

System Design Proposal – ISS Health Monitoring System

1. Introduction

The International Space Station (ISS) is a large spacecraft orbiting around the Earth at an average altitude of approximately 250 miles. It started its operation on the 2nd of November 2000, when the first crew arrived. Astronauts have been living there ever since. The ISS serves both as a home and a workplace to six international astronauts and cosmonauts at a time (NASA, 2020).

Astronauts living in space can have both short and long term health problems including Loss of Bone Mineral Density, Loss of Muscle Mass, Cardiovascular System problems, Negative physiological effects, etc. (NCBI, 2001).

2. Current Health Monitoring System

NASA's healthcare centres have defined a "health standard" target for all of its astronaut crews which drives all health-related systems and functioning requirements (NASA, 2007). Traditionally, the ISS was equipped with bulky medical devices where astronauts monitored their vital signs and reported them to the ground staff (Government of Canada, 2019). However, today, with the usage growth of IoT devices, ISS astronauts started using wearable devices (such as smartwatches, shirts, etc.) to monitor their vital signs twenty-four-seven. These IoT devices send continuous real-time data including the crew's heart rate, blood pressure levels, body temperature, breathing rate and oxygen levels to the ground staff for monitoring (LSDA, n.d).

Such non-obtrusive monitoring devices include the Biomonitor shirt or "Astroskin" developed by Quebec's Carré Technologies Inc. (Government of Canada, 2019), the "CardiacSense" medical watch developed by CardiacSense and the Israel Aerospace Medicine Institute (PR Newswire, 2021) and more.

While these devices are disrupting the dated medical devices used in the International Space Station, their usage creates new security and privacy threats. Both these devices and the data receiving centres on the ground need to operate on secured and protected network links to shield the data from unwanted breaches and attacks.

3. Proposed System (see Appendix A)

Taking into consideration all privacy and security regulations, a secured communication system needs to be developed to connect all the medical monitoring devices aboard the ISS (wearable/non-wearable) with the receiving centres on the ground. A secured domain will be deployed where the health monitoring team's ground computers will be connected. All medical monitoring devices onboard the ISS will wirelessly transmit all health data to a computer located in the International Space Station. This computer will be connected to the same domain and will continuously upload all the health data it receives from the devices to the domain's database. The domain will be accessible from a web application or a command line interface.

The system will adhere to the advice and guidance laid out by the OWASP. This will allow the system to meet the most up-to-date security standards. To allow the system to be more easily maintained and updated into the future, all code written will conform to the PEP 8 style guide and contain sufficient comments and documentation. Coding antipatterns such as God

Objects, Golden Hammers and Spaghetti Code will also be avoided, and instead, a modular approach to writing code will be employed (Parr, 2020).

4. Tools and Libraries that will be used:

- The proposed system will be developed in Python, using the Codio online IDE and PyCharm.
- Pylint will be used to check for any syntax errors, and to ensure that the code conforms to the PEP 8 style guide.
- Flask will be used to develop the web application, along with proper authentication.
- A PostgreSQL database will be used to store the data.
- Fernet will be used for encrypting and decrypting data.
- Scrypt/Bcrypt/Argon2 will be used for password hashing.

5. Domain-Specific Requirements

Operating Systems:

A mixture of Linux and Windows systems have been used onboard the International Space Station since its launch. Currently, the laptops onboard run a mixture of Windows 10 Enterprise and various Linux distributions, such as Scientific Linux (Heath, 2016).

The web application must be compatible and accessible from these operating systems.

Technologies:

The developed application programming interface must support access via a web browser and/or a command-line application. Additionally, users must be able to upload, download, and share data in the application. Therefore, a stable and constant internet connection is required. The source code of all technologies must be available for security auditing. Consequently, the domain will be developed using a three tier architecture (Ninikrishna et al., 2020).

Others:

All privacy and security regulations governed by international law, ESA PDP, HIPPA and HITECH must be met. Moreover, a monolithic approach is required due to scalability concerns.

6. Challenges and Assumptions

High-quality training is required for both the ground staff and the astronauts in order to keep the data transmitted secured within the domain. Exporting, sharing or saving data to third-party devices or servers can result in an unchecked data breach. Additionally, ground computers should only be accessible from the medical team. While only authenticated users will be able to access the data, unauthorized access to the physically connected computer can lead to unwanted data leak.

