SoniTalk

Zwischenbericht | Call 12 | Projekt ID 2110

Inhalt

1 Introduction

Ultrasound communication (UC) is increasingly used for data exchange between mobile phones and devices, as well as for location-based services. UC attractive because it is inaudible and very low-threshold in terms of the hardware required (only microphone and speakers are required). Today, there exist several proprietary solutions for UC on the market, which are developed by companies in a closed source form. This partly raises questions regarding the protection of users' privacy as it is not transparent which data is sent and received and when data transfer takes place.

The aim of the project SoniTalk is to develop a transparent and privacy-oriented protocol for UC that is open source. SoniTalk protects privacy by its own fine-grained permission system which empowers the user to control and manage the ultrasonic activity of each application separately. This intermediate project report summarizes the work performed in the first half of the project.

2 State of the work packages

2.1 Work Package 0 – *Project Management*

Project management includes, first of all, regular communication with the project staff and the coordination of the work. For this purpose, a weekly jour fixe was set up, during which the current status and all further steps are discussed. Additionally, at the beginning of the project a one-day workshop was organized where the whole project team performed brain storming, literature research and searched for related projects to assess the state-of-the-art. Project management further includes reporting (interim report and final report to netidee) as well as financial planning, compilation of receipts and time sheets, as well as controlling.

The project team consisting of Matthias Zeppelzauer (project lead), Alexis Ringot (software architect) and Florian Taurer (developer) is well set up and working efficiently. Slight modifications of the original work plan were necessary because the personnel resources were not available to the planned extent since in the first half of 2017 there was a higher number of concurrent research projects running at our institute than expected. This required a re-planning of the available resources and the projects. In SoniTalk, for this reason a cost-neutral extension of the project was requested. Changes that result from this re-planning and extension are summarized at the respective work packages below. Overall, the project is progressing well and important milestones could already be achieved, such as the specification draft of the protocol, a native implementation of the SoniTalk encoder and a fully functioning prototype for decoding.

2.2 Work Package 1 – *Creation Website*

One of the first tasks was the creation of the SoniTalk project website. We decided for a one-pager to keep the structure as simple as possible. The different sections of the website include a news section, a general description of the project, information about the team members, downloadable resources, press coverage, and a contact form. Furthermore, we designed a logo for the project. The work package was performed as planned and the milestone at the end (MS1) was reached in time.

