AI-Enhanced Interference Cancellation for 6G

(1) **Research Theme**

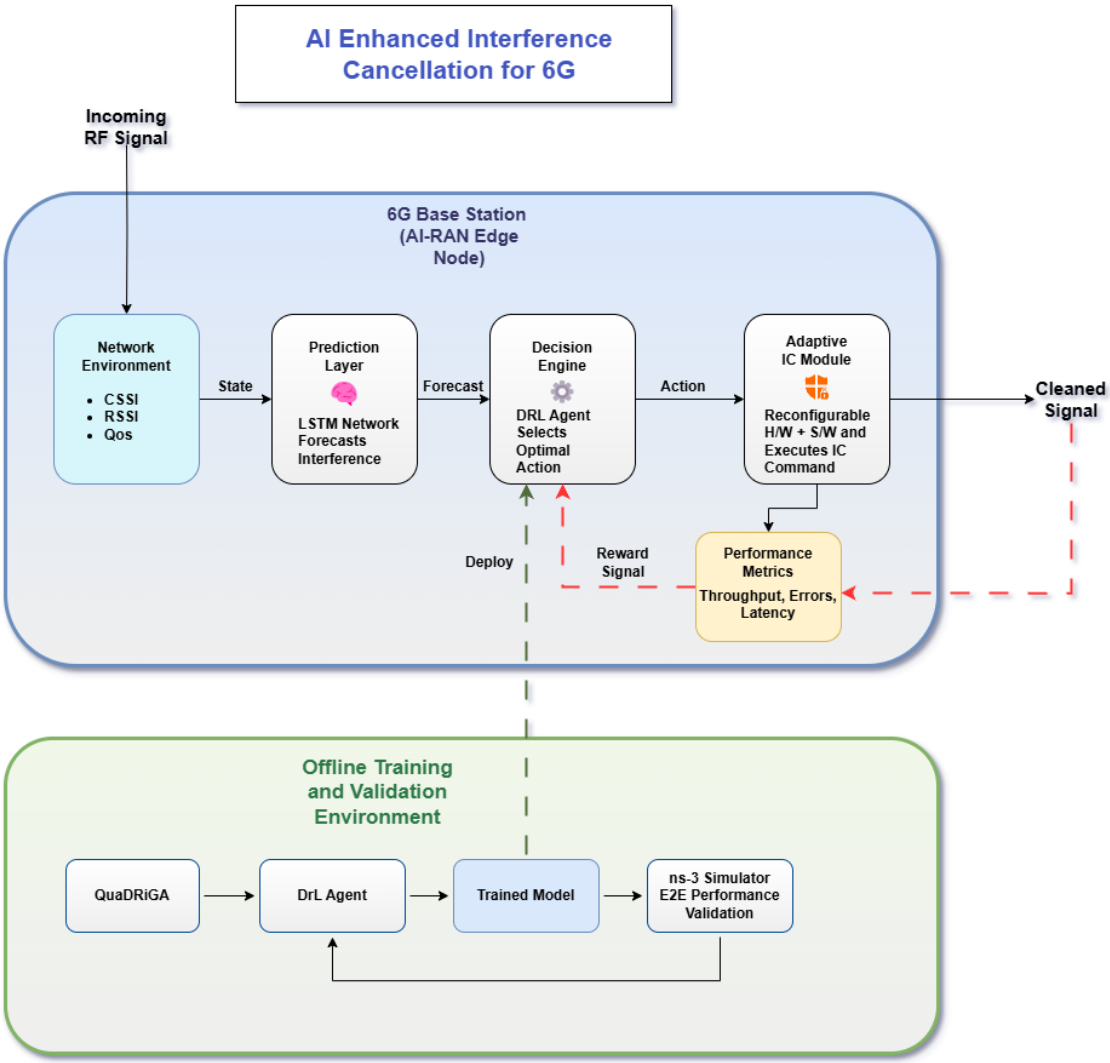
The next generation of wireless, 6G, will enable a hyper-connected world for applications like the Metaverse and autonomous systems. A core 6G strategy is network densification—installing many more base stations to improve capacity. However, this creates massive co-channel interference, where signals clash and disrupt the network. This research will use Artificial Intelligence (AI) as a foundational component of the 6G network to intelligently solve this interference problem, making the network's physical layer adaptive and smart.

(2) **Problem Statement**

- The Paradox: Adding more base stations is meant to improve 6G but backfires by creating overwhelming signal interference.
- The Impact: This interference degrades network performance, causing slower speeds, more errors, and higher latency.
- The Gap: Traditional interference management methods are not effective in these complex 6G environments.
- The Urgency: Future 6G applications like autonomous vehicles, remote surgery, and smart factories demand ultra-reliable, low-latency connections that are impossible to deliver if interference is not controlled.

(3) **Thesis Statement**

This research will develop an AI-based framework embedded directly into 6G base stations to proactively manage interference. The system will use Deep Reinforcement Learning (DRL) to train an AI agent that instantly selects the best interference cancellation (IC) technique (e.g., PIC or SIC) for the current network conditions. This proactive approach allows the system to anticipate and prevent interference *before* it degrades the signal, a major advance over current reactive systems.



(4) **Methodology**

- System Architecture (at the Network Edge)
    - Prediction Layer: An LSTM neural network will forecast upcoming interference levels, enabling pre-emptive control.
    - Decision Engine: A DRL agent will be the "brain," analysing the current state and the forecast to choose the optimal action.
    - Adaptive IC Module: A reconfigurable hardware/software block that executes the agent's command, switching between IC modes.
- DRL Agent Formulation
    - State (What the AI sees): Real-time channel data (CSI), signal strength (RSSI), user mobility, QoS needs, and the LSTM's interference forecast.
    - Actions (What the AI does): Select PIC, SIC, a HYBRID mode, or NO_IC.

    - Reward (How the AI learns): The agent is rewarded for maximizing throughput and reliability but penalized for packet errors and processing delays.

- Simulation & Validation
    - Training: The AI will be trained offline using MATLAB and the QuaDRiGa channel model to generate highly realistic channel data.
    - Testing: The trained agent will be validated in the ns-3 network simulator to evaluate its end-to-end performance under realistic traffic loads.

(5) **Desired Outcomes**

1. A High-Performance DRL-Assisted Interference Canceller: The primary outcome is a working AI system that demonstrably outperforms static interference cancellation methods in dynamic 6G environments.
2. A Proactive Interference Prediction Model: A validated LSTM model capable of short-term channel quality forecasting, a critical enabler for ultra-reliable, low-latency communication (URLLC).
3. A Foundation for the AI-RAN: This work will serve as a proof-of-concept for the broader vision of an AI-native Radio Access Network (AI-RAN), where intelligent agents autonomously optimize the network's physical layer.

(6) **Motivation**

Solving the interference challenge is a critical step to unlocking the potential of 6G. This research is motivated by the opportunity to address this fundamental problem by combining advanced AI techniques with the foundational signal processing work on PIC and SIC trade-offs. The goal is to produce a practical, high-impact solution that contributes to building the powerful and reliable wireless networks of the future.

(7) **Key References**

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