Mobile Technologies for Efficient Service Processes: A case study in the German Machine and Plant Construction Industry

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ABSTRACT

This article deals with the process-oriented integration of product development and service documentation for the support of technical customer services (TCS) in machine and plant construction, illustrated on the example of the heating, air conditioning and sanitary engineering (HAS) branch. Both using mobile application systems and creating a product service system can increase the efficiency of procedures in service provision. The development and provision of the product service system calls for an interdisciplinary perspective. The problem, as well as the solution on the basis of hybrid added value, the structure of the product service system, the IT-concept and the implementation of the service process modeling will be discussed in detail in this article. In conclusion, the concept presented here will be explained in a practical use case.

Keywords

Hybrid Added Value, Product Service Systems, Wireless Mobile Information Systems, Machine and Plant Construction

INTRODUCTION

Problem

With approximately 862,000 employees, the machine and plant construction industry is the largest industry in Germany (VDMA, 2006). Today, companies address the increasing competition in this field by way of customer retention. The manufacturers central aspect here is the expansion and improvement of their service offers, especially in technical customer services (TCS), which can be seen as the interface between the production and the use of the products (LaLonde, 1976; Czepiel, 1980; Peel, 1987; Sterling and Lambert, 1989; Bolumole, Knemeyer, and Lambert, 2006; Harris, 2007). The manufacturers own service organizations are not the only ones acting in this branch, but also outsourced small and medium-sized enterprises and trade and repair businesses, which carry out inspections and maintenance work needed within the product‘s life cycle (Willerding, 1987). To adequately fulfill the tasks connected with these services, a technical customer service team must be provided with the right “mix of information”. The central problem here is to determine the scope, moment and detailing of the decision-relevant information (Sawy and Bowles, 2003; Timm, 2005). Current approaches for the support of TCS often fail due to the increased complexity of the machines and the need for the representation of service processes connected with this. The result is faulty start-up, maintenance and repair work and thus, extended machine down times, which, in the end, result in higher costs for the customer and market deficits for the manufacturer.

Objective and Approach

The case described above is countered in the project PIPE[1] through the integrated development of physical product and service-relevant information clusters, as well as the combination of both of these production factors to form efficient service processes available in mobile form to the TCS. The central assumption of this concept is, that the requirements from the TCS on the customer-oriented maintenance and repair of machines and plants can be guaranteed and the efficiency of the TCS can be increased through the design of a new product service system. This approach is innovative because through the early coupling of product development, documentation, TCS, process consulting and modern information and communication technology, enables the design of a product service system that allows the creation of integrated process-oriented product and service information at the manufacturers with justifiable expenses and effort. Service organizations, like in-house customer service centers or the customer service centers from small and medium sized trade and repair businesses, can access this information mobile.

Application Domain

The field of heating, air conditioning and sanitary engineering (HAS) is ideal for achieving trend-setting research results in regard to the problem, objective and approach. On the one hand, manufacturers in this field produce sophisticated, technically complex products, and on the other hand, TCS is carried out, for the most part, by trade and repair businesses and service organizations from the HAS trade (Hoppe and Sander, 1996) (cp. Figure 1). The diversity of maintenance objects from the HAS branch direct the TCS to very different challenges, for example, the repair of defective cisterns or the repair of operational faults within complex heat generation plants (Bundesinstitut für Berufsbildung, 2004; MacQuiston, 2005; Haines, 2006).

