netidee PROJEKTE

SoniTalk

Final Report | Call 12 | Project ID 2110

Inhalt

1 Introduction

Ultrasonic communication (UC) is increasingly used for data exchange between mobile phones and other devices, as well as for location-based services. UC is 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 project report summarizes the overall work performed in the project.

2 Project Description

Project goals

The main goal of the project was the establishment of a first open standard for UC and providing an open source reference implementation. Specific aims of the project included:

1. Creation of a project website with responsive design
2. Specification of a robust ultrasonic transmission protocol
3. Implementation of an encoder and decoder for robust message transmission with the SoniTalk protocol;
4. Implementation of the SoniTalk Manager (background service) with permission system and rights management
5. Implementation of a demo application for proof-of-concept demonstration of the SoniTalk protocol

All goals were achieved except for goal 4 (the SoniTalk Manager). The original idea of having a background service that supervises the data transfer was rejected because the implementation of a standalone background service is difficult and on certain platforms such as iOS not possible at all (see Section 1.4). Instead of a central manager, we have switched to an SDK-like architecture, which uses a shared library to integrate the SoniTalk functionality into third-party applications. The demo application (goal 5) shows how to integrate the SDK into an application.

Target groups

SoniTalk addresses different target groups. SoniTalk is primarily aimed at companies that want to offer services and apps for end customers based on UC. Thus, the business model behind SoniTalk is primarily a B2B model. Particular target groups include:

- **IT security companies**: SoniTalk can be used to realize secure key exchange, multifactor-authentication and tap-proof offline communication. Therefore, especially companies that offer software services in the area of IT security for other companies or end users directly represent an important target group.
- **Providers of indoor navigation systems**: SoniTalk in combination with appropriate beacons can be used for precise indoor localization. This acoustic localization is much more resource-saving than existing visual navigation methods, which are based on cameras and complex image processing methods. SoniTalk can be used as a cost-effective complementary information channel to increase navigation accuracy. Thus, companies developing indoor navigation systems represent one target group for SoniTalk.
- **Providers of cashless and contactless payment systems as well as companies that manufacture ATMs or payment terminals**: UC can replace NFC for cashless payment and authentication at ATMs. NFC requires well-equipped mobile devices, which are usually rather expensive. With UC via SoniTalk, most mobile devices could use these services in one go. In addition, UC could be used as an additional authentication channel to existing authentication methods, relying for example on face recognition, to increase their security level.
- **Open Source Community**: a further target group are open source developers who deal with security-relevant applications and location-based services. By publishing the source code of the SoniTalk SDK publicly, we hope to stimulate (i) the further development of the SoniTalk SDK and (ii) the integration of SoniTalk into other open source projects.
- **Artists & Museums**: finally, a target group represent artists who want to use SoniTalk for easy device pairing and synchronization or to make visitors able to interact with their installations via ultrasound.

Overview on project results

The major results and outcomes of the project are twofold: First, we have developed a first open standard for UC. The first version of the standard has been completed in February 2019 and is currently under review as an internet draft by the IETF (the Internet Engineering Task Force). The second major outcome is the SoniTalk SDK, which has been completed in April 2019 and is provided to the community under GNU Lesser General Public License (LGPL). Currently the Android platform is supported which, according to Gartner, Inc., has a worldwide market share of 87.7%. In addition, a demo application has been implemented and released, which demonstrates the basic possibilities of the SoniTalk SDK and shows how it can be integrated into a mobile application. A detailed list of project results is provided in Section 4.

3 Documentation of Work Packages

3.1 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 project 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 consisted of Matthias Zeppelzauer (project lead), Alexis Ringot (software architect) and Florian Taurer (developer). Slight modifications of the original work plan were necessary because the personnel resources were not available to the planned extent. Indeed, 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. For this reason, a cost-neutral extension of the project until May 2019 was requested. Changes that result from this re-planning are summarized in the sections for the respective work packages below. Overall, the project progressed very well, all milestones could be reached, all deliverables were finished. The obtained results exceed our initial expectations and motivate us to continue our research and work on UC and SoniTalk.

Results: Contract with IPA signed, Initial project plan finished and acknowledged by IPA, regular jour fixes installed and held, list of project results finished, intermediate report submitted and acknowledged, final report submitted,

3.2 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. The website was and is constantly updated with news related to the progress of the project. The website will be maintained after the end of the funding period.

