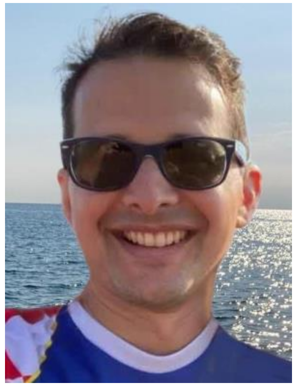
# O'REILLY ARCHITECTURE KATAS WINTER 2024

GITHUB REPO LINK

# THE TEAM

SYSTEM SAVANTS

Vishal Gamji



Gibran Castillo

Harshada Kandalgaonkar

Subodh Gupta

# OUR STORY …

Ch1. Introduction
[Problem Background & Business Goals]

Ch2. Navigating Challenges
[Architecture Analysis]

Ch3. Dueling Architectural & Operational Obstacles [Architecture Decision Records]

Ch4. Eureka!
[The Proposed Solution]

Ch5. Curtains Close
[The End]

# CHAPTER 1: INTRODUCTION

## PROBLEM BACKGROUND & BUSINESS GOALS

**StayHealthy, Inc.:** A leading medical software company in San Francisco with two major products: MonitorThem and MyMedicalData.

**MonitorMe:** StayHealthy, Inc. is exploring growth opportunities with MonitorMe. A real-time patient monitoring solution for hospitals, integrating with existing products for enhanced patient care.

**The Vision:** Disrupt patient monitoring industry with a reliable solution for hospitals that incorporates real-time data analysis, insights, and flexible EHR integration.

# CHAPTER 2: NAVIGATING CHALLENGES

## ARCHITECTURE ANALYSIS

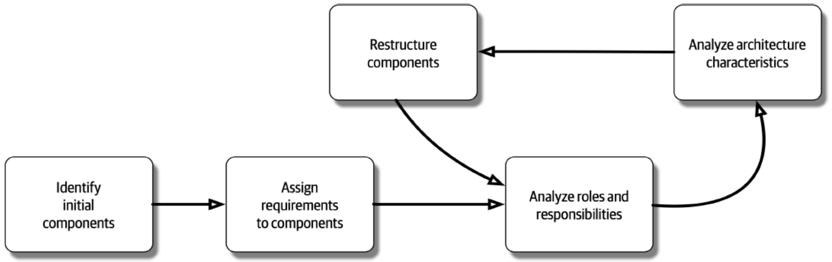
**Technical Complexity:** Developing MonitorMe to handle data from multiple patient-monitoring devices with varying transmit rates and data volumes, ensuring data integrity and low latency.

**On-Premises Hosting & Deployment:** Packaging and deploying this solution surfaces operational obstacles and introduces a risk element for StayHealthy Inc. as they haven't operated in this business model.

**Integration Hurdles:** Seamlessly integrating MonitorMe with MyMedicalData for EHR updates, while ensuring data security and patient confidentiality.

**Scalability and Future Expansion:** Building a system capable of expanding to accommodate more devices and patients without compromising performance.

# 2.1 ACTORS, ACTIONS, AND COMPONENTS



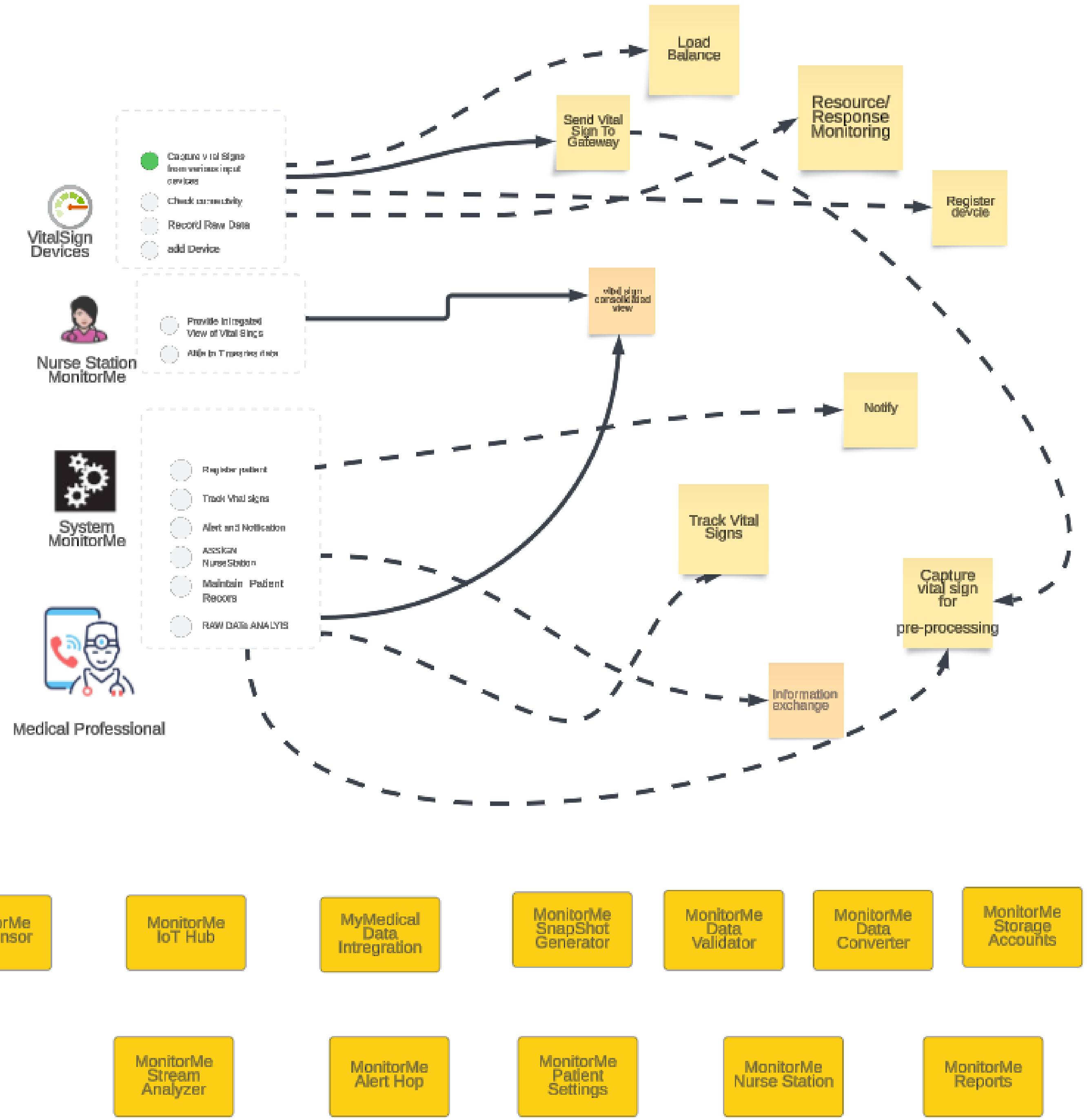
Identify initial components

Assign requirements to components

Analyze roles and responsibilities

Analyze architecture characteristics

Restructure components



VitalSign Devices

- Capture vital Signs from various input devices
- Check connectivity
- Record Raw Data
- add Device

Nurse Station MonitorMe

- Provide Integrated View of Vital Sings
- Alife in Triggering data

System MonitorMe

- Register patient
- Track Vital signs
- Alert and Notification
- ASSIGN NurseStation
- Maintain Patient Recors
- RAW DATa ANALYIS