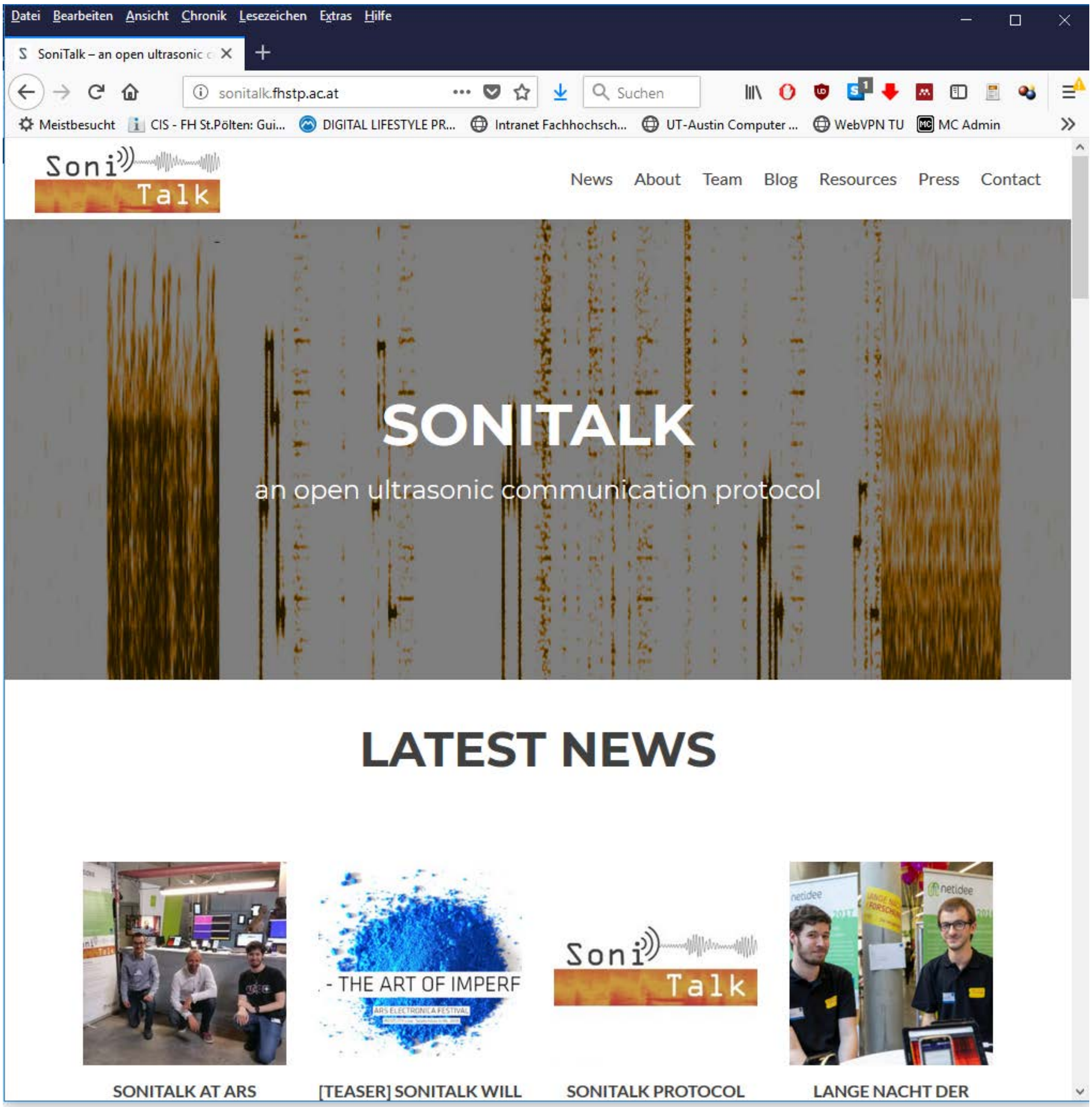

Figure 1: The SoniTalk project website and the project logo

2.3 Work Package 2 – *Review of Standards*

The major task in WP 2 was the literature research on ultrasonic communication. All results of this research (articles, press articles, related software and libraries, competing technologies,

etc.) were collected and added to our (previously generated) Wiki on ultrasonic communication (http://sonicontrol.fhstp.ac.at/soniwiki, link available in the “resource”-section of the SoniTalk website; see also Figure 2 for a screenshot).
Additionally, we tested out different publicly available prototypes for ultrasonic data transmission. A major insight from these tests was that even though they were partly quite sophisticated in their signal encoding, the transmission under real-world conditions was not reliable. The work package was performed as planned and milestone MS2 was reached in time.