Result: Project webpage

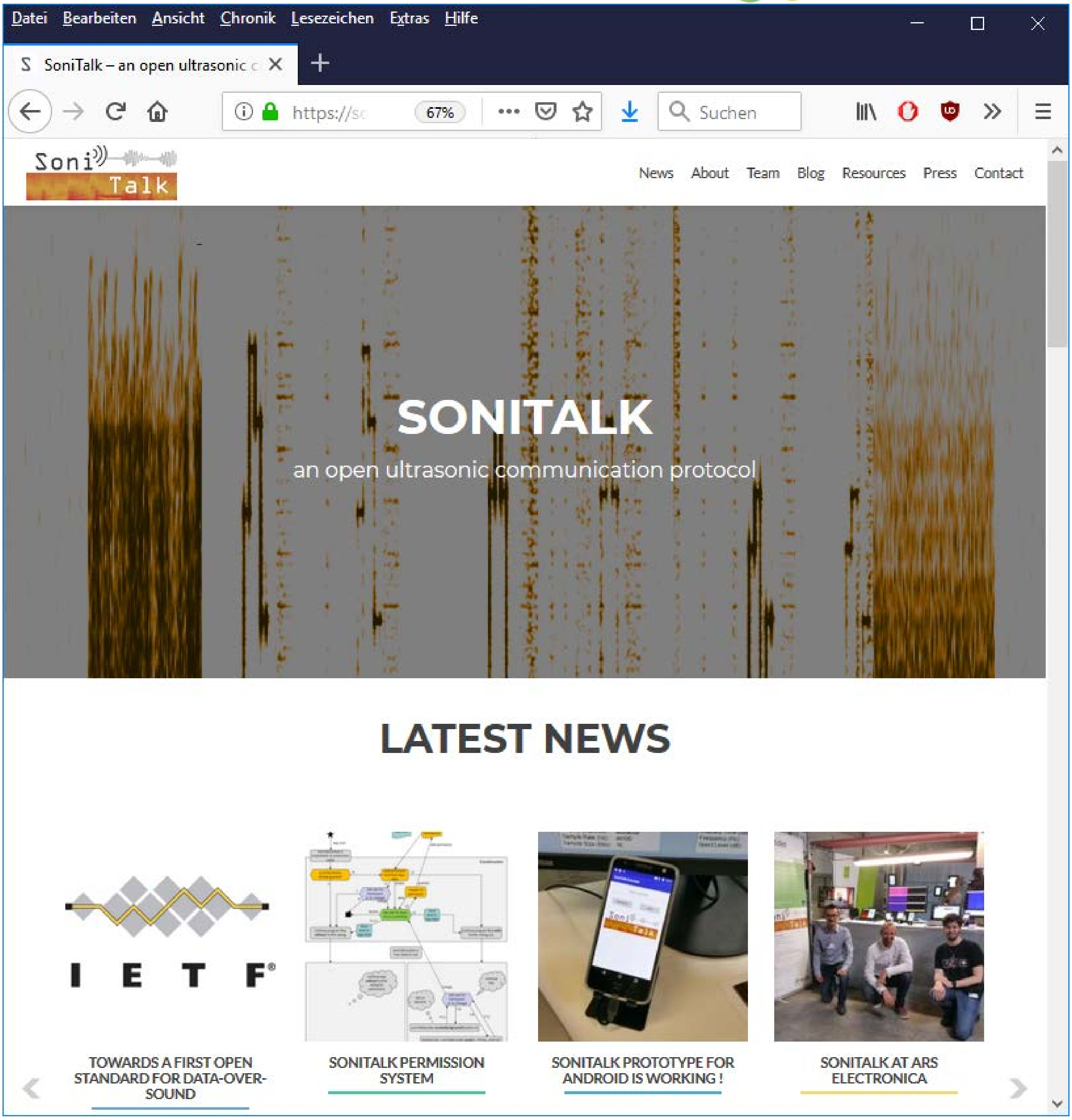

Figure 1: The SoniTalk project website and the project logo

3.3 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).