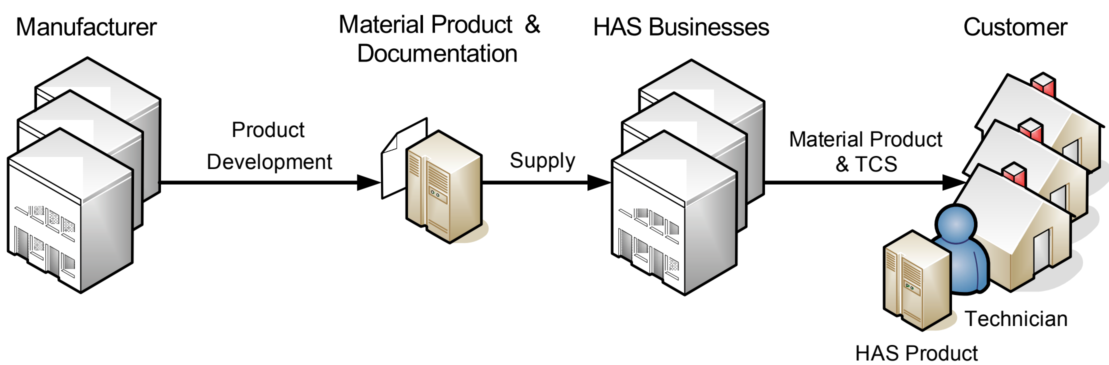

Figure 1. Status quo of the value-added chain in the HAS branch

This article is structured in the following manner: the central challenges for the technical customer service in the HAS branch as seen by the manufacturer, the trade and repair businesses and the customer service technicians are described in the next Section. Then, in the following Section, an approach is introduced that is suitable to meet these challenges. Potential applications for this concept are illustrated in a new Section by means of a real use case in the HAS branch. A summary of the results and an outlook in the last Section conclude the article.

CUSTOMER SERVICE PROCESSES IN HEATING, AIR CONDITIONING AND SANITARY ENGINEERING

Challenges as Seen by the Manufacturers

Products from the HAS branch are provided to the market predominately through the approximately 50,000 specialized HAS enterprises and their approximately 300,000 employees in Germany. The TCS is rendered by the manufacturer‘s customer service team or service partners selected by the manufacturer or specialized HAS enterprises (Willerding, 1987; Hoppe and Sander, 1996). The challenge for manufacturers in the field of TCS consists in communicating repair and product knowledge to the respective customer service organizations. Thus, training is provided for customer service technicians, telephone support set up for carrying out repairs via call centers and technical documents are made available, whether in paper or

[1] PIPE stands for „Process-oriented Integration of Product Development and Service Documentation for the Support of Technical Customer Service". The project is funded by the BMBF (German Federal Ministry of Education and Research) in the context "Innovation with Service Provision" (promotional reference: 01FD0623).

electronic form, for example on CD-ROM. For manufacturers, this challenge is extremely time-consuming with regard to the provision and transfer of this knowledge. Thus, in some businesses, more and more jobs for technical consultants are being created, in order to manage the increasing demand for repair information. Despite these high expenses on the part of the manufacturers, many mistakes are still made by the TCS. On the one hand, the defective maintenance and repair work results in extra costs for the manufacturer for additional services (for example: warranties, guarantees, goodwill) that cannot be allocated to the customer. And on the other hand, the manufacturer runs the risk of losing important market shares due to customer dissatisfaction.

Challenges as Seen by the HAS Companies

HAS trade and repair businesses must also differentiate themselves from their competitors, keep existing customers and win new customers (MacQuiston, 2005). This takes place more and more over the TCS. The challenge for HAS businesses in the field of TCS is that they must use products from different manufacturers and filter out the right information for certain repair situations from the abundance of information provided by manufacturers (Howell, Sauer, and Coad, 2005) (cp. Figure 1). It is not only difficult, but also cost-intensive for the trade and repair businesses to balance out the wide-range of knowledge from the customer service technicians, transfer this information to adequate repair tasks and compensate for the loss of knowledge in a company due to the retirement of experienced employees. In analogy to the argumentation of the manufacturers' perspective, extra costs also result for the HAS businesses from additional customer service assignments.

Challenges as Seen by the HAS Customer Service Technicians

The way the HAS trade works has changed from the function-oriented division of labor to a more process-oriented view. The entire customer order process has become a main focus – especially in TCS. The customer service technician renders his services more or less “solo”, on location; i.e., he is responsible for carrying out his work correctly and identifying and procuring the spare parts required. The successful execution of the repair – and with it, the economic success of the HAS company – is considerably affected by the effectiveness and efficiency of the work done. The main problem for the customer service technicians is however, the large number of manufacturers and products to be serviced. Even experienced customer service technicians, let alone inexperienced technicians, can hardly manage the resultant complexity of the TCS-tasks. Due to this complexity, the identification and optimum design of service processes has gained in importance, as well as the support of the TCS by mobile, internet-based information systems, which allow the customer service technicians to access the most current service information at any time and at any place (Kirste and Fachgruppe Mobilität und Mobile Informationssysteme, 2006; Isaac and Leclercq, 2006).

HYBRID ADDED VALUE AS A STIMULUS FOR INNOVATION

Approach

The main idea of the project PIPE is to increase efficiency for the TCS in machine and plant construction. To do so, a methodology for the development of product service systems was developed based on the integrated process-oriented examination of product development and service documentation and such a product service system was prototypically implemented using the HAS branch as an example. The research results can be generally applied to the machine and plant construction branch and allow the “hybridization” of existing, as well as future technical products.

