ITECH2300 – Mobile Networks and Wireless Communications

Case Study: Wireless Network Design for Nanya Arid Zone Research Station

1. Background

The Nanya Arid Zone Research Station is a significant conservation area located in far western New South Wales, Australia. Covering 40,000 hectares, Nanya is characterized by unique natural features such as salt lakes, old-growth Mallee vegetation, and a variety of intact ecosystems. It serves as a vital refuge for biological diversity and is managed by Federation University as part of Australia's protected conservation area network. The station is adjacent to the Scotia Sanctuary and the Tarawi Nature Conservation Reserve, expanding the total protected area to approximately 3,000 km². For further information, please visit: https://federation.edu.au/institutes-and-schools/iiss/research/nanya-station

2. Research Activities and Environmental Challenges

Nanya hosts a range of research projects focused on conservation and ecological studies. These projects include:

- The removal of farm dams and the erection of fencing to mitigate the impact of introduced grazing animals.
- Techniques like ripping to encourage vegetation regrowth.
- In-depth studies of specific plant and animal species, some of which are rare or endangered.

The station is equipped with permanent traplines, an extensive spatial database, permanent monitored vegetation quadrats, and a regular program of remote sensing projects. These efforts are supported by satellite, lidar, and UAV imaging. Notable species present at Nanya include the Southern Ningaui, Malleefowl, and Bolam's Mouse, among others.

3. Current Communication Infrastructure

Nanya is located approximately 1,000 kilometers west of Sydney, between Broken Hill and Mildura, and 150 kilometers from the nearest town. The nearby pastoral stations use microwave telephone links and satellite internet services. Currently, Nanya operates two automatic weather stations that upload data to the internet via the Telstra cell tower at Coombah, located 50 kilometers away. However, connectivity issues arise, particularly for the southern weather station, which is on the edge of the tower's coverage. A proposed third weather station remains out of range due to these limitations.

4. Need for a Comprehensive Wireless Network (NanyaNet)

The research station requires a landscape-scale data network, referred to as "NanyaNet," to streamline and enhance data collection and monitoring efforts. The primary objectives for this network include:

1. **Continuous Data Monitoring:** Minimizing the need for physical visits to the site for data retrieval, such as from wildlife cameras.
2. **Enhanced Monitoring Capabilities:** Deploying additional sensors and devices to monitor various ecological aspects, including the continuous observation of malleefowl mounds.
3. **Real-Time Data Transmission:** Establishing reliable communication channels for real-time data transfer from remote locations to the central hub.
4. **Scalability and Adaptability:** Designing a network that can accommodate future technological advancements and expand to include new sensors and monitoring devices.

5. Environmental and Logistical Challenges

The Nanya station is located in a remote and harsh environment, characterized by extreme weather conditions, including high temperatures, dust, and occasional floods and fires. These factors pose significant challenges for deploying and maintaining electronic equipment and communication infrastructure.

This case study provides a comprehensive overview of the current situation and needs at the Nanya Arid Zone Research Station. It sets the stage for exploring the design and implementation of a robust wireless network, addressing the specific challenges posed by the environment and logistical constraints. Students are expected to use this information to develop solutions for the assignments.

Case Study Assignment 1: Design a Wireless Network for NanyaNet

Scenario Overview

The Nanya Arid Zone Research Station, located in a remote and harsh environment, requires a robust wireless network to facilitate continuous monitoring of wildlife and environmental conditions. This case study assignment challenges you to apply your knowledge and skills from the first six weeks of lectures to design an effective wireless communication network for the station.

Assignment Questions (Total Marks: 50)

- **Q1** (5 Marks) Considering Nanya's remote location and environmental conditions, which communication channel (e.g., microwave, satellite, cellular) would be most suitable for establishing the primary data link? Justify your choice based on bandwidth, latency, and reliability requirements.

- **Q2** (5 Marks) Discuss the potential use of unlicensed frequency bands (e.g., ISM bands) versus licensed bands for the wireless network. What are the advantages and disadvantages of using each in the context of NanyaNet?
- **Q3** (5 Marks) Given the distances involved and the need for reliable communication, describe how you would address potential transmission impairments (week 3) such as attenuation, noise, free space loss, atmospheric absorption, refraction, and interference.

- **Q4** (5 Marks) Describe the type of channel modeling (week 4) you would use to predict the wireless network's performance in the Nanya environment. Consider factors such as terrain, vegetation, and atmospheric conditions.
- **Q5** (5 Marks) Explain how you would account for multipath propagation effects in your channel model. What techniques can be employed to mitigate these effects?
- **Q6** (5 Marks) The station experiences extreme weather conditions, including high temperatures and dust. How would these conditions affect signal propagation, and what measures can be taken to ensure network reliability?

