

Motivation

The traditional Radio Access Network (RAN) architecture is resource-intensive, costly, and inflexible, making it less suitable for the stringent requirements of 5G. Cloud-RAN (C-RAN) offers a centralized and virtualized alternative, but most existing solutions rely on virtual machines (VMs), which are less efficient. Our project aims to address these limitations by leveraging container-based migration to reduce resource overhead, improve scalability, and minimize network latency and downtimes, all while meeting the demands of modern telecommunications and contributing to the advancement of 5G technologies.

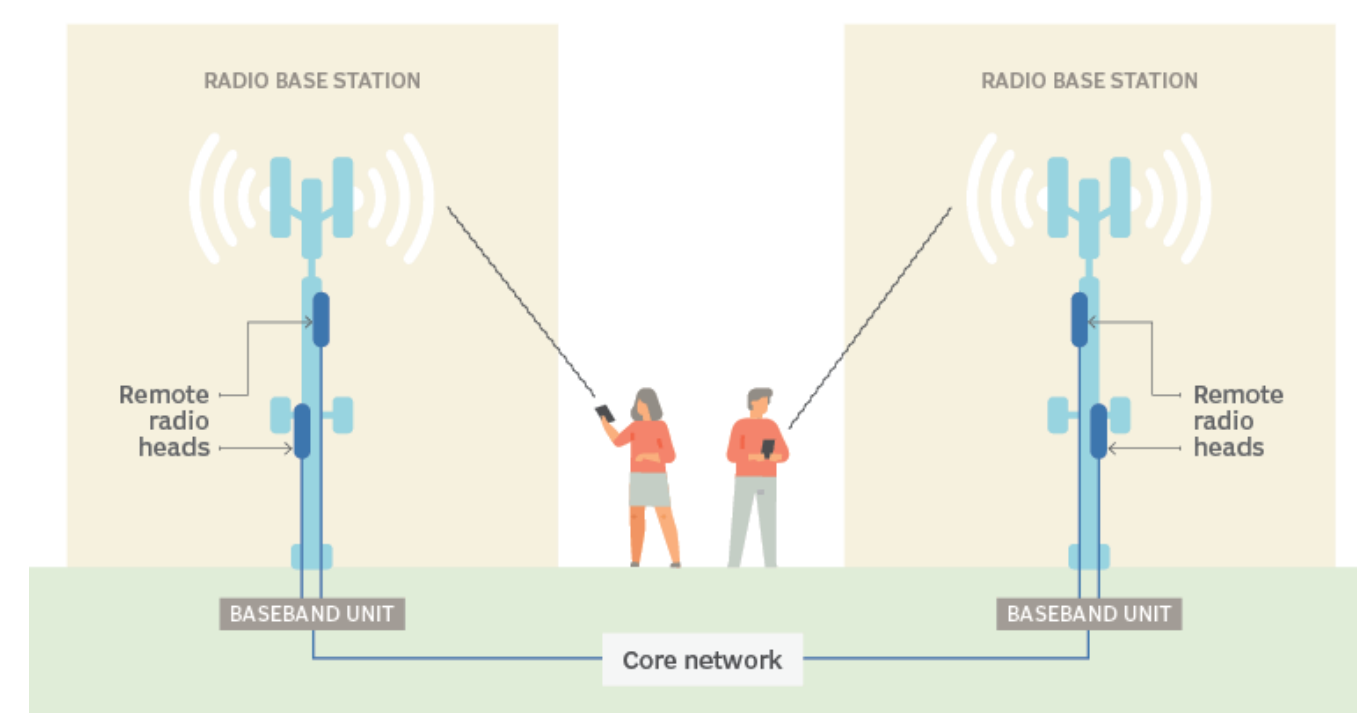


Figure 1. Basic RAN Architecture [3]