The technical products of the machine and plant construction branch and their documentation are the material components of the product service system. Existing or future technical plants become product service systems by realizing services for the development, provision, use and revision of integrated service process descriptions, which cover the complete life cycle of the service process documentation. In addition, an information system must allow the cost-efficient collection and modeling of relevant service information at the manufacturers. Service organizations should be able to access this information mobile. Two important implications of the approach described above are:

- Through the integrated design of a new product service system, TCS-requirements for the customer-oriented start-up, maintenance and repair of machines and plants can be guaranteed and the efficiency of procedures in the TCS increased.
- By coupling product development, documentation, TCS, process consulting and modern information technology at an early stage, product service systems are created, which for the first time, describe the life cycle of integrated process-oriented product and service information at the manufacturers with justifiable expenses and effort.

The scenario in Figure 2 shows the result of the PIPE project for hybrid added value in machine and plant construction. It can be seen as an extension of the status quo for the value-added chain in the HAS branch. There are *two* cycles which contribute to the continual improvement of the product service system and in doing so, first to the improvement of product development on the part of the manufacturer and second, to the improvement of service offers on the part of HAS businesses (cp. Figure 2). The first cycle exists between the design process of the new product service system by the PIPE Service provider and both of the feedback processes from the HAS businesses (cp. Figure 2, right). The feedback relates on the one hand, to the requirements of the HAS businesses to the components of the product service systems and, on the other hand, to the evaluation of the actual quality of the components rendered by the HAS businesses using the product service system, which is additionally evaluated by the end customer.

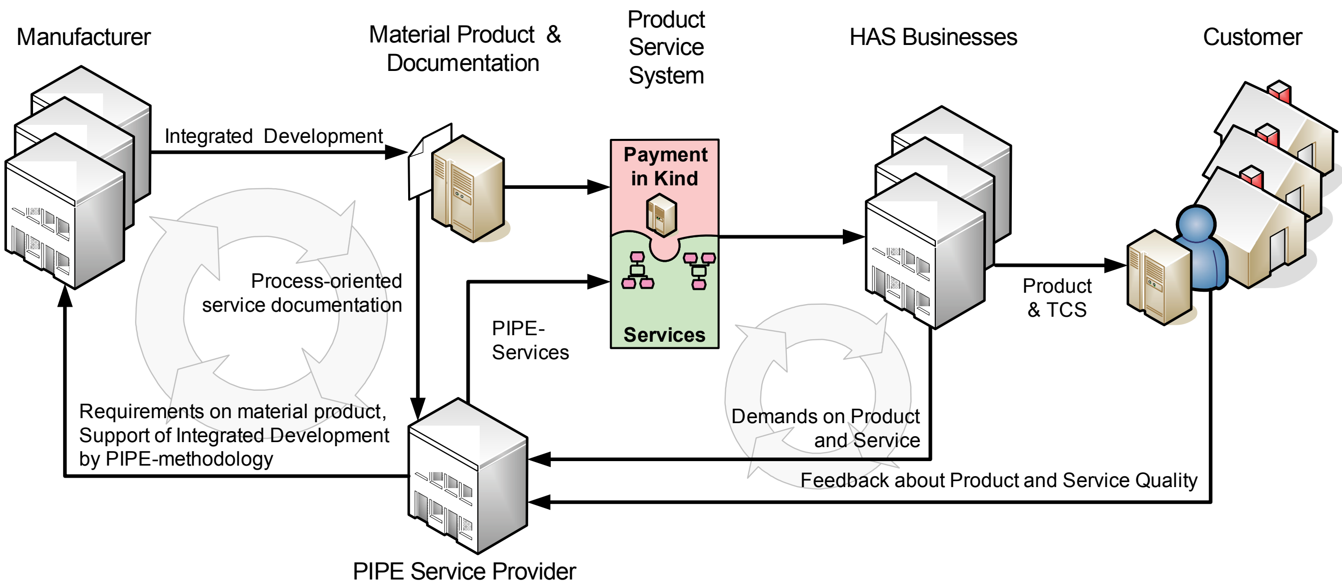

Figure 2. Hybrid added value with the PIPE concept

The second cycle exists between the manufacturers and the PIPE service provider, to whom the manufacturers send the documentation of the plants, as well as basic information pertaining to service processes (cp. Figure 2, left). In the opposite direction, the PIPE service provider first passes on feedback from the HAS businesses to the manufacturer and second, supports the product development on the manufacturer's side using the PIPE methodology. This results in the process-oriented integration of product development and service documentation, which can be used to improve the TCS in machine and plant construction.

