

GOALS

The **main goal** is a low latency teleoperation module for the **Elfin collaborative**.

This will allow **Canonical Robots** robotic physiotherapy application (**Physiobot**) to be teleoperated by a **physician**.

CHALLENGES

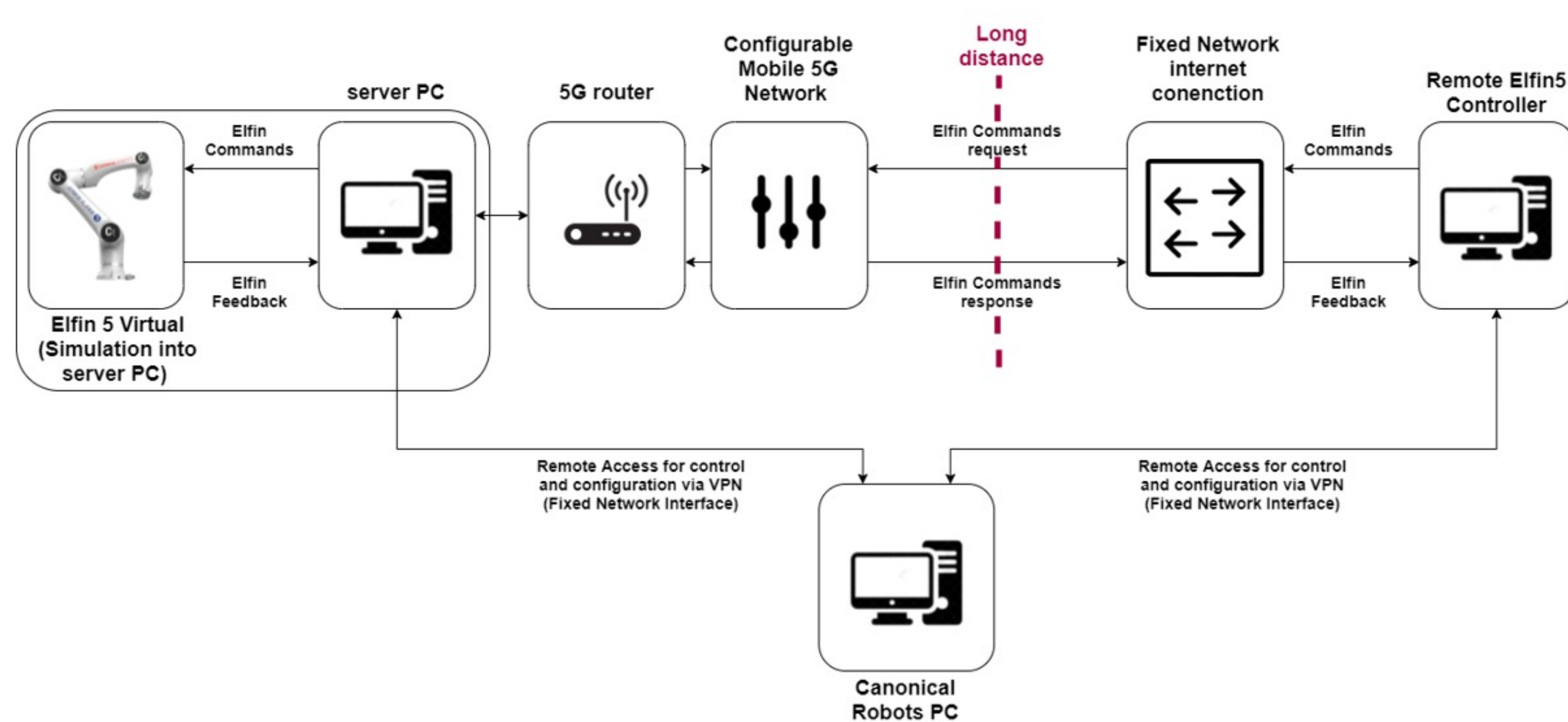
Test in a **real-like** scenario the **viability** of the solution.

Designing an experiment that translates well to **real-life network conditions**.

Measure and analyze the key parameters to evaluate the system performance.

DEMO SETUP

5G set-up deployed at the **UMA campus** for testing of the low latency **cobot teleoperation module**.



RESULTS

Related to the **module performance** the **key metrics** that were **measured** were the following:

- **Robot status fluctuation time (RSFT)** – the status of the robot is sent to the remote controller each **80ms**. The **RSFT remains within the range of 10ms**.
- **Command roundtrip time (CRT)** - this is the elapsed time between the moment the command from the remote robot controller is sent to the remote host and at the moment the confirmation message comes back to the remote controller.

MORE RESULTS

- **Status data** that is sent periodically (**RSFT**) is within the **10ms range**.
- **Latencies measured (CRT)** are well **below the 70ms target** for our application.

	LTE LOS PS	LTE NLOS PS	5G LOS PS	5G NLOS PS
RSFT min	6,723	7,776	4,464	6,183
RSFT max	8,5905	9,936	5,704	7,9005
RSFT avg	7,47	8,64	4,96	6,87
RSFT sd	0,466	0,54	0,31	0,43
CRT min	50,95	52,731	40,13	42,83
CRT max	65,11	67,3785	51,27	54,72
CRT avg	56,62	58,59	44,59	47,59
CRT sd	3,54	3,66	2,78	2,97

Robot teleoperation module characterization for different network configurations

	LTE LOS PS	LTE NLOS PS	5G LOS PS	5G NLOS PS
RSRP max	-83.37	-115.18	-76.43	-113.12
RSRP min	-91.37	-119.00	-77.25	-119.25
RSRP avg	-87.3	-117.36	-76.68	-116.90
RSRQ max	-6.25	9.68	-5.18	-9.43
RSRQ min	-11.62	-16.18	7.43	-18.00
RSRQ avg	-7.73	-12.04	-5.59	-11.84
SNR max	30.00	7.50	29.95	5.28
SNR min	23.40	0.70	29.14	2.34
SNR avg	27.83	3.73	29.62	4.19

Network condition characterization for different network configurations used during the experiment

CONCLUSIONS

- These results **confirm the viability** of the **cobot teleoperation** for the **Physiobot**.
- These data indicate that the **system scales well with network traffic until it reaches values close to network saturation** where the teleoperation module works outside of its minimum operating parameters.
- These data indicate that the **system scales well with network traffic until it reaches values close to network saturation** where the teleoperation module works outside of its minimum operating parameters.

POST MORTEM

- We consider using the **UDP protocol** instead of TCP.
- Detected need of a **watchdog** implementation that **prevents the robot teleoperation on low-quality connection** conditions.
- We plan to work on the **final implementation** of the **teleoperation module** and its **integration** into the **Physiobot** application.