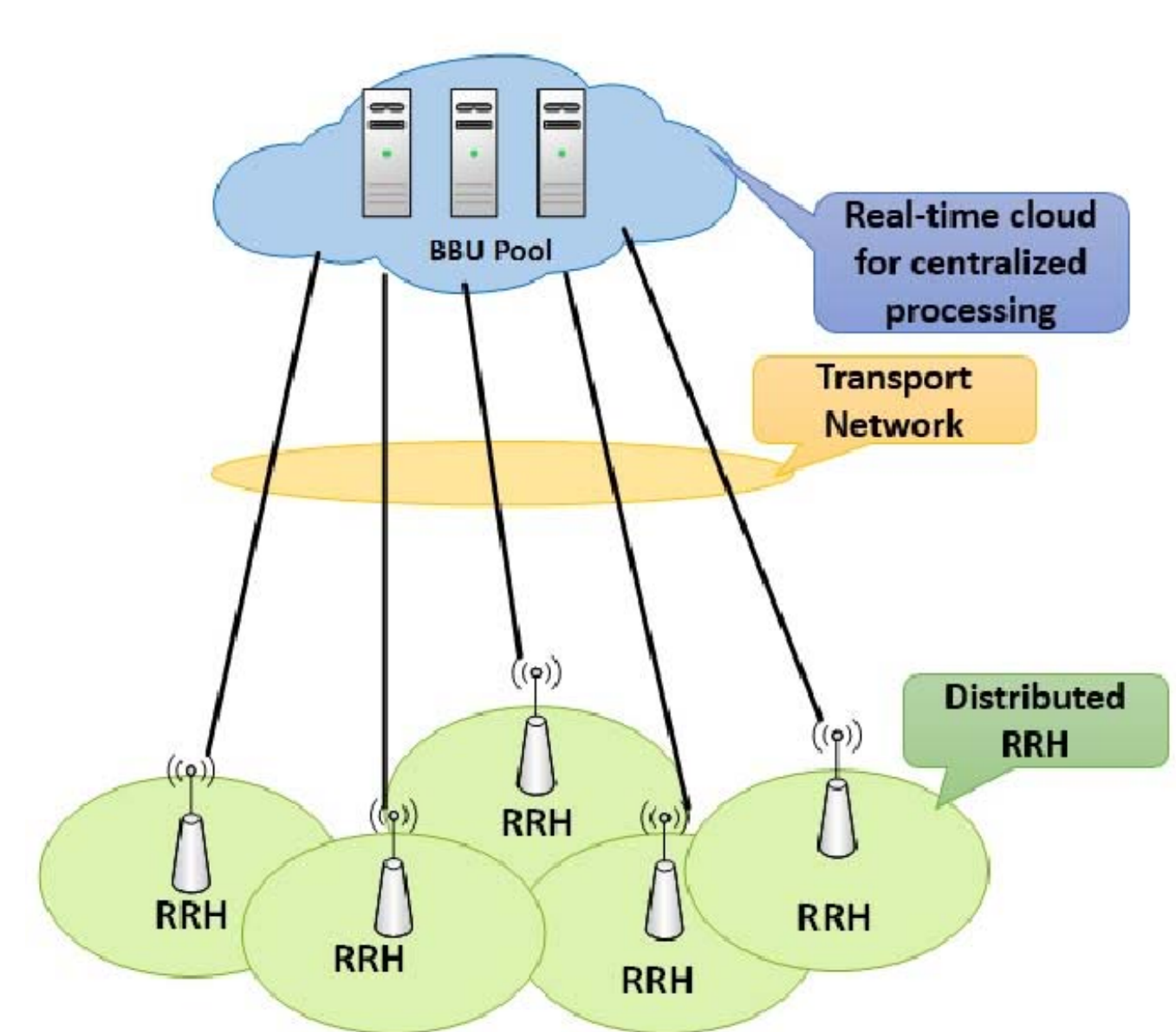


Figure 2. C-RAN Architecture [4]

Project Definition

This project focuses on implementing a container-based live migration system for Cloud-RAN. The goal is to migrate server processes between virtual machines with no disruption, ensuring high availability. Our approach combines a custom containerization tool (Jailor), the utilization of CRIU (Checkpoint/Restore in Userspace)[1], and a Software Defined Networking (SDN) controller to handle dynamic traffic routing. By simulating real-world traffic with UDP server-client applications, we aim to optimize migration techniques such as pre-copy, post-copy, hybrid, and custom methods, tailored to the unique requirements of 5G networks.

System Design

Diagrams below demonstrates how components work together and how the data flows between them.

