AmbiAct

RRI Industry case study

Frenken, Thomas

CEO oldntec GmbH

Eckert, Ralf

CTO Oldntec GmbH

Jüptner, Alexander

Die Johanniter

Prof. Dr. Hein, Andreas

Carl von Ossietzky University Oldenburg, Department of Inofrmatics

Corresponding Author: Thomas Frenken, thomas.frenken@oldntec.de

Abstract: The ambiact is a smart meter for social alarm systems. This innovative product is designed as a plug-adapter and can be placed between the power outlet and any appliance. If a connected appliance is not used for an individually untypically amount of time, (generally for more than 24 hours), the ambiact automatically generates an emergency call. This provides people living alone (especially the elderly) with more safety in their homes since help is called even if it cannot be actively summoned by themselves. People feel an increased quality of life since daily manual handling of care phones is no longer necessary, and social alarm operators get more satisfied customers and can even save costs by avoiding false alarms due to people forgetting regular handlings of their care phone. The impact achieved by the project was the development of an innovative and patented product which is accepted by both the customer (e.g. care providers) and the end-user.

Keywords: Industry, responsible research, social alarm systems.

Citation: The full citation information will be inserted here once the paper is accepted.

Executive Summary

The ambiact was developed at the request of the Johanniter-Unfall-Hilfe (JUH), Germany's largest social alarm operator, together with OFFIS, a non-profit research institute, from an initial idea in 2011, to a prototype (Figure 1), to a legally-approved product in 2014 (Figure 2). The product is now sold by the oldntec GmbH. Development took place through a publicly funded research project and start-up funding.

Figure 1: Prototype of the ambiact (mid-2012)

The development of the ambiact was carried out in accordance with the principles of RRI, although the project participants only became aware of the idea of RRI after the product's development process had been actively pursued for more than two years. All five principles of RRI were addressed: Societal engagement was reached by performing continuous interviews with social alarm customers and operators and by performing two field trials with nearly 100 participants over more than 13 months. All results from these field trials were made publicly available on demand, and were presented during lectures, scientific talks, and public presentations. Gender equality was addressed by selecting participants equally between women and men. Disabled people were not excluded from the trials. All actions involving private persons, especially the field trials, were approved by a local ethics committee.

Figure 2: Product Version of the ambiact (end-2014)

The project partners learned that the cooperation of all stakeholders during the development process was a key factor in the suc-

cessful development of the ambiact. They learned that:

> (1) early engagement of all stakeholders saves costs during development since necessary changes in the product - in terms of acceptability - can be made early in the development process and occasionally in later stages,
>
> (2) the possibility for timely feedback on problems or suggestions by stakeholders increases their willingness to participate in the development free of charge and with enthusiasm, and
>
> (3) science education is not only helpful for subsequent easier adoption of the new product in the care process, but is also a simple and effective marketing tool for the new product.

The impact achieved by the project was the development of an innovative and patented product which is accepted by both the customer (e.g. care providers) and the end-user. It is currently sold by a start-up company, the oldntec GmbH, to social alarm operators in Germany, and will soon be marketed across Europe. An even more sustainable impact is that the Johanniter-Unfall-Hilfe learned that a close cooperation with technical partners can lead to societally highly desirable and useful products. As a result they formed a business development partnership with the oldntec GmbH in order to maintain the cooperation. Other institutions from the health domain also see the advantages demonstrated by the successful development of the ambiact and are contacting the oldntec GmbH in order to start corporate developments which will be undertaken according to the principles of RRI.

Field of Research or Industry

The development of the ambiact falls under the research field of sensor-based activity detection, an aspect of the ambient assisted living (AAL) research domain, and is relevant for the healthcare industry, and more specifically for social alarm operators.

Due to demographic changes there are an increasing number of elderly people living alone in modern societies. Very often, elderly people wish to live in their own homes as long as possible, even alone. This is also economically reasonable since moving to nursing homes is much more expensive for the healthcare system. However, living alone in old age can become dangerous due to an increased risk of emergency situations. The obvious solution is that people visit their elderly relatives regularly. However, especially in industrialized countries this is often not possible due to geographical or time constraints. Additionally, relatives may not be able to combine care with their normal jobs which can again become problematic for modern economies.

