

UNIVERSITY OF APPLIED SCIENCES RAPPERSWIL  
DEPARTMENT OF COMPUTER SCIENCE

BACHELOR THESIS

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# XMPP-Grid Broker

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## *DON'T PANIC*

*"It looked insanely complicated, and this was one of the reasons why the snug plastic cover it fitted into had the words DON'T PANIC printed on it in large friendly letters."*

The Hitchhiker's Guide to the Galaxy

# Abstract

Fabian HAUSER and Raphael ZIMMERMANN

*XMPP-Grid Broker*

# Management Summary

# Acknowledgements

We would like to thank our advisor, Prof. Dr. Andreas Steffen, for his continuous support and helpful comments.

# Contents

<b>Abstract</b>	<b>iii</b>
<b>Management Summary</b>	<b>iv</b>
<b>Abstract</b>	<b>iv</b>
<b>Acknowledgements</b>	<b>v</b>
<b>Contents</b>	<b>vi</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	1
1.1.1 Present Situation . . . . .	1
1.1.2 Problem and Vision . . . . .	1
1.2 Delimitation . . . . .	1
<b>2 Analysis</b>	<b>2</b>
2.1 Terminology . . . . .	2
2.2 Technical Background . . . . .	2
2.2.1 XMPP (eXtensible Messaging and Presence Protocol) . . . . .	2
2.2.2 Relevant XMPP Extensions . . . . .	3
2.2.3 IETF Internet-Draft: Using XMPP for Security Information Ex- change . . . . .	4
2.3 Requirements Analysis . . . . .	4
2.4 Domain Analysis . . . . .	4
2.5 Risk Analysis . . . . .	4
<b>3 Concept</b>	<b>5</b>
3.1 Architecture . . . . .	5
3.2 Wireframes . . . . .	5
<b>4 Implementation and Testing</b>	<b>6</b>
4.1 Code Quality . . . . .	6
4.2 Complexity . . . . .	6
4.3 Testing . . . . .	6
4.4 Documentation . . . . .	6
<b>5 Discussion and Conclusion</b>	<b>7</b>
5.1 Achieved Result . . . . .	7
5.2 Discussion . . . . .	7
5.3 Lessons Learned . . . . .	7
5.4 Future work . . . . .	7
5.5 Conclusion . . . . .	7

<b>Bibliography</b>	<b>I</b>
<b>List of Figures</b>	<b>II</b>
<b>List of Tables</b>	<b>III</b>
<b>Glossary</b>	<b>IV</b>
<b>Appendices</b>	<b>VI</b>
A.1 Task Description . . . . .	VI
A.2 Project Plan . . . . .	IX
A.3 Development Guide . . . . .	XXVI
A.4 Architectural Decisions . . . . .	XXIX
A.5 Time Accounting . . . . .	XLIV
A.6 Meeting Minutes . . . . .	XLVI
A.7 Requirements . . . . .	LVI
A.7.1 Authentication . . . . .	LVI
A.7.2 List Topics and Collections . . . . .	LVII
A.7.3 Create a New Topic . . . . .	LVIII
A.7.4 Create a New Collection . . . . .	LVIII
A.7.5 Delete an Existing Topic . . . . .	LIX
A.7.6 Delete an Existing Collection . . . . .	LIX
A.7.7 Manage Topic/Collection Subscriptions . . . . .	LIX
A.7.8 Manage Topic Affiliations . . . . .	LX
A.7.9 Manage Persisted Items of a Topic . . . . .	LXI
A.7.10 Manage Subscription Requests (optional) . . . . .	LXII
A.7.11 Validate Controller Configuration (optional) . . . . .	LXII
A.8 Wireframes . . . . .	LXIII
A.9 Comparison of XMPP Server and Libraries . . . . .	LXVIII
A.9.1 Server . . . . .	LXVIII
A.9.2 Libraries . . . . .	LXIX
<b>Declaration of Authorship</b>	<b>LXXI</b>



## Chapter 1

# Introduction

In this chapter, present the motivation and legitimisation of our thesis and highlight the delimitations.

### 1.1 Motivation

In this section, we legitimate this thesis and explain the value and applicability of our proposed solution.

#### 1.1.1 Present Situation

The IETF standard draft *Using XMPP for Security Information Exchange* [4] as summarised in section 2.2.3 defines a protocol to exchange security-relevant information between endpoints. The draft was created by the Managed Incident Lightweight Exchange (MILE) Working Group to support computer and network security incident management.

To demonstrate the viability of the draft a rapid prototype was developed in November 2017 [14].

#### 1.1.2 Problem and Vision

Currently, there exists no implementation of the *XMPP* grid draft management functionality which is ready for production use regarding usability and security.

To solve this problem, a graphical interface with bindings to a suitable *Broker* must be proposed and implemented. The interface should permit network administrators to manage and review *Topics*, persisted items and *Platforms*. Additionally, subscription and publishing permissions of *Topics* and *Platforms* must be manageable.

### 1.2 Delimitation

## Chapter 2

# Analysis

## 2.1 Terminology

Taking into account that the intended audience for this thesis are developers and operators of security reporting systems, we mostly use the Security Automation and Continuous Monitoring (SACM) terminology [2] and thereby follow the same guidelines as the XMPP grid draft [4].

## 2.2 Technical Background

The following sections introduce the underlying XMPP protocol and the relevant extensions (*XEPs*) used by the XMPP grid draft as well as a summary of it and the corresponding XMPP terminology.

### 2.2.1 XMPP (eXtensible Messaging and Presence Protocol)

The Extensible Messaging and Presence Protocol (in short *XMPP*) is an open protocol that enables the near-real-time exchange of small data between any network endpoints, hereafter called *Platforms* [12]. While originally designed as an Instant Messaging (IM) protocol, XMPP can be used for a wide range of data exchange applications [11].

XMPP is made of small building blocks defined in the core protocol [12] and numerous extensions called *XEPs* [13]. The core is comprised of functionality for setup and encryption of communication channels, *XML* streams, error handling and more. Additional functionality such as *Service Discovery* [7] and *Publish-Subscribe* [8] are defined in separate extensions.

Although XMPP supports peer-to-peer communication, it is often used in a traditional client-server architecture. A client (*Platform*) can send data to any addressable entity (any other *Platforms*) using *Jabber* Identifiers, hereafter called *JID*. If the *JID* of the receiver has a different domainpart than the current server (*Controller*), the message is forwarded to the responsible XMPP server under its domain [12].

The data exchanged over XMPP is *XML* which makes the protocol structured and extensible, but leads to some protocol overhead. XMPP communicates over unidirectional data streams with a server, which are basically long-lived *TCP* connections. The client opens a channel to the server over this connection, and the server opens one back (i.e. `<stream>` *XML* tags). In both streams, an *XML* document is opened after the connection is established. During the conversation, an arbitrary amount of *stanzas* (specified *XML* child elements) are written to the stream. Before a connection may be terminated, the root element is closed (i.e. `</stream>`) and both streams form valid *XML* documents [12][9].

The core *stanza* types are *Messages* (<message/>), *Presence* (<presence/>) and *Info/Query* (<iq/>). *Messages* can contain arbitrary data similar to email but are optimised for immediate delivery. *Presence stanzas* deal with network availability and the propagation of user presence information. An *Info/Query stanza* consists of a request and response (similar to the GET and POST HTTP methods), which is used for feature negotiation, configuration and general information exchange. Because of these coarse semantics, XMPP provides a generalized communication layer [12][11].

Figure 2.1 illustrates an example setup with two servers and three clients.

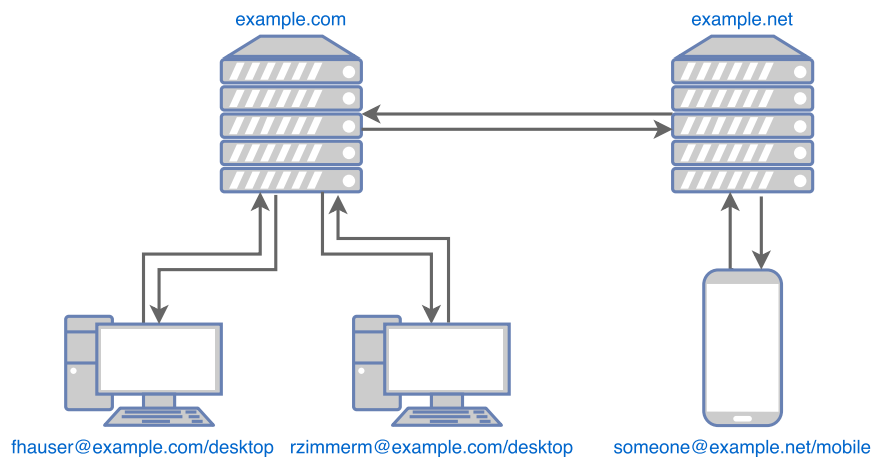


FIGURE 2.1: Two XMPP domains (servers), one with two users and one with a single mobile user.

### 2.2.2 Relevant XMPP Extensions

The XMPP grid draft [4] is based on multiple *XEPs*, most notably *Publish-Subscribe*. In this section, we give an overview of the most relevant used *XEPs*.

**XEP-0004: Data Forms** is a flexible protocol that can be used in workflows such as service configuration as well as for application-specific data description and reporting. The protocol provides form processing, common field types and extensibility mechanisms [5].

**XEP-0030: Service Discovery** enables entities to discover information about the identity and capabilities of other entities, e.g. whether the entity is a server or not, or items associated with an entity, e.g. a list of *Publish-Subscribe* nodes [7].

**XEP-0059: Result Set Management** allows entities to manage the receipt of large result sets, e.g. by paging through the result or limiting the number of results. *Result Set Management* is often desired when dealing with large dynamic result sets, as from service discovery or publish-subscribe, and time or other resources are limited [10].

#### **XEP-0060: Publish-Subscribe**

The *Publish-Subscribe* Extension, hereafter referred to as *PubSub* or *Broker*, enables XMPP entities (*Provider*) to broadcast information via *Topics* to subscribed entities (*Consumer*) [8].

Nodes, hereafter referred to as *Topics*, are the communication hubs. Entities can create topics and configure them, e.g. set up subscription timeouts or limit publishing and subscription rights. The configuration mechanism is based on data forms (XEP-0004). An XMPP-Server *may* restrict node creation to certain entities, which means that possibly not every XMPP-Server that supports *Publish-Subscribe* also implements this feature [3].

The protocol defines a hierarchy of six affiliations of which only the implementation of 'owner' and 'none' is *required*. The implementation of the remaining four affiliations is *recommended*. An owner of a topic can manage the subscriptions and affiliations of other entities associated with a given topic.

To simplify the creation of topics, *PubSub* defines five topic access models ("node access models") that *should* be available: open, presence, roaster, authorize and whitelist.

The open model allows uncontrolled access while presence and roaster are specific for IM. Using the authorize model, the owner has to approve all subscription requests. The whitelist model enables the owner to maintain a list of entities that are allowed to subscribe.

### 2.2.3 IETF Internet-Draft: Using XMPP for Security Information Exchange

This IETF Internet draft describes how the XMPP protocol enhanced with the previously discussed XEPs, most notably the *PubSub* extension, can be used for the exchange and distribution of security-relevant information between network devices.

One of the primary motivation for using XMPP for this task is the fast propagation of such security-relevant data. Using XMPP for such a task also comes with its downsides. Most notably, because the XMPP server (*Broker/Controller*) is the central configuration component in charge of managing access permission, its compromisation has serious consequences.

The draft describes a trust model, thread model as well as specific countermeasures, e.g. to use at least TLS 1.2. These countermeasures also define restrictions of the XMPP protocol and its extensions, e.g. by limiting the topic access models of *PubSub* to whitelist and authorized only [4].

