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A DATA-STREAM-RING ARCHITECTURE FOR HIGH-BANDWIDTH, REAL-TIME HEALTH SERVICES ON THE MOON SURFACE

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ABSTRACT

A Data-Stream-Ring architecture for high-Bandwidth, real-time health services on the moon surface is proposed. The architecture connects in a ring, lunar surface habitats which include control towers, data center facilities and Cardiac Intensive Care Units. The modular lunar surface habitats simulate earth airport facilities on the lunar surface (Lunarports) providing services in the domains of Health, Habitation, Energy, Mobility, Logistics, Power and In-Situ Data Stream Processing. In this paper we'll focus on the provision of Telecardiology Services which monitor and diagnose cardiac issues, in order to pro-actively guide operations teams to rescue humans at risk. Our research is based on data stream processing services at large scale (Internet-of-Space) by adapting the technology developed by our team at UCLA (Hoffman cluster) and at ARIS HPC infrastructure of Greece (GRNET), capable to monitor millions of Internet-of-Things in real-time (478 million IoT with latency on the order of milliseconds).

1 INTRODUCTION

This paper presents a data-stream-ring architecture developed within the context of Simulation Exploration Experience (SEE) in years 2024 and 2025, an international competition led by NASA, which brings together students, industry, professional associations, and faculty, for an annual modeling and simulation challenge. The author of the SEE presentation (Conroy 2015) presents a Habitat Demonstration Unit, where NASA architects, engineers and scientists have developed sustainable, space-based living quarters, workspaces and laboratories for next-generation human spaceflight missions. As published in (Simpson et al. 2020) for more than 60 years NASA has played a very significant role in helping the development and promotion of a variety of remote medical monitoring and treatment solutions both for astronauts and for the general population.

Inspired by the efforts of the NASA teams, we have identified the need for the provision of real-time services, to support a large number of vehicles, astronauts and "things" living in Habitat Demonstration Units in a similar manner to the paradigms followed on earth. We have thus extended the already well-matured concept of the Internet-of-Things, introducing the concept of the **Internet-of-Space (IoS)**, proposing In-Situ Data Stream Processing and terminal services to everyone and everything in the domains of, Health, Habitation, Energy, Mobility, Logistics and Power. For the provision of such services, we propose a fundamental infrastructure, a lunar surface habitat equivalent to an earth airport facility which we name **Lunarport**.

This paper focuses on the domain of Health proposing a data-stream-ring architecture for high-bandwidth, real-time health services on the moon surface. One of the main services the Lunarport will offer telemedicine -- especially telecardiology services to humans living in habitats on the moon and astronauts on missions. More specifically, the health of humans, will be monitored through large scale ECG systems in the form of IoS devices. Electrocardiogram (ECG) signals will be transmitted through the Internet-of-Space to a Cardiac Intensive Care Unit, a habitat hosted at the Lunarport.

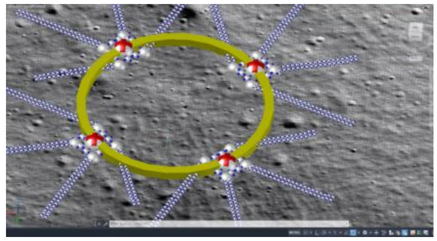

Figure 1: The innovative Data-Stream-Ring Architecture connecting four Cardiac Centers in respective Lunarports, providing distributed, real-time telecardiology services on the moon surface.

At the Lunarport Cardiac Intensive Care Unit, doctor teams supported by real-time analyses of ECGs generated by state-of-the-art Artificial Intelligence algorithms, can monitor and diagnose cardiac issues, and pro-actively guide operations teams to rescue humans at risk. For the provision of real-time, data stream processing services to a large number of humans and IoS devices, we'll be extending the technology developed by our team at UCLA (Hoffman cluster) and at ARIS HPC infrastructure of Greece (GRNET) (Michael et al. 2022), capable to monitor millions of Internet-of-Things in real-time (478 million IoT with latency on the order of milliseconds, 4.7 Gbit/s total average aggregated throughput).

2 THE INNOVATIVE DATA-STREAM-RING ARCHITECTURE

Figure 1 shows modular Lunarports, in a ring topology implementing four Cardiac Center habitats with respective Cardiac Intensive Care Units, Data Center facilities and terminal services for human support. The schematic of each Lunarport has been inspired by the design of the Frankfurt airport terminal 3 (Frankfurt Airport 2025). For moon operations, the ring topology allows for astronauts at risk to access the nearest Lunarport connected to the ring. From the perspective of computer networks, connectivity to the high-bandwidth backbone ring of the data streams generated from remote IoT is improved. Different teams of doctors located at the Cardiac Centers, perform specialized analyses in real-time. Doctor teams can access **the same real-time information** enabled by the Data-Stream-Ring architecture. This novel architecture extends the spatio-temporal cuboid data stream model of the work "Blue Danube" (Michael et al. 2022). Initial tests of the ring architecture have been performed by our team at the ARIS HPC infrastructure of Greece giving satisfactory results in respect of the real-time performance requirements. Exhaustive experimentation and a full paper publication is planned for the near future.

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