Figure 3: Care Phone, Alarm Button, and Reset Button

Social alarm systems were introduced in the 1980s. The idea is to place so-called care phones (Figure 3) in the homes of people in need of care and to connect these phones to service-centers. In case of an emergency, the vulnerable person can establish a connection to the service-center by pressing an alarm button (Figure 3) worn around the neck or the wrist. The service-center evaluates the situation and sends help if necessary. Studies have shown that people feel much safer at home with a care phone, and that tremendous savings can be made for healthcare systems by prolonging the time before an elderly person needs to move to a nursing home.

However, social alarm systems have a single point of failure: the alarm button. If the button is not being worn at the moment of an emergency, or if the button cannot be pressed, no help will come. Therefore, the so-called passive alarm was introduced. The passive alarm consists of a security clock inside the care phone which is often set to 24 hours. The time runs down and if it runs out, an alarm is generated automatically. Thereby, help can be sent at most 24 hours after an accident, even if the alarm button is not being worn. In order to prohibit false alarms, people have to reset the security clock every day. This happens by pressing a button on the care phone. However, having to operate this reset button manually is very unpopular since it reminds elderly people of their own frailness every day. Additionally, elderly people tend to be forgetful or even have dementia and are thus often not able to handle a daily button press which excludes them from using the passive alarm. Therefore, only few people use the passive alarm although the increased security it offers is well known.

An opportunity to address the single point of failure in social alarm systems without burdening elderly people is to detect emergency situations automatically or, even better, detect risk factors for these situations in order to avoid them occurring. Such situations and risk factors may be detected by sensor-based activity monitoring. The general idea is to place sensors in people's homes and to use the data collected to detect anomalies in their behavior. One possible kind of sensor are smart meters which monitor electrical signals and can detect appliance usage. The idea of utilizing appliance usage for activity monitor-

ing is straightforward. Today, the execution of most instrumented activities of daily living (iADL) is associated with the usage of appliances. An example is preparing breakfast, which often involves the use of a coffee machine, an electric kettle, the oven, or a toaster. If a sensor system learns how often and when certain appliances are used, and then detects that the usage has stopped for a long time, it is very likely that something untypical has happened and that the situation should be investigated. Therefore, activity monitoring may be used to trigger passive alarms via care phones.

Research in the field of sensor-based activity monitoring has been conducted for several years and research systems became more and more complicated. However, most research systems were not usable in daily life, and often failed in apparently simple situations such as vacations, irregular doctor-visits, or the presence of pets.

Event or Activity

Nevertheless, it seemed worth exploring further the results from the activity monitoring research field in social alarm systems. In 2011, the Johanniter-Unfall-Hilfe (JUH), Germany's largest operator of social alarm service-centers, initiated a cooperation with OFFIS – the Institute for Information Technology, a non-profit research center linked to the University of Oldenburg, in order to develop an approach to activity monitoring for social alarm systems that is viable in daily life.

At the end of 2011 two patents were filed that described the idea of using changes in electrical key figures in order to perform activity monitoring through appliance supervision, and to construct a technical system for realizing this idea as a plug adapter. The system was named "ambiact". Starting in October 2012, a national research project funded by the NBank was conducted for one year. The objective of the project was to develop a prototype of the ambiact and to evaluate its feasibility in the field. A field trial with more than 60 households was conducted and the results were very positive. Using these results, it was decided to industrialize the ambiact and sell it as a product. A start-up support grant (named EXIST) was acquired by two former OFFIS employees. From October 2013 onwards, the ambiact was redesigned and evaluated again twice, and is now sold as a product by the oldntec GmbH, a start-up company founded by the former project partners.

From 2011 it took three years until the product ambiact was sold to the first customers. The whole research, development, and evaluation process adhered to a cooperation between social alarm customers, service-center operators, researchers, and engineers. After pursuing this cooperation for more than two years in order to develop a practicable and accepted product, the project partners first heard of a name for their procedure: Responsible Research and Innovation (RRI).

Why does it fall under Responsible Research and Innovation (RRI)?

RRI stands for a close cooperation between all stakeholders involved in the development process of a new product or an innovation in order to better meet societal expectations or implications[1]. When starting our activity we did not know about the concept but adhered to its principles for practical reasons. Two main problems / challenges were known before the start of the development:

- Usage of the reset button of the passive alarm was very unpopular among customers of the social alarm. The new solution should be acceptable to the users so that the customers would no longer have to choose between safety and quality of life. Additionally, forgetful and demented people were so far excluded from the usage of the passive alarm since they were not able to handle the daily reset button press.
- Previous technical solutions were not acceptable to the social alarm operators since the required installation or maintenance effort as well as the price were too high. The new solution had to be accepted by the operators as well.