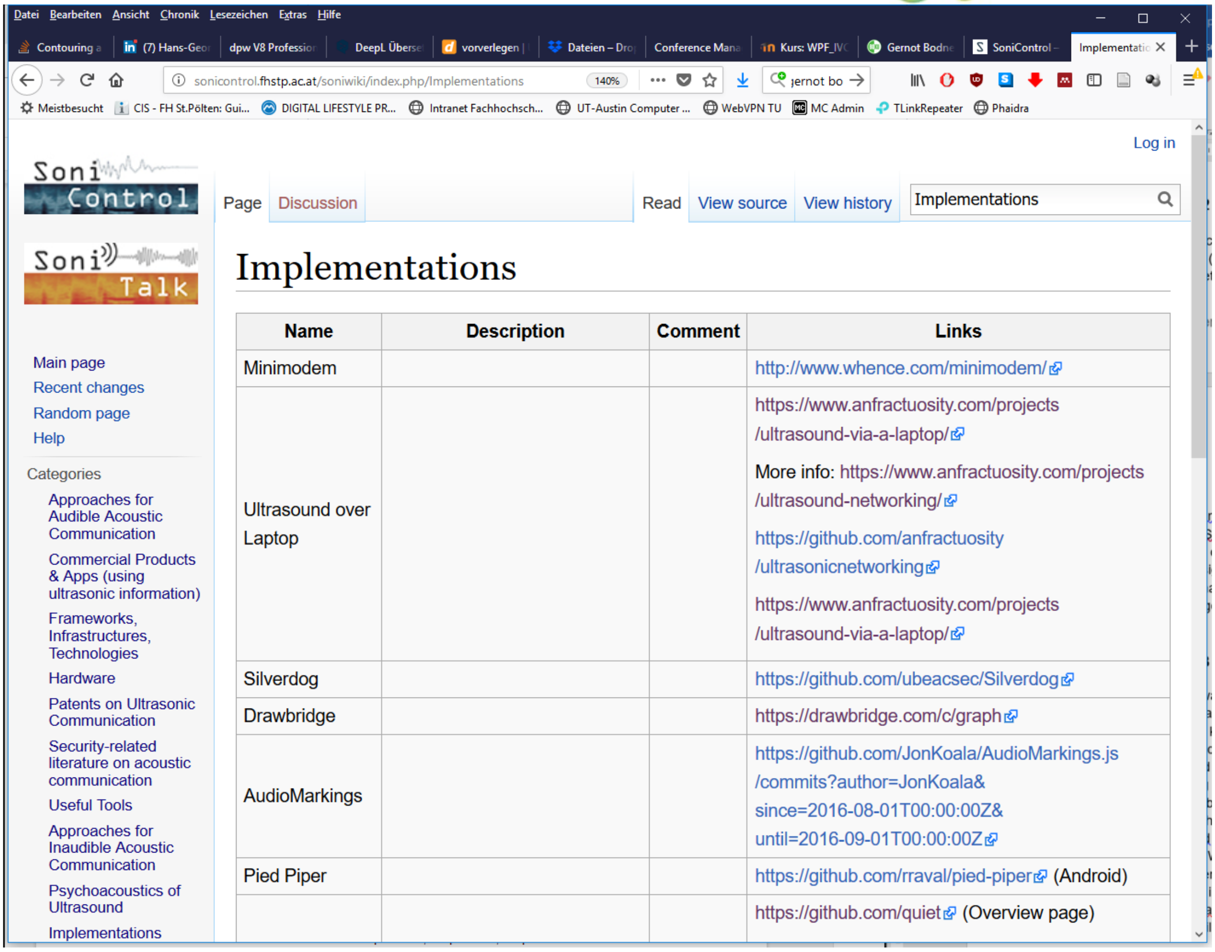

Figure 2: Our comprehensive WIKI about ultrasonic communication containing literature, press articles as well as development resources.

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 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.

Additionally, a student of our university worked on his bachelor thesis in the course of the project with the title "Mobile Ultrasonic Communication". The thesis contributed a literature survey about UC techniques and potential standards that may be adaptable for the SoniTalk Standard proposal. Furthermore, the thesis contains a practical evaluation of the QuietShare[1] library and the different modulation techniques implemented in the library. The study showed that OFDM (orthogonal frequency-division multiplexing) with BPSK (binary phase-shift keying) achieves the best results, outperforming for example GMSK (Gaussian minimum shift keying) and other higher-order phase-based modulation schemes. Distances of up to 3 meters could be bridged, however only with a high quality microphone (AKG D5) and speaker (Thomson DPL912VD). When evaluated on mobile phone loudspeakers and microphones, the possible communication distance dropped significantly (to cm range) and robustness degraded.

[1] https://github.com/alexbirkett/QuietShare, last visited April 2019

Results: updated wiki with related literature, thesis on mobile ultrasonic communication, first tests with existing tools

3.4 Work Package 3 – *Specification*

The major task of WP3 was the specification of the SoniTalk protocol. For this purpose, based on experiments from WP2 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 the 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. The further refinement and rework of the specification towards a first final version was performed in WP8.

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 possible2). 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 has been performed in WP5.

Results: draft specification document (online available)

3.5 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 decoder of SoniTalk.

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[2] 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.

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) instead of using a rapid prototyping tool such as MATLAB first. The developed encoder contains the following features:

- Full UTF-8 encoding of input message
- Frequency-shift keying (FSK) with different numbers of frequencies, amplitudes, and timings according to the SoniTalk specification
- Sending data on several frequencies in parallel
- Adaptive loudness level
- Adding an optional pause between consecutive message blocks
- 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
- Sending message start and end blocks (according to the SoniTalk specification)
- Redundant bit encoding by a Manchester code
- Full compatibility with the SoniTalk standard, supporting all variable parameters

Furthermore, we tested out several methods to maximize the output amplitude of the signal, either by encoding the output signal accordingly or by changing the amplification of certain frequency bands of the audio equalizer. It has turned out, however, that many Android settings and features do not work satisfactorily across different devices. Others produced hearable artifacts and were thus rejected.

Decoder development:

The development of the decoder was more complex than that of 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 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. After implementing the decoder in Matlab, it was ported to Java. The entire decoding algorithm was implemented in Java by using Java libraries for signal processing (IIRJ[3], MaryTTS Signalproc[4] and Apache Commons Lang[5]). The entire implementation was performed in pure Java without native libraries. This is advantageous for the portability of the code in future. Features of the decoder include:

- Energy efficient and robust message detection (basis: bandpass filters)
- Parameter-free decoding scheme using STFT, which purely relies on relative comparisons between different frequency bands and time slots in the message and leverages the redundancy integrated by Manchester encoding
- Spectral normalization for noise reduction
- Error checking by CRC
- Full UTF-8 decoding (from binary code to UTF-8 symbol)
- Enhanced visualizations for validation of the correct function of the algorithm
- Full compliance with the SoniTalk standard, supporting all adaptable parameters