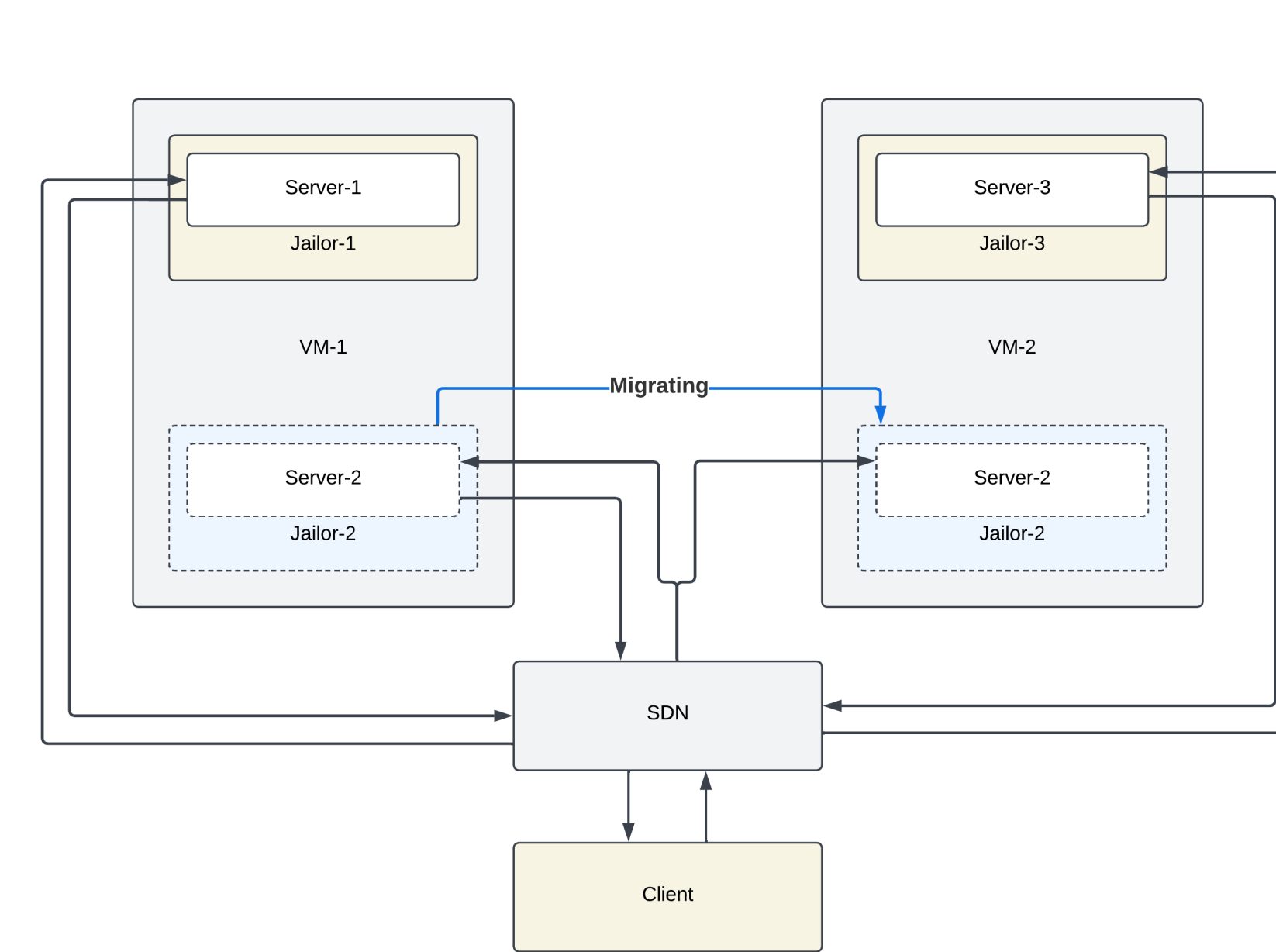


Figure 3. Data flow and system design for Server - Client communication via SDN