Therefore, a close integration and cooperation among engineers, researchers, customers, and operators was required in order to find a technically innovative solution that was acceptable to the customer as well as the operators of social alarm systems. Due to this close cooperation among all stakeholders, the usage of the results in scientific publications and education, the adherence to gender equality issues and ethical guidelines, the development of the ambiact falls under the paradigm of RRI.

Examples of engagement activities

Throughout the development process of the ambiact, customers, operators, and students were engaged at different times. Figure 4 shows a timeline of some of these engagement activities.

[1] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society

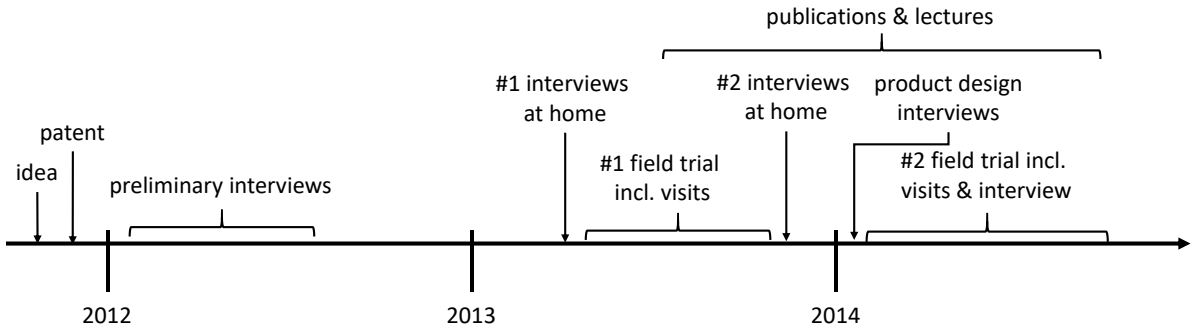

Figure 4: Timeline of Engagement Activities

After the original idea of the ambiact was born in mid-2011, in cooperation between JUH and OFFIS, a specific patent was filed at the end of the year. Early in 2012 development and engagement activities started. Three main types of engagement activities were conducted: interviews, field trials, and lectures.

Interviews: During the development process of the ambiact several interviews were conducted in order to identify factors influencing customers' and operators' acceptance of the new product. Interviews were conducted at five time points:

1. **Before development started:** Preliminary interviews were performed in a lab in early 2012 in order to get a general idea of what properties the product should have. Five potential customers and three operator employees participated. The result was a short list of acceptance factors for the ambiact:

Customers	Operators
1. Unobtrusive 2. No fear of forgetting 3. Looking nice 4. Low / no costs 5. No information shared outside of the home before emergency	1. Easy installation (< 5 minutes) 2. No maintenance effort 3. Low costs (below 200 €) 4. Compatible with all care phone manufacturers

These insights into the acceptance factors were used to refine the idea of the project and to write a funding proposal. In October 2012 a one-year national research project grant was obtained from the NBank in the program "Zukunft und Innovation Niedersachsen", lower Saxony.