Structure of the Product Service System

The product service system to be created consists of several service components in addition to the material components (for example: heating systems). These are thematically centered on the service documentation and divided up into four sections:

- The first section comprises all of the services connected with the service process modeling: the development of a modeling method, the creation of the actual service process models according to this method and tests for the quality assurance of these models.
- The second section focuses on the application of the service process models, especially the mobile use, and thus provision of mobile services for the TCS. This means their provision for online-access via a network, as well as their offline-access via a stand-alone application on CD-ROM, for example for situations where network access is not available at the maintenance site. The transfer of service process models comprises, in addition to transporting information, their suitable conversion – the display of a PDA for example requires a higher reduction level of information as a desktop PC. A request-response-protocol is also conceivable. Thus, one could only transfer the parts of the required process and so, response times are shorter than those for transferring an entire model. Altogether, technical implementation details are highly dependent both on user preferences and the technological platform, so only principal restrictions are taken into account for design decisions at this early stage of development, for example smaller screens and less computing power in handhelds compared to laptops or even stationary computers, or lower bandwidth but higher on-site availability of mobile internet access via GPRS, EDGE or UMTS.
- The third section comprises the controlling of the service processes. The goal here is to reveal room for improvement in service processes and identify construction-related weaknesses in the technical plant itself (an indication for such a weak

spot is for example, an accumulation of repairs on a certain assembly group). The basis for the controlling is an assessment scheme, which gives TCS-employees structured feedback that can be integrated into the product life cycle of the plant and the process life cycle of the service process.

- The fourth section addresses the economical benefit of the service processes by developing and maintaining a business model with several components. Its core is a cooperation model that outlines the economic interaction of the participating parties, for example HAS manufacturers, TCS organizations and their technicians service process model developers, and the portal provider who runs the central service process repository. In doing so, the business model accommodates their economical interests. Further components are the identification of an adaptation to new forms of applications for the service process models (for example: their use in training programs), as well as the provision of tools for marketing. Moreover the increased amount of information which is available about each piece of the attended HAS equipment could allow for a more precise prediction of failures or a more detailed planning of necessary maintenance work to avoid failures. Thus the total cost of ownership of HAS equipment could be calculated more precisely, allowing for comprehensive product-service bundles ("warm dwelling") which could be offered at reasonable prices to the customers instead of separate product and service ("heating and TCS when necessary"), where at least amount and costs of service are rather difficult to predict.

This hybrid approach emphasizes the interdisciplinary component of the PIPE project and combines different topics with each other in an innovative fashion. The business process modeling acts as the methodological basis of the service process modeling. The technical product development represents the basis of the service process models with regards to content. The field of research for mobile application systems is closely connected to the mobile application and controlling of service process models by the TCS on site. The schema of the hybrid added value is especially reflected in the connection of the product and service process life cycles.

IT-Design

The PIPE system-architecture displayed in Figure 3 is the basis for the use of process modeling for mobile application systems in the field of technical customer service. It supports the creation, provision and controlling of the immaterial outputs in the product service system.

