Design & Development of a Multi-Purposed Smartwatch
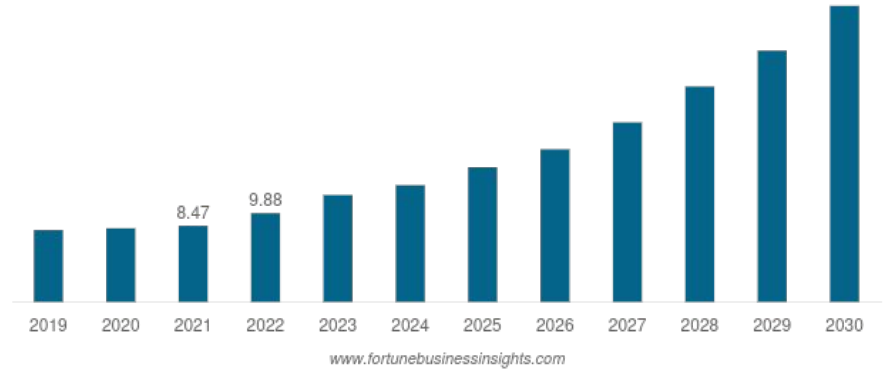
Senior Project

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Introduction

With the rise of IoT and wearable technologies, the modern world has become more

integrated. We see "constantly connected" products such as glasses, watches, fridges

and other household appliances.

North America Smartwatch Market Size, 2019-2030 (USD Billion)

8.47   9.88

2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

www.fortunebusinessinsights.com

The global smartwatch market size is projected to grow from $29.31 billion in 2023 to $77.22 billion by 2030, at a CAGR of 14.84%

Top Selling Smartwatch Brands

As of 2024, the market size is expected to be around 171 Million units, where the most prominent market is North America. According to the market analysis report at Mordor Intelligence, the top-selling brands are:

Apple Inc.
Samsung Electronics Co. Ltd.
Fitbit, Inc.
Garmin Ltd.
Fossil Group, Inc.
Huami Co., Ltd.
Huawei Technologies Co., Ltd.

Apple Watch

- Health and fitness tracking
- Sleep tracking
- Notifications
- Customizable watch faces
- Apps and App Store access
- Voice assistant (Siri)
- Water resistance
- Cellular connectivity (on select models)
- Music and podcasts
- GPS and navigation
- Fall detection and Emergency SOS
- ECG and irregular heart rhythm monitoring
- Family Setup
- Always-On Display (on some models)
- Interchangeable bands

Samsung Watch

- Health and fitness tracking
- Sleep tracking
- Notifications
- Customizable watch faces
- Apps and app store access (Galaxy Store)
- Voice assistant (Bixby)
- Water resistance
- Cellular connectivity (on select models)
- Music and media control
- GPS and navigation
- Fall detection and SOS features
- ECG (Electrocardiogram) functionality on some models
- SpO2 (blood oxygen) monitoring
- Wireless charging
- Interchangeable bands

Huawei Watch

- Health and fitness tracking
- Sleep tracking
- Notifications
- Customizable watch faces
- Apps and app store access (Huawei AppGallery)
- Voice assistant
- Water resistance
- Music and media control
- GPS and navigation
- SpO2 (blood oxygen) monitoring
- Wireless charging
- NFC for contactless payments
- Stress tracking
- Continuous heart rate monitoring
- AMOLED or OLED displays for vibrant visuals

The Smartwatch Project

The scope of the project is to develop a smartwatch and an associated Android application that communicates with it.

- Fitness tracking
- Call Management
- Notifications
- Music and media control
- Reminder
- Alarms
- Lock Screen