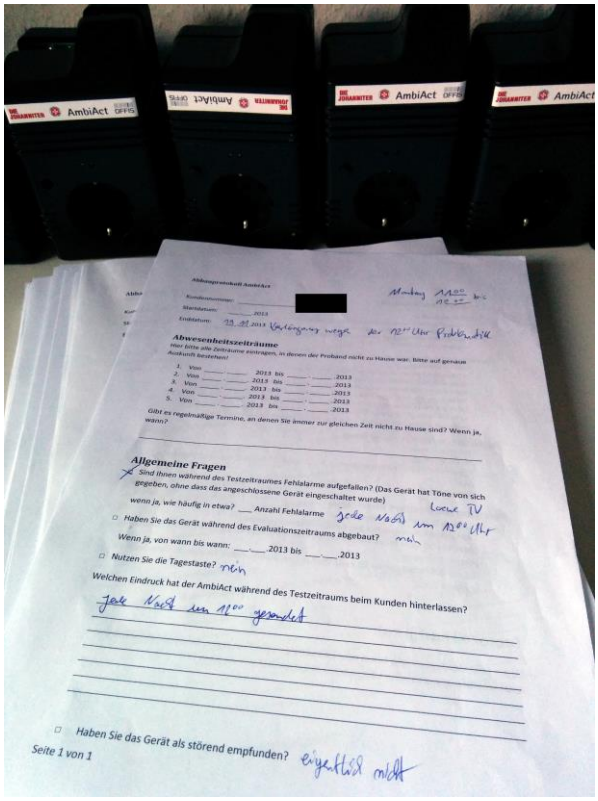

Figure 5: Interview Form of #2 Interview

2. **Before the first field trial:** At the beginning of the funded project, the first interviews were conducted in customers' homes. The participants were recruited by JUH from their customer database. Participants were selected according to a defined inclusion and exclusion list. An equal distribution of male and female participants was aimed at, but due to the higher numbers of female customers in general, and the fact that female customers were more willing to participate in an interview and the later field trial, only 21 male and 61 female customer participants were recruited. The aim of the first interviews was to find out the daily habits of people (e.g. which appliances are used regularly) and their attitude towards the passive alarm system of care phones. Generally speaking, most people said that the most regularly used devices were radios, electric kettles, and coffee machines. Some participants found usage of the reset button acceptable, but most did not.
3. **After the first field trial**: After the end of the first field trial a second interview was performed revisiting daily habits, changes in the usage of electrical devices, times where people were not at home for more than eight hours, and the general perception of the ambiact. The results were very positive, with not a single person refusing the usage of the ambiact, and all finding the ambiact much more acceptable than the reset button.
4. **Before product design**: At the beginning of the commercialization process, in early 2014, 13 customers of JUH, none of them participants in the first field trial, were interviewed. The ambiact prototype was presented to them as an already existing product and they were asked how the product could be made more attractive. The interviews took place in peoples' homes and the ambiacts were placed in the usual outlets. Afterwards the participants were asked whether they would accept the devices in their homes. The main outcome of the product design interviews was that the ambiact should be, a) smaller and b) white. Especially the

change of color was surprising since no participant in the first field trial had ever mentioned that a black device on a typically bright flagged mirror was disturbing. When asked for the reason for the disturbance, people mentioned that visitors could more easily recognize that they are using a social alarm.

Figure 6: Participant of the First Field Trial with an ambiact

5. **During the second field trial** (for more details see below)**.**

Field trials: In order to prove the general functionality of the device and to evaluate its acceptability in daily use, two field trials were conducted during the development process. Both trials were approved by the ethics committee of the University of Oldenburg[2].

Figure 7: Final Version of the ambiact Installed During the #2 Field Trial

1. **First field trial**: During the first interviews 57 people (13 male, 44 female) decided to participate in a field trial. The objective of the first field trial was to prove the general functionality of the ambiact, to identify suitable appliances for daily activity monitoring, and to

[2] Approved by Kommission für Forschungsfolgenabschätzung und Ethik, Carl von Ossietzky Universität Oldenburg, Geschäftsstelle Präsidium, 26111 Oldenburg, granted 2013/03/20 as "Häusliche Akzeptanz- und Funktionstests AmbiAct".

investigate the acceptance of customers towards the new device. All participants gave their consent in accordance with the ethics committee approval from the ethics committee of the University of Oldenburg. The first field trial was conducted between July and November 2013. ambiact prototypes were connected to devices the participants said they were using on a regular basis. During the trial all appliance usages were recorded with a timestamp. The participants were able to call JUH's hotline in order to report possible problems with the ambiacts. On average, 2-4 problems were reported each week. The participant was visited after such each report. The problem was investigated, fixed if possible, and an interview was conducted about how people felt about the device and what they thought about the problem before and after fixing it. Two participants decided to stop the field trial after the report of a problem. Overall, 55 participants completed the field trial, and the data of 50 participants was evaluated. The main outcome of the field trial was that the ambiact was able to detect the usage of all connected devices, except for radios whose load was too low. Regarding suitable devices, the results revealed that TVs, toasters, electric kettles, microwaves, and bedside lamps were the most often and regularly used devices. False alarms could be reduced by more than 90%. More details were published in a scientific paper[3]. Using the results of the first field trial, national business start-up funding was acquired in order to commercialize the ambiact.

