

INTELLIGENT NETWORKING

ENCTNS565

Credits: 4

Year: I

Part: II

Course Objectives

This course provides an in-depth exploration of intelligence in advanced and programmable networking technologies and protocols shaping the future of intelligent communication networks using machine learning. Topics include Intelligent network fundamentals, Intelligence in software-defined networking (SDN), Intelligence in Data Centric Networking/Intent Based Networking and Quantum networking through the application of artificial intelligence and machine learning in such latest networking technologies. The purpose of this course is to provide new knowledge on the latest generation networking technologies making it intelligent through the use of Artificial Intelligence and Machine Learning.

Learning Outcomes	Chapter Contents	Credit hours	Teaching Methods
<ul style="list-style-type: none">□ Understand the evolution and fundamentals of intelligent networking.□ Differentiate between traditional and advanced networking technologies (SDN, IPv6, IBN, DCN, CDN).□ Grasp the basics of quantum and self-organizing networks.□ Apply cognitive networking concepts and recognize its applications.	1 Foundations of Intelligent Networking <ul style="list-style-type: none">1.1 Evolution of intelligent networking1.2 Overview of latest networking technologies: SDN, IPv6, IBN, DCN, CDN.1.3 Overview of Quantum and Self Organization Networks1.4 Fundamental of cognitive networking and its applications.1.5 Basics of Machine Learning and AI in Networking	8	<ul style="list-style-type: none">□ Lectures: Overview of foundational concepts.□ Case Studies: Examples of advancements in intelligent networking.□ Interactive Discussions: Topics like cognitive networking and machine learning.

<input type="checkbox"/> Analyze machine learning methods in networking contexts.	1.6 Supervised, Unsupervised, and Reinforcement Learning in Networking		<input type="checkbox"/> Hands-On Tutorials: Basic implementation of machine learning techniques in networking scenarios. <input type="checkbox"/> Paper presentations.
<input type="checkbox"/> Analyze the architecture and advantages of SDN. <input type="checkbox"/> Evaluate AI applications like QoS/QoE management and traffic prediction. <input type="checkbox"/> Design AI-powered SDN controllers for data-driven decision-making. <input type="checkbox"/> Explore AI-driven network security, anomaly detection, and cloud-edge integration.	2 Intelligence in SDN 2.1 Overview of SDN Architecture 2.2 Advantages of Integrating Intelligence in SDN 2.3 Adaptive QoS and QoE Management in SDN 2.4 Deep Learning Applications in SDN for Traffic Prediction and Classification 2.5 Intelligent NFV & Virtual Network Function (VNF) Placement 2.6 Design and Architecture of AI-Powered SDN Controllers 2.7 Data-Driven Decision Making in SDN Environments 2.8 Integration of SDN with Cloud and Edge Computing Architectures 2.9 AI-Driven Network Security in SDN 2.10 Anomaly Detection and Behavioral Analysis in SDN Environments	12	<input type="checkbox"/> Lecture overview on each topic. <input type="checkbox"/> Hands-On Labs: Working with SDN controllers and simulating traffic prediction. <input type="checkbox"/> Problem-Solving Sessions: AI-driven SDN security scenarios. <input type="checkbox"/> Group Projects: Design and architecture of AI-powered SDN controllers. <input type="checkbox"/> Research Assignments: Exploring adaptive QoS and NFV placement. <input type="checkbox"/> Paper presentations.
<input type="checkbox"/> Workshops: Implementing AI-based cache placement techniques. <input type="checkbox"/> Discussion Panels: Host-centric vs data-centric paradigms.	3 Data Centric Networking 3.1 Overview and Concepts of DCN 3.2 Host-Centric vs Data-Centric Networking	10	<input type="checkbox"/> Lecture overview on each topic.