## 2.3 Requirements Analysis

## 2.4 Domain Analysis

## 2.5 Risk Analysis

## Chapter 3

# Concept

### 3.1 Architecture

### 3.2 Wireframes

We created wireframes for most screens to visualise the initial set of user stories. They helped us to find missing requirements, most notably the support of collections. All wireframes are listed in [Appendix A.8 Wireframes](#).

## **Chapter 4**

# **Implementation and Testing**

### **4.1 Code Quality**

### **4.2 Complexity**

### **4.3 Testing**

### **4.4 Documentation**

## **Chapter 5**

# **Discussion and Conclusion**

### **5.1 Achieved Result**

### **5.2 Discussion**

### **5.3 Lessons Learned**

### **5.4 Future work**

### **5.5 Conclusion**





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# List of Figures

2.1	Two XMPP domains (servers), one with two users and one with a single mobile user. . . . .	3
1	UML Use Case Diagram presenting an overview of the primary user stories. . . . .	LVI
2	Login-Screen Wireframe . . . . .	LXIII
3	Controller Overview Wireframe . . . . .	LXIII
4	All Collections Wireframe . . . . .	LXIV
5	All Topics Wireframe . . . . .	LXIV
6	New Collection Wireframe . . . . .	LXIV
7	New Topic Wireframe . . . . .	LXV
8	Collection Overview Wireframe . . . . .	LXV
9	Topic Overview Wireframe . . . . .	LXV
10	Topic/Collection Affiliations Wireframe . . . . .	LXVI
11	Topic/Collection Configuration Wireframe . . . . .	LXVI
12	Topic Parent Collections Items Wireframe . . . . .	LXVI
13	Persisted Items Wireframe . . . . .	LXVII

# List of Tables

# Glossary

## Broker

"A SACM Broker Controller is a *Controller* that contains *control plane* functions to provide and/or connect services on behalf of other SACM components via interfaces on the *control plane*" [2]

## Component

An encapsulation of software that communicates using Interfaces, that is composed of SACM capabilities. [2, 6]

## Consumer

"In SACM, an entity that contains functions to receive information from other *Components*; as used here, the term refers to an *XMPP Publish-Subscribe Subscriber*." [4]

## control plane

"An architectural component that provides common control functions to all SACM components." [2]

## Controller

"In SACM, a 'component containing control plane functions that manage and facilitate information sharing or execute on security functions'; as used here, the term refers to an XMPP server, which provides core message delivery [RFC6120] used by publish-subscribe entities." [4, 2]

## Data Forms

*XMPP Data Forms Extension*

## Info/Query

*XMPP Info/Query stanza*

## Jabber

Original Name of *XMPP*

## JID

Jabber IDentifier, e.g. bob@example.com/mobile

## Message

*XMPP Message stanza*

## Platform

"Any entity that connects to the *XMPP-Grid* in order to publish or consume security-related data." [4]

**Presence**

*XMPP Presence stanza*

**Provider**

"In *SACM* An entity that contains functions to provide information to other *Components*; as used here, the term refers to an *XMPP Publish-Subscribe Publisher*." [4]

**Publish-Subscribe**

*XMPP Publish Subscribe Extension*

**PubSub**

Common abbreviation for *Publish-Subscribe*

**Result Set Management**

*XMPP Result set Management Extension*

**SACM**

Abbreviation for Security Automation and Continuous Monitoring

**Service Discovery**

*XMPP Service Discovery Extension*

**stanza**

A *XMPP* a fragment of XML that is sent over a stream, e.g. *Message*.

**TCP**

Transmission Control Protocol

**TLS**

Transport Layer Security

**Topic**

"A contextual information channel created on a Broker at which messages generated by a Provider are propagated in real time to one or more Consumers. Each Topic is limited to a specific type and format of security data (e.g., IODEF) and provides an *XMPP* interface by which the data can be obtained." [4]

**XEP**

*XMPP Extension Protocol*

**XML**

eXtensible Markup Language

**XMPP**

eXtensible Messaging and Presence Protocol

# Appendices

## A.1 Task Description

## **Bachelorarbeit 2018**

### **XMPP-Grid Broker**

**Studenten: Fabian Hauser, Raphael Zimmermann**

**Betreuer: Prof. Dr. Andreas Steffen**

**Ausgabe: Montag, 19. Februar 2018**

**Abgabe: Freitag, 15. Juni 2018**

#### **Einführung**

Die IETF Security Automation and Continuous Monitoring (SACM) Working Group verfolgt eine Publish-Subscribe Architektur [1] basierend auf dem XMPP Protokoll [2] mit dem potentiell Hunderte oder Tausende von Endpunkten (PCs oder IoT Geräte) in real-time Sicherheitsinformationen in einem XMPP-Grid publizieren können. Security Information und Event Management (SIEM) Systeme können sich dann als Subscriber gezielt auf gewisse Themen (realisiert als XMPP Nodes) abonnieren.

Ein Rapid-Prototype [3] eines XMPP-Grids basierend auf einem Openfire [4] XMPP Server und einem Python Broker Script wurde am IETF 100 Hackathon Singapur im November 2017 vordemonstriert.

Für die Administration des XMPP-Grids soll eine Broker Applikation mit einem grafischen Management Interface erstellt werden. Damit sollen Themen (XMPP-Nodes) erstellt und gelöscht, sowie Owner, Publisher oder Subscriber Rechte vergeben werden können. Es soll die Möglichkeit geschaffen werden, Themen hierarchisch zu Collections [8] zusammenzufassen. Ebenfalls sollen Management-Views über verfügbare Themen, persistierte Items, Subscriber und Publisher generiert werden können.

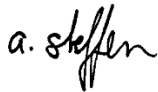
#### **Aufgabenstellung**

- Einarbeiten in den XMPP Grid Internet Draft [1], den XMPP Standard [2], sowie die XEP-0004 [5], XEP-0030 [6], XEP-0060 [7] und XEP-0248 [8] Extensions.
- Erfassen der Requirements für einen XMPP Grid Broker.
- Erarbeiten eines Architekturkonzepts für den XMPP Grid Broker, sowie Evaluation von geeigneten Technologien für die Implementation.
- Implementation, Test und Dokumentation

## Links

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<https://xmpp.org/extensions/xep-0030.html>
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<https://xmpp.org/extensions/xep-0060.html>
- [8] XEP-0248 *PubSub Collection Nodes*  
<https://xmpp.org/extensions/xep-0248.html>

Rapperswil, 19. Februar 2018



Prof. Dr. Andreas Steffen



## **A.2 Project Plan**

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# XMPP-Grid Broker: Project Plan

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*Advisor:*

Prof. Dr. Andreas STEFFEN

Spring Term 2018

# Contents

<b>Contents</b>	<b>i</b>
<b>1 Project Overview</b>	<b>1</b>
<b>2 Project Organization</b>	<b>2</b>
2.1 Roles . . . . .	2
<b>3 Project Management</b>	<b>3</b>
3.1 Components . . . . .	3
3.2 Time Budget . . . . .	3
3.3 Schedule . . . . .	3
3.3.1 Iterations & Milestones . . . . .	3
3.3.2 Meetings . . . . .	4
<b>4 Risk Management</b>	<b>6</b>
<b>5 Infrastructure</b>	<b>8</b>
5.1 Project Management and Development . . . . .	8
5.1.1 Development Tools . . . . .	8
5.2 Backup and Data Safety . . . . .	8
<b>6 Quality Measures</b>	<b>9</b>
6.1 Documentation . . . . .	9
6.2 Project Management . . . . .	9
6.2.1 Sprint Planning . . . . .	9
6.2.2 Definition of Done . . . . .	9
6.3 Development . . . . .	10
6.4 Testing . . . . .	10
<b>Bibliography</b>	<b>I</b>
<b>List of Figures</b>	<b>II</b>
<b>List of Tables</b>	<b>III</b>
<b>List of Abbreviations / Glossary</b>	<b>IV</b>

## Chapter 1

# Project Overview

The goal of the bachelor thesis is to build a broker application and graphical user interface to administer XMPP-Grids according to draft-ietf-mile-xmpp-grid, as described in the task description [3].

## Chapter 2

# Project Organization

All team members have the same strategic rights and duties. Prof. Dr. Andreas Steffen is our project advisor.

### 2.1 Roles

Due to the small team size, most roles are performed by both team members.

**Raphael Zimmermann**

project management, software engineering, quality assurance.

**Fabian Hauser**

infrastructure management, software engineering, quality assurance.

## Chapter 3

# Project Management

### 3.1 Components

For a better overview and to allow us a sophisticated time assessment, we decided to group tasks into categories, i.e. JIRA components. Components represent processes, documents and products which are to be released.

Currently, tasks are separated into following components:

- Application
- Final Submission Document
- Management
- Poster
- Presentation
- Project Plan

### 3.2 Time Budget

The project started with the Kickoff Meeting on 19.02.2018 and will be completed after 16 weeks by 15.06.2018. The two team members are available for 360 hours each during the semester which corresponds to a weekly time budget of 20 hours per person and two weeks with a weekly time budget of 40 hours per person.

Apart from the statutory holidays, there are no further absences planned.

### 3.3 Schedule

The project schedule is an iterative process based on elements of SCRUM.

We decided on a sprint duration of approximately week, but allow deviations in working hours depending on statutory holidays.

#### 3.3.1 Iterations & Milestones

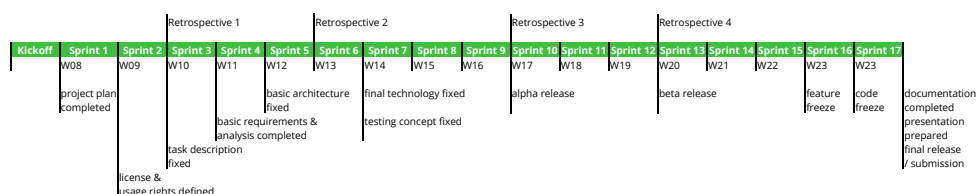


FIGURE 3.1: Overview of the 16 iterations

The goals and milestones resulting from each sprint are shown in Figure 3.2.

TABLE 3.1: Meeting Time Budget

Meeting Type	Total Duration per Person	Total Duration for the Team
Supervision Meetings	12 hours	24 hours
Standup Meetings	16 hours	32 hours
Sprint Planning Meetings	18 hours	36 hours
Retrospective	4 hours	8 hours
Total	50 hours	100 hours

### 3.3.2 Meetings

The team works every Monday (08:00 - 12:00) and Tuesday (08:00 - 17:00) together in the study room and remotely Fridays (08:00 - 17:00). Wednesday and Friday begin with a daily stand-up meeting taking no longer than 15 minutes. Sprint planning meetings are carried out on Tuesday at 10:00. Table 3.1 shows an overview of the total meeting time budget.

Regular meetings with the project advisor take usually place on Monday in Prof. Dr. Steffen's office.

Raphael Zimmermann will take meeting notes for every meeting. Meeting minutes are published on the project website afterwards.

