing vital signs, lab results and imaging data, ensuring that urgent problems are flagged for specialists immediately.

For example, AI-powered ventilator management tools can help clinicians make critical adjustments during remote ICU monitoring.

**Advantages of AI-based DSS in telehealth**

Increase in diagnostic accuracy:
By analyzing a wide range of data, AI systems can identify complex patterns that might be missed by human doctors, leading to more accurate diagnoses and personalized treatment options.

Timely intervention: Real-time analysis of patient data enables faster intervention. AI systems can alert healthcare providers to worsening conditions before they become more serious, improving patient outcomes.

Better access:AI-based systems enable remote care for patients in underprivileged or rural areas where access to healthcare is limited. Telehealth platforms with AI can provide quality care without in-person visits.

Cost reduction: AI OSH can reduce healthcare costs by reducing unnecessary hospital visits, optimizing treatment plans and enabling preventive care. This allows healthcare systems to allocate resources more efficiently [11].

Patient Empowerment: Artificial intelligence systems in telehealth provide patients with personalized, data-driven insights into their health, allowing them to take a more active role in managing their condition. Virtual assistants can help patients throughout their healthcare journey, from diagnosis to treatment adherence.

## Challenges and Considerations

Data Privacy and Security: Since AI systems handle sensitive medical information; there are significant concerns about data privacy, security, and compliance with regulations such as HIPAA. Protecting patient data from cyber threats and breaches is critical.

Bias in AI Algorithms: AI models can inherit bias from the data they are trained on, resulting in inconsistent treatment outcomes. To ensure equity, it is important to address the biases of healthcare AI systems, especially against minorities [12].

Regulatory and Ethical Issues: The use of AI-based OSH in healthcare requires a strong regulatory framework to ensure that these tools are safe, effective, and meet legal standards. Ethical issues related to AI decision-making, transparency, and accountability also needs to be addressed [13].

Integration with Existing Systems: [14]
Many healthcare facilities still use outdated systems, so integrating AI OSH into these systems can be challenging. A major challenge is ensuring the interoperability of telehealth platforms, EHRs, and other digital health tools [15].

## Future Directions

Artificial Intelligence Powered Wearable Devices: Future AI-powered DSS in telehealth will likely be powered by more advanced wearable devices capable of continuous, non-invasive monitoring of various health parameters. This will create conditions for more active health care.

AI and Augmented Reality (AR): By combining artificial intelligence with AR, healthcare providers can examine patients in 3D, improving remote consultations. For example, surgeons could benefit from the help of artificial intelligence in performing complex procedures remotely

Federal training and data sharing: To address privacy concerns, federated training techniques allow artificial intelligence systems to be trained using decentralized data sources without compromising patient privacy. This will enable the development of more reliable AI models in telehealth while maintaining security

Personalized medicine: AI-based OHS will be advanced to deliver more advanced personalized medicine approaches by tailoring interventions based on genetic, environmental, and lifestyle factors. It will revolutionize chronic disease management and preventive care.

## Conclusion

Exploring the use of artificial intelligence systems as medical decision support, such as for the use of telemedicine, poses a significant challenge in terms of accountability. AI systems used in healthcare are subject to a rigorous assessment process to verify compliance with all safety and marketing requirements, including European medical device and high-risk AI system qualifications. However, the AI system raises the question of who is responsible for the damage caused by the prediction error.

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