<ul style="list-style-type: none"> <input type="checkbox"/> Simulation Exercises: Dynamic caching and name-based routing. <input type="checkbox"/> Mini-Projects: AI in secure content access and distribution. 	<ul style="list-style-type: none"> 3.3 Architectural concepts of Named Data Networking (NDN) 3.4 Benefits and Challenges of DCN 3.5 Applications of AI in DCN 3.6 AI-Based Cache Placement and Replacement Techniques 3.7 AI-Based Content Naming and Discovery Techniques 3.8 Dynamic Content Caching Using Reinforcement Learning 3.9 AI-Driven Name-Based Routing Protocols 3.10 Secure Content Distribution and Access Control with AI 		<ul style="list-style-type: none"> <input type="checkbox"/> Understand the shift from host-centric to data-centric networking. <input type="checkbox"/> Identify AI-based techniques for cache management, content discovery, and secure distribution. <input type="checkbox"/> Apply reinforcement learning for dynamic content caching. <input type="checkbox"/> Paper presentations.
<ul style="list-style-type: none"> <input type="checkbox"/> Differentiate traditional networking from IBN. <input type="checkbox"/> Apply machine learning for intent recognition and translation. <input type="checkbox"/> Understand NLP's role in processing user-defined intents. <input type="checkbox"/> Design network slicing strategies for 5G/6G integration. 	<p>4 Intent-Based Networking (IBN)</p> <ul style="list-style-type: none"> 4.1 Overview of IBN Concepts and Architecture 4.2 Traditional Networking vs IBN 4.3 Benefits and Challenges of IBN 4.4 Machine Learning for Intent Recognition and Translation 4.5 Role of NLP in Intent Translation and Parsing 4.6 Understanding and Processing User-Defined Intents 4.7 Automated Threat Detection and Mitigation in IBN 4.8 Integration of SDN and NFV with Intelligent IBN 4.9 Concept of Network Slicing in 5G/6G with IBN 	10	<ul style="list-style-type: none"> <input type="checkbox"/> Lecture overview on each topic. <input type="checkbox"/> Tutorials: NLP techniques for intent parsing. <input type="checkbox"/> Collaborative Projects: IBN integration with SDN and NFV. <input type="checkbox"/> Case Studies: Automated threat detection in IBN. <input type="checkbox"/> Lectures and Demonstrations: Network slicing concepts. <input type="checkbox"/> Paper presentations.

<ul style="list-style-type: none"> □ Explore quantum networking principles, including Qubits and entanglement. □ Analyze protocols like QKD and quantum teleportation. □ Evaluate security vulnerabilities in quantum networks. □ Understand quantum AI applications in traffic analysis. 	<p>5 Quantum Networking [10 hours]</p> <ul style="list-style-type: none"> 5.1 Evolution from Classical to Quantum Networking 5.2 Classical vs Quantum Networks 5.3 Applications and Benefits of Quantum Networking 5.4 Overview of Quantum Bits (Qubits), Superposition and Entanglement 5.5 Quantum Communication Protocols: QKD protocol – BB84, Entanglement-Based QKD 5.6 Quantum Teleportation Protocols 5.7 Quantum Link/Network/Transport Layer Protocol 5.8 Quantum Repeater Chains and Entanglement Distribution 5.9 Security Threats and Vulnerabilities in Quantum Networks 5.10 Quantum AI for Network Traffic Analysis and Anomaly Detection 		<ul style="list-style-type: none"> □ Lecture overview on each topic. □ Interactive Lectures: Quantum protocols and their comparison with classical networks. □ Practical Sessions: Quantum communication protocol simulations. □ Group Discussions: Future applications of quantum AI. □ Research-Based Assignments: Study of quantum repeater chains. □ Paper presentations.
<ul style="list-style-type: none"> □ Predict trends in intelligent network automation and management. □ Develop strategies for self-optimizing and self-healing networks. □ Examine resource optimization techniques using ML. □ Analyze the role of blockchain in secure networking. 	<p>6 Future Directions and Research Challenges in Network Intelligence</p> <ul style="list-style-type: none"> 6.1 Intelligent Network Monitoring, Automation and Management 6.2 Self-Configuring, Self-Optimizing and Self-Healing Networks 6.3 Resource Optimization and Scaling with ML Algorithms 6.4 AI-Based Load Balancing Algorithms in SDN 	10	<ul style="list-style-type: none"> □ Lecture overview on each topic. □ Hackathons: Resource optimization using AI. □ Seminars: Exploring blockchain and decentralized networking. □ Debates: Emerging trends vs established practices.

	6.5 Dynamic Traffic Engineering and Load Balancing Using AI 6.6 Quantum Networking with SDN, NDN and IBN 6.7 Blockchain for Secure and Decentralized Networking 6.8 Emerging Trends and Open Research Challenges in Latest networking		<input type="checkbox"/> Capstone Projects: Innovative solutions for intelligent network challenges.
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Practical:

Students will engage in research based experimental activities in each chapter from 2 to 5.

Evaluation Schemes

a. Internal Evaluation

Type	Weightage
Minor tests	70%
Assignments	30%

b. Final Exam

The questions will cover all chapters of the syllabus. The evaluation scheme will be as indicated in the table:

Chapter	Hours	Mark Distribution*
1	8	8

2	12	12
3	10	10
4	10	10
5	10	10
6	10	10
Total	60	60

*There may be minor deviation in marks distribution.

References

1. Kaur, M., Jain, V., Nand, P., & Rakesh, N. (Eds.). (2024). *Software-Defined Network Frameworks: Security Issues and Use Cases*. CRC Press.
2. Ahmed, S. H., Bouk, S. H., & Kim, D. (2016). Content-centric networks: an overview, applications and research challenges.
3. Bassoli, R., Boche, H., Deppe, C., Ferrara, R., Fitzek, F. H., Janssen, G., & Saeedinaeeni, S. (2021). *Quantum communication networks* (Vol. 23, pp. 1-213). Berlin/Heidelberg, Germany: Springer.