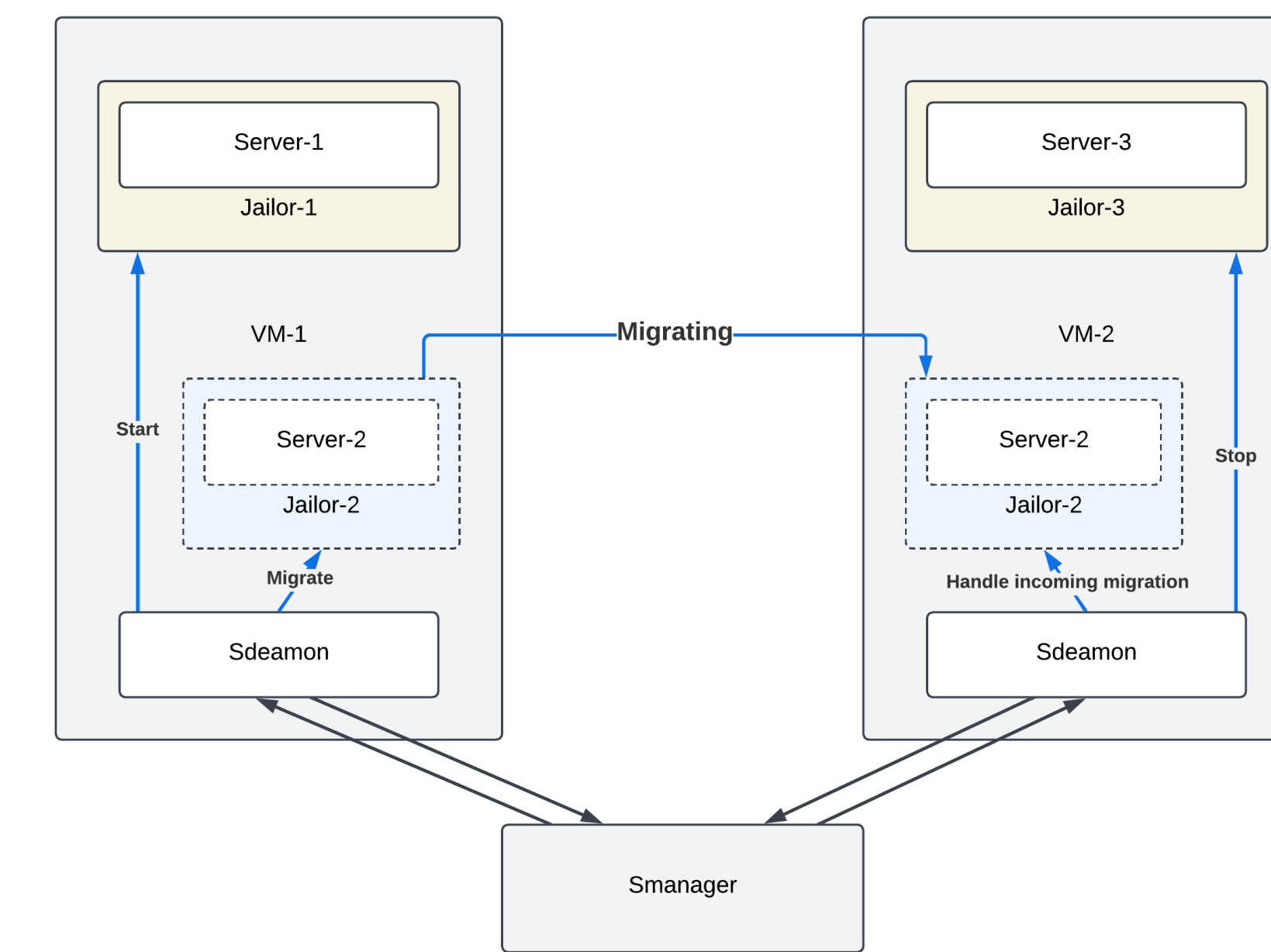


Figure 4. Data flow and system design for Smanager - Sdeamon communication to manage containers