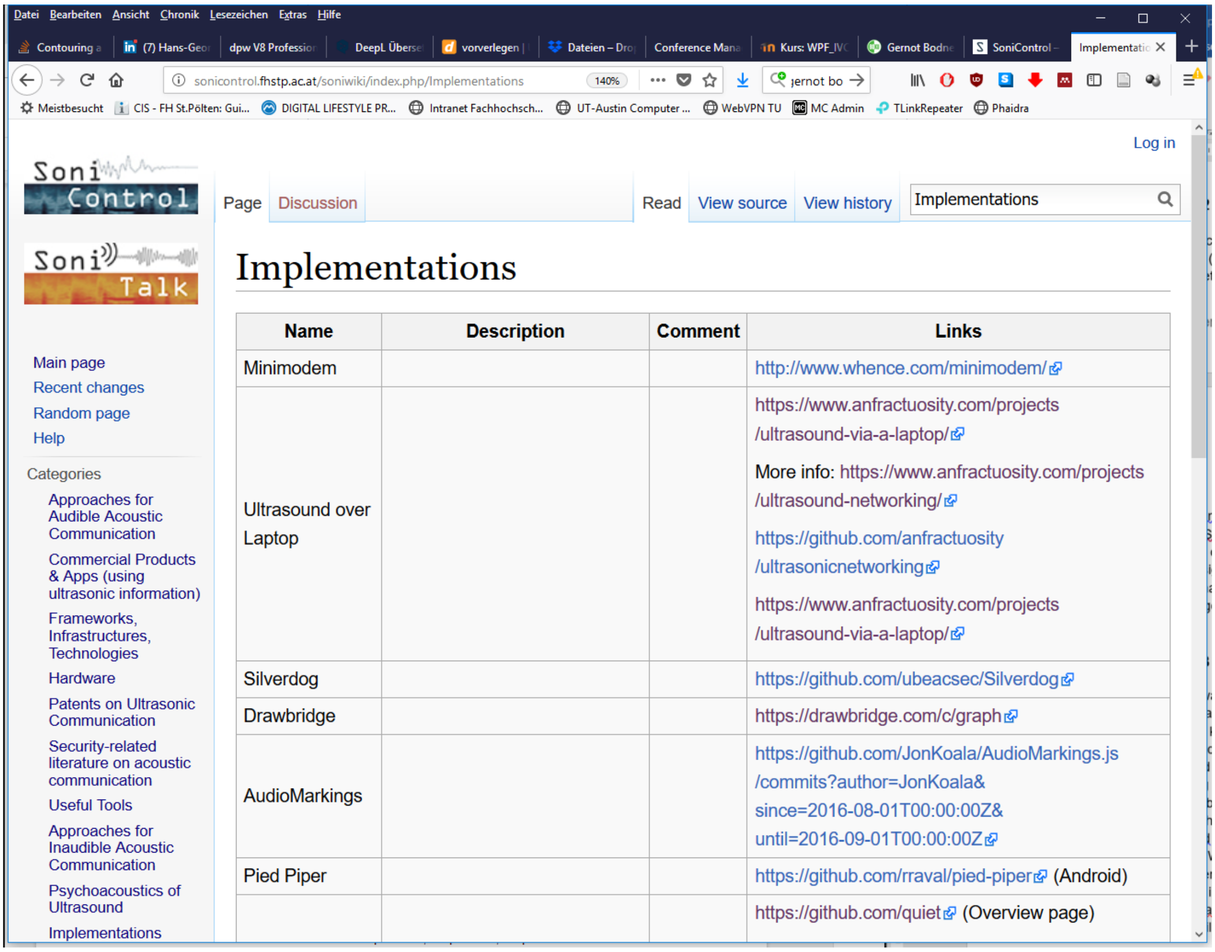

Figure 2: Our comprehensive WIKI about ultrasonic communication containing literature, press articles as well as development resources.

2.4 Work Package 3 – *Specification*

The major task of WP3 was the specification of the SoniTalk protocol. For this purpose we researched on different data transmission approaches (e.g. amplitude modulation, frequency shift keying, phase shift keying, pulse code modulation, etc.) and their suitability for the ultrasonic frequency band. Furthermore, we identified the different noise sources in the ultrasonic frequency band that interfere with our data transmission. Since in ultrasonic data transfer we are encoding information in frequencies very close to the Nyquist limit, many transmission approaches become infeasible and unstable. It has turned out early in the project that a proper definition of the protocol specification requires comprehensive testing. To facilitate early testing, WP3 was temporally extended and WP4 started earlier. In this way the process of protocol implementation / testing (WP4) and protocol specification (this WP) could be performed in parallel and both could benefit from each other. Both, protocol specification (MS3) as well as the prototypical protocol implementation (MS4) were accomplished in month 7. The draft specification of the SoniTalk protocol was made publicly available in the "resource"-section in the project website and will be updated continuously in case of changes. Furthermore, the design of the final SoniTalk software architecture was discussed. The original idea of having a background service (SoniTalk Manager) that manages the data transfer was rejected because the implementation of a standalone background service is difficult and on certain platforms, such as iOS not possible[1]). Since SoniTalk should run on a wide range of platforms, we decided to design SoniTalk as an SDK that can be linked easily to an app and which can be used then by different apps in parallel. To assure privacy protection and transparency to the users a fine-grained permission system will be integrated into the SDK, which the apps will be using implicitly. The detailed specification and implementation of the SDK will be performed in WP5 (see below).