- Temperature
- Touch Gestures
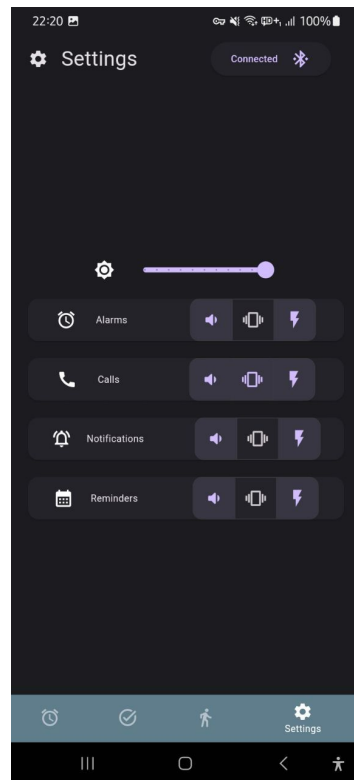- Stopwatch
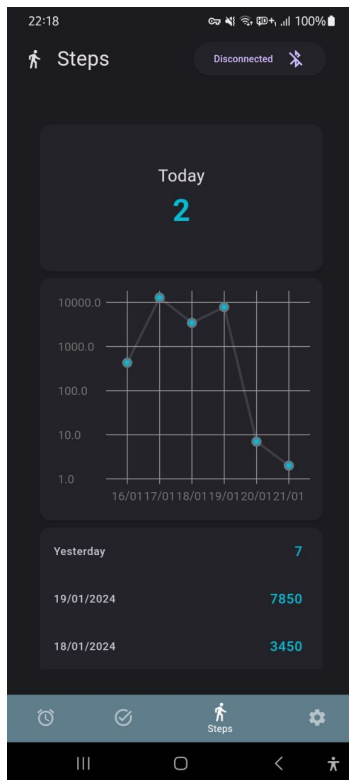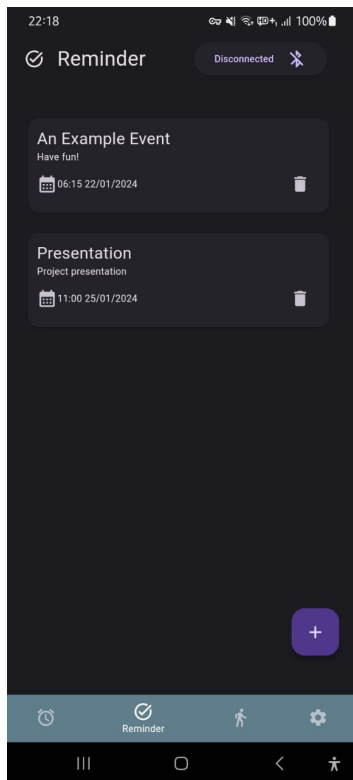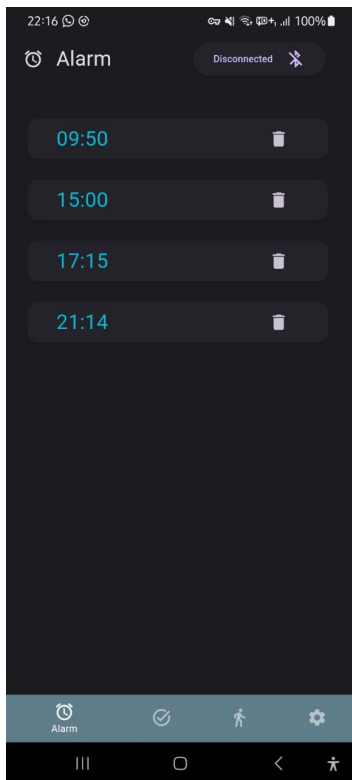- Calendar
- Notepad
- Configuration

The Hardware

- 256KB RAM
- 2MB Disk Space
- HC-06 Standard Bluetooth Communication
- 240x240 px 1.28 inch Touch LCD Screen
- MPU6050 Accelerometer
- 120mAh Battery
- LED
- Buzzer
- Motor
- TP4056 Battery Charging Circuit
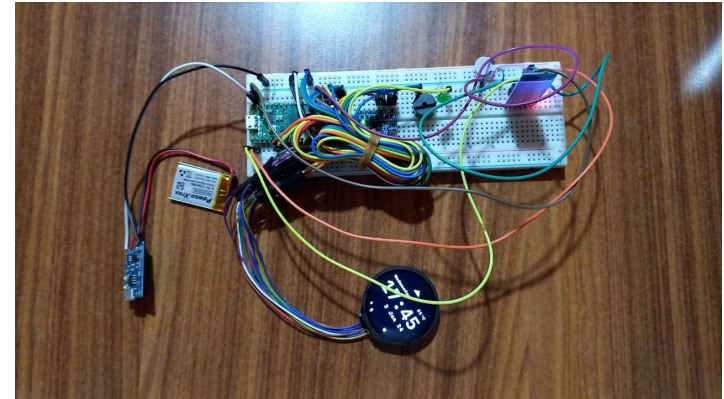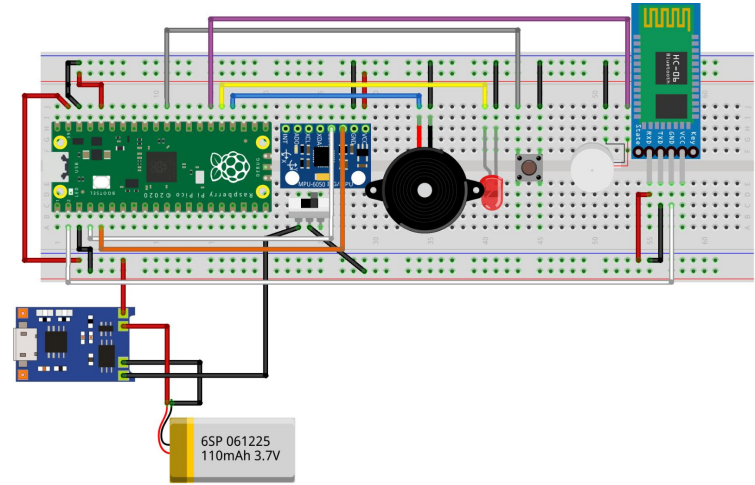
Android Application