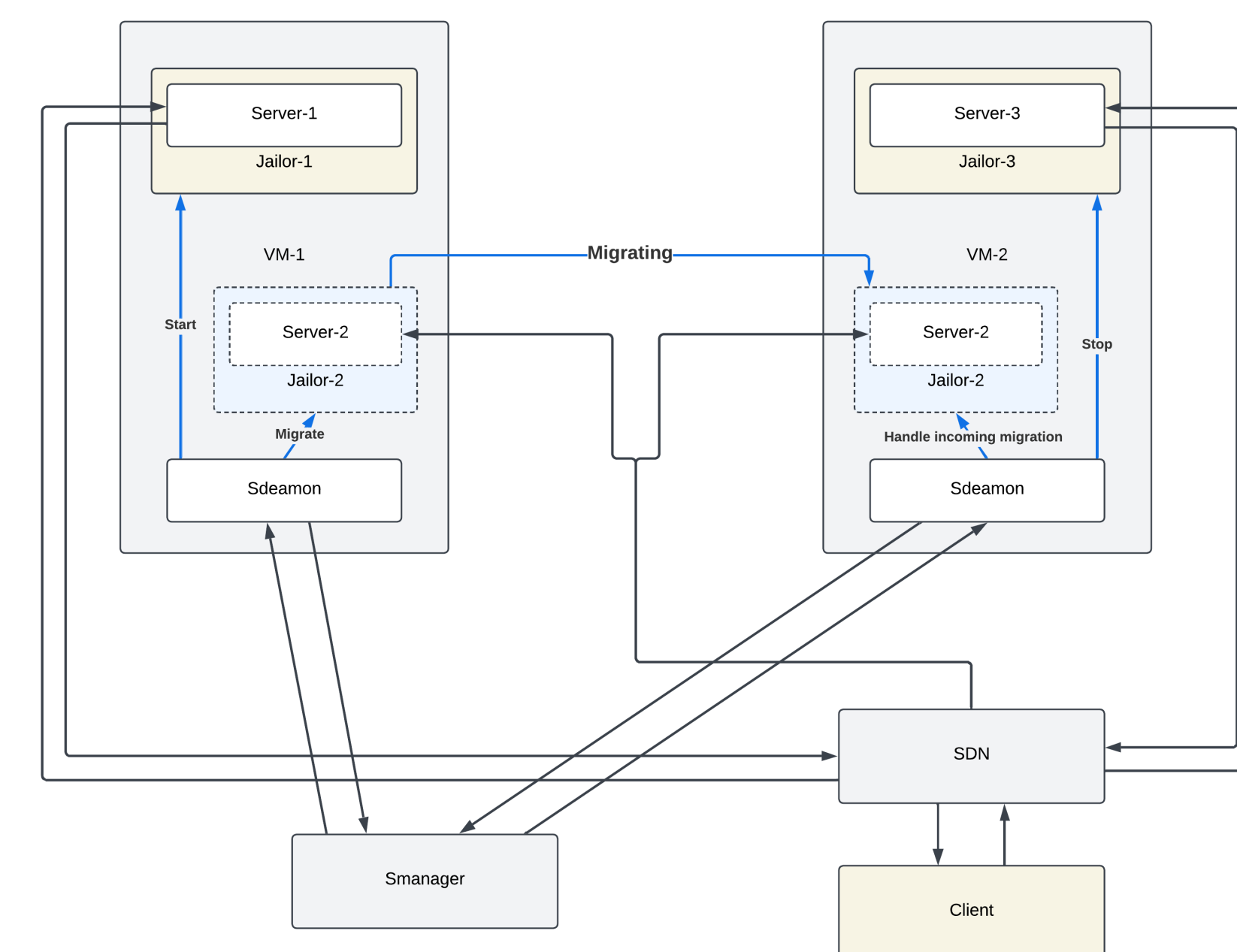


Figure 5. Overall system design

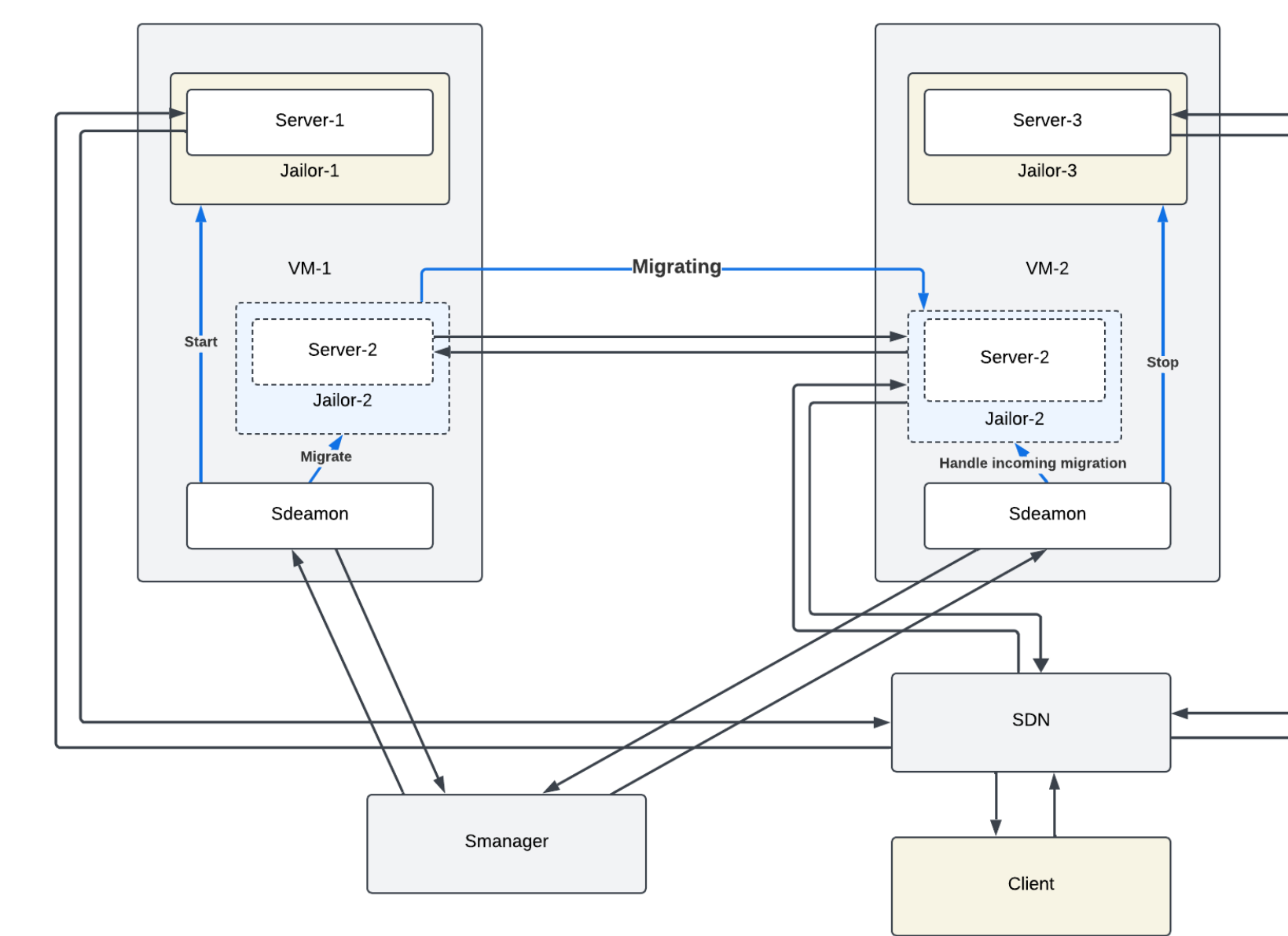


Figure 6. System design of the custom approach to migration

Conclusion

Significant research and progress were made in understanding the complexities of live migration and containerization. A custom containerization tool has been developed. Cold migration between different containerized environments that are working on different virtual machines have been accomplished by utilizing CRIU. The foundational work, tools, and insights gained from this project provide a solid base for future advancements in container-based migration tailored to Cloud-RAN. However, the project is not completed and needs more effort to complete the remaining work.

Future Work

The remaining tasks include:

- Conducting advanced research and practice on CRIU's C API for better migration control.
- Developing optimized migration techniques such as hybrid and novel approaches to minimize downtime.
- Extensive testing and benchmarking against existing containerization tools, such as Docker, Podman, and LXC/LXD, along with their migration solutions to evaluate efficiency and performance.

Related Work

Previous studies have explored virtual machine based and container based approaches for C-RAN. Tasdan and Sevgican demonstrated VM-based live migration but faced resource overhead challenges[6]. Benzer and Topal's work highlighted the advantages of containers for 5G vRAN, using Docker and Kubernetes for improved scalability and reduced latency[7]. Liang's MiGrror technique introduced event-driven synchronization for container migration, significantly reducing downtime[5]. Building on these insights, our project focuses on tailoring container-based migration to meet the stringent demands of 5G networks, combining custom tools and methodologies for enhanced performance.

References

- [1] Criu official website: <https://criu.org/>.
- [2] Project's github repository: <https://github.com/simurgan/comicran>.
- [3] What is rru in telecom?: <https://www.radiall.com/insights/what-is-rru-in-telecom>. 2022.
- [4] Olfa Chabbouh, Sonia Ben Rejeb, Zied Choukair, and Nazim Agoulmine. A novel cloud ran architecture for 5g hetnets and qos evaluation. 2016 International Symposium on Networks, Computers and Communications (ISNCC), pages 1–6, 2016.
- [5] Xinwen Liang. Container migration: A performance evaluation between migror and pre-copy. Western University, Electronic Thesis and Dissertation Repository, 2024.
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