2.5 Work Package 4 – *Implementation protocol*

For the reasons mentioned in WP3, the start of WP4 was shifted to month 4. This enabled extensive testing of different modulation types and transmission schemes and finally the successful design of a first version of the protocol. The implementation of the protocol consisted of two parts: the development of the encoder and the developer of the decoder.

Encoder development:
Since extensive expertise on signal generation was already available from our previous project SoniControl, we decided to implement the SoniTalk encoder directly on the target platform (Android). The developed encoder contains the following features:

- UTF-8 encoding of input message
- Frequency-shift keying (FSK) with different numbers of frequencies, amplitudes, and timings according to the SoniTalk draft specification
- Generation and inclusion of CRC information (parity bits) for error detection
- Fade in and fade out of signal bursts to avoid hearable clicking artefacts
- Generation and sending of encoded signal in near real-time

Decoder development:
The development of the decoder was more complex as the encoder, as a robust detection algorithm for SoniTalk messages as well as a decoding algorithm had to be developed. For this reason, the prototypical implementation was performed on Matlab, which allowed us to efficiently test out different strategies and approaches. Different decoding schemes building upon narrow-band bandpass filterbanks as well as the Görtzel algorithm and Fast Fourier Transform (FFT) were evaluated. Finally, a decoder prototype was implemented with a bandpass filter-based detector algorithm. This approach is particularly energy efficient, which is important in cases where SoniTalk is running for longer times in the background. The actual decoding is performed by a short-time Fourier transform (STFT). An important feature of our

[1] Note that the iOS implementation itself is not part of the project but planned as a future task. Thus, we included an analysis of the restrictions of different platforms already in the design phase.

decoder is that it does not require any thresholds to be set and no models (e.g. of the background noise or the transmission channel) to be built. This makes the decoder robust to different soundscapes and enables the decoder to function instantly on demand. Features of the decoder include:

- Energy efficient and robust message detection (basis: bandpass filters)
- Parameter-less decoding scheme using STFT, which purely relies on relative comparisons between different frequency bands and time slots in the message
- Spectral normalization for noise reduction
- Error checking by CRC
- Binary to UTF-8 decoding
- Enhanced visualizations for validation of the correct function of the algorithm