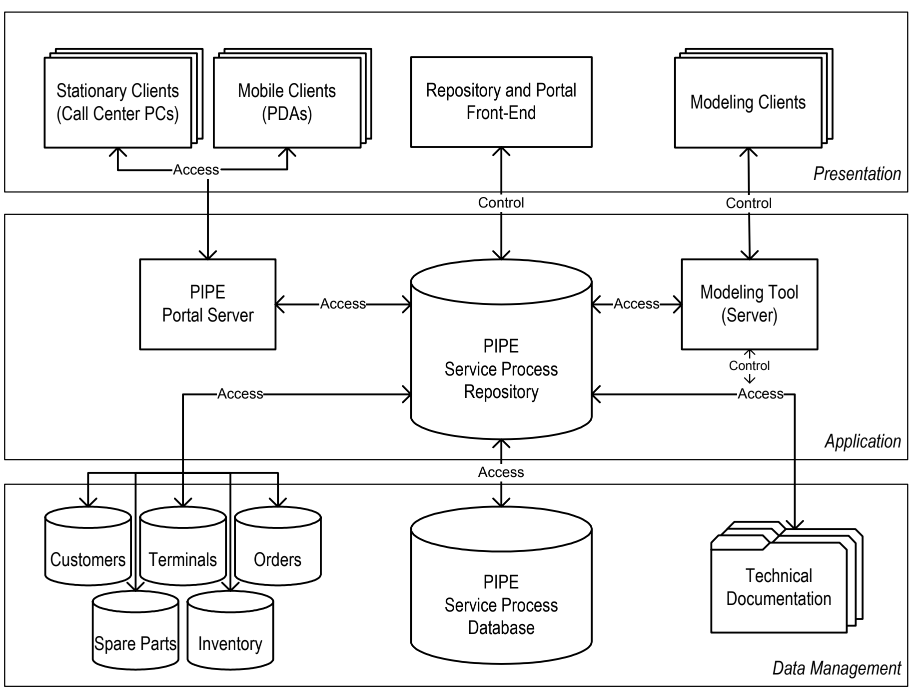

Figure 3. PIPE system architecture

The service process models and services connected with this, such as the creation, maintenance, application and controlling are the focus of the product service system. The architecture's core is a repository for service process descriptions and links to connected master data (for example: customers, devices, parts etc.), as well as technical documentation available in unstructured form (for example, in the form of PDF-files). This repository combines the heterogeneous data sources in a process-oriented view and thus, establishes the technical foundation for the services outlined in Section Structure of the Product Service System.

Other components, set around the repository, support the execution of the PIPE services. The creation and maintenance of models in the repository is locally realized over a client-server-application, which allows several model developers to access the central modeling server over their respective clients at the same time. The modeling server supports the concurrency of different modeling processes by controlling the simultaneous access to resources by locking and unlocking. The bonding of technical documents in the models is also controlled by the modeling system.

Application and controlling are supported over a portal server with the various clients, mobile or stationary access. Through this, the portal server takes over the communication with the clients in two directions. From the repository to the client, a search mechanism is implemented in the portal server that allows a client to search and select a service process model. Then the selected model is converted according to the client‘s requirements and transported to the client by the portal server. The service process is then visualized and interactively supported by the client. In the other direction, from the client to the repository, the portal server receives controlling data from the client and integrates it into the repository. The repository and the portal server are configured and controlled over an integrated front-end.

Implementation and Realization

This section deals with the technical implementation of the introduced concepts. We will focus on the service processes, which constitute the core of the hybrid approach and thus, that of the system architecture. In the following, the structuring of the service processes and their placement in the total concept will be emphasized.

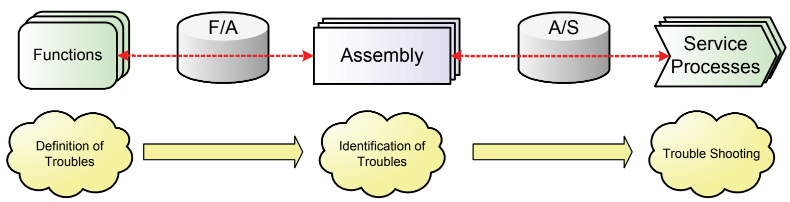

Figure 4. Modeling technical plants with functions and service processes

The main idea of the service process modeling, on which the PIPE approach is based, is the differentiation between function, assembly and service processes in technical plants. The functions, as well as the service processes of a technical plant are directly connected with their assembly. Figure 4 shows how this connection is represented and used in PIPE by defining the malfunction on the basis of the function structure, identifying the assembly groups relevant for the fulfillment of the function and recommending the appropriate service processes.

Functions

The modeling of functions in a technical plant is the basis for the definition of malfunctions, defined as “function failures”. Unlike the definitions of possible malfunctions, the functions of a technical plant can be specified and – as discussed in detail in the next section – assigned to technical assembly groups, which are ultimately the center of reference for the work done by the TCS teams.

The modeling of a function of a technical plant in process logic is not aim leading. The identification of a malfunction in the process flow of the plant may help in organizing the diagnostic steps (“from front to back along the water conduit”), it is however, not relevant for the definition of the malfunction (the organization of the diagnostic steps is recommended to the user by the PIPE system, on the basis of, for example, the empirically calculated failure probability of the individual functions or the respective cost estimates.). It makes more sense to classify functions and assign their respective sub-functions, as displayed in Figure 5. This allows a localization of the malfunction efficiently and by doing so, narrow down the general malfunction of the function “heat water” to the sub-functions “operate burner” and “burn heating oil”. The diagnosis of the malfunction is thus simplified by specifying a few, clearly defined alternatives, which are, in addition, easy to verify (“Heating output reduced”, “Development of smoke”).

