Echo

Design and Implementation Issues of a Secure Cloud-Based Health Data Management System

Frank Steimle, Matthias Wieland, Bernhard Mitschang, Sebastian Wagner, and Frank Leymann

Funded By:

SPONSORED BY THE

GSRT GENERAL SECRETARIAT FOR RESEARCH AND TECHNOLOGY

Federal Ministry of Education and Research

University of Stuttgart Germany

OpenIT Information Technology Solutions

Agenda

- Introduction to the ECHO project
  - *Problem description*
  - *Solution*
- Design and Implementation Issues
- ECHO: An Active Health Data Management System
  - *System Architecture*
  - *RESTful Interfacing the Health Data Management Layer*
  - *Health Data Management*
  - *Automated Provisioning and Management of the Health Data Management Layer*
- Summary and Future Work

Introduction: What the Problem is

- Chronic disease patients may **not have regular communication with physicians**
  - *Lack of time, economic difficulties or negligence*
- This may **induce exacerbation** of their condition, possible hospitalization
- But closer connectivity can ensure **uninterrupted care** and **crisis avoidance**

- Field of Application is **COPD** - chronic obstructive pulmonary disease

Introduction: What We Want to Do

- **Combine** human medical expertise with state-of-the-art technologies, like cloud computing, data mining, and smart phones
- **Enable regular monitoring** of patients and avoidance of medical emergencies
  - *Patients enter Data on a daily basis*
  - *The system analyzes the incoming data*
  - *If the system recognizes a dangerous situation it notifies the patient and the doctor*

Design & Implementation Issues

Design and Implementation Issues (1)

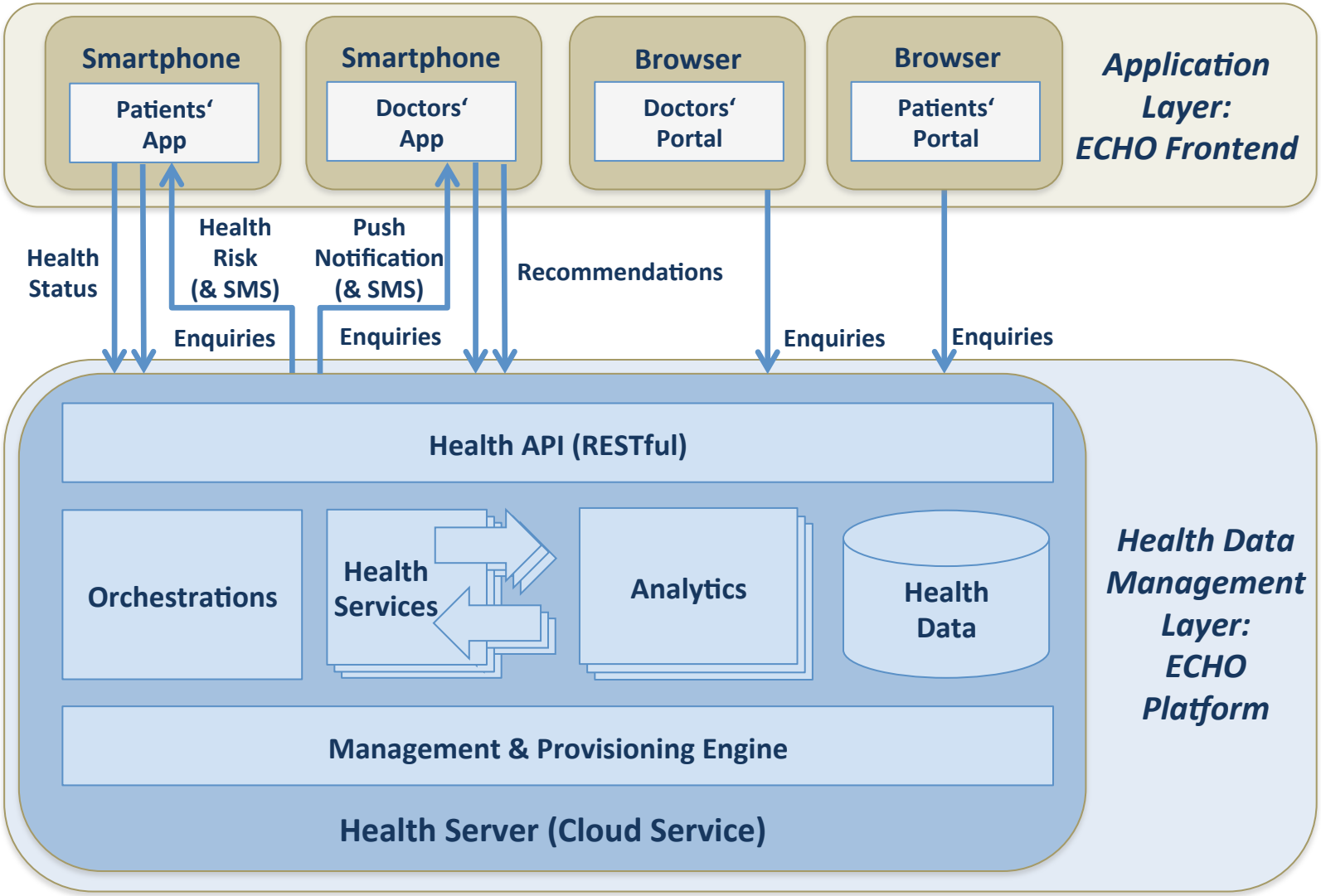
- Data Privacy & Security
  - *Health data are sensitive data and have to be protected by means of encryption, access control, SQL injection prevention, input verification...*
- Support of User Roles
  - *Separation of patients and physicians*
- Different Access Channels
  - *Support many possbilities how a client can access the system: web, mobile, etc.*
- Support of multiple hospitals
  - *The system has to be easily adaptable to different hospitals.*
- Cloud readiness
  - *Enable automatic management and deploying in cloud environments.*

