NIGHT GUARDIAN: EPILEPSY MONITORING PLATFORM

PROYECT MOTIVATION

"Cameron Boyce, the 20-year-old Disney Channel star, died from sudden unexpected death in epilepsy (SUDEP), as confirmed by the Los Angeles County coroner's office in the United States."

Epilepsy is a chronic neurological disorder characterized by the brain's predisposition to generate seizures. A seizure is an abnormal, excessive, and synchronous discharge of cortical neurons, producing motor, sensory, cognitive, emotional, or autonomic symptoms depending on the brain region involved.

The exact cause of epilepsy is not fully understood, and it is unlikely that a single explanation exists. However, seizure activity in the brain can sometimes trigger changes in breathing or heart rhythm. For this project, however, we focus on nocturnal frontal lobe epilepsy (NFLE). This is a focal epilepsy in which seizures occur primarily during sleep, particularly during light non-REM stages. NFLE is characterized by very brief but strong motor episodes: abrupt movements, unusual postures, shouting, or even jumping out of bed. These events are frequently mistaken for parasomnia such as sleepwalking or night terrors. Although the seizures are short, they may occur repeatedly throughout the night, disturbing sleep and, in some cases, posing a life-threatening risk. NFLE can occur at any age, but it is more common in children, adolescents, and young adults, often beginning in childhood or adolescence and persisting in adulthood.

The monitoring system will focus on two key physiological signals:

- **Electrocardiogram (ECG)**: In many cases, heart rate increases minutes before a seizure. These changes may be presented as sudden tachycardia, alterations in heart rate variability, or, less commonly, bradycardia and sinus pause. Reviewing ECG recordings, especially during the night—helps confirm whether a suspicious nocturnal episode coincided with an autonomic change. This strengthens the likelihood that it was a seizure rather than parasomnia, which is a frequent diagnostic challenge in NFLE.
- **Accelerometer**: Accelerometer is especially relevant because NFLE seizures are typically highly motor, brief, and repetitive, involving sudden jerks or abnormal postures of the arms, legs, or trunk. These patterns can be confused with parasomnia. An accelerometer can detect and record such abnormal movements during sleep, providing objective information on seizure frequency and characteristics, even when the patient is unaware. This assists physicians in distinguishing epileptic seizures from other sleep disorders and in evaluating the true nocturnal seizure burden to better tailor treatment.

The goal of this telemonitoring system is to provide continuous overnight monitoring for patients with nocturnal frontal lobe epilepsy (NFLE). Throughout the night, ECG data and accelerometer readings will be collected. The patient's physician can later review these recordings to assess seizure frequency and severity and to adjust treatment as needed.

SUMMARY

This project consists of three independent desktop applications: **Epilepsy Admin**, **Epilepsy Patient**, and **Epilepsy Doctor**. Each application is executed through a graphical Java Swing interface provided by its corresponding `Application` class. Together, they form the *NightGuardian Telemedicine Platform*, enabling secure communication and monitoring of patients with epilepsy.

The communication between applications is performed over **TCP**, using a custom client–server architecture. All exchanged messages are encrypted: an **RSA** key pair is used during the initial key exchange, and afterwards all communication is protected using **AES-GCM** symmetric encryption. Messages are serialized in **JSON format**, ensuring structured and secure transmission without exposing plain text.

The **Epilepsy Admin** application manages two databases: **MedicalDB** and **SecurityDB**.

- *MedicalDB* stores all medical-related information, including patients, doctors, reports, and recorded signals.
- *SecurityDB* contains authentication-related data such as users and roles.

Both databases are accessed through **JDBC**, and they are logically linked via the patient/doctor's e-mail address, handled through the `AdminLinkService` and supporting data-mapping classes. Passwords and each user's public encryption key are stored in SecurityDB and protected using secure hashing.

The Epilepsy Patient application continuously records raw biometric signals from a BITalino device (ECG and accelerometer) throughout the night, storing all data locally without modification. During the recording, the system performs a lightweight real-time analysis whose purpose is not to diagnose, but to monitor potential seizure-like patterns. When the system detects a suspicious event, it immediately presents a pop-up window requesting feedback from the patient to confirm they are safe.

If the patient does not respond within one minute, the system assumes a potential seizure is occurring and automatically notifies the administrator. The administrator is then responsible for alerting the patient's emergency contacts and the appropriate medical authorities, so assistance can be provided at the patient's location. After the recording session ends, only the raw data is compressed into a ZIP file and securely transmitted to the server through an encrypted TCP channel for later clinical review.

The **Epilepsy Doctor** application receives the signals uploaded by patients, enabling the doctor to access, comment on it, and manage the incoming biometric recordings. The application integrates with the server to download patient data, visualize available recordings, and coordinate the clinical workflow.