Medical Professional

Load Balance

Send Vital Sign To Gateway

Resource/ Response Monitoring

Register devcie

vital sign consolidated view

Notify

Track Vital Signs

Capture vital sign for pre-processing

Information exchange

MonitorMe Bio Sensor

MonitorMe IoT Hub

MyMedical Data Intregration

MonitorMe SnapShot Generator

MonitorMe Data Validator

MonitorMe Data Converter

MonitorMe Storage Accounts

MonitorMe Stream Analyzer

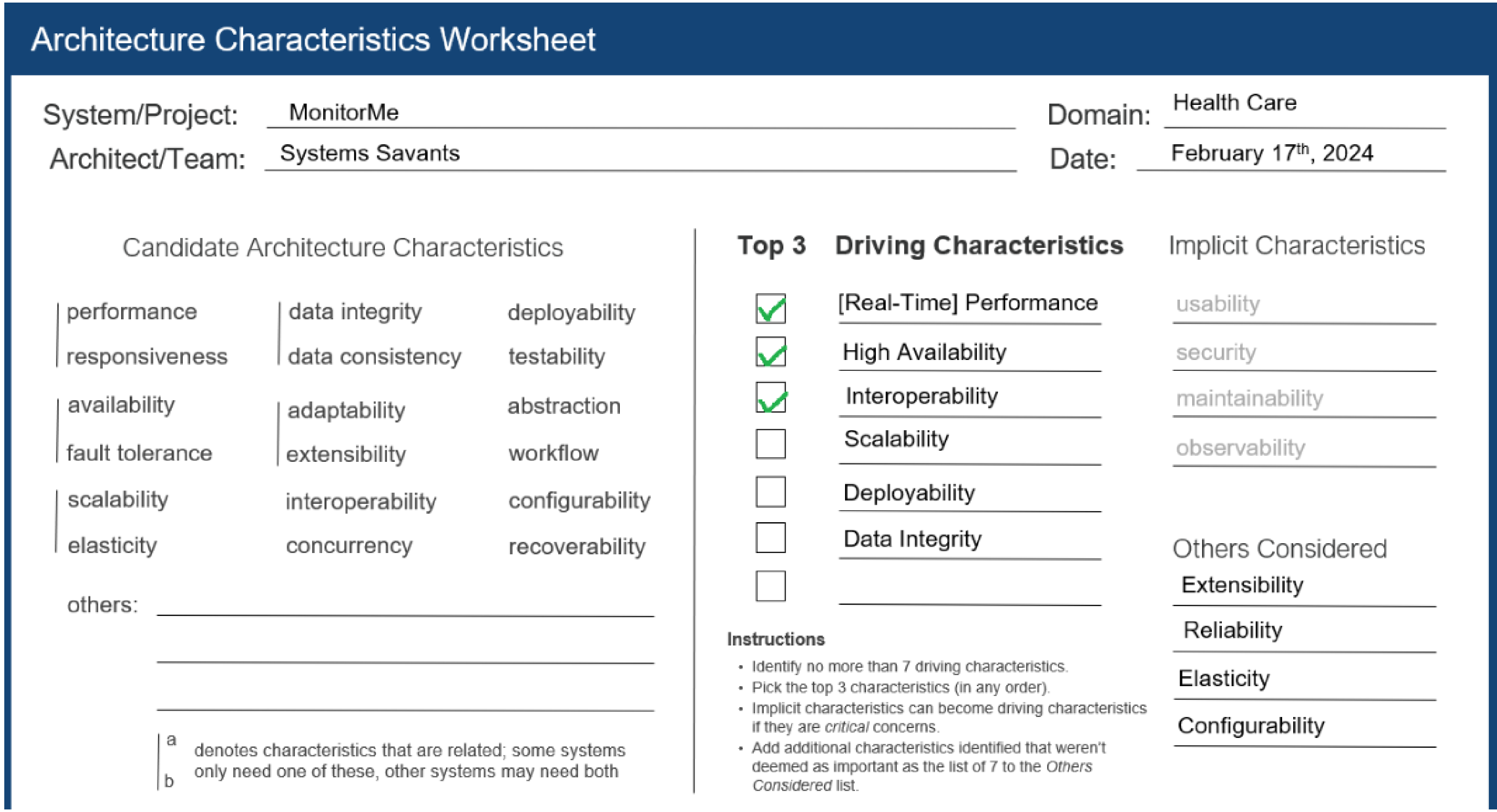
MonitorMe Alert Hop

MonitorMe Patient Settings

MonitorMe Nurse Station

MonitorMe Reports

# 2.2 ARCHITECTURE CHARACTERISTICS



## Architecture Characteristics Worksheet

System/Project: MonitorMe

Architect/Team: Systems Savants

Domain: Health Care

Date: February 17th, 2024

### Candidate Architecture Characteristics

performance
responsiveness
availability
fault tolerance
scalability
elasticity

data integrity
data consistency
adaptability
extensibility
interoperability
concurrency

deployability
testability
abstraction
workflow
configurability
recoverability

others: ______

a
b denotes characteristics that are related; some systems only need one of these, other systems may need both

### Top 3 Driving Characteristics

| | |
|---|---|
| ☑ | [Real-Time] Performance |
| ☑ | High Availability |
| ☑ | Interoperability |
| □ | Scalability |
| □ | Deployability |
| □ | Data Integrity |
| □ | |

### Implicit Characteristics

usability
security
maintainability
observability

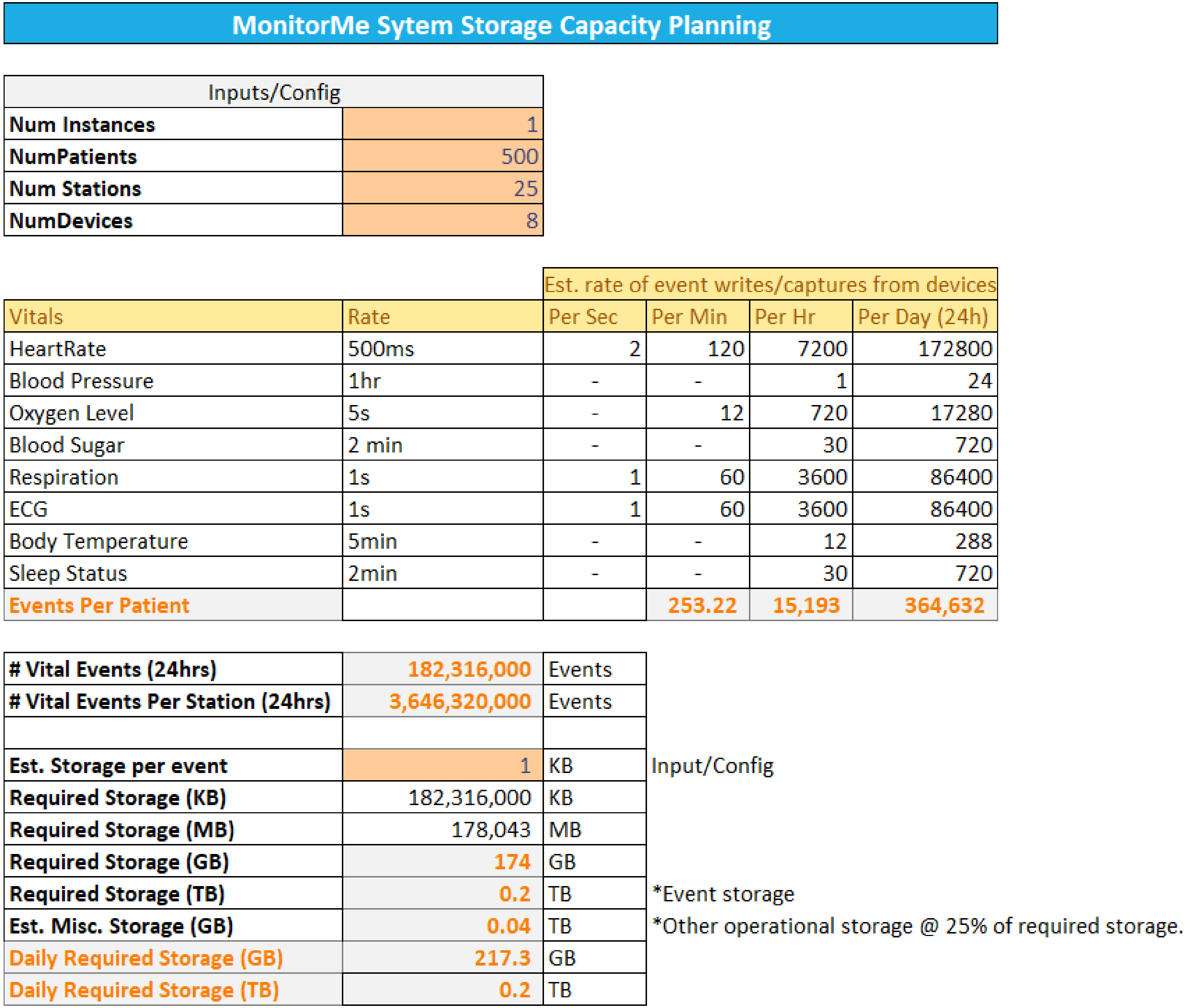
### Others Considered

Extensibility
Reliability
Elasticity
Configurability

**Instructions**

- Identify no more than 7 driving characteristics.
- Pick the top 3 characteristics (in any order).
- Implicit characteristics can become driving characteristics if they are *critical* concerns.
- Add additional characteristics identified that weren't deemed as important as the list of 7 to the *Others Considered* list.