2. **Second field trial**: In 2014, during the start-up funding period, a second field trial was conducted. The objective of the field trial was, 1) To explore the acceptability of the new product to end-users when genuinely relying on its functionality, and 2) To assess how many false alarms still occurred when the ambiact took over daily activity recognition. At the same time, interviews regarding product design were performed and the results were used to redesign the ambiact before starting the second field trial (from black to white design). The trial took place in sheltered accommodation for two reasons, 1) Since the device was not yet final but should be used as if it were, the participants had to be visited daily in order to guarantee their safety, - and 2) since JUH thought that in order to get reliable results without inconveniencing the participants, no formal interviews should be performed but people should simply be encouraged to talk about their problems and experiences informally (i.e. people were asked how they felt about the product and notes were written down afterwards). This meant that the required daily visits and conversations could only be performed economically if the visiting person was close by. Overall, 13 flats in the sheltered accommodation near Hannover, Germany, were equipped with the new ambiact for the second field trial, The trial was performed over seven months from to October 2014. Each participant

3 Eckert, R.; Frenken, T.; Jüptner, A.; Felscher, A.; Frenken, M. & Hein, A. AmbiAct - Innovativer Stromsensor zur Aktivitätserkennung für Hausnotrufsysteme Wohnen - Pflege - Teilhabe "Besser leben durch Technik" (AAL 2013), 2014 - Please contact the author for a copy or data requests.

used two ambiacts. One was connected to the TV, and the second to an appliance in the kitchen chosen by the participant.

In the first two weeks every participant was visited and interviewed daily. Afterwards, visits happened upon demand, but at least once a week. Problems and suggestions were reported to the social alarm service center and forwarded via email to the product developers. Problems were solved the next day during a visit. Suggestions were reviewed every week in a developer meeting and integrated into the product, if reasonable. Redesigned ambiacts were installed in the flats as soon as possible – this happened twice during the field trial. 10 false alarms were raised in the facility. By prompt visits and interviews all but two of these alarms could be assigned to unplanned holidays, admissions to hospital, or longer than expected doctor visits. The reasons for the two remaining alarms could not be found. Written protocols were created for all alarms.

The most serious problem reported was again about the color of the device. After some time of usage in the kitchen, or after plugging the device in and out several times, the edges of the pale white housing became a little dirty. Therefore, some customers received a light grey housing after some weeks. The problems did not occur again.

The second field trial finally proved that the ambiact was a fully functional device that was accepted by customers and operators alike. End-users reported that they completely forgot about the daily activity check after some weeks. Those people who used the reset button before, felt extremely relieved, since the fear of forgetting to press the button was gone. In general, end-users relied on the device and felt safer at home. Due to the satisfaction of the end-users, the operators were very happy with the device as well. Additionally, false alarms dropped by more than 80% during the field trial. It was proven that the device could be installed by a nurse with no technical background after only a single instruction which took less than a minute. At the end of the second field trial, the ambiact had reached its final product design and acceptability for end-users and operators was proven.

Talks and further education: New products in the care domain are, at least in Germany, only slowly adopted. One reason for this is the fear of many professional caregivers that new technical products may make professional care staff unnecessary. This is not the case with the ambiact, of course. However, in order to enhance the adoption of the new device, public talks and talks for educational purposes, particularly in schools for future caregivers, and in several study courses at the University of Oldenburg, were part of the strategy of the project partners. Additionally, talks were given at scientific conferences. Overall, more than 20 talks on the ambiact were given in three years.

Impact achieved

The main impact of the ambiact project was the development of a technologically innovative and patented technical device that is accepted by social alarm customers and operators alike. Such acceptance was reached as a consequence of the involvement of all stakeholders of the eventual product into the development process. Thereby, a product with unique advantages for every stakeholder was created: Social alarm customers get additional safety at home without losing quality of life by remembering to press a button every day. Additionally, caring relatives can feel more confident since they know that in case of an emergency their elderly relatives will get help within 24 hours; they do not have to visit or call every day. Operators get an economical device (compared to other additional sensors for care phones) that helps them to prevent false alarms and makes their customers more satisfied with their service. The ambiact is easy to install, does not require maintenance, and is compatible with all care phones. Researchers profited by being able to conduct more problem-oriented research, being able to file patents, and eventually by selling the ambiact as a product. The ambiact is therefore an innovation which has advantages for all stakeholders.