Results: algorithms for message encoding and decoding

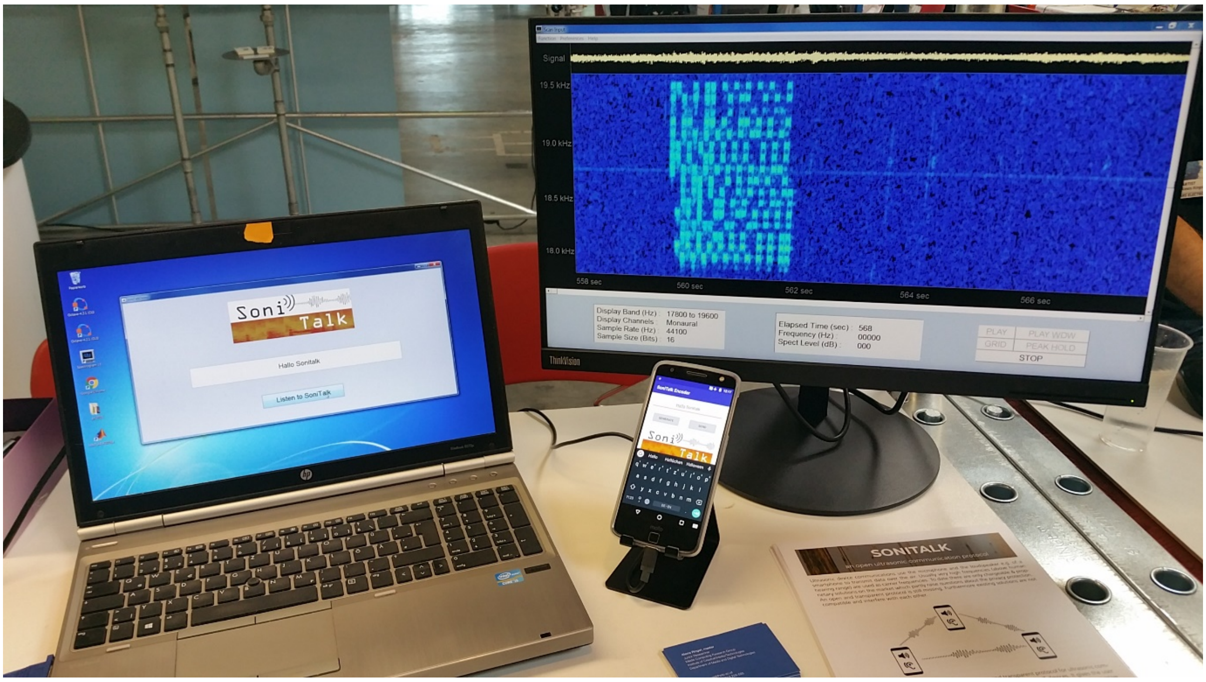

Figure 3: The SoniTalk encoder (on the smartphone) and the SoniTalk decoder (on the laptop). A visualization of the transmitted message can be seen on the larger screen in a live-spectrogram.

3.6 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

[3] https://github.com/berndporr/iirj, last visited April 2019
[4] https://mvnrepository.com/artifact/de.dfki.mary/marytts-signalproc/5.1.2, last visited April 2019
[5] https://mvnrepository.com/artifact/org.apache.commons/commons-lang3/3.8.1, last visited April 2019

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 been finished in time. Some refinements and refactoring were performed in WP6 and 7 during the development of the demonstration application.

A first task was the design of the software architecture of the SDK. The SDK was designed as an Android Archive (AAR) which is similar to a shared library. The AAR can be linked to any application that wants to use functionality from the AAR. The software architecture is detailed in the developer documentation and user documentation and is thus not described in more detail here.

Following tasks were the integration of the encoder and decoder algorithm into the SDK and the implementation of the functions that provide access to these algorithms (see user documentation). Additionally, a status symbol was integrated into the SDK that shows whether the SDK is currently sending or receiving data. By using the status symbol we achieve the same level of transparency as provided for the internet connection on a smart phone (where the user can also see whether information is currently uploaded or downloaded), see Figure 4. This feature is of particular importance because it actively shows when information is sent or received via UC.

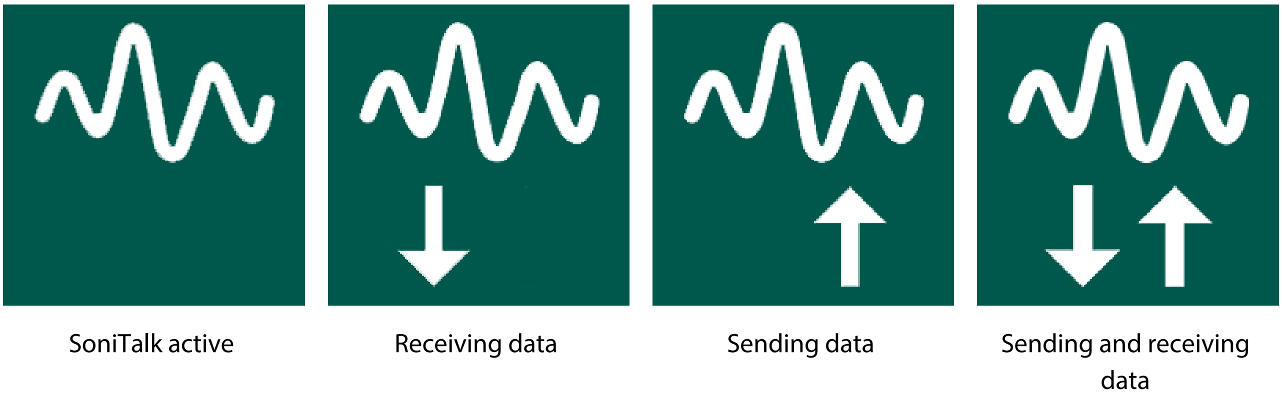

Figure 4: Status symbols of the SoniTalk SDK indicating the current activity

Finally, a fine-grained permission system was integrated into the SDK. The direct integration into the SDK is important to force each app to apply these permissions. Three levels of privacy-related permissions were implemented:

- **Strict** - ask on each communication request: this is the strictest level. On each send or receive attempt the SDK asks for permission from the user. The app cannot circumvent this request.
- **Moderate** - allow until next start of app: this permission allows all bidirectional UC for the current session, i.e. as long as the app is not closed (sent to the background), it is allowed to send and receive data. When the app is closed and reactivated later, it has to ask again for permission
- **Low** - allow always: in this mode, the app is granted general permission for sending and receiving SoniTalk messages. This permission can be revoked by the user through the android permission system.

The user can select one of these permissions. The change from one permission level to the other is always possible later (from any level to any other level). An overview of the permission system's workflow is shown in Figure 4.

Result: SoniTalk SDK as Android Archive (AAR)

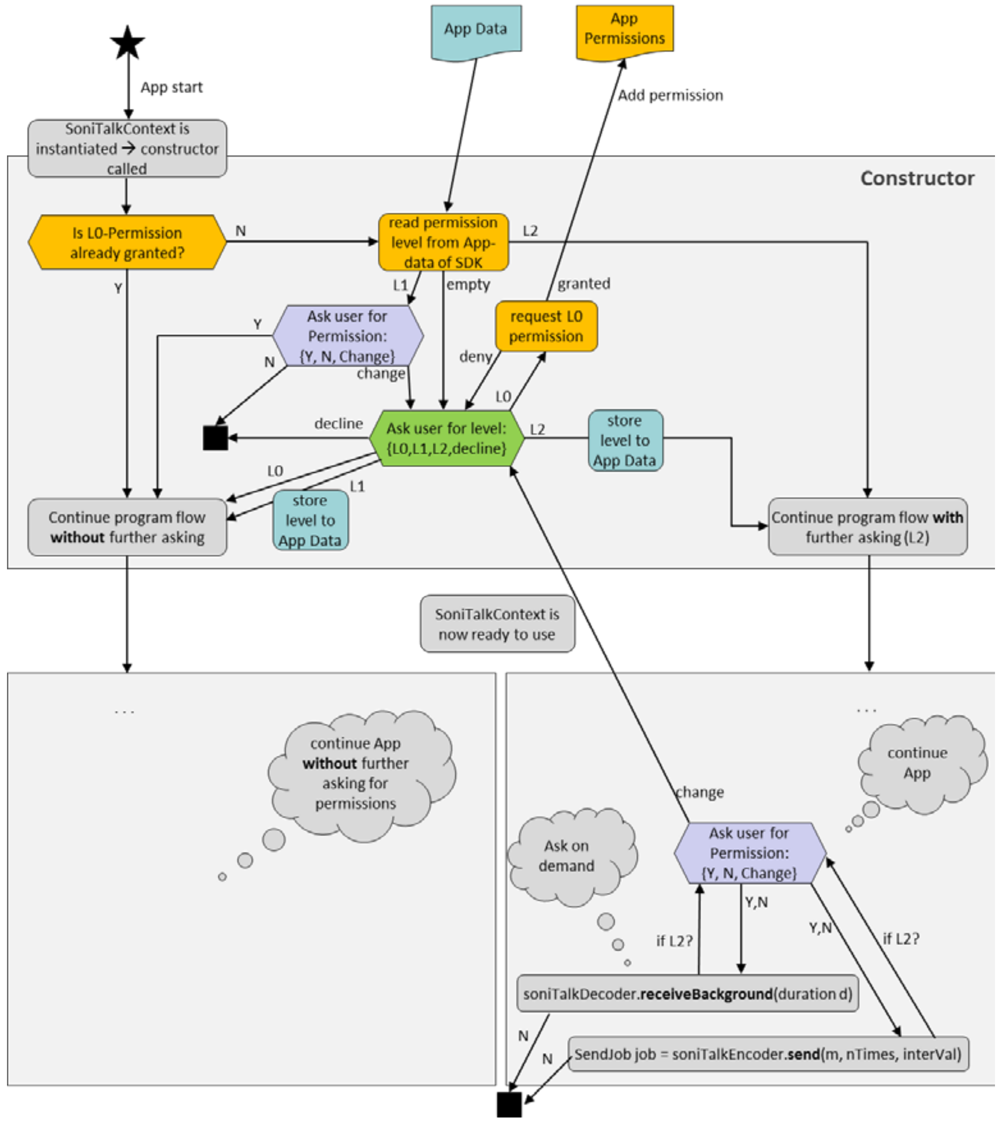

Figure 5: The SoniTalk permission system: Three levels of permission (L0 = low, L1 = moderate, L2 = strict) enable the user to adjust the permissions according to his or her personal preferences.

3.7 Work Package 6 – *Development Application Prototype*

In WP 6 the major task was the development of the application prototype. For the application prototype, we decided for a simple chat application that allows for transmitting text messages via UC between two smartphones. This type of application is well suited for demonstration purposes because people can define the text to send themselves, which increases the involvement and interaction with the application. For easier experimentation, a settings dialog was integrated that enables to change the protocol parameters of SoniTalk. A screenshot of the application is shown in Figure 6.