- **Q7** (5 Marks) Compare and contrast various spread spectrum techniques (Week 6) such as FHSS and DSSS. Which technique would you recommend for NanyaNet, considering the need for low-power operation and resistance to interference? Provide reasons for your choice.
- **Q8** (5 Marks) How can spread spectrum techniques enhance the security of data transmission in the NanyaNet setup? Provide examples of potential security threats and how spread spectrum can mitigate them.

- **Q9** (5 Marks) Given a total area of approximately 1000 km², outline a basic plan for deploying network nodes (e.g., base stations, repeaters, sensors) to ensure coverage throughout the research station. Include considerations for line-of-sight requirements and power supply options.
- **Q10** (5 Marks) propose a method for ensuring reliable data transmission from remote weather stations and wildlife cameras to the central hub, considering the possibility of intermittent cellular coverage.

Submission Guidelines:

- **Format:** Provide detailed, yet concise answers to each question. Diagrams and illustrations are encouraged where applicable.
- **Length:** Each answer should be approximately 150-300 words.
- You are required to submit a single file (.doc or .docx or pdf or .zip). Please name your file as follows: FAMILYNAME_ GivenName _StudentID _ASS1
  For example, SMITH_John_30091234_ASS1.docx
- All submissions for this unit are via the submission links in the Assessment section of the Moodle shell for the unit.

Marking Rubric for Assignment Questions

Q1 (5 Marks) - Communication Channel Selection

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Understanding of Communication Channels	Demonstrates a thorough understanding of the various communication channels, clearly explaining the suitability of the chosen channel for Nanya's conditions.	Shows a good understanding, with a clear explanation of the chosen channel, though minor details may be missing.	Demonstrates basic understanding but lacks depth in explaining the choice of channel.	Shows limited understanding with an unclear or poorly justified choice of communication channel.	Does not demonstrate understanding of communication channels, with no clear justification.
Justification of Choice	Provides a well-reasoned and detailed justification based on bandwidth, latency, and reliability requirements, with relevant examples.	Justifies the choice with relevant considerations, but lacks some depth or specificity.	Provides a general justification, but lacks strong connection to the specific requirements.	Justification is weak, missing key aspects of bandwidth, latency, or reliability.	No justification provided or completely irrelevant to the question.

Q2 (5 Marks) - Use of Frequency Bands

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Comparison of Frequency Bands	Provides a detailed and accurate comparison of unlicensed vs.	Good comparison with relevant advantages and disadvantages,	Provides a basic comparison, but lacks depth or	Shows limited comparison, with missing or unclear points about	No relevant comparison or significant misunderstanding

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
	licensed frequency bands, highlighting advantages and disadvantages in the NanyaNet context.	though may miss some specifics related to NanyaNet.	relevance to the specific context.	frequency bands.	of frequency bands.
Contextual Application	Effectively applies the comparison to the specific needs and conditions of NanyaNet.	Application to NanyaNet is clear but lacks some specifics or depth.	Basic application to NanyaNet, with some relevance but limited detail.	Application to NanyaNet is weak or vague.	No application to NanyaNet, or completely irrelevant.

Q3 (5 Marks) - Addressing Transmission Impairments

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Identification of Impairments	Accurately identifies all relevant transmission impairments, with a clear understanding of each.	Identifies most relevant impairments, with some minor omissions.	Identifies basic impairments but lacks depth in explanation.	Identifies few impairments, with unclear or incorrect details.	Does not identify relevant impairments.
Mitigation Strategies	Provides comprehensive and effective strategies to mitigate each identified impairment, with clear reasoning.	Provides good strategies, though may miss some details or aspects of mitigation.	Provides basic strategies, but lacks detailed reasoning or coverage.	Provides limited strategies with unclear or ineffective mitigation approaches.	No relevant strategies provided or strategies are completely ineffective.

Q4 (5 Marks) - Channel Modeling

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Understanding of Channel Modeling	Demonstrates a thorough understanding of the channel modeling process, accurately selecting an appropriate model for the Nanya environment.	Shows good understanding, with an appropriate model selected, though some aspects may lack detail.	Demonstrates basic understanding with a model selected, but lacks depth or specific relevance to Nanya.	Limited understanding of channel modeling, with an unclear or inappropriate model selected.	No understanding of channel modeling, with no relevant model selected.
Consideration of Environmental Factors	Accurately incorporates terrain, vegetation, and atmospheric conditions into the modeling process with clear justifications.	Considers most relevant environmental factors, with minor omissions or less detailed justifications.	Considers basic environmental factors but lacks strong connection to the modeling process.	Limited consideration of environmental factors, with unclear or incorrect details.	No relevant consideration of environmental factors.