Another impact of the ambiact project is even more sustainable. The oldntec GmbH, producer of the ambiact, and JUH decided to form a new business development partnership based on the experiences of the ambiact project. Care-givers, who know real-world problems, and engineers, who are able to envision and realize technical solutions to these problems, want to develop new products for care in close cooperation. This model of cooperation became known to other care providers. Some contacted the oldntec GmbH with ideas for new products or problems they are seeking a solution to. Thereby, oldntec GmbH agreed to a second partnership for the development of another additional sensor for social alarms only seven months after the company came into existence.

Lessons learned

All former project partners agree that the development of the ambiact was a success, especially due to adherence to the principles of RRI. It was only through the close cooperation of customers, operators, and engineers that a technically innovative and acceptable product could be developed. Lessons learned from this success are:

1. **Early engagement of stakeholders saves on costs**: The engagement of the future customers into the development process, started during the initial idea phase and ending with cooperative product design, saved costs and time. By using interview results, the prototype itself was developed by adhering to acceptability factors for the customers. The continuous interviews during the field trials helped to identify potential problems. Using an agile hardware development process, new prototypes could be enhanced with the feedback from the participants within a few weeks. Using the product design interviews, the prototype could be redesigned

according to customer wishes. The initial redesign matched these wishes. Overall, the ambiact was developed from an initial idea to the final product in only three years with comparatively little cost by using the "work force" of volunteer end-users.

2. **Timely feedback increases compliance**: Previous studies and projects often stated that especially elderly people are doubtful about the usage of new technical products and equally doubtful about taking part in research projects. According to our experience, this is not true. Our experience was that demonstrating to people that their problems are taken seriously, and providing timely feedback on how those problems are addressed, massively increases their will to help. Therefore, every participant complaining about a problem received a short report on which actions were performed in order to address his or her concerns. Thereby, people considered themselves as co-developers of the product and not only as guinea pigs during its development.

3. **Science education is easy marketing**: During the whole development process several lectures were given at schools for future caregivers and at universities around Oldenburg. Additionally, the ambiact was presented in several scientific talks and public presentations, e.g. fairs. While the main motivation for this was to inform future researchers and even users of the ambiact about the new product (e.g. some students from the University of Oldenburg now work for JUH and are very well informed about the product), we also experienced an unplanned side-effect. People who heard about the ambiact talked to relatives and friends about the idea. In several cases, people who had elderly relatives that could profit from the product, and even people working at other social alarm operators thereby heard about the ambiact and contacted the project partners, and later the oldntec GmbH, wanting to learn more about it. Similar effects were achieved by exhibiting the ambiact in two local living / home labs. Thereby, science education not only informed potential users of the new product's availability, but was also a very effective and economical type of marketing.

Funding: This case study was conducted for the "Responsible Industry" project. The "Responsible Industry" project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 609817.

Acknowledgements: This case study was conducted for the EU-funded project "Responsible Industry" and was originally published on the project's website. A link to the page where the case study was published can be found here.

Appendix

Relevance to the five RRI Horizon 2020 action lines

During the development of the ambiact all five issues of RRI were addressed:

1. **Engage society more broadly in its research and innovation activities:** The integration of social alarm customers and operators was an integral part of the development process of the ambiact. The engagement happened through several interviews and the participation of elderly people and the operators in two field trials.
2. **Increase access to scientific results:** All research results from the ambiact project and the start-up funding project were made publically available on demand. Scientific talks and published papers increased visibility.
3. **Ensure gender equality, in both the research process and research content:** While recruiting participants for the field trial, we attempted an even distribution between men, women, and disabled people. An initial list of customers of JUH, from which the participants were chosen, was created according to this principle. However, since women were more willing to participate in the field trials than men, and since there are generally more elderly women living alone in old age, in the end the distribution of genders reflected demographic data. Disabled people were neither specifically selected nor excluded and were able to participate in the field trial if they were on the participant list.
4. **Take into account the ethical dimension:** All actions, especially in the field trials were presented to and approved by the ethics committee of the University of Oldenburg. Especially during the first field trial this was vital since the participants could not at that point rely on the functionality of the ambiact since it was not yet a finished product.
5. **Promote formal and informal science education:** Several lectures at schools for future caregivers and at universities around Oldenburg were given about the ambiact. Additionally, two students wrote their thesis about topics related to the ambiact. The ambiact was presented at several public presentations and fairs. As soon as the first prototype was operational, the device was exhibited in a living lab ("IDEAAL apartment" at OFFIS in Oldenburg) and a home lab ("Schlaues Haus[4]" in Oldenburg). From 2011 to 2014 approximately 1,107 people visited the IDEAAL, and several thousand visited the "Schlaues Haus".