Design and Implementation Issues (2)

- Easy Development of Applications
  - *Provide Uniform API, good documentation, and tool support.*
- Scalability
  - *System should react fast even if many users access it. Plus, it has to deal with more and more data.*
- Automatic Health Data Analysis and Active Behavior
  - *The System should automatically analyze data provided by the patient and react to possible health problems by generating notifications.*
- Data Quality
  - *The system has to implement mechanisms that ensure data quality.*
- Extensible service-based Architecture
  - *It should be possible to create new services by composing existing services, like Health Services which manage patients' data or Analytic Services which analyze patients' data.*

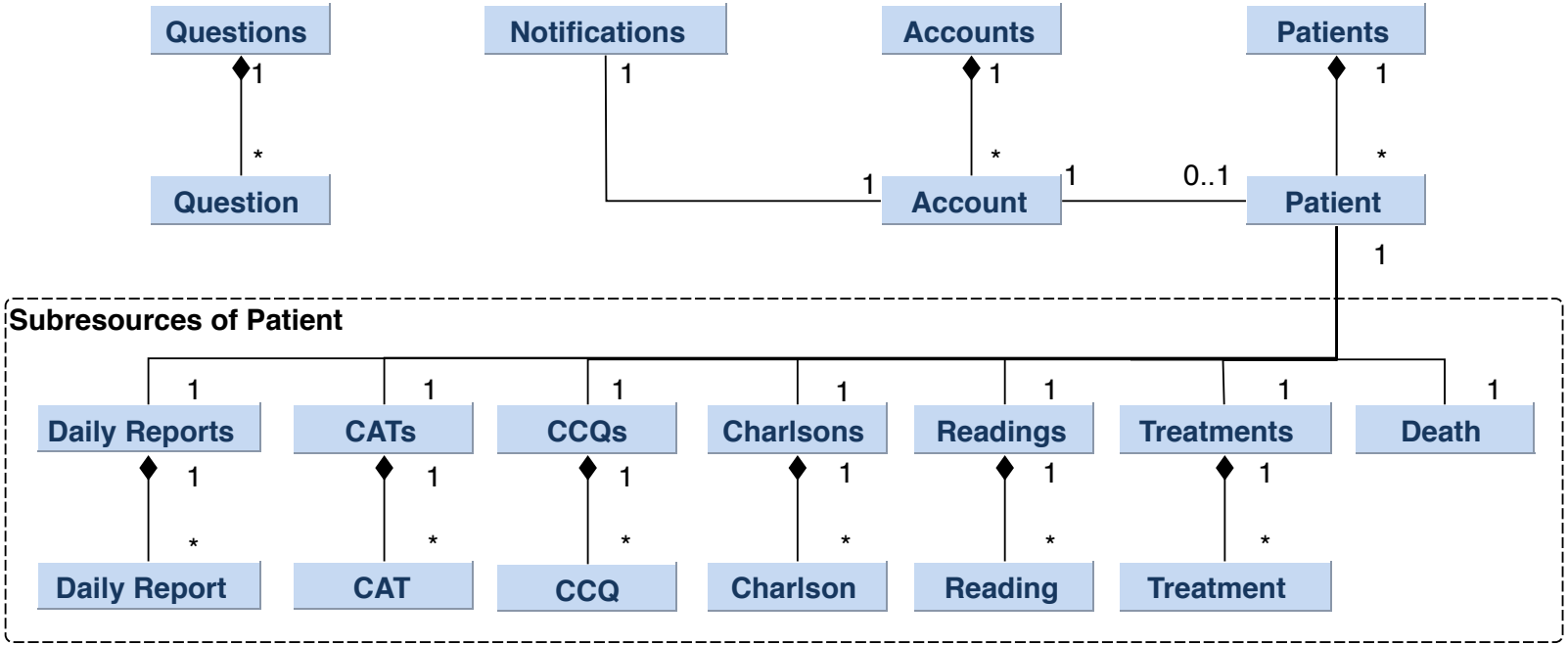
The ECHO System:
An Active Health Data Management System