<b>Sprint</b>	<b>Sprint 1</b>	<b>Sprint 2</b>	<b>Sprint 3</b>	<b>Sprint 4</b>
<b>Tag</b>	<b>0.1.0</b>	<b>0.2.0</b>	<b>0.3.0</b>	<b>0.4.0</b>
<b>Date</b>	20.02.2018 – 27.02.2018	27.02.2018 – 06.03.2018	06.03.2018 – 13.03.2018	13.03.2018 – 20.03.2018
<b>Milestones</b>	- license & usage rights defined	- task description fixed	- basic requirements & analysis completed	- basic architecture fixed
<b>Time Budget</b>	40	40	40	40
<b>Tasks</b>	- setup remaining project infrastructure - read relevant XFP standards etc. - begin with chapter "initial situation" - analyze existing python proof-of-concept	- collect non-functional requirements (NFRs) - compile set of user stories - draft technology fixed - research frameworks and technology; Prepare architectural decisions - chapter "Initial Situation" completed - signed task description	- extend NFRs; user stories; wireframes - make first architectural decisions - draft technology fixed - implement proof of concepts for critical components	- make big architectural decisions - implement proof of concepts for critical components
<b>Documents / Chapters / Artefacts</b>				
<b>Sprint</b>	<b>Sprint 5</b>	<b>Sprint 6</b>	<b>Sprint 7</b>	<b>Sprint 8</b>
<b>Tag</b>	<b>0.5.0</b>	<b>0.6.0</b>	<b>0.7.0</b>	<b>0.8.0</b>
<b>Date</b>	20.03.2018 – 27.03.2018	27.03.2018 – 03.04.2018	03.04.2018 – 10.04.2018	10.04.2018 – 17.04.2018
<b>Milestones</b>		- final technology fixed - testing concept fixed		
<b>Time Budget</b>	40	40	40	40
<b>Tasks</b>	- implement proof of concepts for critical components - draft testing concept	- implement proof of concepts for critical components - finalise testing concept - Chapter "Our Approach" completed	- implement most important user stories - make further architectural decisions	- implement most important user stories - make further architectural decisions
<b>Documents / Artefacts</b>				
<b>Sprint</b>	<b>Sprint 9</b>	<b>Sprint 10</b>	<b>Sprint 11</b>	<b>Sprint 12</b>
<b>Tag</b>	<b>0.9.0</b>	<b>0.10.0</b>	<b>0.11.0</b>	<b>0.12.0</b>
<b>Date</b>	17.04.2018 – 24.04.2018	24.04.2018 – 01.05.2018	01.05.2018 – 08.05.2018	08.05.2018 – 15.05.2018
<b>Milestones</b>	- alpha release			- beta release
<b>Time Budget</b>	40	40	40	40
<b>Tasks</b>	- implement most important user stories - make further architectural decisions - write integration tests - alpha release bundle	- implement secondary user stories - write integration tests	- implement secondary user stories - write integration tests	- implement secondary user stories - write integration tests - beta release bundle
<b>Documents / Artefacts</b>				
<b>Sprint</b>	<b>Sprint 13</b>	<b>Sprint 14</b>	<b>Sprint 15</b>	<b>Sprint 16</b>
<b>Tag</b>	<b>0.13.0</b>	<b>0.14.0</b>	<b>0.15.0</b>	<b>0.16.0</b>
<b>Date</b>	15.05.2018 – 22.05.2018	22.05.2018 – 29.05.2018	29.05.2018 – 05.06.2018	05.06.2018 – 12.06.2018
<b>Milestones</b>			- future freeze	- code freeze
<b>Time Budget</b>	40	40	40	80
<b>Tasks</b>	- implement remaining user stories - improve code base - write integration tests	- implement remaining user stories - improve code base - write integration tests	- implement remaining user stories - improve code base - write integration tests	- fix eventual bugs - write documentation - final release bundle - poster - abstract
<b>Documents / Artefacts</b>				
<b>Sprint</b>	<b>Sprint 17</b>			
<b>Tag</b>	<b>1.0.0</b>			
<b>Date</b>	12.06.2018 – 15.06.2018			
<b>Milestones</b>	- documentation completed - presentation prepared - final release / submission			
<b>Time Budget</b>	40			
<b>Tasks</b>	- write documentation - submit documents - personal reports - management summary - presentations - time accounting			
<b>Documents / Artefacts</b>				

FIGURE 3.2: Detailed overview with tasks and milestones of all 16 sprints.



## Chapter 4

# Risk Management

An assessment of the project-specific risks is carried out in Table 4.2 as time loss during the whole project. The risk matrix in Table 4.1 provides an overview of the risk weighting.

To account for these risks, we reduce our weekly sprint time by the total weighted risk applicable to the planned task topics (on average approximately 13.5%). We also review the risk assessment after every sprint, adapt it and take measures if necessary.

Severity Probability	High ( $\geq 5d$ )	Medium ( $2-5d$ )	Low ( $\leq 2d$ )
High ( $\geq 60\%$ )	1		
Medium (30-60%)	6		
Low ( $\leq 30\%$ )		3, 4, 5	

TABLE 4.1: The risk matrix. Numbers reference to the risk assessment Table 4.2

TABLE 4.2: Risk assessment table. Time in hours over the total project duration.

#	Title	Description	Prevention / Reaction	Risk [h]	Probability	= [h]
1	Incomplete reference documentation	The reference documentation / standards are incomplete or difficult to comprehend.	Discuss missing parts with project advisor	60	60%	36
2	Communication errors	Errors due to miscommunication or misapprehension.	Maintain a high level of interaction, precise specification of tasks responsibilities, conduct meetings if ambiguities exist.	30	50%	15
3	Problems with project infrastructure	The used project infrastructure is not or only partially available, or data loss occurs within management software.	Clean setup and self-hosting of the tools to prevent third-party dependencies.	45	30%	13.5
4	Scope creep	The project's scope is extended over the project course.	Define the project scope and limitations precisely. Discuss changes with the project advisor.	45	30%	13.5
5	Dependency errors	There are errors/bugs in third-party dependencies, i.e. libraries.	Carefully select libraries and limit third-party dependency to a minimum.	30	30%	9
6	Missing dependency documentation	Selected libraries are lacking proper documentation	The documentation quality of a library should be a selection criterion.	30	40%	12
Total weighted risk						99

## Chapter 5

# Infrastructure

### 5.1 Project Management and Development

For project management we utilise JIRA[1]. As document/code storage, git repositories on Github are used, the continuous integration/deployment will be defined in the course of the project.

These applications are hosted on our HSR project server, which runs a standard Ubuntu Linux 17.10.

#### 5.1.1 Development Tools

The development tools will be defined in the course of the project.

### 5.2 Backup and Data Safety

An incremental backup of the project server including the source code and documentation is created on an independent system every night.

As our documents and code is stored in a git repository, they are also distributed on all development systems.

## Chapter 6

# Quality Measures

To maintain a high standard of quality, we take the following measures:

- short sprint reviews
- four extended retrospectives
- code reviews
- automated unit and integration testing
- publish all documentation on the project website using continuous integration/delivery.
- using continuous integration for source code

### 6.1 Documentation

The official documents such as the final submission document, meeting minutes as well as this project plan are written in  $\text{\LaTeX}$  respectively ASCIIDoc and published on the project website <sup>1</sup> containing all PDF documents.

The sources are in both cases kept under version control in the same repository, which allows us to use the same tools and processes for documentation and code. The continuous integration server builds and publishes the website whenever new changes are pushed to the repository.

### 6.2 Project Management

Because the project plan allows for an iterative process, we use JIRA with its SCRUM-features (such as sprint creation or boards) for project management.

#### 6.2.1 Sprint Planning

Each sprint is mapped to JIRA, which allows the project advisor to trace the project progress. Sprints are represented as boards on which the current state and assignee of any issue is easily visible ("To Do", "In Progress", "Review", "Done").

#### 6.2.2 Definition of Done

An issue may be closed if *all* of the following conditions are met:

- All functionality conforms to the specification. Any deviations must be discussed and decided by the team.
- The source code is reasonably documented.

---

<sup>1</sup><https://xgb.redbackup.org>

- No code is commented out.
- No warnings and errors by the compiler or any other quality tool.
- A review is performed and accepted in a pull request.
- The corresponding branch is merged into the stable branch (e.g. master).
- All documents are up to date including the project website.
- Reasonable unit and integration tests exist and pass.
- The complete continuous integration pipeline works.
- All time is logged.

## 6.3 Development

We decided to use GitHub Flow[2], a straightforward development workflow.

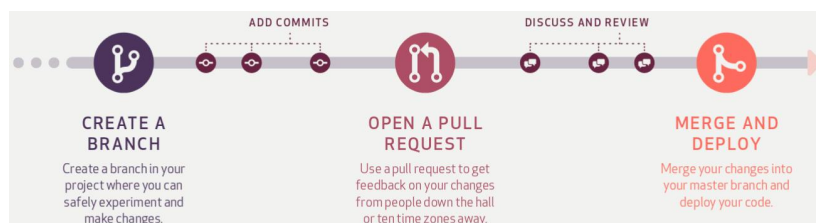


FIGURE 6.1: GitHub Flow illustrated ( Source [2])

Since the effective technology will be fixed later in the project, concrete coding guidelines, tools, metrics and an error policy will be defined when appropriate.

## 6.4 Testing

All functionality must be automatically testable using continuous integration. Any non-trivial function/method must be verified with unit tests.

Integration tests verify extended test scenarios.

A minimal performance analysis will be carried out at the end of the project.

# Bibliography

- [1] Atlassian Inc. Open Source Services by Atlassian Inc. <https://developer.atlassian.com/opensource/>, 2017.
- [2] Github Inc. Github Flow. <https://guides.github.com/introduction/flow/>, 2013.
- [3] A. Steffen. Task Description "xmpp-grid broker". <https://xdg.redbackup.org/documents/task-description.pdf>, 2017.

# List of Figures

3.1	Overview of the 16 iterations . . . . .	3
3.2	Detailed overview with tasks and milestones of all 16 sprints. . . . .	5
6.1	Organigram . . . . .	10

# List of Tables

3.1	Meeting Time Budget . . . . .	4
4.1	Risk matrix . . . . .	6
4.2	Risk assessment . . . . .	7



## **List of Abbreviations / Glossary**

## **A.3 Development Guide**

# Development Guide

# Tools

- Git  $\geq$  2.0 for version control

## Writing Guidelines

In order to have a consistent style of writing, we defined the following guidelines. These guidelines apply to all documents related to the redbackup project.

- Keep it brief, clear and objective
- Write short and straightforward sentences
- Do not use synonyms for concepts etc. (always use the same wording, e.g. 'client' or 'node')
- Abbreviations must be introduced the first time they occur in the text (except well-known ones)
- Prevent ambiguity in sentences
- Use personal style ("we") whenever appropriate; usually for the description of our work.
- When a gender-specific pronoun is required, use "he/she".
- Use present tense except for the description of (our) completed work.

## Definition of Done

To maintain our high quality needs, we determined following definition of done guidelines:

- All functionality conforms to the specification. Any deviations must be discussed and decided by the team.
- A review is performed and accepted in a pull request.
  - The source code is reasonably documented.
  - No code is commented out.
  - No warnings and errors by the compiler or any other quality tool.
  - Reasonable unit and integration tests exist and pass.
  - All documentations are up to date including the project website.
  - The complete continuous integration pipeline works.
  - The code is formatted according to the guidelines (i.e. according to RustFmt)
- The corresponding branch is merged into the stable branch (e.g. master).
- All time is logged.

## **A.4 Architectural Decisions**

# Architectural Decisions

# Architecture Style

There are three common variants to participate in XMPP communication and manage server configurations: As XMPP-server plugin, XMPP component or an XMPP Client/Bot.

The implementation style fundamentally restricts the set of implementation languages and has a profound impact on the fundamental architecture.

The following aspects must be taken into account to find the most suitable architecture style:

- All required management functionality must be supported over the available APIs and protocols.
- Compatibility with most XMPP servers
- Keep the implementation complexity as low as possible

## Considered Options

- XMPP server plugin, e.g. for [Openfire Plugin](#).
- XMPP Component ([XEP-0114](#)).
- XMPP Client/Bot

## Decision Outcome

Chosen option: XMPP Client/bot, because it is not coupled to a specific XMPP server as the Server Plugin and, in contrast to the XMPP Component, supports strong authentication.

## Pros and Cons of the Options

### Server Plugin

- Good, because all features could be implemented directly on the XMPP server.
- Good, because there is minimal protocol overhead and abstraction.
- Bad, because a very high coupling to a specific XMPP server is required and compatibility/interoperability is therefore limited
- Bad, because the high coupling to a specific XMPP server usually limits the possible implementation language.

### XMPP Component

- Good, because the application style fits very well in the Components model.
- Bad, because the specification of Components is marked as *Historical* and might therefore not be implemented by many XMPP Servers.
  - Note: Openfire supports Components

- Bad, because some XMPP client libraries might support Components.
- Bad, because the authentication mechanisms might not suffice the required standards of the ietf draft.
- Bad, because it uses a own handshake based digest authentication message.