# 2.3 Capacity Planning

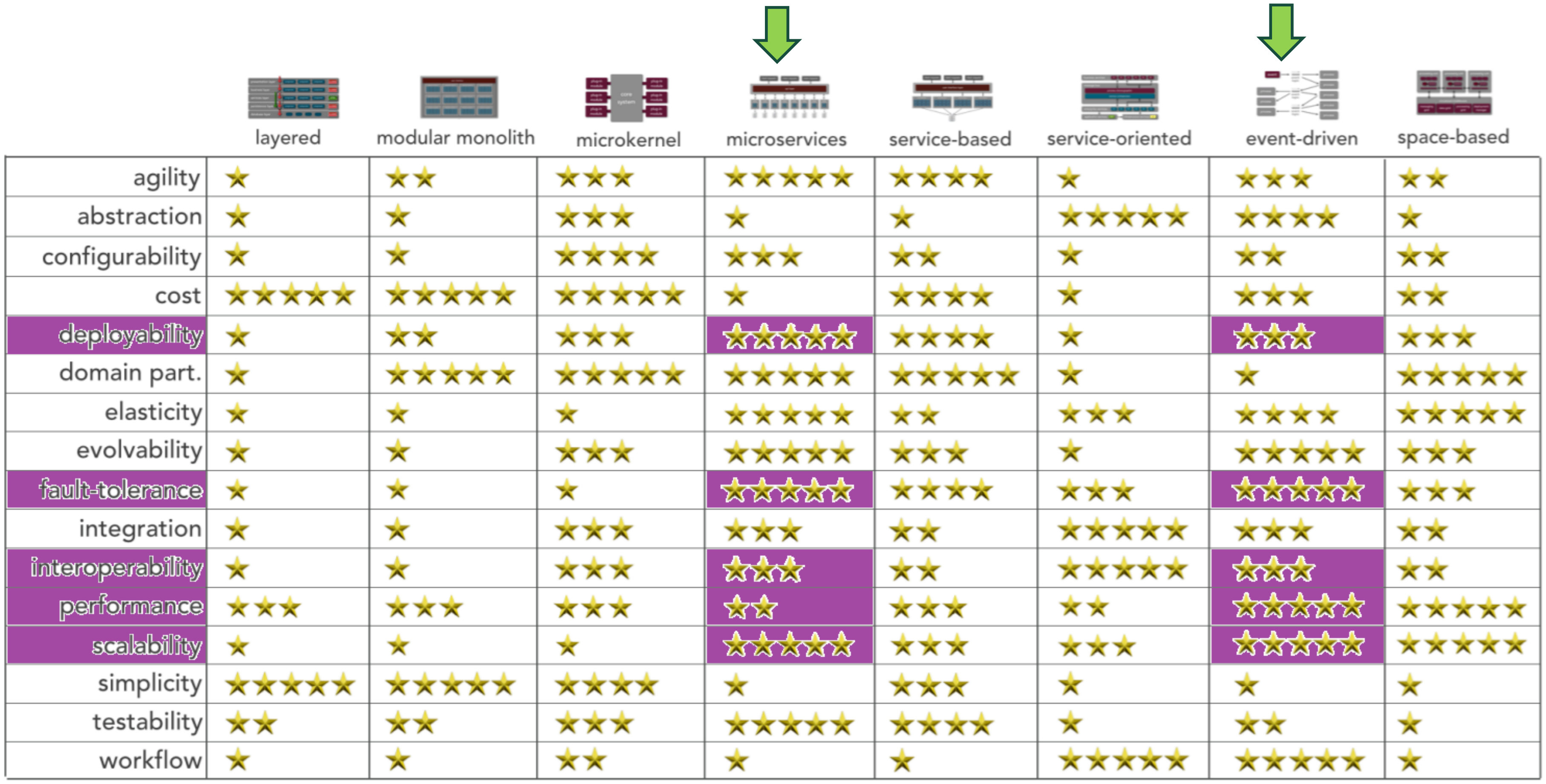


## MonitorMe Sytem Storage Capacity Planning

| Inputs/Config | |
|---|---|
| **Num Instances** | 1 |
| **NumPatients** | 500 |
| **Num Stations** | 25 |
| **NumDevices** | 8 |

| | | Est. rate of event writes/captures from devices | | | |
|---|---|---|---|---|---|
| Vitals | Rate | Per Sec | Per Min | Per Hr | Per Day (24h) |
| HeartRate | 500ms | 2 | 120 | 7200 | 172800 |
| Blood Pressure | 1hr | - | - | 1 | 24 |
| Oxygen Level | 5s | - | 12 | 720 | 17280 |
| Blood Sugar | 2 min | - | - | 30 | 720 |
| Respiration | 1s | 1 | 60 | 3600 | 86400 |
| ECG | 1s | 1 | 60 | 3600 | 86400 |
| Body Temperature | 5min | - | - | 12 | 288 |
| Sleep Status | 2min | - | - | 30 | 720 |
| **Events Per Patient** | | | **253.22** | **15,193** | **364,632** |

| | | | |
|---|---|---|---|
| **# Vital Events (24hrs)** | **182,316,000** | Events | |
| **# Vital Events Per Station (24hrs)** | **3,646,320,000** | Events | |
| | | | |
| **Est. Storage per event** | 1 | KB | Input/Config |
| **Required Storage (KB)** | 182,316,000 | KB | |
| **Required Storage (MB)** | 178,043 | MB | |
| **Required Storage (GB)** | **174** | GB | |
| **Required Storage (TB)** | **0.2** | TB | *Event storage |
| **Est. Misc. Storage (GB)** | **0.04** | TB | *Other operational storage @ 25% of required storage. |
| **Daily Required Storage (GB)** | **217.3** | GB | |
| **Daily Required Storage (TB)** | **0.2** | TB | |



| | layered | modular monolith | microkernel | microservices | service-based | service-oriented | event-driven | space-based |
|---|---|---|---|---|---|---|---|---|
| agility | ★ | ★★ | ★★★ | ★★★★★ | ★★★★ | ★ | ★★★ | ★★ |
| abstraction | ★ | ★ | ★★★ | ★ | ★ | ★★★★★ | ★★★★ | ★ |
| configurability | ★ | ★ | ★★★★ | ★★★ | ★★ | ★ | ★★ | ★★ |
| cost | ★★★★★ | ★★★★★ | ★★★★★ | ★ | ★★★★ | ★ | ★★★ | ★★ |
| deployability | ★ | ★★ | ★★★ | ★★★★★ | ★★★★ | ★ | ★★★ | ★★★ |
| domain part. | ★ | ★★★★★ | ★★★★★ | ★★★★★ | ★★★★★ | ★ | ★ | ★★★★★ |
| elasticity | ★ | ★ | ★ | ★★★★★ | ★★ | ★★★ | ★★★★ | ★★★★★ |
| evolvability | ★ | ★ | ★★★ | ★★★★★ | ★★★ | ★ | ★★★★★ | ★★★ |
| fault-tolerance | ★ | ★ | ★ | ★★★★★ | ★★★★ | ★★★ | ★★★★★ | ★★★ |
| integration | ★ | ★ | ★★★ | ★★★ | ★★ | ★★★★★ | ★★★ | ★★ |
| interoperability | ★ | ★ | ★★★ | ★★★ | ★★ | ★★★★★ | ★★★ | ★★ |
| performance | ★★★ | ★★★ | ★★★ | ★★ | ★★★ | ★★ | ★★★★★ | ★★★★★ |
| scalability | ★ | ★ | ★ | ★★★★★ | ★★★ | ★★★ | ★★★★★ | ★★★★★ |
| simplicity | ★★★★★ | ★★★★★ | ★★★★ | ★ | ★★★ | ★ | ★ | ★ |
| testability | ★★ | ★★ | ★★★ | ★★★★★ | ★★★★ | ★ | ★★ | ★ |
| workflow | ★ | ★ | ★★ | ★ | ★ | ★★★★★ | ★★★★★ | ★ |

# 2.4 ARCHITECTURE STYLE SELECTION

MICROSERVICES
+
EVENT-DRIVEN

**Architectural Decisions:** Adopting a microservice and event-driven architecture to ensure scalability, fault tolerance, and real-time performance.