Q5 (5 Marks) - Multipath Propagation Effects

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Explanation of Multipath Effects	Provides a clear and detailed explanation of multipath propagation effects, showing	Good explanation, though may miss some minor details or aspects of	Basic explanation, with some understanding but lacks depth.	Limited explanation, with unclear or incorrect understanding	No relevant explanation of multipath effects.

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
	deep understanding.	multipath effects.		of multipath effects.	
Mitigation Techniques	Proposes effective techniques to mitigate multipath effects with clear reasoning.	Proposes good techniques, though may lack some detail or effectiveness.	Proposes basic techniques, but lacks strong connection to the specific problem.	Proposes limited or unclear techniques with ineffective mitigation.	No relevant techniques proposed.

Q6 (5 Marks) - Effects of Extreme Weather

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Understanding of Weather Effects	Demonstrates a clear and accurate understanding of how extreme weather affects signal propagation.	Good understanding, with minor omissions or less detailed aspects.	Basic understanding, but lacks depth or specific relevance to Nanya.	Limited understanding with unclear or incorrect details about weather effects.	No relevant understanding of weather effects.
Mitigation Measures	Proposes comprehensive measures to ensure network reliability in extreme weather, with clear reasoning.	Proposes good measures, though may lack some detail or effectiveness.	Proposes basic measures, but lacks strong connection to the specific conditions.	Proposes limited or unclear measures with ineffective mitigation.	No relevant measures proposed.

Q7 (5 Marks) - Spread Spectrum Techniques

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Comparison of Techniques	Provides a detailed and	Good comparison	Basic comparison,	Limited comparison	No relevant comparison or

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
	accurate comparison of FHSS and DSSS, highlighting key differences and relevance to NanyaNet.	with relevant points, though may miss some specifics.	but lacks depth or strong connection to NanyaNet.	with unclear or incorrect details.	significant misunderstanding of techniques.
Recommendation	Recommends the most suitable technique with a clear and well-reasoned justification based on NanyaNet's needs.	Provides a good recommendation with relevant justifications, though lacks some detail.	Provides a basic recommendation, but lacks strong reasoning or connection to the specific context.	Provides a weak recommendation with unclear or insufficient justification.	No recommendation or completely irrelevant choice.

Q8 (5 Marks) - Spread Spectrum for Security

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Understanding of Security Enhancements	Demonstrates a clear understanding of how spread spectrum techniques enhance security, with relevant examples.	Shows good understanding, with some relevant examples, though may miss some details.	Basic understanding of security enhancements, but lacks depth or specific examples.	Limited understanding with unclear or incorrect details about security.	No relevant understanding of security enhancements.
Application to NanyaNet	Effectively applies spread spectrum techniques to	Applies techniques with relevant connections to	Basic application with limited relevance to	Weak or vague application with unclear	No relevant application or completely

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
	mitigate potential security threats in the NanyaNet setup.	NanyaNet, though lacks some detail.	the specific setup.	or ineffective connections.	irrelevant to NanyaNet.

Q9 (5 Marks) - Network Deployment Plan

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Coverage Plan	Provides a detailed and feasible plan for deploying network nodes, ensuring comprehensive coverage with clear justifications.	Good plan with relevant considerations, though may miss some specifics.	Basic plan, but lacks strong connection to coverage needs or feasibility.	Limited plan with unclear or incorrect details about coverage.	No relevant plan or completely infeasible coverage strategy.
Consideration of Technical Factors	Effectively considers line-of-sight, power supply options, and other technical factors in the deployment plan.	Considers relevant technical factors with some detail, though may miss some aspects.	Basic consideration of technical factors, but lacks depth or strong connection to the plan.	Limited consideration with unclear or incorrect details.	No relevant consideration of technical factors.

Q10 (5 Marks) - Reliable Data Transmission

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Understanding of	Demonstrates a thorough understanding	Shows a good understanding, addressing	Basic understanding of challenges,	Limited understanding with unclear	No relevant understanding

Criteria	Excellent (5)	Good (4)	Satisfactory (3)	Needs Improvement (2-1)	Unsatisfactory (0)
Transmission Challenges	of the challenges related to intermittent cellular coverage and the need for reliable data transmission.	most challenges, but may miss some specifics.	but lacks depth or strong connection to the specific context.	or incorrect details about transmission challenges.	of transmission challenges.
Proposed Solution	Proposes a comprehensive and feasible method for ensuring reliable data transmission, with clear and well-reasoned justifications.	Provides a good solution with relevant justifications, though may lack some detail.	Basic solution, but lacks strong reasoning or feasibility.	Weak or vague solution with unclear or insufficient justification.	No relevant solution or completely impractical approach.