### **XMPP Client/Bot**

- Good, because a Bot is basically a normal XMPP client, which is supported by every XMPP server
- Good, because all XMPP client libraries implement this feature.
- Good, because secure connections to the XMPP server are supported (SASL).
- Bad, because the application is conceptually not a normal XMPP-Client.



# Platform

The chosen platform has a fundamental impact on the resulting application as well as on the user experience: Where is it used, from whom and from which device.

## Considered Options

- Client Application with Command Line Interface
- Client Application with Graphical User Interface
- Web application

## Decision Outcome

Chosen option: Web Application because it can easily be installed, updated and provides maximal user acceptance. The development team has experience in writing web applications meaning they know common pitfalls and limitations of the platform. Command line users might use the already existing proof of concept instead.

## Pros and Cons of the Options

### Client Application with Command Line Interface

- Good, because cross-platform support can be achieved relatively easy (depending on the chosen language/runtime).
- Good, because the development team has experience writing command line applications.
- Good, because all OS-functionality is available.
- Good, because command line tools are relatively simple to implement.
- Bad, because additional runtimes might be required (python, JVM, .NET etc.).
- Bad, because not all users appreciate command line tools.
- Bad, because cross-platform testing is expensive.
- Bad, because mobile devices (phones, tablets, chromebooks) are not supported.
- Bad, because updates must be performed on every client.
- Bad, because additional rights are required for setup.

### Client Application with Graphical User Interface

- Good, because graphical interfaces have a broad acceptance.
- Good, because all OS-functionality is available.
- Bad, because additional runtimes might be required (python, JVM, .NET etc.).
- Bad, because additional libraries are required (e.g. QT).

- Bad, because cross-platform testing is expensive.
- Bad, because mobile-devices (phones, tablets, chromebooks) are not supported.
- Bad, because updates must be performed on every client.
- Bad, because additional rights are required for setup.
- Bad, because the development team has no experience writing graphical user interfaces.

## **Web Application**

- Good, because graphical interfaces have a broad acceptance.
- Good, because the development team has experience writing command line applications.
- Good, because no additional runtime on the client side (except the browser) is required.
- Good, because no additional rights are required for setup.
- Good, because updates must only be performed on the server side (clients need no updates but the platform, i.e. the browser).
- Good, because it scales well.
- Bad, because only limited OS-functionality is available.
- Bad, because testing of multiple browsers and browser versions is expensive.
- Bad, because the supported features vary significantly depending on the browser and version.
- Bad, because a backend server is required although its importance might vary on the chosen architecture.
- Bad, because it has a potentially large attack vector depending on how and where it is deployed.

# SASL Authentication Strategy

User Story: 1.2 Authentication: Secure XMPP Connection

The [XMPP grid draft](#) states in section 8.3.1 that

The XMPP-Grid Controller MUST authenticate the XMPP-Grid Platform either using the SASL EXTERNAL mechanism or using the SASL SCRAM mechanism (with the SCRAM-SHA-256-PLUS variant being preferred over the SCRAM-SHA-256 variant and SHA-256 variants [RFC7677] being preferred over SHA-1 variants [RFC5802]).

The chosen authentication mechanism has an impact on the implementation of the broker application as well as on the XMPP server support.

Note that this architectural decision has no impact on the communication between the Controller and other Platforms (i.e. other XMPP clients and the XMPP server).

## Considered Options

- SASL SCRAM
  - SASL SCRAM-SHA-256-PLUS is described in [RFC 7677](#).
  - In summary, SASL SCRAM-SHA-256-PLUS means XMPP over TLS with the client authenticating using a username (JID) and password with challenge-response-exchange.
  - In our case, we may assume that SASL SCRAM-SHA-256-PLUS is currently the only variant supporting a strong hash mechanism
- SASL EXTERNAL
  - SASL EXTERNAL is described in [RFC 4422 Appendix A](#).
  - The SASL EXTERNAL mechanism for XMPP in combination with [TLS/PKIX](#) certificates is described in [XEP-0178](#).
  - In our case, we may assume SASL EXTERNAL means XMPP over TLS with the client authenticating using an X.509 certificate, as this is currently the only practical available implementation.

## Decision Outcome

Chosen option: SASL EXTERNAL, because it offers the highest security level and is well suited for large-scale deployments.

## Pros and Cons of the Options

## **SASL SCRAM**

- Good, because SASL SCRAM is widely supported and used by XMPP servers.
- Good, because SASL SCRAM is easy to use for small deployments, as it only requires a JID and password for authentication.
- Good, because SASL SCRAM fulfils the XMPP grid draft requirements.
- Bad, because the key management is on the XMPP Controller, which leads to a single point of failure and might lead to additional administration efforts.
- Bad, because shared keys (i.e. the password) are used, which cannot be limited to a validity date or selectively revoked.
- Bad, because shared keys(i.e. the password) are difficult to manage in a large scale, decentralised and automated infrastructure.

## **SASL EXTERNAL**

- Good, because a very high-security level can be achieved with X.509 certificates.
- Good, because certificates can be integrated efficiently in a large scale, (mostly) decentralised and automated infrastructure.
- Good, because SASL SCRAM fulfils the XMPP grid draft requirements.
- Bad, because a Certification Authority (CA) must be used to issue certificates, which may lead to additional administration efforts and complexity, especially for small deployments.
- Bad, because not all XMPP server and clients have comprehensive support for SASL EXTERNAL.

# Role Management

The XMPP Publish-Subscribe mechanism (XEP-0060) lacks an explicit description of how to implement role-based authentication for topics(nodes). It implies two possibilities on how to do so: collection nodes and the roster access model.

The following aspects must be taken into account:

- Preferably use existing XMPP protocols/mechanisms
- The chosen strategy must be usable in most practical use-cases.

## Considered Options

- Usage of Collection Nodes (XEP-0248)
- Roster Access Model which supports groups (XEP-0144)
- Custom Roles implemented on the Broker

## Decision Outcome

Chosen option: Usage of Collection Nodes (XEP-0248), because the mechanism is the least intrusive that yet allows a powerful role-concept. We must, however, keep in mind that the XEP is deferred and might therefore not be fully supported by all XMPP servers.

## Pros and Cons of the Options

### Usage of Collection Nodes (XEP-0248)

- Good, because existing XMPP mechanisms can be used.
- Good, because with it few consumers can subscribe to many topics indirectly.
- Good, because publishing permissions are managed on a topic level which encourages per-device-topics.
- Good, because this mechanism is used in production.
- Bad, because XEP-0248 is deferred
- Bad, because the Collection Nodes must be structured in a specific way to support access management

### Roster Access Model which supports groups (XEP-0144)

- Good, because existing XMPP mechanisms can be used.
- Good, because XEP-0144 is a draft (not deferred).
- Bad, because the roster concept aims for IM.
- Bad, because the Roster Access Models is discouraged by the IETF XMPP grid draft.

## **Custom Roles implemented on the Broker**

- Good, because it enables maximal flexibility
- Bad, because existing XMPP mechanisms cannot be used.
- Bad, because the controller must manage its own data instead of delegating it to the XMPP server.
- Bad, because the controller must periodically check that the affiliations are still appropriately configured on the XMPP server.

# Webapplication Communication Topology

As we decided to build a web-application, it remains open how the communication the backing XMPP server flows.

## Considered Options

- **XMPP from the Browser with WebSockets (RFC 7395)**  
Directly speak XMPP over a WebSocket connection with the XMPP server.
- **XMPP from the Browser with BOSH (XEP-0206)**  
Directly speak XMPP over a HTTP long polling connection with the XMPP server.
- **XMPP via WebAPI Proxy**  
Create a standalone application that proxies the XMPP server and exposes a web-API to the client (e.g. a RESTful API).

## Decision Outcome

Chosen option: XMPP from the Browser with WebSockets to reduce duplicated code and use standardised XMPP features. In comparison to XMPP via WebAPI Proxy, it simplifies the deployment of new features because they must not be added in two places (the UI and the WebAPI). In comparison to BOSH, WebSockets offer a stateful TCP-connection based on relatively modern standards while BOSH is used by many frameworks as a fallback option.

## Pros and Cons of the Options

### XMPP from the Browser with WebSockets (RFC 7395)

- Good, because when building an SPA-Client, it is sufficient to serve just static files which provides a higher level of security and performance.
- Good, because actively maintained clients exists (e.g. stanza.io). Some libraries also support fallback to BOSH.
- Good, because existing client-certificates can be re-used.
- Good, because existing XMPP-mechanisms are used.
- Bad, because additional server plugins must be enabled which is an additional attack vector. (Workaround: Implement a custom proxy)
- Bad, because it is not a standard yet (Proposed Standard).

### XMPP from the Browser with BOSH (XEP-0206)

- Good, because when building an SPA-Client, it is sufficient to serve just static files which provide higher levels of security and performance.
- Good, because actively maintained clients exists (e.g. strophe.js).
- Good, because existing client-certificates can be re-used.

- Good, because existing XMPP-mechanisms are used.
- Bad, because additional server plugins must be enabled which is an additional attack vector.  
(Workaround: Implement a custom proxy)
- Bad, because it is not a standard yet (Draft).

### **XMPP via WebAPI Proxy**

- Good, because it decouples the client from the effective XMPP calls (separation of concerns).
- Good, because only minimal HTTP and JavaScript features are used leading to a broad compatibility.
- Bad, because the indirection can limit the performance significantly.
- Bad, because a server application must be installed and maintained (security updates).
- Bad, because existing XMPP-mechanisms are not used.



# Frontend Framework

To create a user interface for the web-application frontend, we must utilise a framework. User Interfaces are too complex these days to implement them in pure JavaScript.

The frontend framework fundamentally restricts the set of implementation languages and has a profound impact on the web interface architecture.

The following aspects must be taken into account to find the most suitable architecture style:

- The effort to learn and master the frameworks best practices must be reasonable.
- The framework must be scalable because the web application is not trivial.
- The number of third party libraries must be kept to a minimum to prevent cost-intense maintenance work in the future.

## Considered Options

- [SPA](#) with Angular5
- [SPA](#) with React
- [SPA](#) with Vue.js
- Django App

## Decision Outcome

Chosen option: Angular because it comes with batteries included and we, therefore, must not rely on additional third-party libraries for everyday tasks. Because Angular is opinionated, there is a clear way to do things which will help us to structure the application. For these benefits, we are willing to accept a steeper learning curve.

## Pros and Cons of the Options

### SPA mit Angular5

- Good, because it scales well.
- Good, because the performance is automatically optimised for production builds.
- Good, because it comes with all tools required for building and structuring a sophisticated SPA: components, modules, dependency injection and more.
- Good, because it is very popular, especially in (modern) enterprise applications.
- Good, because it has a large community and is built by Google.
- Good, because it is opinionated, there is a clear way to do things.
- Good, because it uses TypeScript that brings additional safety.
- Bad, because it is heavyweight and hard to learn/understand.

- Bad, because API migrations in the past were costly and hard.
- Bad, because it uses TypeScript which brings indirections and cannot be eliminated.
- Neutral: It is a tool for everything and cannot be used partially.

## SPA mit React

- Good, because it scales well.
- Good, because it is lightweight.
- Good, because it encourages functional programming and discourages state.
- Good, because it provides components.
- Good, because it uses modern JavaScript features (ES6).
- Good, because it has a large community and is built by Facebook.
- Bad, because its "lightweightness" leads to lots of third-party dependencies.
- Bad, because it is not trivial to learn (e.g. "pseudo" inline HTML requires custom attributes `className`).
- Bad, because it only defines a minimal core and many standard problems must be solved manually.
- Bad, because additional libraries such as Redux must be used and understood to create complex applications.
- Neutral: Uses JS for everything which is a matter of taste.
- Neutral: Can be used partially.