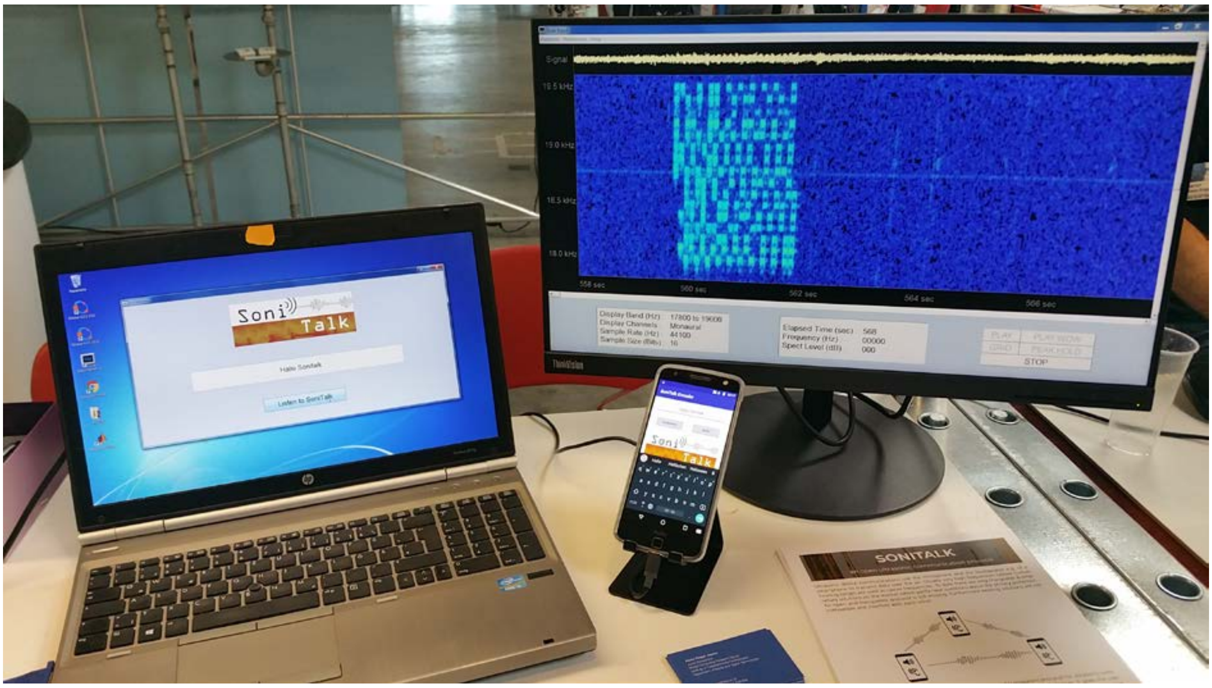

Figure 3: The SoniTalk encoder (on the smartphone) and the SoniTalk decoder (on the laptop). A visualization of the transmitted message can be seen on the larger screen in a live-spectrogram.

2.6 Work Package 5 – *Implementation SoniTalk SDK*

As mentioned already in Section 2.5, we have decided to reject the idea to implement a central service that manages the data transfer because of compatibility problems with the different mobile platforms. Instead, we decided to implement SoniTalk as a light-weight SDK that can easily be integrated into mobile applications. The implementation of the SDK has started in month 8 and is ongoing. A major task is the implementation of the decoder on the target platform (Android). Following tasks will be the implementation of the SDK interface (public functions for sending and receiving data) and the permission system to assure transparency and privacy protection. WP5 is scheduled for month 8-10

2.7 Work Packages 6 – 7

Work packages 6-9 have not started yet. Due to the extension of the project runtime WP6 (Development of application prototype) moved to month 11-12, WP7 (Testing and publishing) moved to month 13-14.

2.8 Work Packages 8 - *Dissemination*

Dissemination activities include public relations work and regular updates to the website and the blog of netidee's website. We have posted at least one blog per month and at the same time posted the information also on the news section of our website (sonitalk.fhstp.ac.at). For easier dissemination a project one-pager was designed which we use as a folder to take away during exhibitions.
Further dissemination activities included:

- the presentation of SoniTalk at the 22th *Netzpolitischer Abend* in the Meta Lab in Vienna (January 29, 2018)
- the presentation of SoniTalk at the “Digital Livestyle Preview” event in Munich (June 28, 2918) for a selected group of international journalists of different IT-related media and magazines.
- the exhibition of SoniTalk at the ARS Electronica festival (September 6-10) in Linz where around 300 visitors could try out ultrasionic communcitaion and see how this technology works.

A great and notable success on the technical side was the demonstration of our technology at ARS electronica where we could test and evaluate the robustness of the ultrasonic data transmission under real-world conditions. During the whole event, SoniTalk proved a high robustness in data transmission even when many disturbing sound sources (voices, echoes etc.) were present in the exhibition hall. This proved the applicability of the proposed protocol in practice. Due to the exhibition of the project at ARS Electronica the start of WP8 was re-scheduled to month 8.

3 Summary Plan

The following organizational changes have been performed:

- Cost-neutral extension of the project by 5 months
- Parallel processing of WP3 and 4 to better support the development of the SoniTalk protocol, i.e., earlier start of WP4 (month 4) and extension of WP3 to month 7
- Shift of WPs 5-7 according to the extended project runtime

The following change to project content have been performed:

- Decision to implement a light-weight SDK instead of a stand-alone manager to increase the applicability of SoniTalk to a broader set of platforms and to facilitate easier integration into apps.

4 Dissemination / Networking

Please see Section 2.8 for a summary on dissemination and networking activities in the project.

Future activities include the presentation of SoniTalk (together with SoniControl) at the ACM Multimedia Conference in Seoul, South Korea, 22 - 26 October 2018 (http://www.acmmm.org/2018/) which is the premier conference for multimedia experts and practitioners across academia and industry. Furthermore, we plan the presentation of SoniTalk at future events of our university and dissemination to a broader public via a press release through our marketing department when SoniTalk is officially released.

We are grateful to netidee for supporting the project and helping us to realize our ideas