Smartwatch Applications

Pop-Up Events

- Messages from Bluetooth or changes in the system can trigger pop-up events.
- If a pop-up is triggered, the current state's data is preserved to recreate on exit.
- If a pop-up is already active, a comparison is made between pop-ups. If a more priority pop-up arrives, it replaces the current one.
- Pop-ups trigger device GPIOs such as LED, buzzer and motor which are configured on settings.

Challenge 1 - Resource Management:

Uncompressed Version	RLE Encoding	Component System

Pico has 2MB of flash memory. After the competition of the media application, the disk size passed 3MB. Since the compiled binary was too big to fit into the

Pico, and the compilation failed.

The images contained a lot of replicated bytes. Images would be stored and encoded to trim the binary size. Whenever an image is needed, it is decoded and displayed on the screen. Decompressing resulted in memory fragmentation and system panic

By storing only the partitions of images the replicated bytes were removed.
Screen images are generated by placing different components to the screen at runtime therefore saving both memory and disk size.
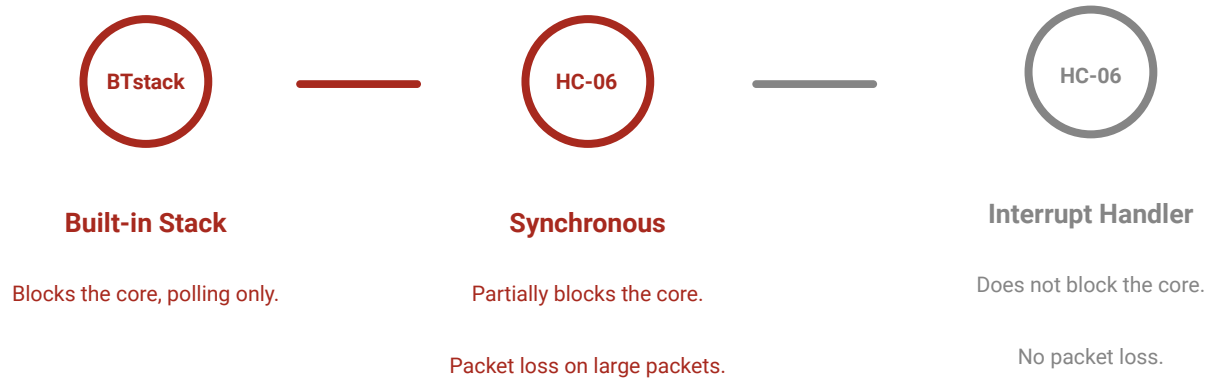
Challenge 2 - Event Scheduling
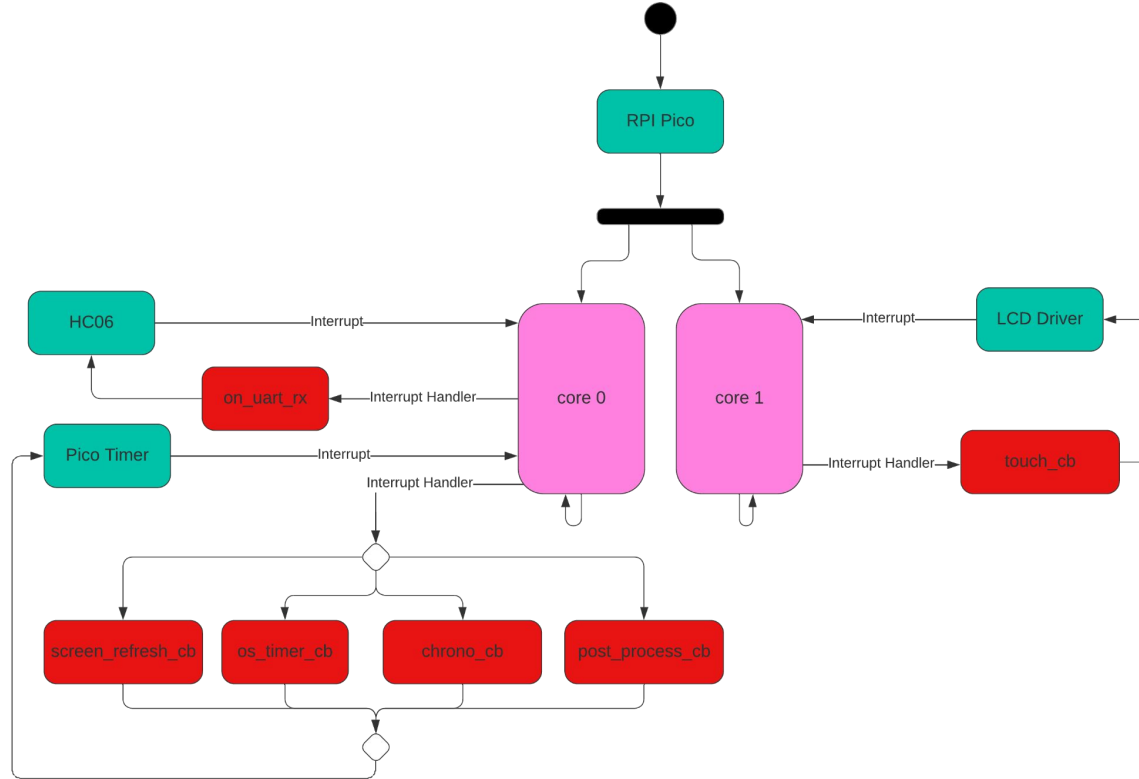
Challenge 3 - Display Scheduling

- The Display struct keeps track of the current state at any given time. A function call represents each screen state/application.
- They are stacked on top of each other using the function stack.
- Whenever a module function is called, the watch enters a new state; when a state ends, it returns its status.
- At any given time, the currently running module tracks three things:
  - Whether screen's enum disp_t is not DISP_SYNC or not.
  - Whether the type of the current state matches with the running function's state.
  - Whether a popup request has been attempted.