## SPA mit Vue.js

- Good, because it scales well.
- Good, because it is lightweight.
- Good, because it provides components.
- Good, because it makes no assumptions about the JavaScript version used.
- Good, because it elegantly separates template (HTML), styling (CSS) and logic (JS).
- Good, because the core team also maintains fundamental additional such as routing and state management.
- Good, because it has a large and active community.
- Bad, because its "lightweightness" leads to lots of third-party dependencies.
- Bad, because it only defines a relatively small core and some standard problems must be solved manually.
- Bad, because there is no standard way for non-trivial setups (complex SPA, automated testing, etc.).
- Bad, because additional libraries such as Vuex must be used and understood to create complex applications.

- Neutral: Can be used partially.

## Django App

- Good, because Django has excellent documentation.
- Good, because Django has a (mostly) stable API.
- Good, because Django is used in other projects in the [INS](#).
- Good, because Django has a very active community.
- Bad, because multiple languages (Python and JavaScript) are required in the frontend.
- Bad, complex client logic (e.g. paging) must still be implemented in JavaScript and might require an additional framework.
- Bad, because it is very heavyweight (includes ORM, migrations and much more) with lots of features that we do not need.
- Bad, because it requires a backend instance in comparison to the SPAs.

## **A.5 Time Accounting**

**TODO**

## **A.6 Meeting Minutes**

# Meeting 2018-02-19

## Attendees

- Fabian Hauser, fhauser
- Raphael Zimmermann, rzimmerm
- Prof. Dr. Andreas Steffen, SFF

Minute Taker: rzimmerm

## Agenda

1. Administrative tasks
2. Where to start
3. Date and time for the next meeting
  - 2018-02-26, 09:00 in SFFs office

## Discussions / Decisions

1. Administrative tasks
  - All documentation artifacts will be published on the project website.
  - We will use JIRA for project planning.
  - We will decide later, which continuous integration tools we use.
    - The decision must allow the INS to take over the project after the BA.
    - reasons for the decision must be documented.
  - Decisions on the programming language and frameworks are made later.
    - Our experience and productivity in a given eco system must be considered as well.
2. Where to start
  - Read the draft [XMPP for Security Information Exchange](#).
  - Learn more about XMPP (Read the specs and the mentioned XEPs).
  - IODEF payloads are not the main focus of this project.
  - It would be nice if a first draft is ready for the IETF Hackathon, starting on March 17.
  - Main goals of the project:
    - Design a solid architecture (Openfire plugin or standalone?).
    - Implement the requirements according to the IETF Draft:
      - Vanilla XMPP with Discovery und Publish/Subscribe XEPs.
      - Define Topics/Nodes and manage permissions.

- Administrative utilities such as purge, list topics, show number of items, identifier etc.
  - Most is already implemented in the form of a proof of concept.
3. Date and time for the next meeting:
- 2018-02-26, 09:00 in SFFs office

## Upcoming absences

*no upcoming absences*



# Meeting 2018-02-26

## Attendees

- Fabian Hauser, fhauser
- Raphael Zimmermann, rzimmerm
- Prof. Dr. Andreas Steffen, SFF

Minute Taker: rzimmerm

## Agenda

1. Open questions regarding the task
2. Date for oral exam
3. Is there a presentation during the semester?
4. Date and time for the next meeting

## Discussions / Decisions

1. Open questions regarding the task
  - Some requirements can influence the chosen architecture fundamentally (e.g. to write a "bot", a component or a plugin)
    - a "normal" user (in the "bot" or the component variant) might have limited access to some node. According to SFF, this issue can be ignored because, in a real-world application, such behaviour should be limited by strict policies.
    - SFF emphasises that the authentication mechanisms use must be robust and certificate based.
  - Next steps:
    - Write User stories
    - Draw basic architecture in C4-Diagrams
    - Risk analysis (e.g. abuse cases)
    - Evaluation of XMPP servers and libraries. SFF notes that we should not spend too much time evaluating the server and assume that OpenFire fulfils most requirements.
  - Issues to address in the XMPP servers and library evaluation:
    - Can an administrator restrict users to create new topics
    - Recommended features can be checked queried using service discovery. We can also check for undesired configurations (e.g. everyone can publish)
    - Ensure that the libraries support all required functionality, especially authentication!
    - Assess the performance and usability of the libraries

- It is desirable if the service runs is "always on", e.g. to answer subscription requests. However, this is not strictly required according to SFF.
- Any kind of Interface is conceivable, a web interface, however, is very flexible. The core functionality does not have to be available separately.
- The scope of the website is fine according to SFF.

## 2. License

- GNU-FDL for the documentation is fine
- The license for the code will be AGPL but might change depending on the frameworks we use

## 3. Is there a presentation during the semester?

- An interim with the internal co-examiner will be carried out.
- The primary purpose of this presentation is to get familiar with the requirements of the co-examiner (testing, documentation, protocols etc.)
- Should be carried out if a small demo is ready

## 4. Date for oral exam

- If possible, the oral exam will be carried out in early July.
- We will continuously complete parts of the document to reduce the examination efforts

## 5. Date and time for the next meeting

# Upcoming absences

*no upcoming absences*

# Meeting 2018-03-05

## Attendees

- Fabian Hauser, fhauser
- Raphael Zimmermann, rzimmerm
- Prof. Dr. Andreas Steffen, SFF

Minute Taker: rzimmerm

## Agenda

1. Discuss and clarify Requirements/Wireframes
2. Current state of the Task Description
3. Date and time for the next meeting

## Discussions / Decisions

1. Discuss and clarify Requirements/Wireframes
  - We discussed the open issues in the current requirements draft.
    - The application is meant to run in production and must, therefore, meet strict security requirements
      - Especially TLS  $\geq$  1.2 and certificate-based
      - The existing python scripts were the prototype and this project is intended to be a proper implementation
    - Response time is not very crucial for this application as it is designed for maintenance work and not real-time interventions.
    - We must propose an authentication model, e.g. using TLS mutual authentication and exactly one broker user.
    - SFF notes that SASL is quite complex. We might not need it although the IETF draft explicitly requires it.
    - The number of consumers and producers depends strongly on the concrete application. In most cases, however, there will be much more publishers than subscribers. SFF gave the following estimates as reference values.
      - > 1000 Producers
      - 100 Subscribers
      - 1-4 Toplevel Topics
      - > 1000 Subtopics (eg. one for every publisher)
      - > 10000 Persisted Items (note that these items might contain large payloads)

- We plan to include search, filtering and paging functionality for most listings. We will include these features in the next requirements draft.
- SFF points out that subtopics are missing in the current draft as well as the wireframes. We will include this in the next requirements draft.
- SFF notes that a role concept might be needed to simplify the administration. We might be able to use existing XMPP features for this (e.g. XEP-0144).
- According to SFF, Subscription Requests and Validation are nice to have but have low priority.
  - Instead of validation, unsupported functionality should not be visible
- For deleting persisted items, SFF suggests a "bulk delete" functionality, which allows administrators to delete all items that match certain criteria.
- SFF prefers a standalone application over a server plugin to reduce coupling.
- The implementation language is not of paramount importance to SFF although he prefers Python or Java. A single page app written in JavaScript using a Python backend is also a viable option for him.
  - We should not rely on too many third-party libraries that save us several hours during the project but might require extra maintenance effort in the future (SFF gave a Django paging extension as an example)

## 2. Current State of the Task Description

- SFF will complete the task description after he receives the revised user stories and wireframes.

## 3. Date and time for the next meeting

- 2018-03-12, 09:00 in SFFs office

# Upcoming absences

- No weekly meeting on 2018-03-19 (SFF is absent)

# Meeting 2018-03-12

## Agenda

1. Discuss Requirements / Wireframes
2. Architectural Decisions
  - Architectural Decision: Roles
  - Architectural Decision: XMPP over Websockets/BOSH/Backend
  - Architectural Decision: Client Framework
3. Current State of the Task Description
4. Date and time for the next meeting

## Discussions / Decisions

1. Discuss Requirements / Wireframes
  - We will send SFF the updated wireframes and requirements.
  - Next week, SFF will accept/reject the current state as the target set of requirements for the thesis.
  - SFF considers the current wireframes as good.
2. Architectural Decisions
  - Architectural Decisions Template
    - SFF appreciates the current format.
    - We must give more context for non-experts (e.g. what is an XMPP-Bot?).
  - Architectural Decision: Roles
    - We discussed the pros and cons as described in the Architectural Decision.
    - The biggest downside is the limited Openfire support as well as the deferred state of XEP-0248.
    - SFF ratifies this solution.
  - Architectural Decision: XMPP over Websockets/BOSH/Backend
    - SFF says, that this is an interesting approach to experiment with.
    - We must conduct experiments to ensure that all functionality indeed works as expected.
    - SFF says, that from a security aspect, a new interface is not that bad as long as it uses secure authentication mechanisms such as TLS.
    - If we decide to use WebSockets/BOSH, we should investigate how an adapter could be implemented.
  - Architectural Decision: Client Framework (e.g. React, Vue, Angular)
    - For SFF, the most important criteria is to not rely on too many third-party dependencies.

- Otherwise, we should use the best tool for the task.
- The institute has not preferred framework.

### 3. Current State of the Task Description

- Will be finished until the next meeting, based on our revised requirements.
- SFF will send the current draft.

### 4. Date and time for the next meeting

- No weekly meeting on 2018-03-19
- Next weekly meeting is on 2018-03-23 10:00

## Upcoming absences

- No weekly meeting on 2018-03-19 (SFF is absent)

# Meeting 2018-03-23

## Agenda

1. Discuss Requirements / Wireframes
2. Current State of the Task Description
3. Date and time for the next meeting

## Discussions / Decisions

1. Discuss Requirements / Wireframes
2. Current State of the Task Description
3. Date and time for the next meeting
  - No weelky meeting on 2018-03-19 (SFF is absent)
  - No weelky meeting on 2018-04-02 (Easter Monday)

## Upcoming absences

- No weelky meeting on 2018-03-19 (SFF is absent)
- No weelky meeting on 2018-04-02 (Easter Monday)

## A.7 Requirements

The following sections describe the primary requirements in the form of user stories [1]. Figure 1 shows an overview of the primary use stories.

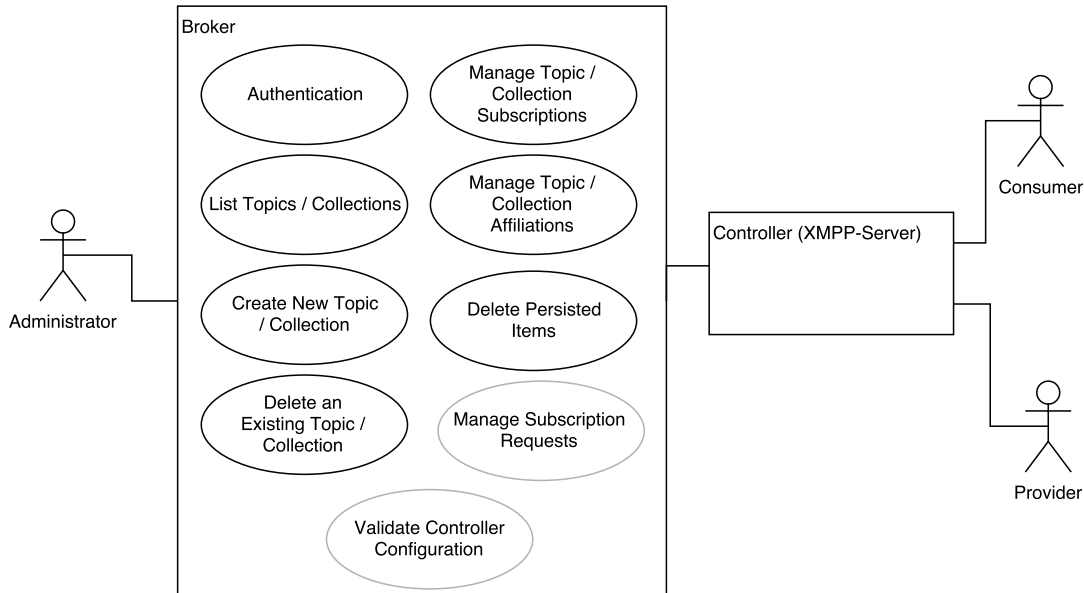


FIGURE 1: UML Use Case Diagram presenting an overview of the primary user stories.