Current Usage of the ambiact

As of today, the ambiact is already used in Germany as part of the social alarm system. The ambiact is now installed together with care phones for those customers interested in using the passive alarm. The appliance connected to the ambiact is chosen together with

[4] Clever house.

the customer and entered into the operator's customer database. Most operators provide one ambiact for free (since they save costs by avoiding false alarms). Those customers who want a shorter alarm period than 24 hours for the passive alarm, will have to use a second ambiact. However, since it is not yet clear who pays for the second ambiact this option is not yet offered by the operators. During the installation, an emergency chain is defined with each customer. Such chains often include calling a neighbor or relative before sending an ambulance if the customer does not explicitly call for help during an alert.

The operator's workflow with the ambiact is basically the same as without the device. If the care phone generates a passive alarm, a telephone connection is established between the care phone and the operator's call center. The employee sees to whom the care phone belongs and first tries to talk to the customer. If he or she reacts and calls for help, an ambulance is sent. If he or she does not call for help but says that it is a false alarm, the employee tries to find out why the ambiact did not send a signal for the reset. Possible actions are to change the connected appliance or to install a second ambiact – both would be done by a technician within the next few days. If the customer does not react, the defined emergency chain is started.

The ambiact easily integrates into the workflow of social alarm customers and replaces or complements the previously used reset button. Overall, the installation of the ambiact does not take more time than the previously required explanation of the usage of the reset button. In fact, it saves time during the installation, saves costs during the operation, and most customers are very happy with the ambiact product.

Future Directions for the ambiact

The ambiact was designed to fit into the current work-process of social alarm providers. Therefore, the ambiact does not currently collect any user data over a longer period, nor does it send any information outside of the users' homes. Its only functionality is to recognize if a connected appliance was used and transmit the usage to a connected care phone. The care phone itself initiates an emergency call if the ambiact does not transmit a usage signal within a defined period of time, just as the care phone did previously when the user did not press the reset button.

However, the ambiact and the technology behind it could be used for more complex scenarios in the future. The most obvious ones are:

1. **Intelligent alarming**: Some operators already asked for more intelligent alarm generation. Instead of only recognizing appliance usage or missing usage, the ambiact could learn typical usage patterns and generate a context-sensitive alarm. The ambiact could, for instance, learn that the toaster is not used on Sundays since the customer has breakfast in a restaurant, but generate an alarm due to missing usages of the toaster only from Monday to Saturday.

2. **Health state estimation**: By connecting several ambiacts within a household to each other, activity profiles could be generated. Recognizing, for instance, that a person has a decreasing number of appliance usage may point to limited activity and thus a potential worsening in their health state.
3. **Estimation of self-care ability**: Knowing to which devices the ambiacts in a local network are connected may even be used to estimate a person's self-care ability or a deterioration of it. If ambiacts were connected to several devices in the kitchen, recognizing that fewer devices were used or that devices are used less often may point to a decrease in self-care ability.

Although all these scenarios could still be implemented locally, without sending information outside of people's homes before an anomaly is detected, they also raise considerable privacy, security and safety issues. If complex profiles were generated, the ambiact would require a strong encryption in order to secure the customers' data. In the opinion of the authors, one reason the ambiact is accepted by customers is that it only collects as much information as is needed for its functionality – which is to provide an alarm in case of untypical behavior expressed by not using a certain device daily. Implementing the functionality mentioned above would require a sustained dialogue with customers. However, for research purposes such functionality could be implemented.

Contact the Author

In case of any additional questions about the article or the ambiact please contact Dr. Thomas Frenken, CEO oldntec GmbH, at thomas.frenken@oldntec.de.

Figure 8: Technical Developers of the ambiact,
Thomas Frenken (CEO oldntec GmbH) and Ralf Eckert (CTO oldntec GmbH)