Result: SoniTalk Application Prototype

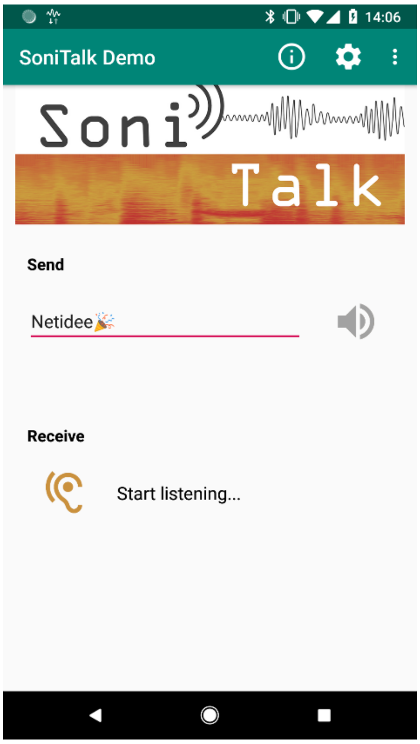

Figure 6: The SoniTalk application prototype: a chat app that enables to send and receive messages via ultrasound

3.8 Work Package 7 – *Test & Publishing*

The main purpose of WP 7 is to test the app and thereby also the SDK in different environments and situations and to consolidate the source code. A number of bugs were fixed and improvements were made to the code. The stability of the permissions system was tested in different situations and application contexts as well as the correctness of the status symbols and status changes was verified. Furthermore, the correct behavior of the app and the SDK was evaluated when a phone call comes in and in cases where the app is sent to the background and later is brought to the foreground again.

Finally, the SDK and the application prototype were published under LGPL and GPL respectively on GitHub, accessible under: https://github.com/fhstp/SoniTalk

Result: Refined SoniTalk SDK and Application Prototype on GitHub platform

3.9 Work Package 8 - *Dissemination*

Dissemination activities include public relations work and regular updates to the website and the blog on the netidee website. We have posted at least one blog per month and at the same time posted the information also in the news section of our website (https://sonitalk.fhstp.ac.at). For easier dissemination a project one-pager was designed which we use as a folder to take away during exhibitions, see Figure 7.

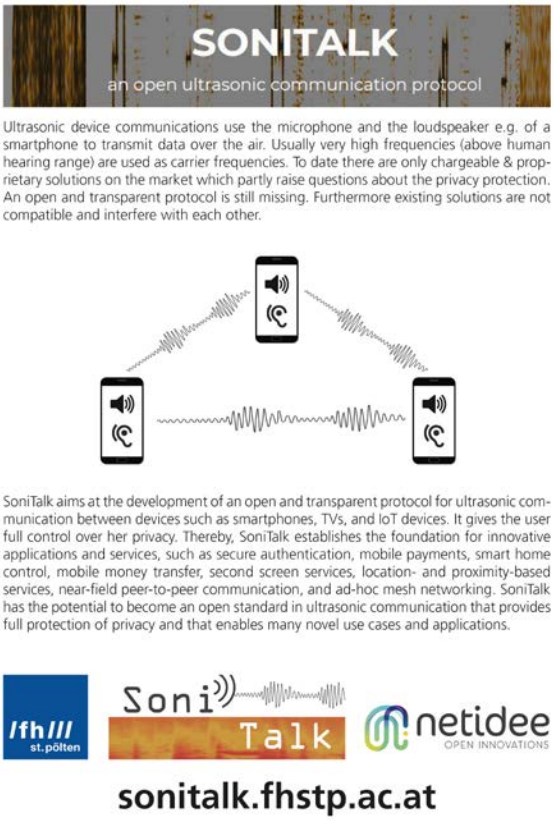

Figure 7: SoniTalk project one-pager for exhibitions

Further dissemination activities included:

- the presentation of SoniTalk at the 22th **Netzpolitischer Abend** in the Meta Lab in Vienna (January 29, 2018)
- Radio Interview with Matthias Zeppelzauer: Camouflage für das Leben in der Überwachungsgesellschaft, **Ö1**, Lukas Plank, 08.02.2019
- the exhibition of SoniTalk at the **Lange Nacht der Forschung** (April 13, 2018) in St. Pölten
- the presentation of SoniTalk in a **Keynote** held by Matthias Zeppelzauer 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, 2018) in Linz where around 300 visitors could try out ultrasonic communication and see how this technology works.
- 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.
- Presentation of SoniTalk and the risks and chances of ultrasonic communication at the **DeepSec Conference** 2018 in Vienna on November 30, 2018 in the course of the Reversing and Offensive-oriented Trends Symposium (ROOTS).

- The project was recently submitted to the "**riz up GENIUS Ideen- und Gründerpreis 2019**" of riz up Niederösterreichs Gründeragentur GmbH in the category "Innovative Research and Development". We are currently awaiting the decision.

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.

Our strong involvement in ultrasonic communication and related topics among others in project SoniTalk motivated a group of lawyers to publish a first evaluation of the legal situation of ultrasonic communication (with respect to the General Data Protection Regulation and the telecommunications act), see: https://www.eylaw.at/news/detail/rechtliche-einordnung-von-audio-tracking. Their major conclusion is that explicit consent from the user is a fundamental requirement for UC. SoniTalk is the first UC technology providing this level of transparency.