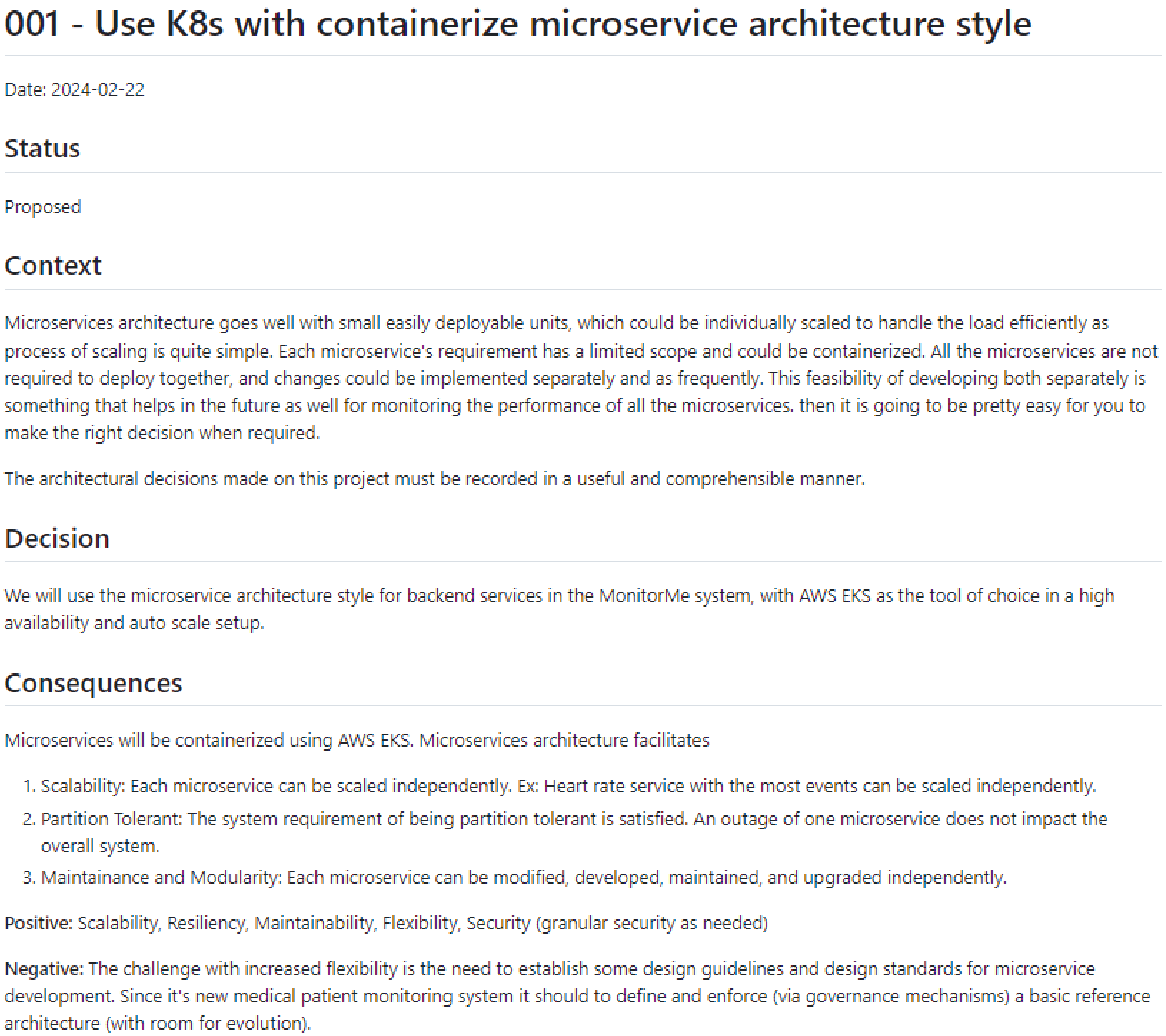
**Security and Compliance:** Implementing layered security measures and achieving compliance with health data regulations without governmental requirements.

**Interoperability and Data Integrity:** Ensuring the system works flawlessly with existing hospital infrastructure and maintains high data accuracy for life-critical decisions.

# CHAPTER 3:
# DUELING ARCHITECTURAL & OPERATIONAL OBSTACLES

# 3.1 ARCHITECTURE DECISION RECORD

## HIGHLIGHT 1 ADR-001



# 001 - Use K8s with containerize microservice architecture style

Date: 2024-02-22

## Status

Proposed

## Context

Microservices architecture goes well with small easily deployable units, which could be individually scaled to handle the load efficiently as process of scaling is quite simple. Each microservice's requirement has a limited scope and could be containerized. All the microservices are not required to deploy together, and changes could be implemented separately and as frequently. This feasibility of developing both separately is something that helps in the future as well for monitoring the performance of all the microservices. then it is going to be pretty easy for you to make the right decision when required.

The architectural decisions made on this project must be recorded in a useful and comprehensible manner.

## Decision

We will use the microservice architecture style for backend services in the MonitorMe system, with AWS EKS as the tool of choice in a high availability and auto scale setup.

## Consequences

Microservices will be containerized using AWS EKS. Microservices architecture facilitates

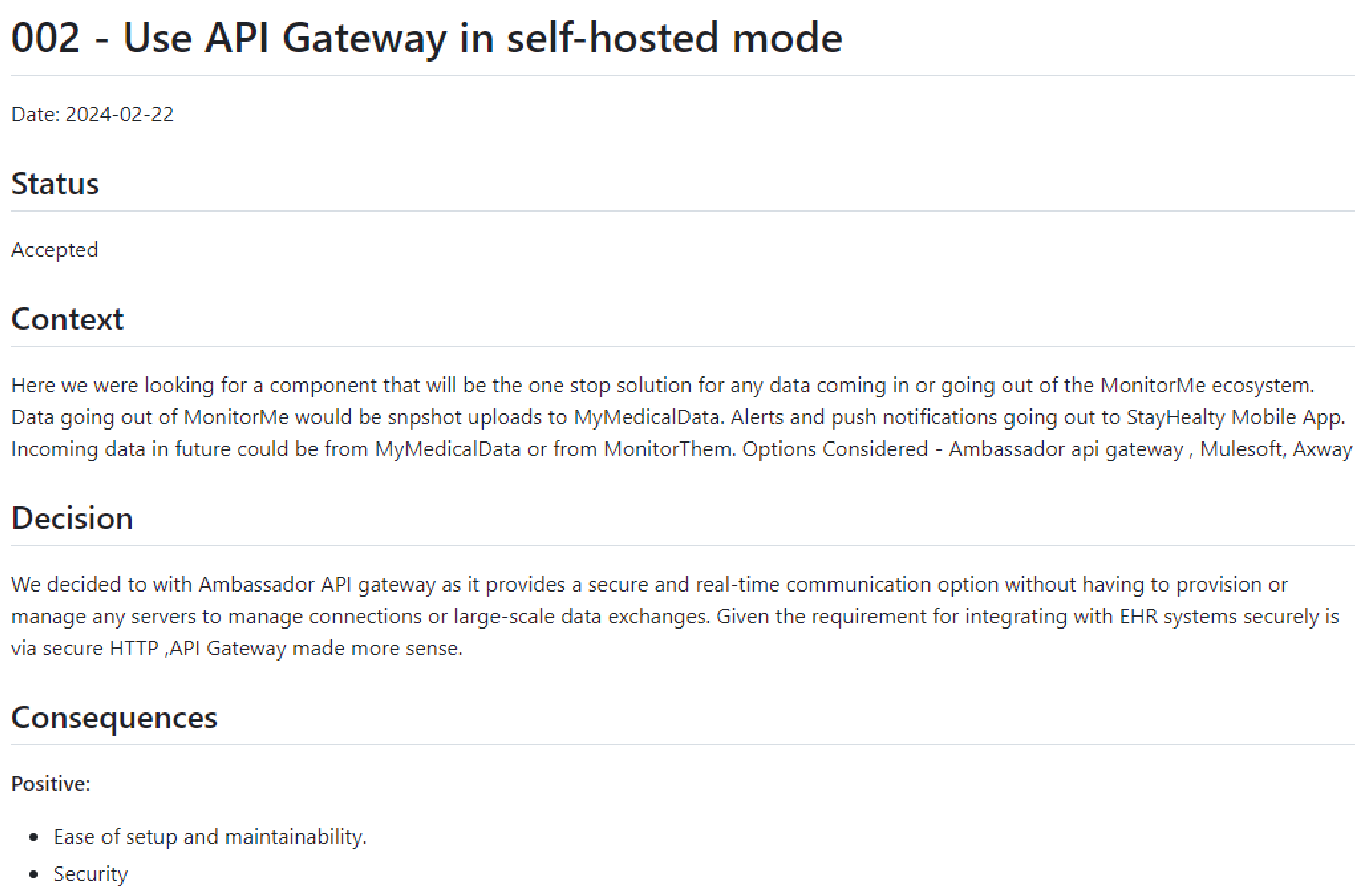
1. Scalability: Each microservice can be scaled independently. Ex: Heart rate service with the most events can be scaled independently.
2. Partition Tolerant: The system requirement of being partition tolerant is satisfied. An outage of one microservice does not impact the overall system.
3. Maintainance and Modularity: Each microservice can be modified, developed, maintained, and upgraded independently.