ECHO System: Architecture



Health API: Resources

- Health API used to store data/query the system.
- RESTful HTTP-API to simplify application development
- Resources:

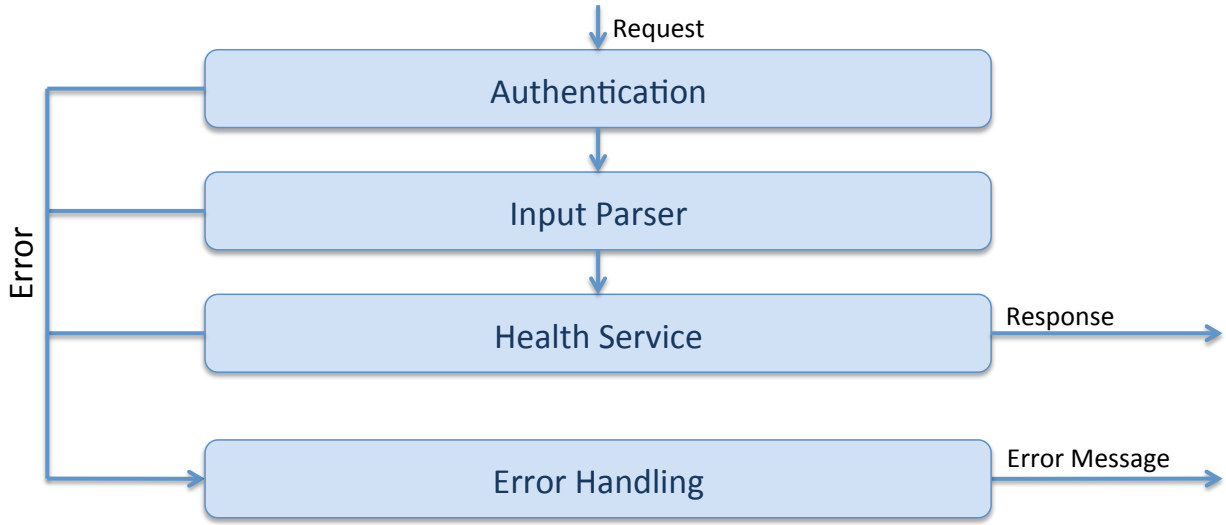


Health API: Security

- Transport Security: SSL
- Authentication: Token-Based
  - *OAuth 2.0 Library*
  - *JSON Web Token*
- Token is digitally signed and contains user information
- Token has to be send in the Authentication-Header
- Token can expire
- Refresh Token can be used to get a new Token

Health API: Implementation

- Implemented using node.js & Express-Framework
- Calling a Health Service via the Health API:

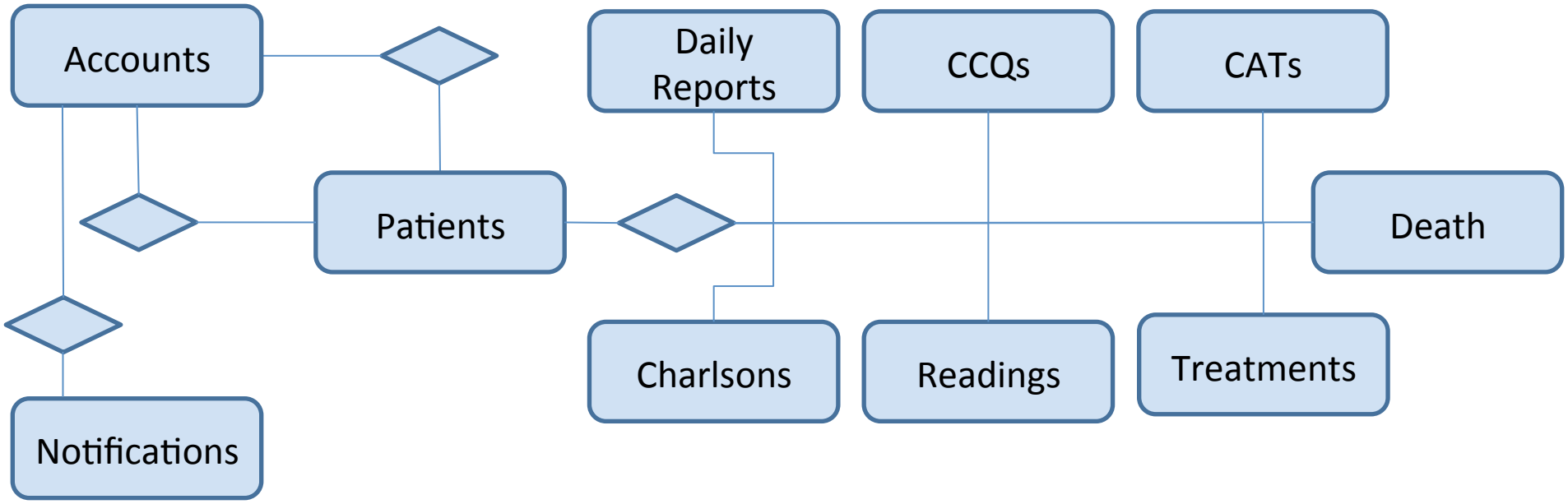


Health API: Documentation

- Swagger is used for Documentation of the Health API
- It is a Description Language for REST Services based on JSON
- Swagger enables:
  - *Service Discovery*
  - *Model Definitions*
  - *Generation of Client and Server Stubs*
- ECHO System comes with SwaggerUI
  - *interactive documentation*

Health Data Management: Health Data Model

- MySQL for Health Data Management
  - *RDBMS because it enforces data integrity and has security features like views*
- Health Data Model:



Health Data Management: Simple Analyses

- Data entered by the patient:
  - *Q1: Did your shortness of breath increase?*
  - *Q2: Did your cough increase?*
  - *Q3: Did your sputum change?*
  - *Q4: Did you have chest pain or discomfort?*
  - *Q5: Did you take the same medications? Or increased them?*
  - *...and some measurements, like heart rate and temperature*

- Rule-based Analysis:
  - *e.g., Q1, Q2 & Q3 answered with "yes" → "Call your physician!"*