### A.7.1 Authentication

#### A.7.1.1 Login

As an Administrator,  
I want to log in  
- preferably using an existing client TLS certificate -  
so that only I can inspect and manage Topics.

#### A.7.1.2 Secure XMPP Authentication

As an Administrator concerned with security requirements,  
I want to use either SASL EXTERNAL or SASL SCRAM mechanism for authentication -

- preferably the SCRAM-SHA-256-PLUS variant and
- preferably using mutual certificate-based authentication including revocation status checking

- so that the Controller is fully compatible with the XMPP grid draft [4].  
To achieve this goal, I am willing to accept:

- More costly and less user friendly authentication
- limited compatibility of supported XMPP servers



### **A.7.1.3 Secure XMPP Connection**

As an Administrator concerned with security requirements,  
I want to use minimally TLS 1.2 [RFC5246] to communicate with the XMPP server  
at all times  
to achieve maximal security and compatibility with the XMPP grid draft [4].

### **A.7.1.4 Secure Connection**

As an Administrator concerned with security requirements,  
I want to use minimally TLS 1.2 [RFC5246] to communicate with the Broker  
to achieve maximal security.

### **A.7.1.5 Multiple Administrations**

As an Administrator,  
I want to grant access to administrators  
so that they can also manage the application.

### **A.7.1.6 Audit Trail**

As an Administrator concerned with security requirements,  
I want to be able to access an audit log  
- preferably using existing XMPP mechanisms -  
so that I can reconstruct what other Administrations did on the Controller.

### **A.7.1.7 Logout**

As an Administrator,  
I want to log out  
so that I can terminate a session.

## **A.7.2 List Topics and Collections**

### **A.7.2.1 List All Topics**

As an Administrator,  
I want to see a list of all Topics of the associated Controller  
so that I can quickly assimilate which Topics exist.

### **A.7.2.2 List All Top-Level-Collections**

As an Administrator,  
I want to see a list of all Top-Level-Collections of the associated Controller  
so that I can quickly assimilate which Collections exist.

### **A.7.2.3 List All Parent-Collections of a Topic**

As an Administrator,  
I want to see a list of all transitive parent Collections that contain a given Topic  
so that I can quickly assimilate in which Collections items are published.

**A.7.2.4 List All Subtopics and Subcollection of a Collection**

As an Administrator,  
I want to see a list of all Collections and Topics that a given Collection contains  
so that I can quickly assimilate the collection hierarchy.

**A.7.2.5 List Available Topics With Limited Access (optional)**

As an Administrator,  
I want to see a list of all Topics of the associated Controller to which I have limited access to,  
to simplify troubleshooting and locate errors.

**A.7.2.6 List Available Collections With Limited Access (optional)**

As an Administrator,  
I want to see a list of all Collections of the associated Controller to which I have limited access to,  
to simplify troubleshooting and locate errors.

**A.7.2.7 Topic and Collection Paging**

As an Administrator,  
I want to be able to page through any set of Collection/Topic with more than 10 Items  
so that I can work with more than 1000 Collections and Topics more effectively.

**A.7.2.8 Topic and Collection Name Filter**

As an Administrator,  
I want to be able to quickly filter any set of Collections/Topics with more than 10 Items  
so that I can work with more than 1000 Collections and Topics more effectively.

**A.7.3 Create a New Topic**

As an Administrator,  
I want to create a new Topic on the associated Controller  
so that I am not tied to a fixed set of Topics.

**A.7.4 Create a New Collection**

As an Administrator,  
I want to create a new Collection on the associated Controller  
so that I can flexibly patch Topics together.

**A.7.4.1 Override Default Topic Configuration**

As an Administrator in the process of creating a new Topic,  
I want to override the default configuration (e.g. the affiliations)  
so that I can restrict access and provide reasonable defaults.

#### **A.7.4.2 Override Default Collection Configuration**

As an Administrator in the process of creating a new Collection,  
I want to override the default configuration (e.g. the affiliations)  
so that I can restrict access and provide reasonable defaults.

#### **A.7.4.3 Initial Topic Consumers and Providers**

As an Administrator in the process of creating a new Topic,  
I want to specify an initial set of Consumers and Providers  
so that I can restrict access to that Topic and provide reasonable defaults.

#### **A.7.4.4 Initial Collection Consumers**

As an Administrator in the process of creating a new Collection,  
I want to specify an initial set of Consumers  
so that I can restrict access to that Collection and provide reasonable defaults.

#### **A.7.5 Delete an Existing Topic**

As an Administrator,  
I want to delete an existing Topic on the associated Controller  
so that I can get rid of obsolete Topics.

#### **A.7.6 Delete an Existing Collection**

As an Administrator,  
I want to delete an existing Collection on the associated Controller  
so that I can get rid of obsolete Collections.

##### **A.7.6.1 Fault Prevention On Topic-Delete**

As an Administrator in the process of deleting a Topic,  
I want a mechanism to prevent me from deleting the wrong Topic on the associated Controller  
(e.g. require me to enter the name of the Topic manually).

##### **A.7.6.2 Fault Prevention On Collection-Delete**

As an Administrator in the process of deleting a Collection,  
I want a mechanism to prevent me from deleting the wrong Collection on the associated Controller  
(e.g. require me to enter the name of the Collection manually).

#### **A.7.7 Manage Topic/Collection Subscriptions**

##### **A.7.7.1 List Consumers**

As an Administrator,  
I want to list all Consumers (including their JIDs) of a given Topic/Collection on the associated Controller,  
so that I can verify that specific Consumers are subscribed, and others are not.

**A.7.7.2 Inspect Detailed Subscription Configuration**

As an Administrator,  
I want to inspect the detailed Topic/Collection subscription configuration of a given Consumer,  
so that I can reproduce and reason about the receipt of data on that Consumer and find potential misconfiguration.

**A.7.7.3 Partially Modify Subscription Configuration**

As an Administrator,  
I want to modify parts of the Topic/Collection subscription configuration of a given Consumer,  
so that I can fix misconfiguration.

**A.7.7.4 Unsubscribe Consumer**

As an Administrator,  
I want to manually unsubscribe a specific Consumer from a particular Topic/Collection on the associated Controller,  
so that I can remove obsolete or undesired subscriptions.

**A.7.7.5 Subscribe Consumer**

As an Administrator,  
I want to manually subscribe a specific Consumer on a particular Topic/Collection on the associated Controller,  
so that I can faster setup and manage Consumers.

**A.7.8 Manage Topic Affiliations****A.7.8.1 Inspect Affiliations**

As an Administrator,  
I want to list all Affiliations (JID and "Role") for a particular Topic/Collection on the associated Controller  
so that I can find potential misconfiguration.

**A.7.8.2 Modify Affiliations**

As an Administrator,  
I want to modify the Affiliation ("Role") of a given JID for a particular Topic/Collection on the associated Controller  
so that I can fix potential misconfiguration.

**A.7.8.3 Fault Prevention When Modifying My Affiliation**

As an Administrator in the process of modifying my Affiliation for a particular Topic/Collection on the associated Controller,  
I want a mechanism to prevent me from accidentally downgrading my rights.

#### **A.7.8.4 Meaningful Error For Topics/Collection With Limited Access**

As an Administrator,  
I want to receive a meaningful error message when inspecting a Topic/Collection to which I have limited access  
so that I can quickly comprehend why the configuration options are limited.

### **A.7.9 Manage Persisted Items of a Topic**

#### **A.7.9.1 Inspect Persisted Items**

As an Administrator,  
I want to list all Persisted Items for a particular Topic on the associated Controller  
so that I can get an overview and check for misconfiguration.

#### **A.7.9.2 Filter Persisted Items**

As an Administrator,  
I want to be able to filter all persisted Items of a specific Topic by

- the timestamp of its publication
- the publishers JID

so that I can work with more than 10000 persisted items more effectively.

#### **A.7.9.3 Paged Persisted Items**

As an Administrator working with filtered persisted items,  
I want to be able to page through the resulting items  
- given that this feature is supported by the associated Controller -  
so that I can work with more than 10000 persisted items more effectively.

#### **A.7.9.4 Delete a Persisted Item From a Topic**

As an Administrator,  
I want to delete a particular persisted item from a specific Topic  
- given that this feature is supported by the associated Controller -  
so that I can clean up test items and remove obsolete or corrupted items.

#### **A.7.9.5 Purge All Persisted Items From a Topic**

As an Administrator,  
I want to purge persisted items from a specific Topic  
- given that this feature is supported by the associated Controller -  
so that I can clean up test items and remove obsolete or corrupted items.

#### **A.7.9.6 Delete Set of Persisted Item From a Topic (optional)**

As an Administrator,  
I want to delete a set of persisted item that match a given criteria from a specific Topic  
- given that this feature is supported by the associated Controller -  
so that I can clean up test items and remove obsolete or corrupted items.

## **A.7.10 Manage Subscription Requests (optional)**

### **A.7.10.1 List Subscription Request**

As an Administrator,  
I want to list pending subscription requests for a given Topic  
- given that this feature is supported by the associated Controller -  
so that I can quickly assimilate pending requests.

### **A.7.10.2 Accept Subscription Request**

As an Administrator,  
I want to accept a pending subscription request for a given Topic  
- given that this feature is supported by the associated Controller -  
to enable more dynamic access models than just maintaining a black- or whitelist.

### **A.7.10.3 Reject Subscription Request**

As an Administrator,  
I want to reject a pending subscription request for a given Topic  
- given that this feature is supported by the associated Controller -  
so that I can deny user access in accordance with the XMPP standards.

## **A.7.11 Validate Controller Configuration (optional)**

### **A.7.11.1 Validate Supported XEPs Configurations**

As an Administrator,  
I want to validate that a minimum set of XEPs are supported by the associated Controller  
so that I can quickly identify incompatibilities.

### **A.7.11.2 Validate Optional XEP Implementations**

As an Administrator,  
I want to validate that the required features that are marked as optional or recommended in the XEPs are implemented by the associated Controller  
so that I can quickly identify incompatibilities.