**Positive:** Scalability, Resiliency, Maintainability, Flexibility, Security (granular security as needed)

**Negative:** The challenge with increased flexibility is the need to establish some design guidelines and design standards for microservice development. Since it's new medical patient monitoring system it should to define and enforce (via governance mechanisms) a basic reference architecture (with room for evolution).

# 3.2 ARCHITECTURE DECISION RECORD

## HIGHLIGHT 2 ADR-002



# 002 - Use API Gateway in self-hosted mode

Date: 2024-02-22

## Status

Accepted

## Context

Here we were looking for a component that will be the one stop solution for any data coming in or going out of the MonitorMe ecosystem. Data going out of MonitorMe would be snpshot uploads to MyMedicalData. Alerts and push notifications going out to StayHealty Mobile App. Incoming data in future could be from MyMedicalData or from MonitorThem. Options Considered - Ambassador api gateway , Mulesoft, Axway

## Decision

We decided to with Ambassador API gateway as it provides a secure and real-time communication option without having to provision or manage any servers to manage connections or large-scale data exchanges. Given the requirement for integrating with EHR systems securely is via secure HTTP ,API Gateway made more sense.

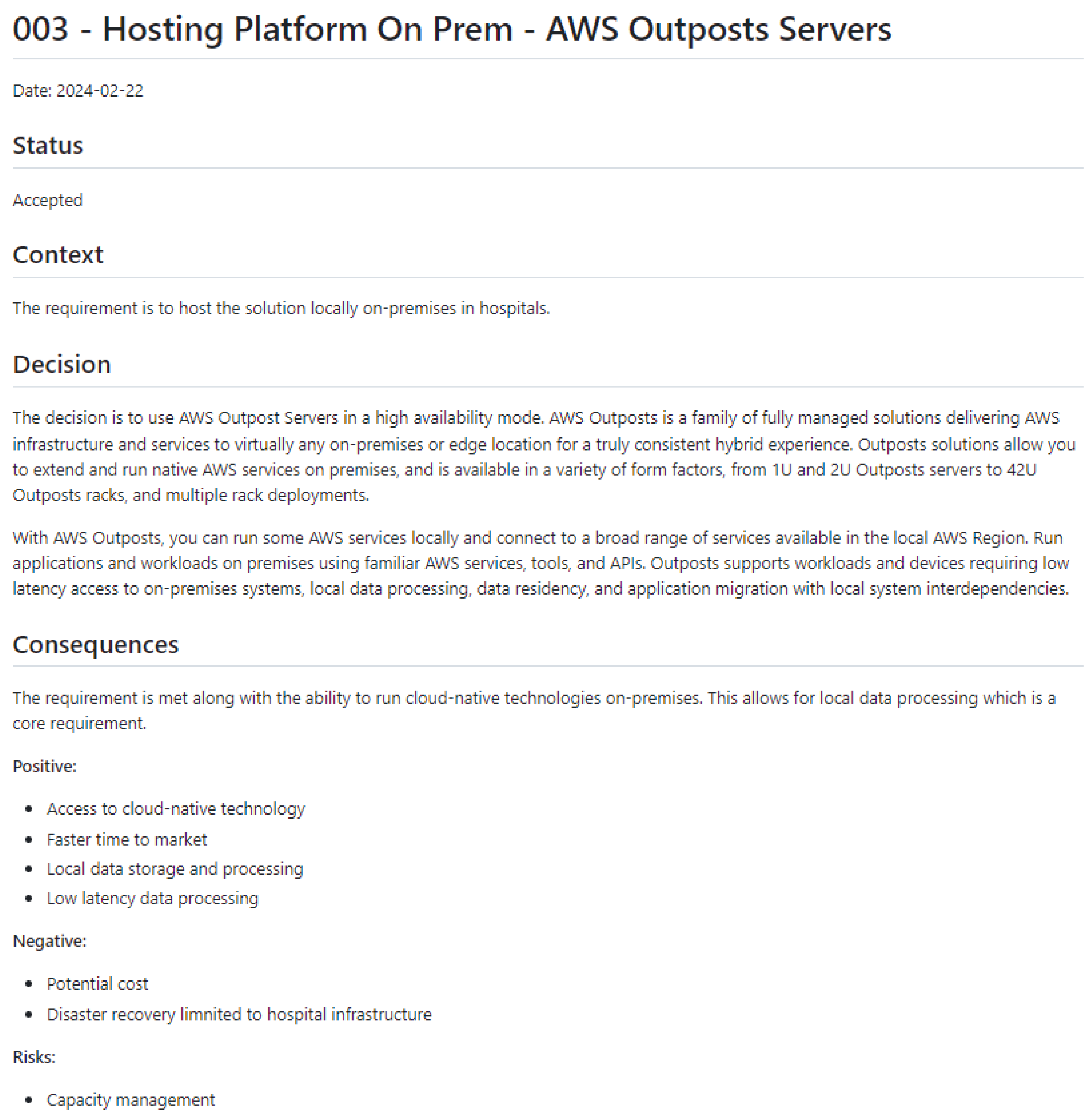
## Consequences

**Positive:**

- Ease of setup and maintainability.
- Security

# 3.3 ARCHITECTURE DECISION RECORD

## HIGHLIGHT 3 ADR-003



# 003 - Hosting Platform On Prem - AWS Outposts Servers

Date: 2024-02-22

## Status

Accepted

## Context

The requirement is to host the solution locally on-premises in hospitals.

## Decision

The decision is to use AWS Outpost Servers in a high availability mode. AWS Outposts is a family of fully managed solutions delivering AWS infrastructure and services to virtually any on-premises or edge location for a truly consistent hybrid experience. Outposts solutions allow you to extend and run native AWS services on premises, and is available in a variety of form factors, from 1U and 2U Outposts servers to 42U Outposts racks, and multiple rack deployments.

With AWS Outposts, you can run some AWS services locally and connect to a broad range of services available in the local AWS Region. Run applications and workloads on premises using familiar AWS services, tools, and APIs. Outposts supports workloads and devices requiring low latency access to on-premises systems, local data processing, data residency, and application migration with local system interdependencies.

## Consequences

The requirement is met along with the ability to run cloud-native technologies on-premises. This allows for local data processing which is a core requirement.

**Positive:**

- Access to cloud-native technology
- Faster time to market
- Local data storage and processing
- Low latency data processing

**Negative:**

- Potential cost
- Disaster recovery limnited to hospital infrastructure

**Risks:**

- Capacity management

**ARCHITECTURE & DEPLOYMENT SHOWCASE:** ON-PREMISES IMPLEMENTATION AT HOSPITAL LOCATIONS WITH AWS OUTPOSTS SERVERS, ENSURING DATA PRIVACY AND LOCAL PROCESSING NEEDS.

