INTELLIGENT HUMAN + ROBOT WORK CELL SIMULATION AND ORCHESTRATION

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Problem Statement

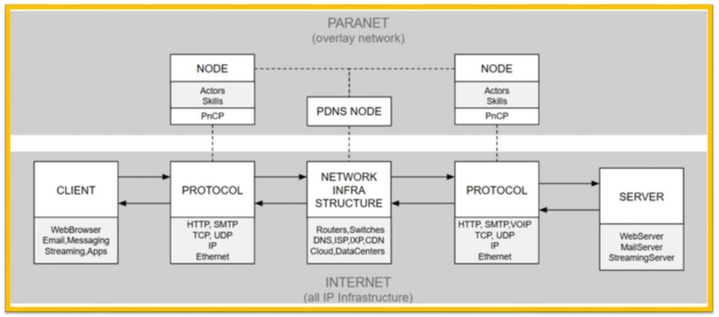
This project aims to assist in the development of a centralized system for seamless human-robot collaboration, that optimizes task coordination, communication, and workflow efficiency using Paranet and NVIDIA Omniverse IsaacSim

- **Main Goal:** highlight the orchestration capabilities of the Paranet regarding human input and autonomous coordination between heterogeneous robots through a work cell simulation

Paranet Framework

Framework and Tools

- **Paranet:** secure skills network for intelligent machine collaboration on top of the IP infrastructure that supports goal-driven workflows with autonomous agents



[1]

- **Paraflow:** programming language developed by Otonoma that is used throughout the project to establish actor's skills, events, rules, and tasks to be completed
- **Paracord:** graphical user interface created by Otonoma that allows a human to interact with the orchestration system, simulation, and robots directly

Orchestration, Action, and Deployment Layers

Orchestration Layer (Decision-Making)

- **Role**: Determines what actions should be performed, by whom, and when
- **Components:** Paranet, Paracord

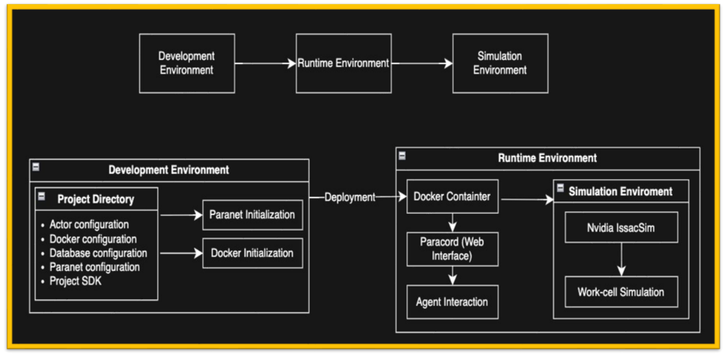
Action Layer (Execution)

- **Role:** Executes specified tasks and returns a status response
- **Code Abstraction:** Actors can use Python, Rust, SQL, etc. through "Skills" written in Paraflow configuration files

Deployment Layer (Docker Integration)

- **Role:** Packages all software dependencies
- **Resource Management:** Partitions the required resources for both layers

Top-Level System Architecture



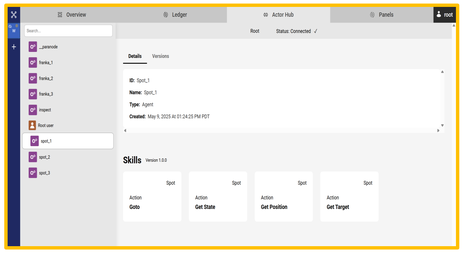
System Architecture

- **Development Environment:** configures the project and handles deployment to the runtime environment
- **Runtime Environment:** hosts Docker containers, managing Paracord for agent orchestration and NVIDIA IsaacSim for the work cell simulation

Paracord Interface

User Accessibility

- **Paracord Interface:** includes features like an **actor hub**, a **ledger** for logging conversations between actors, and an **overview** that shows the connections between the digital twins and Paranet actors



Implementation

How We Successfully Implemented the Simulation

- **Omniverse Simulation:** programmed in Python, leveraging IsaacSim API and Paracord SDK to bridge the simulation filles with Paracord
- **App.py:** the main entry point, launching the Isaac Sim environment, instantiating and registering actors from Paraflow definitions, and establishing a connection to the Paracord Interface.
- **Actors Directory:** Paraflow files where we defined each actor's configuration, including their available skills and tasks
- **Warehouse Directory:** IsaacSim Python scripts using robotic controllers like RMPFlow to define robot behavior and movement, translating skill requests into low-level control actions

Work Cell Simulation

Work Cell Environment

- Simulated factory environment where multiple robots collaborate with a human user to perform orchestrated tasks, demonstrating intelligent coordination and response to system events.

Actors

- 3 Franka Arms
- 2 SPOT Robots
- 1 Human Operator

Scenario

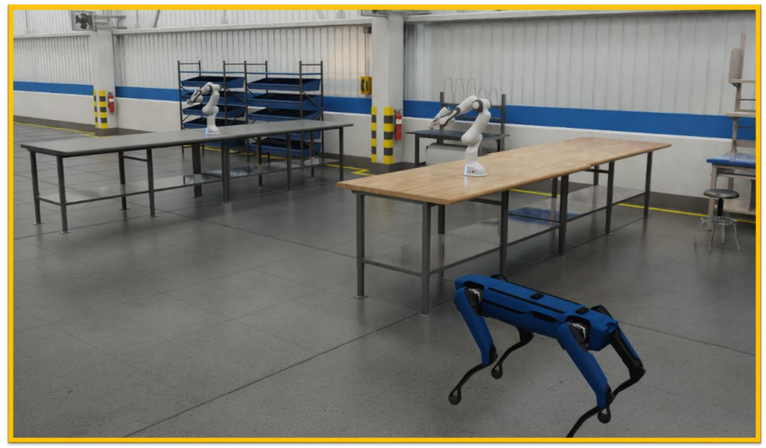
- One Franka Arm is disabled
- Two SPOT robots are available to perform the inspections upon request

User Interaction

- Inspection requested from Paracord Interface

System Response

- Paranet selects closest SPOT to Franka Arm
- SPOT inspects the arm
- Franka Arm is restored and waves to confirm
- SPOT returns to home location



Future Work, References, & Acknowledgements

Future of the Project

- Transition from simulation to deployment on physical robotic platforms without need for any code rewriting
- Scale up the work cell for more complex tasks and environments
- Conduct iterative hardware testing to refine system performance
- Adapt the orchestration framework for use in non-industrial domains

Acknowledgements

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References:

[1] "The Paranet," Otonoma.com, 2025. https://docs.paranet.otonoma.com/

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