Moreover, the crew located in the International Space Station must keep their wearable IoT devices charged, otherwise, no data will be transmitted.

References:

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Parr, K. (2020) Anti-patterns You Should Avoid in Your Code. Available from: <https://www.freecodecamp.org/news/antipatterns-to-avoid-in-code/> [Accessed 06 June 2021].

Appendix A

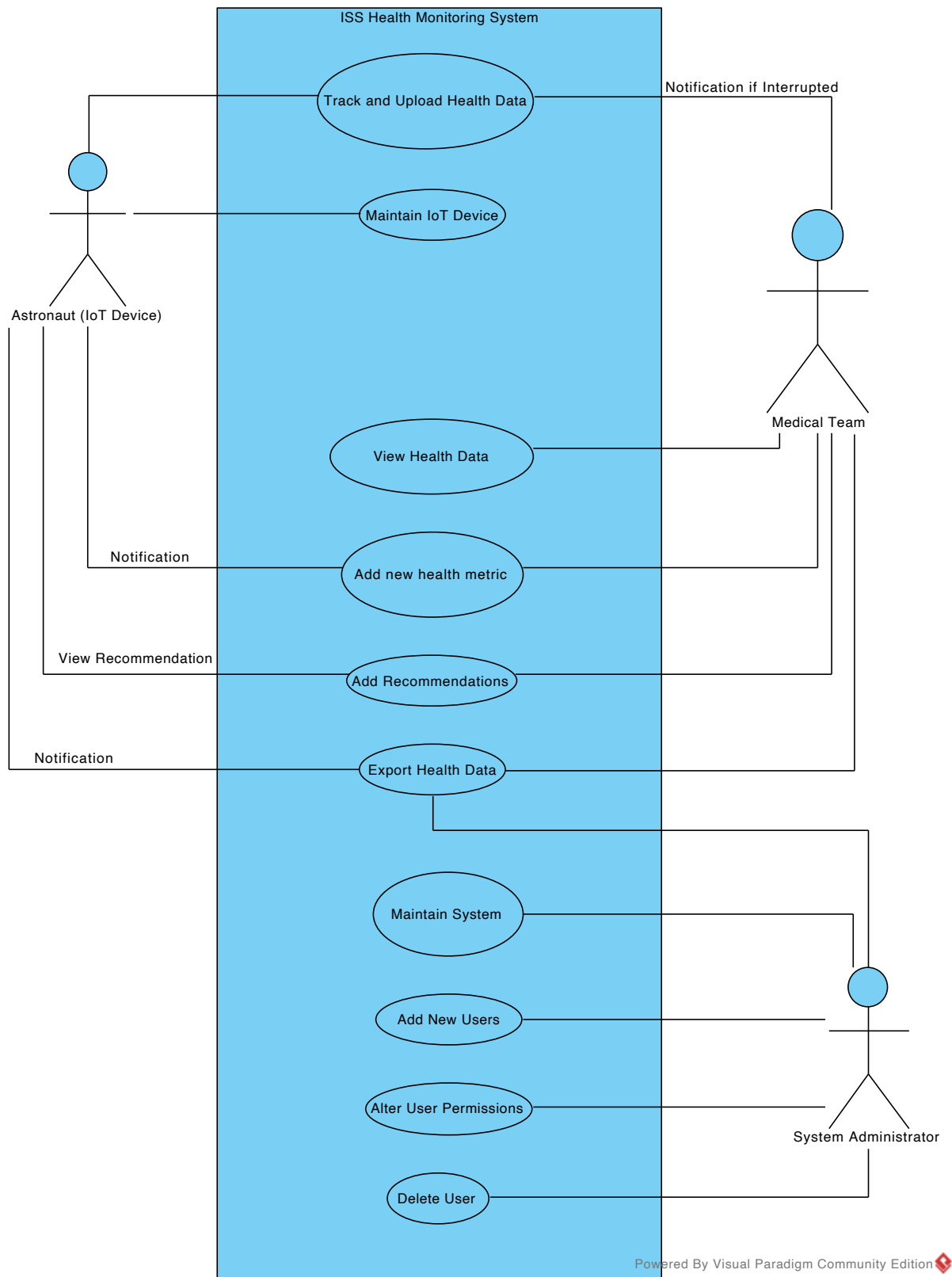


Fig 1.1 “Use Case Diagram”