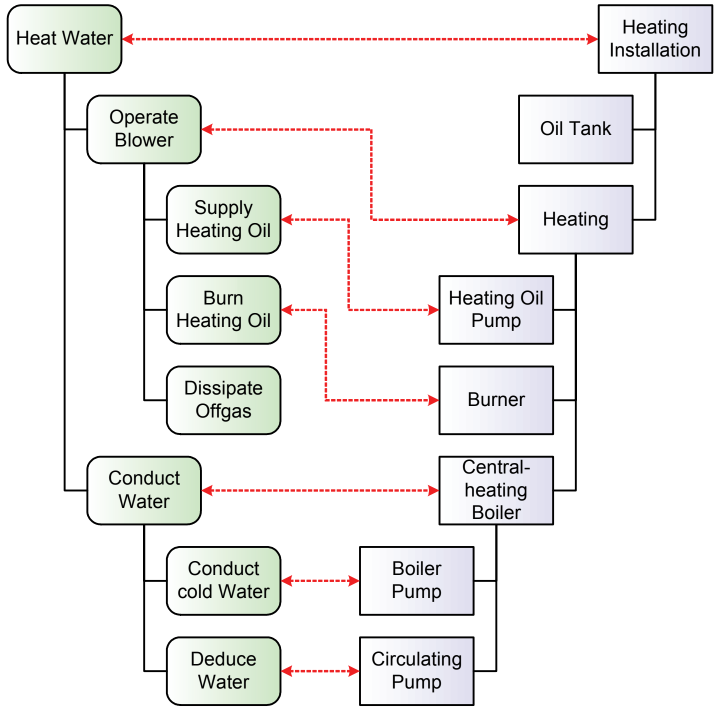

Figure 5. Relations between functions and assembly groups

Assembly groups

The technical arrangement of the plant into different assembly groups is followed by the functional arrangement (cp. Figure 5, right). It results from the technical product development, where first, simple component parts are manufactured and then put together in several steps to form more complicated assembly groups (the technical arrangement of a product can be seen as a given in industrial manufacturing, because for example, the disposing of materials takes place over the respective parts lists).

The connection of assembly groups with functions takes place on the basis of technical task sharing – an assembly group is assigned to the functions it is necessary for. The objective here is to identify the assembly groups that come into question as a cause for the malfunction. This results in a m:n-relationship between assembly groups and functions. The m:n-relations between functions and assembly groups are represented as 1:1-relations in Figure 5 due to reasons of clarity. In addition, a tree structure was used for the classification of functions and assembly groups. Other approaches are also conceivable here, for example m:n-relations between the functions resp. assembly groups.

Service processes

The objective of the malfunction diagnosis is fault repair, which is achieved by executing service processes on the assembly groups of the technical plant. This is made possible by connecting service processes with assembly groups on different levels (cp. Figure 6). The combination of several assembly groups results in functions, which exceed the sum of the individual functions in an assembly group – a heater can, for example, heat water, which is something that none of its assembly groups can do alone. Analogue to this, new service processes result from the construction of assembly groups. These apply to the interaction of the individual components. Therefore, the hierarchical arrangement of service processes and sub-processes is also intended here, as described for example in (Scheer, Thomas, and Adam, 2005). The composition of an assembly group does not lead to the adoption of the processes of its components, but rather makes it possible to complement new processes.