**REAL-TIME MONITORING:** WITH AN AVERAGE RESPONSE TIME OF LESS THAN A SECOND, MONITORME REVOLUTIONIZES PATIENT CARE, ENABLING HEALTHCARE PROFESSIONALS TO RESPOND SWIFTLY TO PATIENT NEEDS.

**FUTURE-PROOF AND SCALABLE:** DESIGNED TO ACCOMMODATE ADDITIONAL MONITORING DEVICES AND INTEGRATE WITH EVOLVING MEDICAL SOFTWARE LANDSCAPES, ENSURING LONG-TERM VIABILITY.

## CHAPTER 4:

# THE EUREKA MOMENT

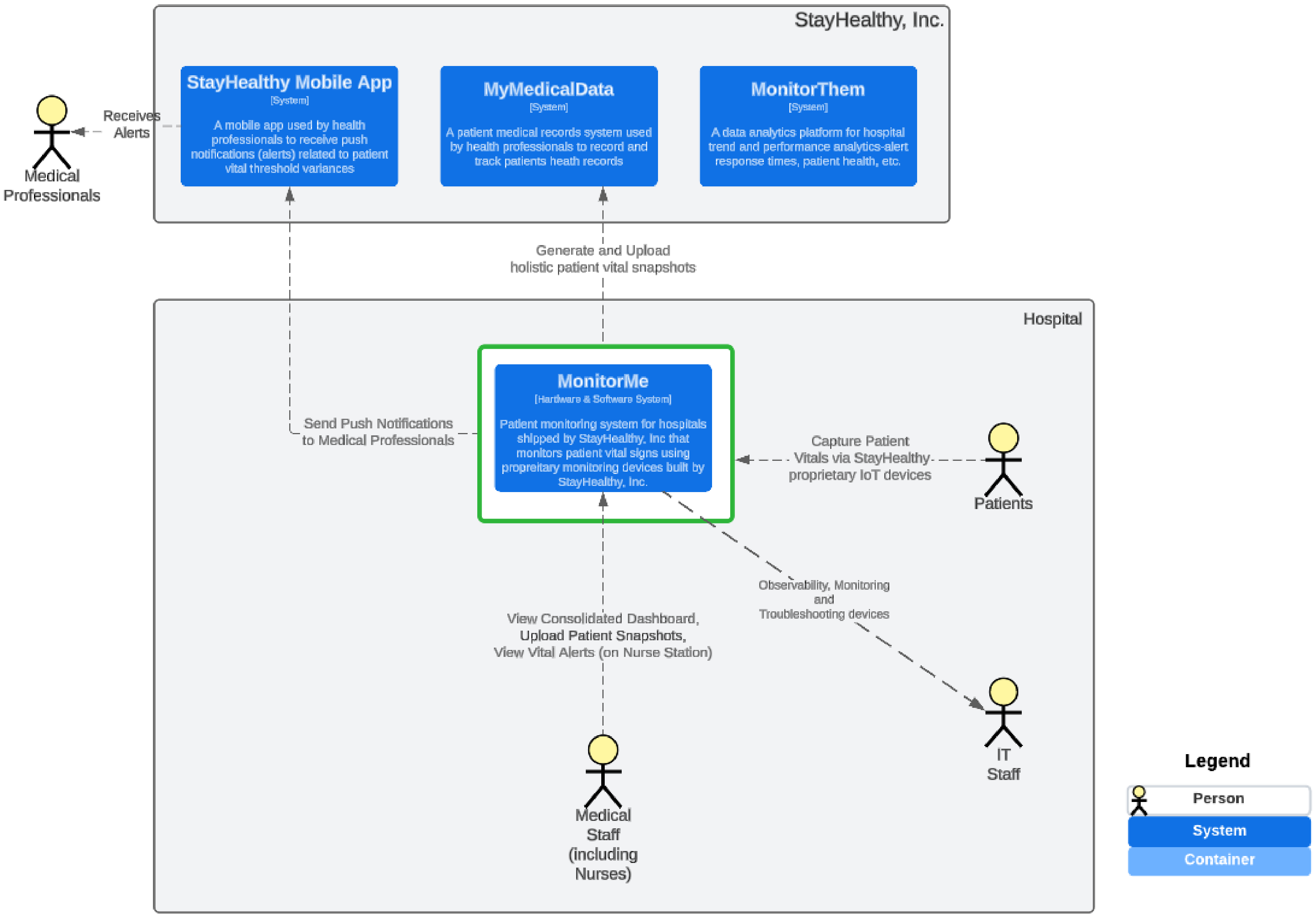
[THE PROPOSED SOLUTION]

# 4.1 HIGH LEVEL ARCHITECTURE

## C4 MODEL

## SYSTEM CONTEXT DIAGRAM (C1)

## System Context Diagram



StayHealthy, Inc.

**StayHealthy Mobile App**
[System]
A mobile app used by health professionals to receive push notifications (alerts) related to patient vital threshold variances

**MyMedicalData**
[System]
A patient medical records system used by health professionals to record and track patients heath records

**MonitorThem**
[System]
A data analytics platform for hospital trend and performance analytics-alert response times, patient health, etc.

Medical Professionals

Receives Alerts

Generate and Upload holistic patient vital snapshots

Hospital

**MonitorMe**
[Hardware & Software System]
Patient monitoring system for hospitals shipped by StayHealthy, Inc that monitors patient vital signs using propreitary monitoring devices built by StayHealthy, Inc.

Send Push Notifications to Medical Professionals

Capture Patient Vitals via StayHealthy proprietary IoT devices

Patients

Observability, Monitoring and Troubleshooting devices

IT Staff

View Consolidated Dashboard, Upload Patient Snapshots, View Vital Alerts (on Nurse Station)

Medical Staff (including Nurses)

**Legend**

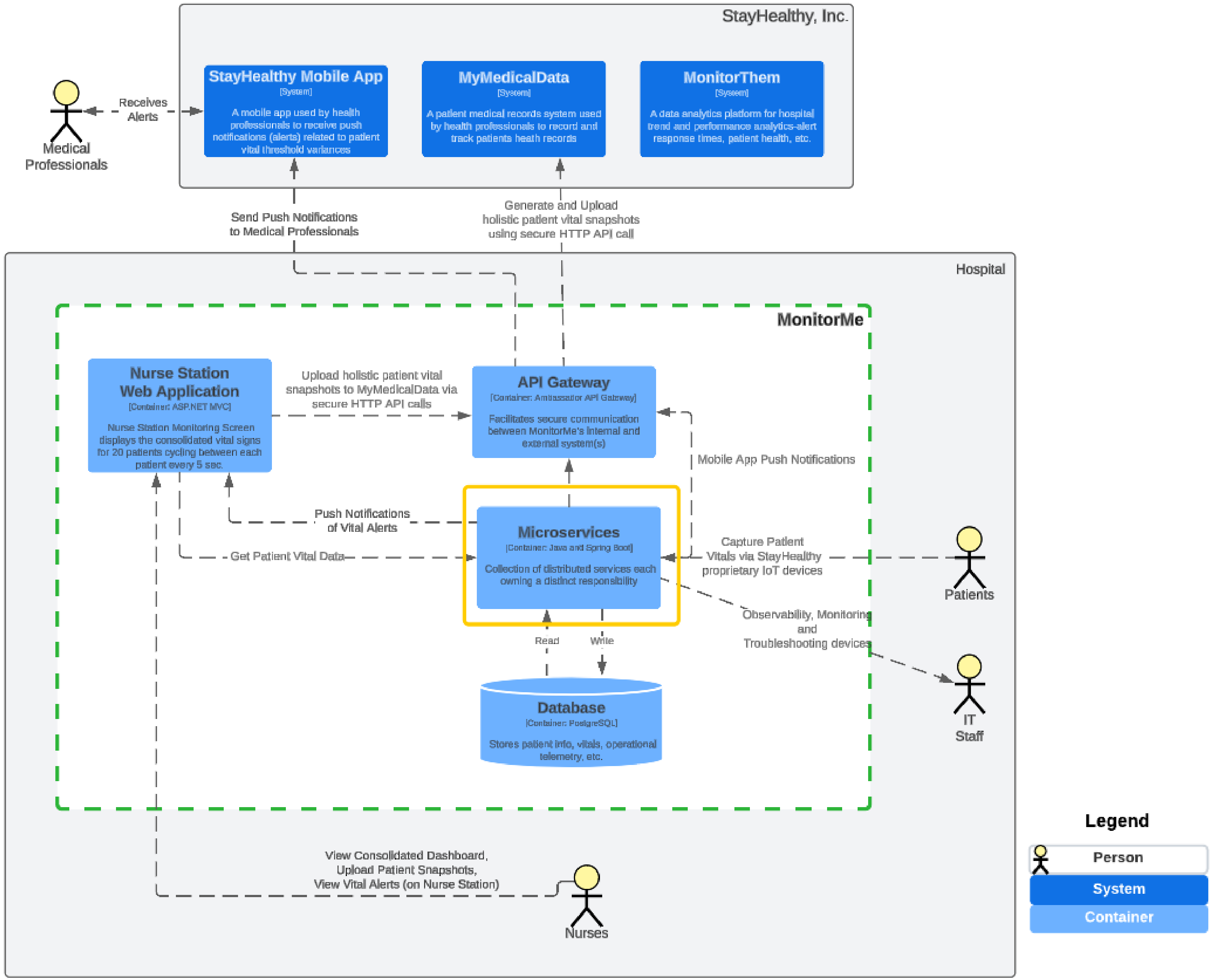
| |
|---|
| Person |
| System |
| Container |