Another activity in WP9 was the further development of the standard from the initial draft published in WP3 to a first final draft, which is ready for submission to IETF. The submitted draft document available under: https://datatracker.ietf.org/doc/draft-zeppelzauer-data-over-sound is currently in processing by IETF. Note that by submitting the standard to IETF we comply with the funding requirement by netidee to publish the developed protocol "as IETF RFC or other suitable standardization proposal".

Finally, the user and developer documentation and the additional documents explicitly required by netidee were finalized and published by the end of WP8.

Results: Project one-pager, regularly posting blogs to SoniTalk website and netidee website, finished and published user documentation and developer documentation, External Communication Documentation (see Section 7), constantly updated SoniTalk / SoniControl Wiki with new literature and links to related projects, final draft of the SoniTalk specification.

4 List of Project Results

1	*Intermediate project report*	*CC-BY Sharelike-3.0 AT*	*https://www.netidee.at/sonitalk*
2	*Final project report*	*CC-BY Sharelike-3.0 AT*	*https://www.netidee.at/sonitalk*

3	*Developer Documentation*	*CC-BY Sharelike-3.0 AT*	*https://www.netidee.at/sonitalk*
4	*User Documentation*	*CC-BY Sharelike-3.0 AT*	*https://github.com/fhstp/SoniTalk*
5	*Project OnePager*	*Lizenz*	*https://www.netidee.at/sonitalk*
6	*External Communication Documentation*	*CC-BY Sharelike-3.0 AT*	*see this document (section 7)*
7	*Literature research*	*CC-BY Sharelike-3.0 AT*	*https://sonicontrol.fhstp.ac.at/soniwiki/index.php/Main_Page* *https://www.netidee.at/sonitalk*
8	*SoniTalk protocol and SDK*	*LGPL*	https://github.com/fhstp/SoniTalk *https://www.netidee.at/sonitalk*
9	*SoniTalk demonstrator*	*GPL*	https://github.com/fhstp/SoniTalk *https://www.netidee.at/sonitalk*
10	*SoniTalk Specification*	*IETF Trust Legal Provisions*	*https://datatracker.ietf.org/doc/draft-zeppelzauer-data-over-sound/* *https://sonitalk.fhstp.ac.at/wp-content/uploads/2017/07/draft-zeppelzauer-data-over-sound-00.txt* *https://www.netidee.at/sonitalk*

5 Exploitation of Project Results in Practice

Several exploitation directions or strategies for the continuation of the project and the further development of SoniTalk are planned. Initially, the aim is to acquire a third-party-funded research project involving partners from industry. In this project, the SoniTalk SDK shall be extended by advanced communication functionalities and evaluated in various case studies in the areas of Industry 4.0 and Internet of Things.

Several cooperation partners have already been consulted regarding pilot projects for the concrete use of SoniTalk, including a media company wishing to use SoniTalk to embed information into media streams and a sensor manufacturer wishing to use SoniTalk to read data from hard-to-reach sensors.

Aside from these efforts to acquire funding for further development, we plan to extend SoniTalk (and to port it to other platforms) in the course of master theses, which we will provide at our university for our students.

Ultimately, we have been in contact with media artists who are interested in using SoniTalk for their project (e.g. interactive installations).

6 Dissemination / Networking

Please see Section 3.9 for a summary on dissemination and networking activities that have been performed in the project.

Future planned dissemination activities include a demonstration of SoniTalk either at the "Forschungsfest Niederösterreich" or at the "European Researchers' Night" (both in September 2019). The "Haus der Digitalisierung" initiative[6] represents another dissemination platform that we consider for the future.

Furthermore, we plan the presentation of SoniTalk at future events of our university and the dissemination to the broader public via a press release through our marketing department after the project has been officially finished.

7 External Communication Documentation

The external communication documentation is a required deliverable for every netidee project. Due to the thematic context, we have decided to include this documentation directly in the final project report.

As requested a separate work package for documentation and communication with external parties has been established, see WP8 in Section 3.9. The work in this WP helped significantly to communicate the project to a broader public (e.g. presentation at *ARS Electronica* and *Lange Nacht der Forschung*) but also to the relevant scientific community (e.g. presentation at *ACM Multimedia* and *DeepSec* conferences). See Section 3.9 for a summary of all efforts for dissemination and for raising visibility of the project.

The different dissemination strategies are connected with varying expenses and benefits. A coarse estimation of different efforts is summarized in the following table and shall help other projects to optimize and align their dissemination efforts.

Strategy	**Expense**	**Benefit**
Radio interviews	Low	Average

[6] https://noe.gv.at/noe/Haus_der_Digitalisierung___Das_niederoesterreichische_Oek.html, last visited April 2019

Press release	Average	Very high
Publication at conference	High	Average
Presentation at Community event	Average	Average
Exhibitions	High	High
Application for prices/contests	High	High if gained, otherwise none

Table 1: Dissemination strategies, their expense and potential benefit

8 Planned Activities after netidee Project

We plan a number of extensions and further development of SoniTalk that shall be subject of follow-up projects and master theses at our university. Activities in this respect include:

- The extension of SoniTalk SDK on iOS and on low-threshold hardware such as microcontrollers like Arduino,
- The implementation of higher-level communication layers (e.g. network, transport and session layer according to the OSI model
- The integration of the SoniControl firewall (https://sonicontrol.fhstp.ac.at) into the protocol to add an additional security layer to the protocol.