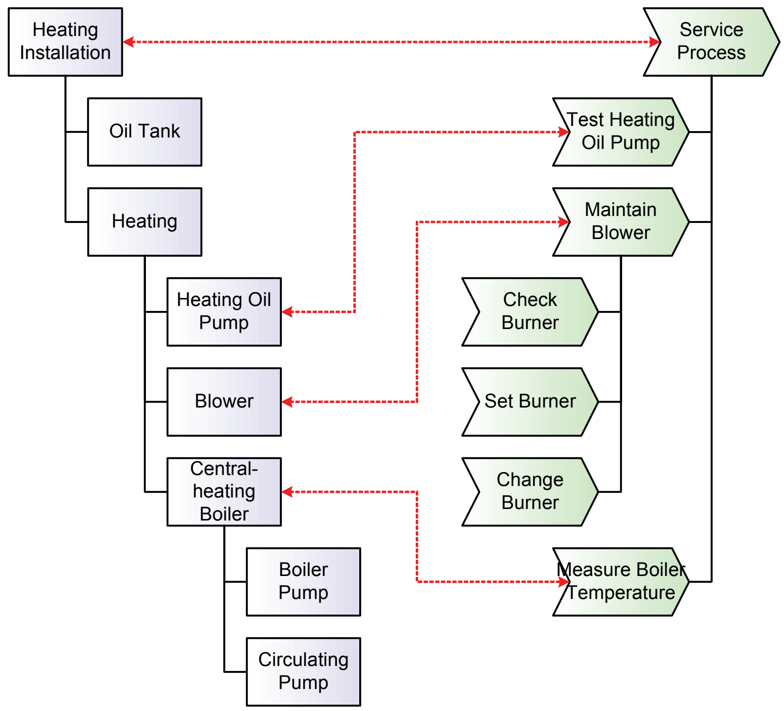

Figure 6. Relations between assembly groups and service processes

If, with the structuring of functions described above, assembly groups as possible carriers of the malfunction are identified, measures for their repair can be selected and carried out via the connection with the service processes. In doing so, the linkage of assembly groups and processes is also represented as a m:n-relation. The existence of several service processes for an assembly group (1:n) is obvious, but it is also possible for a generic service process ("Turn off electricity") to be used on several assembly groups (m:1).

APPLICATION SCENARIO "HOT WATER IS NOT HOT"

In the following, a realistic mobile application scenario will illustrate the approach represented above. The scenario describes a malfunction in a heating device for hot water, which is found to be faulty on site, at the customers. The starting point for the scenario is the fault "Hot water is not hot", i.e. there is a malfunction in the device that affects its functioning so that the water in the device is not heated as intended (the scenario is based on a heating device of the type Cerastar ZWR 18–3 KE 23 from the Robert Bosch GmbH, thermo technology division, product range: Junkers). The processing of this repair procedure makes high demands on the TCS, because almost any part of the heating system could be the cause of the problem. This scenario is therefore ideally suited for demonstrating the general feasibility of the approach described in the third Section. In addition, we will outline in the following how the PIPE system architecture from Section IT-Design and the implementation in Section Implementation and Realization are used in the application scenario.

Preparation for Troubleshooting

As a preparatory measure, the manufacturer must first make the necessary service process information for the faulty device available over the PIPE repository (cp. Figure 3). The function, product and service process structure (cp. Section Implementation and Realization), as well as the service process models created using the modeling software and connected to the relevant technical documents (for example: spread sheets and exploded views) belong to the service information. The service process displayed in Figure 7 is the result of this scenario.

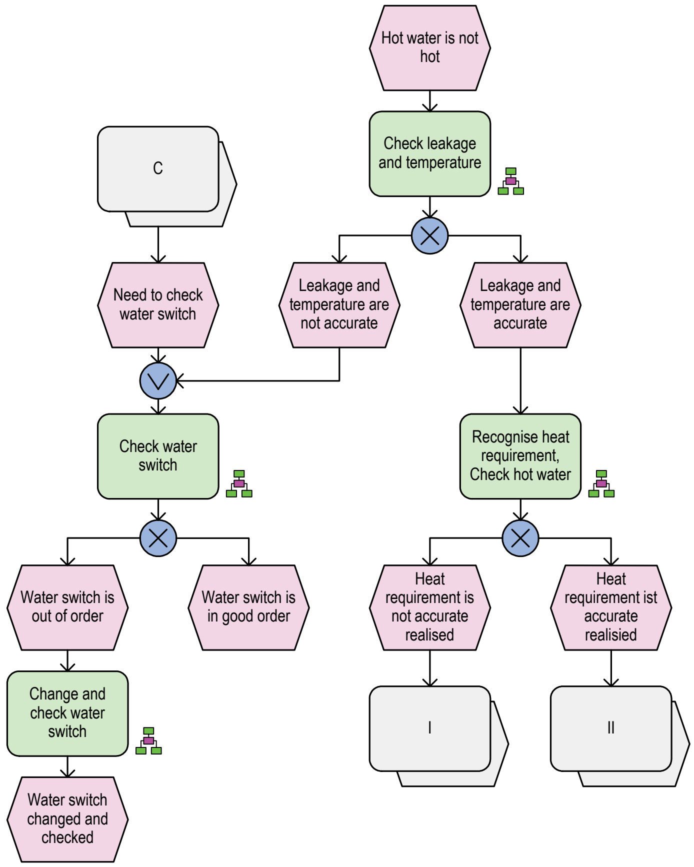

Figure 7. EPC-Model "Troubleshooting: hot water is not hot" (Section)

The event-driven process chain (EPC) is used as a modeling language here (Keller, Nüttgens, and Scheer, 1992). The model has 28 functions on the top-most hierarchy level. Due to lack of space, Figure 7 only shows a section of the model. The model construction was based on the identification of the parts of the heating device, which could be the cause of the problem. Eight parts were identified and ordered depending on their processing order for repair. Each part was mapped to testing, as well as to testing and change-functions. Functions for collecting general device and plant data, which could for example, allude to the registration of hot water leakage or the analysis of the flow pressure on a gas connection, were added to the repair process.