# 4.2 HIGH LEVEL ARCHITECTURE

## C4 MODEL

## CONTAINER DIAGRAM (C2)

## Container Diagram



StayHealthy, Inc.

Medical Professionals

Receives Alerts

StayHealthy Mobile App
[System]
A mobile app used by health professionals to receive push notifications (alerts) related to patient vital threshold variances

MyMedicalData
[System]
A patient medical records system used by health professionals to record and track patients heath records

MonitorThem
[System]
A data analytics platform for hospital trend and performance analytics-alert response times, patient health, etc.

Send Push Notifications to Medical Professionals

Generate and Upload holistic patient vital snapshots using secure HTTP API call

Hospital

MonitorMe

Nurse Station Web Application
[Container: ASP.NET MVC]
Nurse Station Monitoring Screen displays the consolidated vital signs for 20 patients cycling between each patient every 5 sec.

Upload holistic patient vital snapshots to MyMedicalData via secure HTTP API calls

API Gateway
[Container: Ambassador API Gateway]
Facilitates secure communication between MonitorMe's internal and external system(s)

Mobile App Push Notifications

Push Notifications of Vital Alerts

Get Patient Vital Data

Microservices
[Container: Java and Spring Boot]
Collection of distributed services each owning a distinct responsibility

Capture Patient Vitals via StayHealthy proprietary IoT devices

Patients

Observability, Monitoring and Troubleshooting devices

IT Staff

Read

Write

Database
[Container: PostgreSQL]
Stores patient info, vitals, operational telemetry, etc.

View Consolidated Dashboard, Upload Patient Snapshots, View Vital Alerts (on Nurse Station)

