**PROJECT PITCH**

**PROJECT NAME:** *Availability and Sustainability Aware Service Function Chains (SFC) Allocation and Embedding in Edge-Cloud Continuum*

**PROJECT MEMBERS:**

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**1. The Golden Circle**

* **Why (Purpose):** The rapid growth of network services, driven by virtualization and edge computing, demands efficient and resilient solutions. However, current approaches often prioritize either availability (reliability) or sustainability (energy efficiency and carbon footprint) leading to imbalances. ***We believe that next-generation networks must be both highly available and environmentally sustainable to meet the demands of modern applications and a greener future.*** This project aims to bridge this gap, ensuring networks can deliver uninterrupted services while minimizing their environmental impact. ***This is important because it directly addresses the increasing need for sustainable technology solutions, driven by energy costs, environmental concerns, and corporate social responsibility.***
* **How (Process):** We will achieve this by developing and evaluating novel algorithms that optimize the allocation and embedding of Service Function Chains (SFCs) in an edge-cloud continuum. This involves:
  + Developing new embedding policies within a simulation environment that consider both availability and carbon footprint metrics.
  + Employing metaheuristic algorithms like Simulated Annealing (SA), Particle Swarm Optimization (PSO), and Genetic Algorithms (GA) to optimize the placement and redundancy of Virtual Network Functions (VNFs).
  + Using a robust simulation environment based on real-world data (Google Cluster Traces) to realistically model network behavior and resource consumption.
  + Analyzing and comparing the performance of different algorithms and policies under various network conditions and traffic loads.
* **What (Product):** The project will deliver:
  + A set of optimized algorithms for SFC allocation and embedding that demonstrably balance availability and sustainability.
  + A comprehensive simulation framework for evaluating SFC performance in edge-cloud environments.
  + Empirical evidence demonstrating the effectiveness of the proposed solutions, including quantitative results on availability, carbon footprint reduction, latency, and execution time.
  + A research paper that publishes our findings and contributes to the field of network function virtualization and sustainable computing.

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**2. PDSA Cycle**

* **Plan:**
  + **Goal:** Develop a system for SFC allocation and embedding that maximizes availability while minimizing carbon footprint in an edge-cloud continuum.
  + **Theory:** By jointly considering availability and sustainability metrics during SFC placement and VNF redundancy optimization, we can achieve a superior balance compared to existing approaches that focus on only one objective.
  + **Success Metrics:**
    - Availability: Percentage of time the SFC is operational.
    - Carbon Footprint: kgCO2 emissions due to energy consumption.
    - Latency: End-to-end delay of the SFC.
    - Redundancy level: Number of redundant VNF instances.
    - Execution time: Time taken by the algorithms to find a solution.
  + **Action Plan:**
    - Refine the existing simulation framework to accurately model the edge-cloud environment and SFC behavior.
    - Implement the proposed embedding policies (availability-aware, carbon-aware, tradeoff-aware) within the framework.
    - Implement the VNF redundancy optimization algorithms (SA, PSO, GA).
    - Design experiments to evaluate the performance of the algorithms under different scenarios (varying SFC types, traffic loads, and weight factors for availability/sustainability).
    - Collect data on the success metrics.
* **Do:**
  + Implement the embedding policies and optimization algorithms in the simulation environment.
  + Run the experiments as designed in the Plan phase, generating data for various network configurations and traffic patterns.
* **Study:**
  + Analyze the collected data to evaluate the performance of the proposed solutions.
  + Compare the results against baseline approaches that prioritize only availability or only sustainability.
  + Identify the strengths and weaknesses of each algorithm and policy.
  + Determine the optimal weight factor (α) for balancing availability and carbon footprint in the tradeoff-aware policy.
  + Determine if the theory was correct. Did jointly optimizing for availability and sustainability yield better results?
* **Act:**
  + Based on the analysis, refine the algorithms and policies to further improve their performance.
  + Document the findings and prepare a research paper for publication.
  + Consider extending the work to address:
    - Dynamic network conditions (e.g., fluctuating traffic loads, node failures).
    - Correlated failures in the network.
    - Other optimization objectives (e.g., resource utilization, operational cost).
    - Different network topologies and VNF types.
  + Use the refined algorithms to inform the next cycle of planning and experimentation, potentially expanding the scope or focusing on specific areas for improvement.
  + Potentially, develop a proof-of-concept implementation on a real-world testbed to validate the simulation results.
  + Explore using machine learning algorithms to adapt the optimization process in real-time.

**3. Technologies to Explore (Study-Act)**

* **Simulation Framework:** Extend and refine the existing simulation framework. Consider using or integrating with existing network simulators like CloudSimSDN.
* **Programming Languages:** Python (with libraries like NetworkX, NumPy, Pandas).
* **Optimization Libraries:** Explore libraries for implementing metaheuristic algorithms (e.g., DEAP for GA in Python).
* **Cloud/Edge Platforms:** To move beyond simulation, consider experimenting with cloud platforms (AWS, Azure, Google Cloud) and edge computing frameworks (e.g., Kubernetes, K3s, AWS Greengrass, Azure IoT Edge).
* **Machine Learning:** Explore the use of machine learning techniques (e.g., reinforcement learning) for dynamic adaptation of the optimization process. Tools like TensorFlow or PyTorch could be used.
* **Data Visualization:** Utilize libraries like Matplotlib, Seaborn, or Plotly to create clear and informative visualizations of the results.

**4. High-Level Idea for Feedback**

The core idea is to develop a system that can intelligently place and manage network functions in a distributed environment, ensuring that services are always available while minimizing their environmental impact. This system will use advanced algorithms to make real-time decisions about where to place network functions and how many redundant copies to create, based on factors like current network conditions, energy consumption patterns, and the desired balance between availability and sustainability.

**Questions for Feedback:**

1. **Feasibility:** Does this project seem feasible within the scope of a course project, given the time and resource constraints?
2. **Novelty:** Is the proposed approach sufficiently novel and distinct from existing work in the field?
3. **Impact:** What aspects of this project are likely to have the most significant impact, both in terms of research contribution and practical application?
4. **Technology Choices:** Are there any other technologies or tools that you would recommend exploring for this project?
5. **Alternative Approaches:** Can you suggest any alternative approaches or directions for this research that might be worth considering?
6. **Expansion:** How might this project be expanded or extended in future work beyond the scope of the current course?