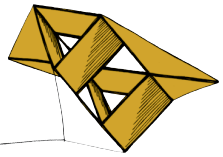

Real-Time Concept for SmartCGMS

Petr Kocián[1]

1 Introduction

Diabetes mellitus is a globally widespread metabolic disorder characterized by elevated blood glucose levels, which, if left untreated, can lead to severe complications. Managing blood glucose levels is essential for diabetic patients. Continuous glucose monitoring (CGM) systems provide an estimate of the patient's blood glucose levels. SmartCGMS is a framework for continuous glucose monitoring (CGM) systems introduced in Ubl, M. and Koutny, T. (2019). CGM systems help diabetic patients monitor their blood glucose levels. The purpose of bringing SmartCGMS to low-power devices is to create a closed-loop system - an artificial pancreas. A closed-loop system is a set of devices that can autonomously control a diabetic patient's blood glucose levels based on measurements from a CGM sensor by injecting insulin using an insulin pump. The SmartCGMS framework is capable of implementing a closed-loop system with SmartCGMS components (e.g., prediction algorithms, and data receivers and transmitters). Therefore, the goal of this project was to propose, implement, and evaluate a SmartCGMS concept for low-power devices (ARMv6 and Xtensa). The concept must maintain compatibility with desktop devices (x86-64/AMD64), where computationally intensive pre-clinical simulations take place.

2 The SmartCGMS Concept

Only the necessary parts of SmartCGMS were modified to maintain maximum compatibility across high-performance and low-power platforms. In addition to modifying the SmartCGMS codebase, it was essential to provide a way to compile SmartCGMS components for low-power devices. A preprocessor tool that modifies the source code files of SmartCGMS components was implemented. It allows the compilation of SmartCGMS components across all supported platforms. The low-power platforms (Raspberry Pi Zero W and ESP32) use FreeRTOS as the underlying real-time operating system (RTOS). However, the concept can be easily ported to a different RTOS.

Based on a proposal by Otta, M. (2022), the SmartCGMS concept was also compiled into WebAssembly (WASM). It is a binary format that is executed by a WASM virtual stack machine or a WASM interpreter. It is an emerging approach to creating portable software in the Internet of Things. Compiling SmartCGMS into WASM allows us to execute the compiled application on any platform that runs a WASM interpreter without further modifications. The platform-dependent code is handled by the WASM interpreter and WASM System Interface (WASI) and the SmartCGMS concept code can stay platform-independent.

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3 Evaluation

To verify that the concept functions correctly, we compared the same SmartCGMS components executing in the SmartCGMS concept and the original SmartCGMS framework. The results confirmed that the concept works as expected on all supported platforms.

The evaluation further focused on compilation into WASM and WASM interpreters. We selected the WASM Micro Runtime (WAMR) interpreter thanks to its support for multiple platforms including the ESP32. The WASM module was successfully deployed to WAMR running on GNU/Linux and to a web server. Using WASM allows us to verify the functionality of the compiled binary before deploying it to a real device. An example usage scenario of the SmartCGMS concept is illustrated in figure 1. Using a physiological in silico model running on the web, we could visualize the expected behavior of a prediction algorithm and then deploy it to the patient without any modifications.

Executing the WASM SmartCGMS module on the ESP32 was unsuccessful due to the large size of the WASM module and interpreter and the limited DRAM available on the ESP32. Future work should focus on practical experimentation with the supported low-power devices and evaluating alternative WASM runtimes with low memory overhead.

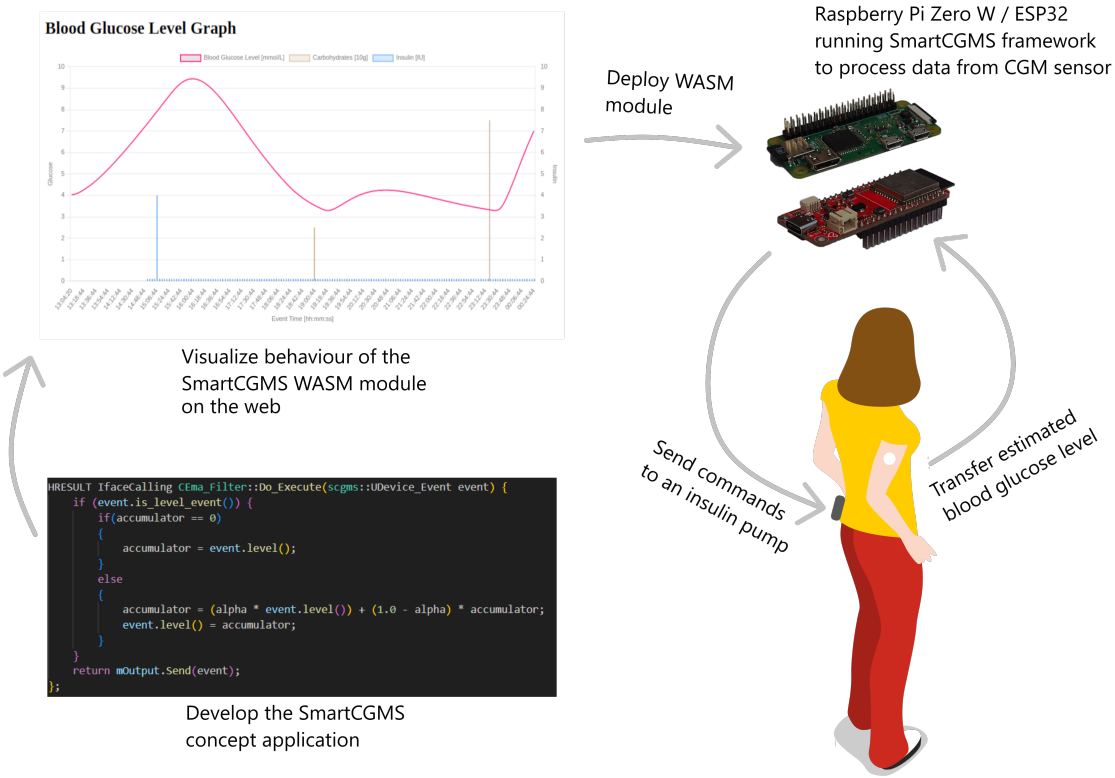

Figure 1: Development cycle of the SmartCGMS concept compiled as a WebAssembly module

References

Otta, M., 2022. Towards a health software supporting platform for wearable devices. *Procedia Computer Science, 210*, pp.112-115.

Ubl, M. and Koutny, T., 2019. SmartCGMS as an environment for an insulin-pump development with FDA-accepted in-silico pre-clinical trials. *Procedia Computer Science, 160*, pp.322-329.