Nurses

Legend

Person

System

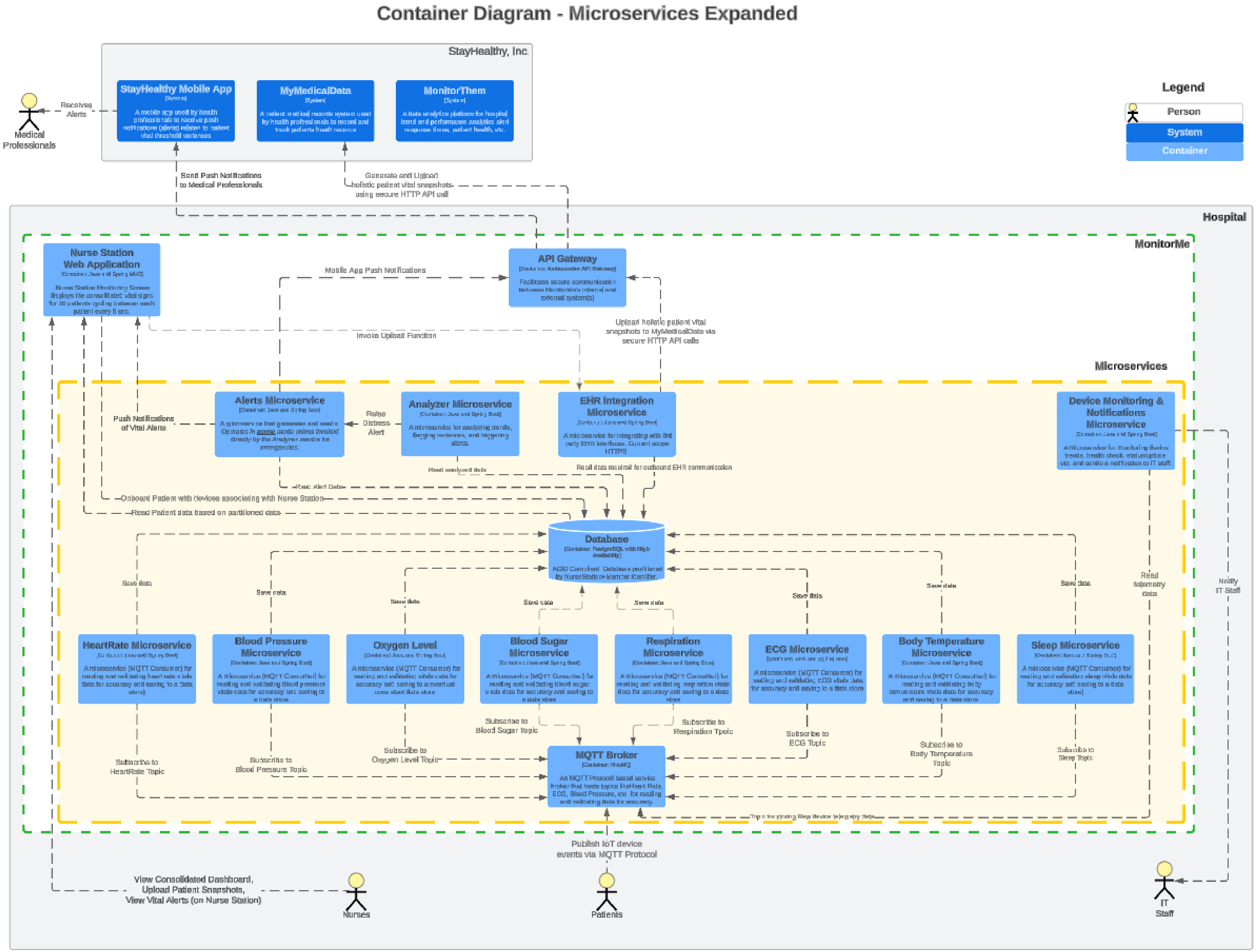
Container

# 4.3 HIGH LEVEL ARCHITECTURE

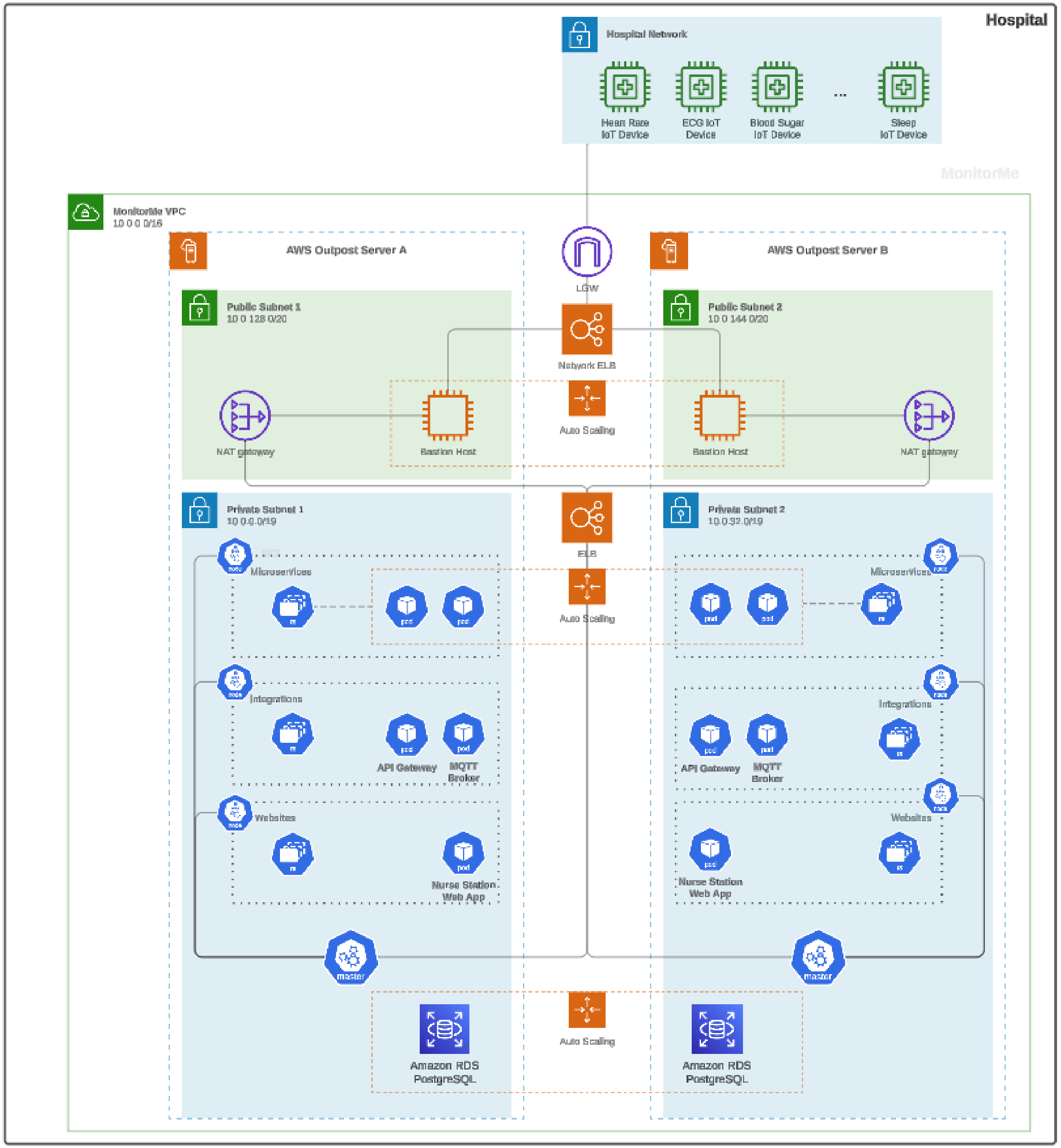
## C4 MODEL

## CONTAINER DIAGRAM (C2)

## MICROSERVICES EXPANDED


Container Diagram - Microservices Expanded
StayHealthy, Inc.
StayHealthy Mobile App
[System]
A mobile app used by health professionals to receive push notifications (alerts) related to patient vital threshold variances
MyMedicalData
[System]
A patient medical records system used by health professionals to record and track patients health records
MonitorThem
[System]
A data analytics platform for hospital trend and performance analytics alert response times, patient health, etc.
Receives Alerts
Medical Professionals
Send Push Notifications to Medical Professionals
Generate and Upload holistic patient vital snapshots using secure HTTP API call
Legend
Person
System
Container
Hospital
MonitorMe
Nurse Station Web Application
[Container: Java and Spring MVC]
Nurse Station Monitoring Screen displays the consolidated vital signs for 20 patients cycling between each patient every 5 sec.
API Gateway
[Container: Ambassador API Gateway]
Facilitates secure communication between MonitorMe's internal and external system(s)
Mobile App Push Notifications
Invoke Upload Function
Upload holistic patient vital snapshots to MyMedicalData via secure HTTP API calls
Microservices
Alerts Microservice
[Container: Java and Spring Boot]
A microservice that generates and sends alerts. Operates in async mode unless invoked directly by the Analyzer service for emergencies.
Push Notifications of Vital Alerts
Raise Distress Alert
Analyzer Microservice
[Container: Java and Spring Boot]
A microservice for analyzing trends, flagging variances, and triggering alerts.
EHR Integration Microservice
[Container: Java and Spring Boot]
A microservice for integrating with 3rd party EHR interfaces. Current scope HTTPS
Device Monitoring & Notifications Microservice
[Container: Java and Spring Boot]
A microservice for monitoring device trends, health check, status/uptime etc. and sends a notification to IT staff.
Read analyzed data
Read data required for outbound EHR communication
Read Alert Data
Onboard Patient with devices associating with Nurse Station
Read Patient data based on partitioned data
Database
[Container: PostgreSQL with High Availability]
ACID Compliant. Database partitioned by NurseStation+Member Identifier.
Save data
Save data
Save data
Save data
Save data
Save data
Save data
Save data
Read telemetry data
Notify IT Staff
HeartRate Microservice
[Container: Java and Spring Boot]
A microservice (MQTT Consumer) for reading and validating heart rate vitals data for accuracy and saving to a data store)
Blood Pressure Microservice
[Container: Java and Spring Boot]
A Microservice (MQTT Consumer) for reading and validating blood pressure vitals data for accuracy and saving to a data store
Oxygen Level
[Container: Java and Spring Boot]
A microservice (MQTT Consumer) for reading and validating vitals data for accuracy and saving to a eventual consistent data store
Blood Sugar Microservice
[Container: Java and Spring Boot]
A Microservice (MQTT Consumer) for reading and validating blood sugar vitals data for accuracy and saving to a data store
Respiration Microservice
[Container: Java and Spring Boot]
A Microservice (MQTT Consumer) for reading and validating respiration vitals data for accuracy and saving to a data store
ECG Microservice
[Container: Java and Spring Boot]
A microservice (MQTT Consumer) for reading and validating ECG vitals data for accuracy and saving to a data store
Body Temperature Microservice
[Container: Java and Spring Boot]
A Microservice (MQTT Consumer) for reading and validating body temperature vitals data for accuracy and saving to a data store
Sleep Microservice
[Container: Java and Spring Boot]
A microservice (MQTT Consumer) for reading and validating sleep vitals data for accuracy and saving to a data store)
Subscribe to HeartRate Topic
Subscribe to Blood Pressure Topic
Subscribe to Oxygen Level Topic
Subscribe to Blood Sugar Topic
Subscribe to Respiration Tpoic
Subscribe to ECG Topic
Subscribe to Body Temperature Topic
Subscribe to Sleep Topic
MQTT Broker
[Container: HiveMQ]
An MQTT Protocol based service broker that hosts topics like Heart Rate, ECG, Blood Pressure, etc. for reading and validating data for accuracy.
Topic for storing Raw device telemetry data
Publish IoT device events via MQTT Protocol
View Consolidated Dashboard, Upload Patient Snapshots, View Vital Alerts (on Nurse Station)
Nurses
Patients
IT Staff

# 4.4 DEPLOYMENT DIAGRAM



**INNOVATIVE SOLUTION:** MONITORME REPRESENTS A SIGNIFICANT LEAP FORWARD IN PATIENT CARE, COMBINING REAL-TIME MONITORING WITH ROBUST DATA ANALYSIS AND SECURE EHR INTEGRATION.

**IMPACT ON HEALTHCARE:** ENHANCING PATIENT OUTCOMES, REDUCING HEALTHCARE COSTS, AND PAVING THE WAY FOR DATA-DRIVEN HEALTHCARE SOLUTIONS.

**STAYHEALTHY, INC.'S COMMITMENT:** CONTINUING TO INNOVATE AND SUPPORT THE HEALTHCARE INDUSTRY WITH SOLUTIONS THAT SAVE LIVES AND IMPROVE PATIENT CARE.

# CHAPTER 5:
# THE END

*Credits: Dall-E generated.

# 5.1 NURSE STATION DASHBOARD VIEW

*Credits: Dall-E generated.

# 5.2 MEDICAL PROFESSIONAL MOBILE APP VIEW