Challenge 4 - Communication Protocol

BTstack

HC-06

HC-06

Built-in Stack

Blocks the core, polling only.

Synchronous

Partially blocks the core.

Packet loss on large packets.

Interrupt Handler

Does not block the core.

No packet loss.

Resolution

The subject of this project is the design and development of a smartwatch

with integrated functionalities such as touchscreen control, Bluetooth connectivity,

multimedia control, notifications, call status monitoring, clock features, stopwatch,

alarm, reminder, and step counting. The smartwatch was programmed directly on the

microcontroller in the C programming language without using any operating system.

A mobile application for Android devices was also created to communicate with the

smartwatch and control various features.

Project Objectives

01   **Smartwatch Hardware**
- To incorporate a touchscreen, buzzer, motor, accelerometer and a microcontroller to the design

02   **Smartwatch Software**
- Develop a firmware using the C programming language without relying on a operating system.
- Create interfaces for different scenarios, allowing users to control multimedia, receive notifications, and
- monitor call status.

03   **Watch Features**
- Implement basic clock functions, including timekeeping, stopwatch, alarm, reminder, and step counting, directly on the smartwatch.
- Ensure these features continue operating in the background without interfering with other functionalities.

04   **Mobile Application**
- Design and develop an Android application that communicates with the smartwatch via Bluetooth.
- Enable transmitting multimedia controls, notifications, and call status information from the mobile app to the smartwatch.

05   **3D Printed Case**
- Design a compact 3D printable case for the smartwatch to protect the embedded system.

Questions

Thanks for Listening