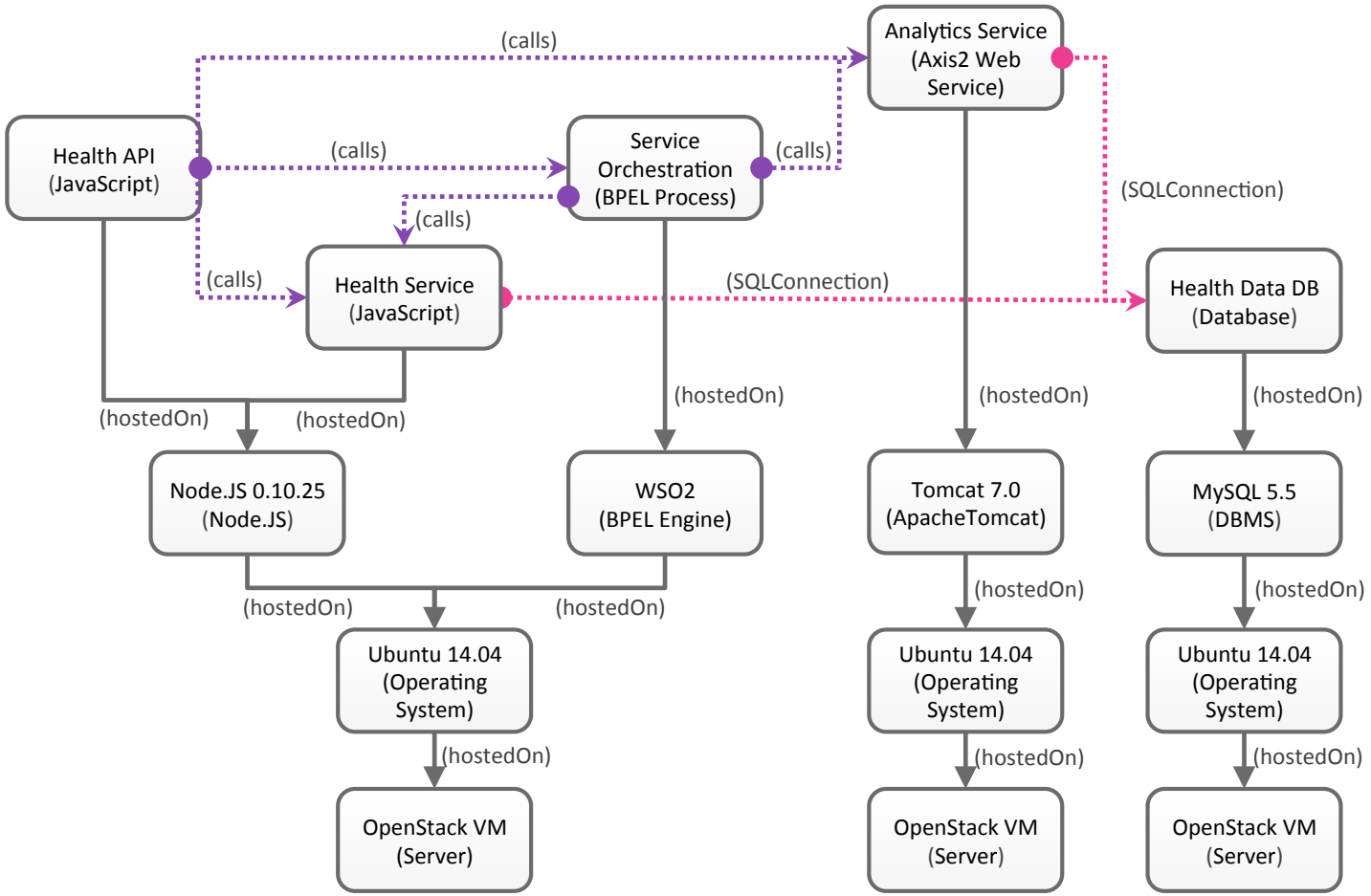
Health Data Management: Security

- Database user for each system user
  - *This user is used by the health service to store/query data*
  - *Views filter data depending on logged in user*
  - *Right management of Database is used to secure data*
- User Roles
  - *Available roles: patient, doctor, admin*
  - *MySQL does not support user roles*
  - *Stored Procedure sets appropriate access privileges*
- Injection Prevention
  - *Node.js has no support for prepared statements*
  - *Stored procedures for “writing” Health Services*

Automated Provisioning and Management of the Health Data Management Layer

- System has to be easily deployable in different IT environments
- Management tasks (e.g., backup/workload-depending scaling) should be automated.
- We used the TOSCA standard to achieve this
  - *Topology and Orchestration Specification for Cloud Applications*
  - *TOSCA is used to describe the platform and the management functions in a machine-readable and self-contained manner*
- TOSCA descriptions can be deployed in any supported cloud environment

ECHO TOSCA Topolgy



Summary

Design and Implementaion Issues: Revisited

Issue	Solution
Data Security	Views, Encryption, Token-based Authentification
User Roles	Roles: doctor, patient and admin
Access Channels	Mobile/Web via REST Interface
Multiple Hospitals	HDML can provide Questions
Cloud Readiness	TOSCA
Easy App Development	REST Interface, Swagger Descriptions
Active Behavior	System analyzes Data and creates Notifications
Scalabiltiy	REST, Node.js can easily be scaled up
Extensible Architecture	New services can be composed from existing ones

Summary and Future Work

- We have build an active Health Data Management System
- Our system can be deployed in many different cloud environments
- We identified issues and showed how to solve them

- Future Work:
  - *HL7 support*
  - *Data Mining*
  - *Customizable Analyzes*

Echo

THANK YOU

http://chroniconline.eu

SPONSORED BY THE

Federal Ministry of Education and Research

University of Stuttgart
Germany