9 Suggestions for Further Development by 3rd Parties

SoniTalk is a complementary technology to Bluetooth, NFC and WLAN that provides a number of unique properties. Due to its low hardware requirements it is a promising technology for different applications in the security, IoT, and networking domain. As such, there are many possible applications. An overview of these is shown in Figure 8.

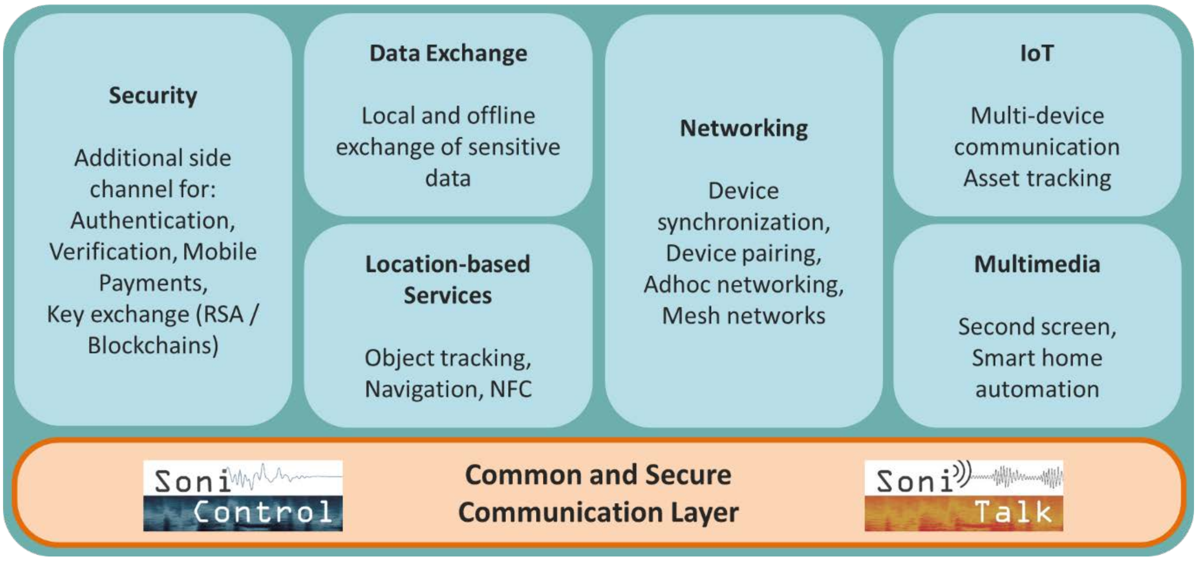

Figure 8: The range of possible applications of SoniTalk

In the **security area**, SoniTalk can be used to establish an additional channel for authentication. This would allow novel multi-factor authentication methods to be implemented (e.g. for online banking). SoniTalk could also be used to exchange cryptographic keys (e.g. RSA keys) to establish an encrypted connection between two devices. Since UC explicitly requires the physical proximity of two devices, a higher degree of security can be achieved. By using a SoniTalk connection, particularly sensitive data can be exchanged between two partners in a completely offline fashion without using an existing infrastructure such as WLAN or Internet connection (which could potentially be intercepted). Since the SoniTalk signals do not leave the room in which they are sent, the probability of an unnoticed "interception" of the message is minimal.

Similarly to today's NFC, SoniTalk could also be used for mobile **payments** or for withdrawing money from ATMs. Unlike NFC, which is not built into every device, UC technology can be used by virtually every mobile phone available today. Further applications are mobile money transfer (also for crypto currencies) between adjacent devices, as well as fast and efficient **pairing** of devices.

SoniTalk could be further employed for **localization** and provide **location-based information**. This requires appropriate beacons[7], which are permanently installed and send messages via the SoniTalk protocol. By receiving these messages on a mobile phone, a very precise localization can be achieved, and the corresponding location-dependent information can be retrieved. By combining SoniTalk with other technologies such as WLAN and Bluetooth, existing localization methods or location-based services could be improved in their accuracy and made more robust.

SoniTalk could further be used as a network protocol for dynamic networks (so-called ad-hoc networks and mesh networks). Ad-hoc networks are set up dynamically and without a server infrastructure between nearby devices with the aim, for example, of sending information across several devices to a desired destination. For example, in the event of a natural disaster in which the Internet and all other communication networks fail locally, SoniTalk could be used to create a network between users' nearby mobile phones to send important information or emergency calls to neighboring people.

A promising application domain of SoniTalk is the Internet of Things (IoT). SoniTalk is particularly suitable here because it has very low hardware requirements (only microphone and speaker are required which many devices already have built in). In the IoT area SoniTalk would enable the synchronization and direct communication of different devices, sensors and machines with each other as well as the tracking of objects (asset tracking) in warehouses. Another application in this context is home automation.

[7] Such a beacon is currently under development at our institute in the course of a netidee-supported master thesis, i.e. scholarship UNITA: https://unita.fhstp.ac.at.

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