A.8 Wireframes



FIGURE 2: Login-Screen Wireframe

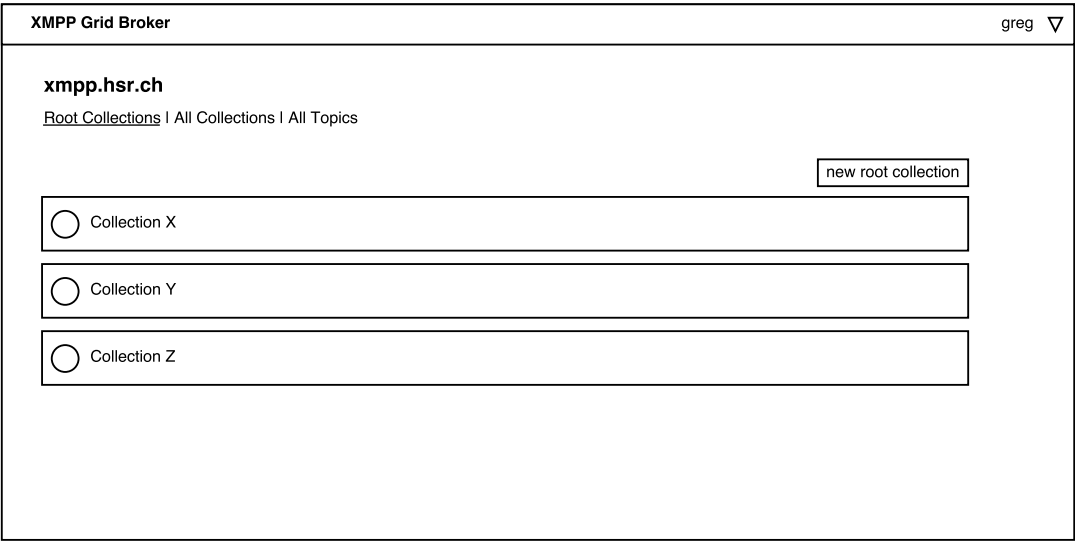


FIGURE 3: Controller Overview Wireframe

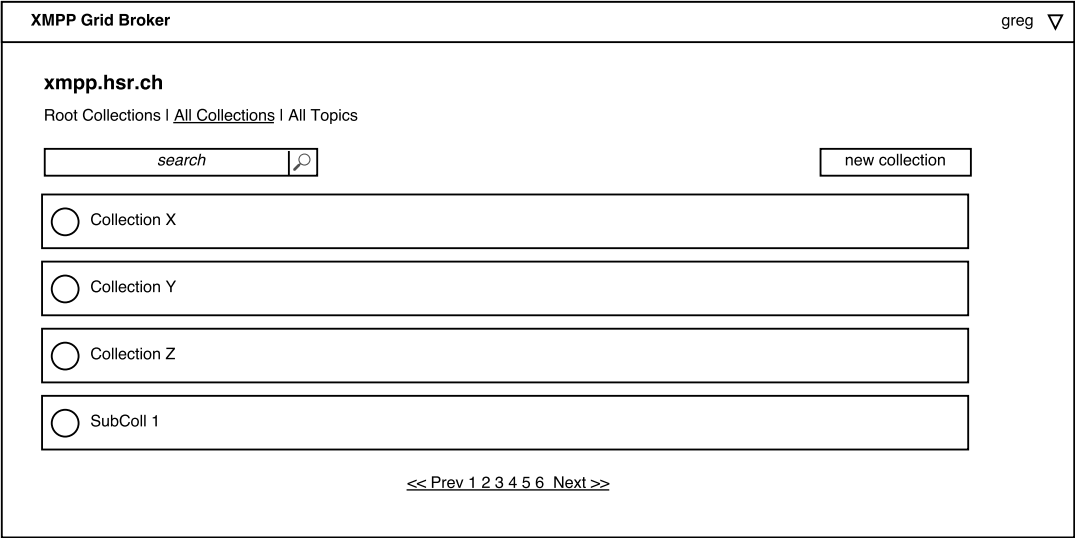


FIGURE 4: All Collections Wireframe

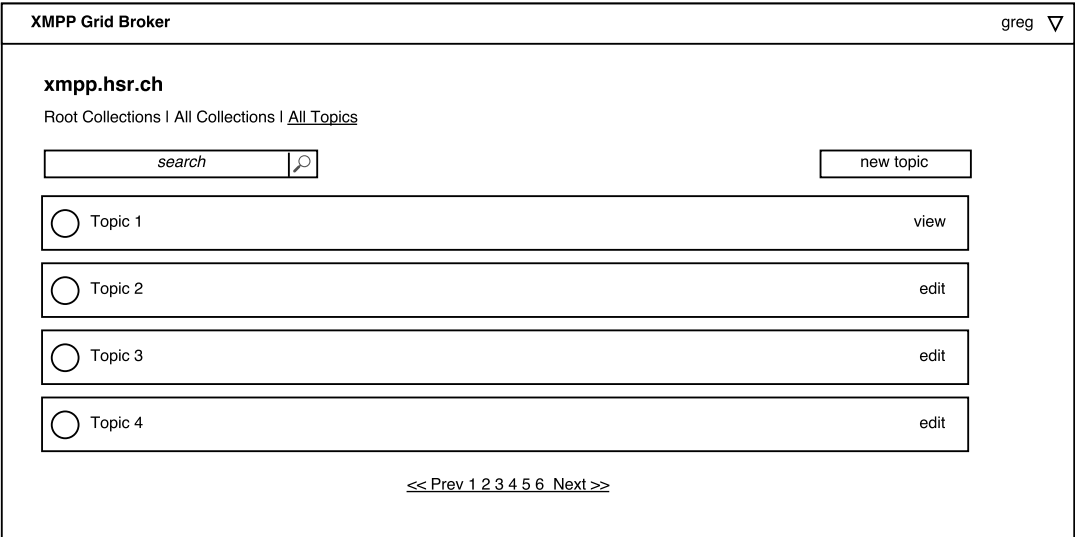


FIGURE 5: All Topics Wireframe

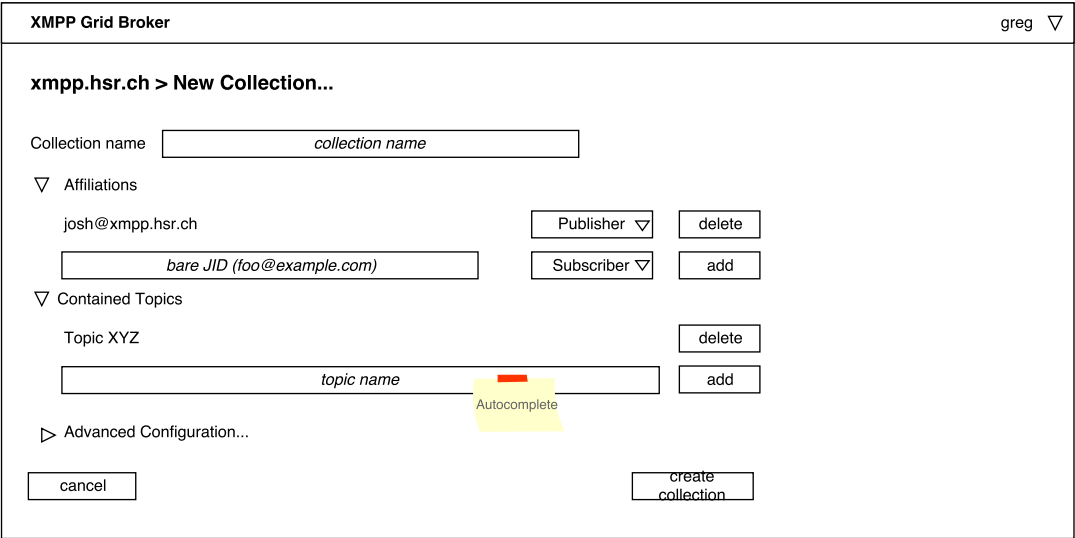


FIGURE 6: New Collection Wireframe



XMPP Grid Broker

greg ▾

xmpp.hsr.ch > New Topic...

Topic name

topic name

▽ Affiliations

josh@xmpp.hsr.ch

Publisher ▾

delete

bare JID (foo@example.com)

Subscriber ▾

add

▽ Parent Collections

Collection 1

collection name

delete

add

▶ Advanced Configuration...

cancel

create topic

Autocomplete

FIGURE 7: New Topic Wireframe

XMPP Grid Broker

greg ▾

xmpp.hsr.ch > Root Collection 1 > Subcollection 1

Overview | Affiliations | Configuration

Affiliations and Configuration tabs are identical with those of topics.

Subcollections:

○ Subcollection 2

add subcollection...

edit | remove

Subtopics:

○ Topic 1

add subtopic...

edit | remove

○ Topic 2

edit | remove

○ Topic 3

edit | remove

○ Topic 4

edit | remove

FIGURE 8: Collection Overview Wireframe

XMPP Grid Broker

greg ▾

xmpp.hsr.ch > Topic 1

Subscriptions (1) | Affiliations | Configuration | Parent Collections | Persisted Items

Pending Subscription Requests

○ joe@xmpp.hsr.ch

accept | reject

Subscribed Consumers

manually subscribe...

○ josh@xmpp.hsr.ch

edit | unsubscribe

○ josh@xmpp.hsr.ch

edit | unsubscribe

○ josh@xmpp.hsr.ch

edit | unsubscribe

○ josh@xmpp.hsr.ch

edit | unsubscribe

FIGURE 9: Topic Overview Wireframe

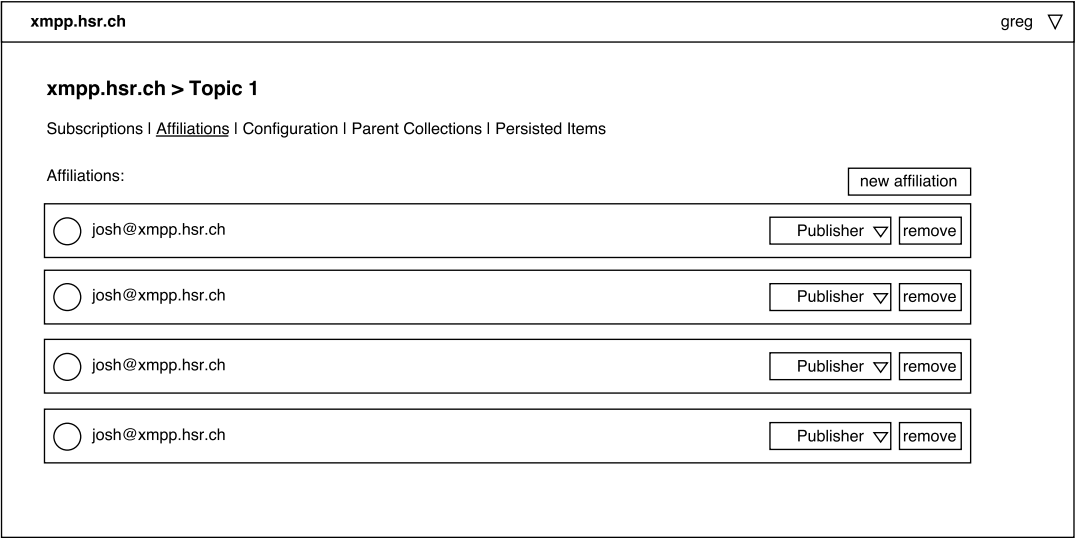


FIGURE 10: Topic/Collection Affiliations Wireframe

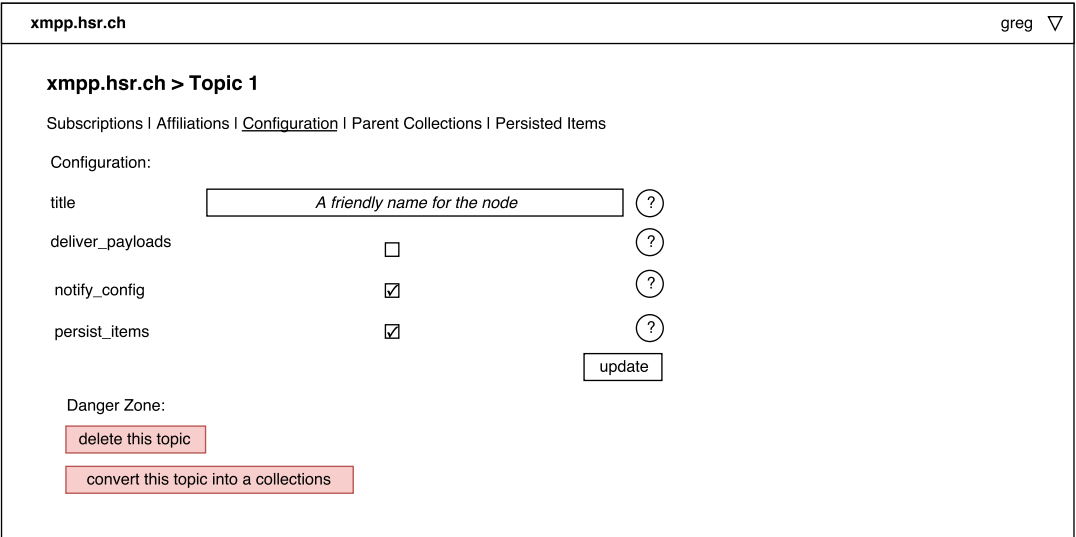


FIGURE 11: Topic/Collection Configuration Wireframe

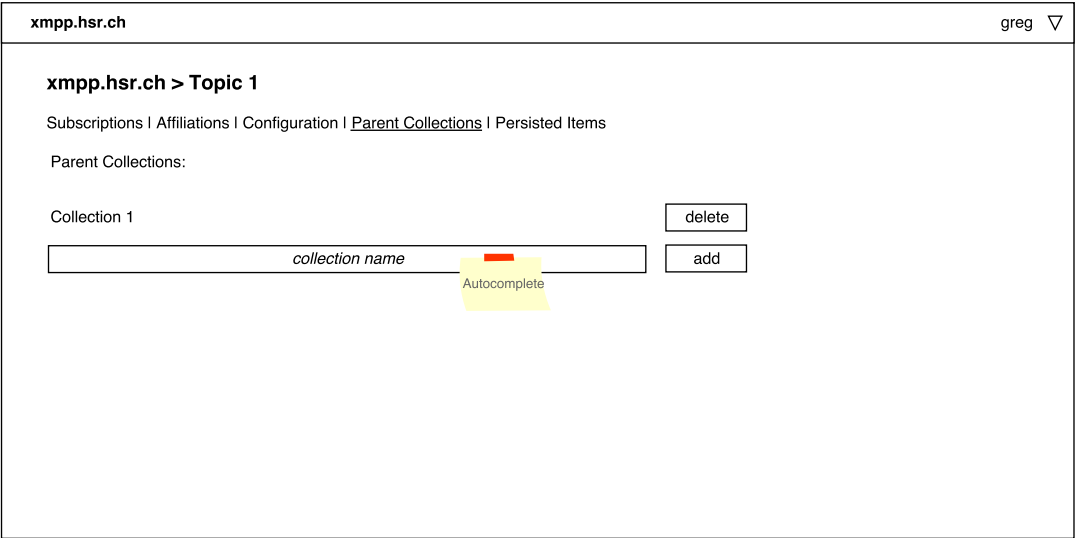


FIGURE 12: Topic Parent Collections Items Wireframe

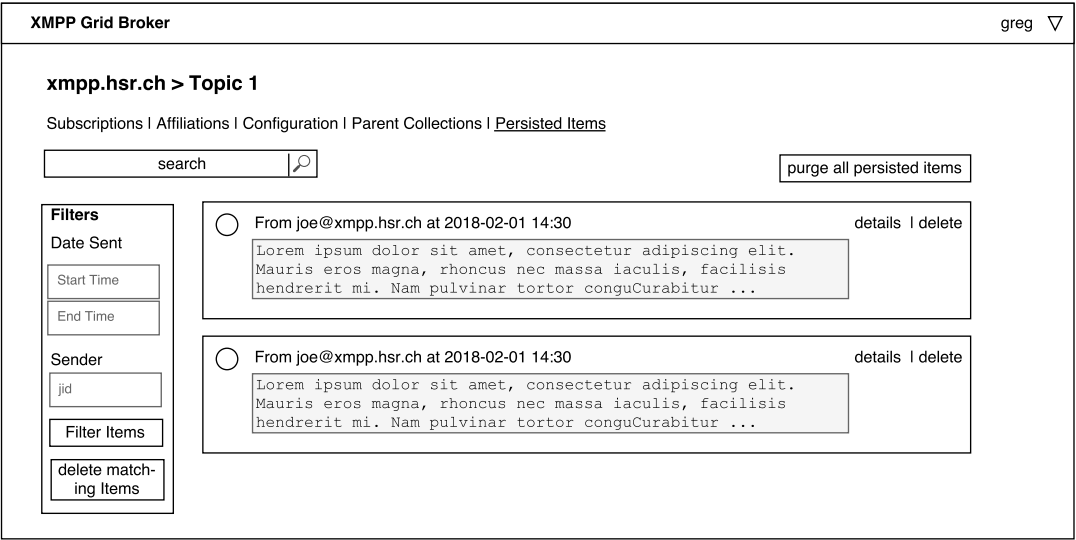


FIGURE 13: Persisted Items Wireframe

## A.9 Comparison of XMPP Server and Libraries

### A.9.1 Server

To find a suited server to develop, test and document our application with, we considered the three major open source XMPP servers, which are still under active maintenance and provide extensive documentation on their XEP-implementations.

For our implementation, we might require the following XEPs respectively RFCs. Any deviations are noted under “XEP/RFC Support”.

**XEP-0004** Data Forms

**XEP-0030** Service Discovery

**XEP-0059** Result Set Management

**XEP-0060** Publish-Subscribe

**XEP-0114** Jabber Component Protocol

**XEP-0133** Service Administration

**XEP-0178** Best Practices for Use of SASL EXTERNAL with Certificates

**XEP-0206** XMPP Over BOSH

**XEP-0248** PubSub Collection Nodes

**RFC-7395** An XMPP Subprotocol for WebSocket

#### A.9.1.1 Openfire

Programming Language    Java

Plugin Architecture        Java JAR<sup>1</sup>

XEP/RFC Support	XEP-0133	Partial, also not explicitly supported <sup>2</sup>
	XEP-0178	Partial, also not explicitly supported <sup>3</sup>
	XEP-0248	Partial, as part of outdated XEP-0060 <sup>4</sup>
	All other required XEPs are supported <sup>5</sup>	

<sup>1</sup><http://download.igniterealtime.org/openfire/docs/latest/documentation/plugin-dev-guide.html>

<sup>2</sup><https://issues.igniterealtime.org/browse/OF-284>

<sup>3</sup><https://github.com/Connectify/Openfire/blob/master/src/java/org/jivesoftware/openfire/net/SASLAuthentication.java> and <https://issues.igniterealtime.org/browse/OF-1191>

<sup>4</sup><https://igniterealtime.jiveon.com/thread/38929>

<sup>5</sup><http://download.igniterealtime.org/openfire/docs/latest/documentation/protocol-support.html>

**A.9.1.2 Prosody**

Programming Language	Lua
Plugin Architecture	Luascript <sup>6</sup>
XEP/RFC Support	XEP-0059 Not supported
	XEP-0178 Not supported
	XEP-0248 Not supported
	All other required XEPs are supported <sup>7</sup>

**A.9.1.3 Ejabberd**

Programming Language	Erlang
Plugin Architecture	Erlang/Elixir <sup>8</sup>
XEP/RFC Support	XEP-0178 Partial, commercially only <sup>9</sup>
	RFC-7395 Partial, not explicitly supported <sup>10</sup>
	All other required XEPs are supported <sup>11</sup>

**A.9.2 Libraries**

To find a suited library to implement our application with, we considered various open source XMPP libraries, which are still under active maintenance and provide extensive documentation on their XEP-implementations. We also limited the programming languages to Python, Java and JavaScript as discussed in the project meeting of 2018-03-05 (see A.6 Meeting Minutes).

For our implementation, we might require the following XEPs. Any deviations are noted under “Limitations”.

**XEP-0004** Data Forms

**XEP-0030** Service Discovery

**XEP-0059** Result Set Management

**XEP-0060** Publish-Subscribe

**XEP-0114** Jabber Component Protocol

**XEP-0133** Service Administration

**XEP-0178** Best Practices for Use of SASL EXTERNAL with Certificates

**XEP-0206** XMPP Over BOSH

**XEP-0248** PubSub Collection Nodes

<sup>6</sup><https://prosody.im/doc/developers/modules>

<sup>7</sup><https://prosody.im/doc/modules> and <https://prosody.im/doc/xep-list>

<sup>8</sup><https://docs.ejabberd.im/developer/extending-ejabberd/modules/>

<sup>9</sup>Server to server only in community edition

<sup>10</sup><https://docs.ejabberd.im/xmpp>

<sup>11</sup><http://www.ejabberd.im/protocols>

**RFC-7395** An XMPP Subprotocol for WebSocket (mentioned only if differs from XEP-0206 implementation status)

Name	Language	Plugins	Limitations
SleekXMPP <sup>12</sup>	Python 2	Yes <sup>13</sup>	<b>Not Supported:</b> XEP-114, XEP-133, XEP-248, XEP-0206 <b>Partial:</b> XEP-0060 <sup>14</sup>
SliXMPP <sup>15</sup>	Python 3	Yes <sup>16</sup>	<b>Not Supported:</b> XEP-114, XEP-133, XEP-248, XEP-0206 <b>Partial:</b> XEP-0060 <sup>17</sup>
aioxmpp <sup>18</sup>	Python 3.4	Yes <sup>19</sup>	<b>Not Supported:</b> XEP-0114, XEP-0133, XEP-0178, XEP-248, XEP-0206
Smack <sup>20</sup>	Java	Yes <sup>21</sup>	<b>Not Supported:</b> XEP-0114, XEP-0206
Babbler <sup>22</sup>	Java	Yes <sup>23</sup>	<b>Not Supported:</b> XEP-0133, XEP-0248
XMPP-FTW <sup>24</sup>	JS(Browser)	Yes <sup>25</sup>	<b>Not Supported:</b> XEP-0114, XEP-0133, XEP-0248 <b>Unclear:</b> XEP-0206, XEP-0178 <b>Note:</b> Requires Server Abstraction
stanza.io <sup>26</sup>	JS(Browser)	Yes <sup>27</sup>	<b>Not Supported:</b> XEP-0114, XEP-0133, XEP-0248 <b>Partial:</b> XEP-0178 <sup>28</sup>
strophe.js <sup>29</sup>	JS(Browser)	Yes <sup>30</sup>	<b>Not Supported:</b> XEP-0114, XEP-0133, XEP-0248 <b>Partial:</b> XEP-0178 <sup>31</sup>

<sup>12</sup><http://sleekxmpp.com/xeps.html>

<sup>13</sup>[http://sleekxmpp.com/create\\_plugin.html](http://sleekxmpp.com/create_plugin.html)

<sup>14</sup>Client-side only

<sup>15</sup><https://github.com/poezio/slixmpp/blob/master/docs/xeps.rst>

<sup>16</sup>[https://github.com/poezio/slixmpp/blob/master/docs/create\\_plugin.rst](https://github.com/poezio/slixmpp/blob/master/docs/create_plugin.rst)

<sup>17</sup>Client-side only

<sup>18</sup><https://docs.zombofant.net/aioxmpp/devel/#from-xmpp-extension-proposals-xeps>

<sup>19</sup><https://docs.zombofant.net/aioxmpp/devel/api/public/index.html#apis-mainly-relevant-for-extension-developers>

<sup>20</sup><https://download.igniterealtime.org/smack/docs/latest/documentation/extensions/index.html>

<sup>21</sup><https://github.com/igniterealtime/Smack/tree/master/documentation>

<sup>22</sup><https://sco0ter.bitbucket.io/babbler/xeps.html>

<sup>23</sup><https://sco0ter.bitbucket.io/babbler/customextensions.html>

<sup>24</sup><http://docs.xmpp-ftw.org/manual/>

<sup>25</sup><http://docs.xmpp-ftw.org/>

<sup>26</sup>[https://github.com/legastero/stanza.io/blob/master/docs/Supported\\_XEPs.md](https://github.com/legastero/stanza.io/blob/master/docs/Supported_XEPs.md)

<sup>27</sup>[https://github.com/legastero/stanza.io/blob/master/docs/Create\\_Plugin.md](https://github.com/legastero/stanza.io/blob/master/docs/Create_Plugin.md)

<sup>28</sup>Not explicitly supported

<sup>29</sup><https://github.com/strophe/strophejs-plugins>

<sup>30</sup><https://github.com/strophe/strophejs-plugins>

<sup>31</sup>Not explicitly supported

# Declaration of Authorship

We, Fabian HAUSER and Raphael ZIMMERMANN, declare that this thesis and the work presented in it are our own, original work. All the sources we consulted and cited are clearly attributed. We have acknowledged all main sources of help.

Fabian Hauser

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Raphael Zimmermann

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