Troubleshooting

The guiding theme of the project PIPE is to help the TCS repair the malfunction described above quickly and efficiently. To do this, the customer service technician receives a mobile terminal (PDA, notebook). Thus, he can access the service process repository via the PIPE portal server (cp. Figure 8). The troubleshooting is divided up into two phases: the identification of the device, as well as the diagnosis and repair of the malfunction.

Identification of the defective device

In step one, the customer service technician identifies the faulty device. This can take place mobile on-site, because device-specific documents must no longer be brought along for the preparation of the TCS-assignment. The TCS is given a library of service information via online-access to the PIPE repository. This dispenses with the time-consuming identification of the device by the customer via telephone or by the HAS business on the basis of old bills. In addition, service documents in paper form must no longer be managed, searched and transported. After the device type is identified it is taken up in the context of the dialogue with the PIPE server, so that only the information relevant for the device is automatically visible for all subsequent TCS operations.

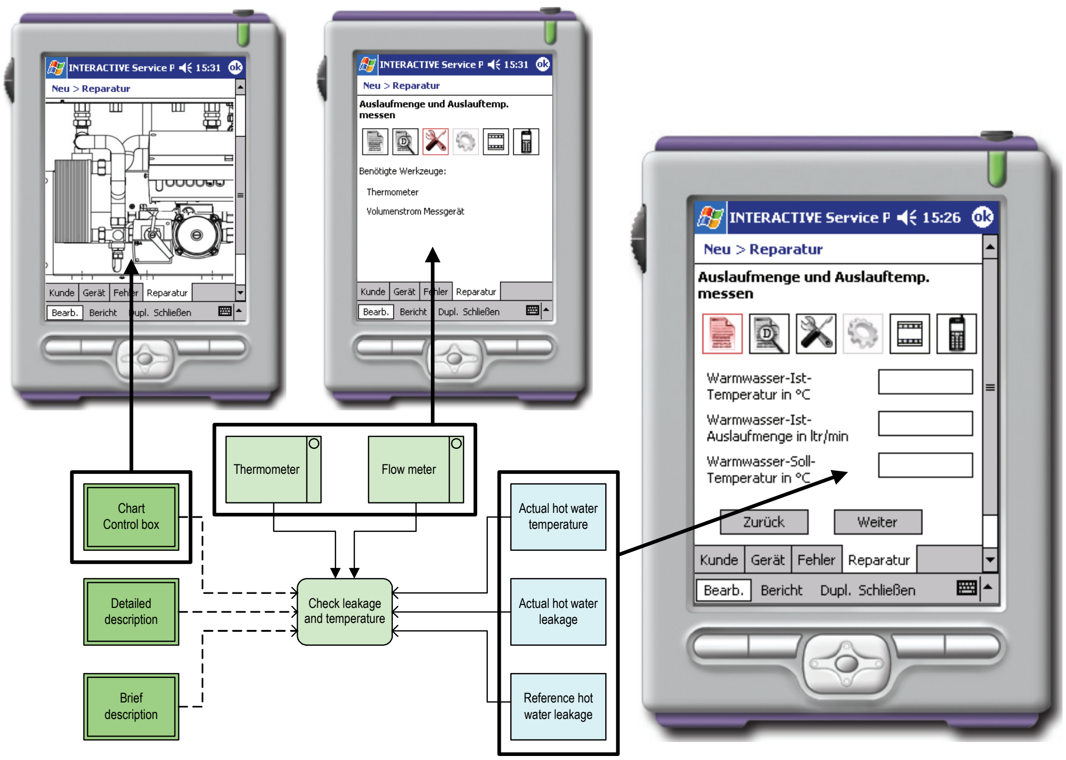

Figure 8. Mobile application "Interactive Service Portal"

Diagnosis and Troubleshooting

After identifying the device, its product, function and service process structure is made available to the customer service technician via his mobile terminal (cp. Figure 8). Now the diagnostic process for the malfunction begins as described in Section Implementation and Realization: the parts of the heating device eligible for causing the selected malfunction are identified based on the function that failed – this process is displayed in summarized form in Figure 7. The order of the diagnostic steps can, for example be determined dynamically by the empirical analysis of failure probability or the effort for the diagnostic steps. The customer service technician always has, however, the possibility to leave the recommended diagnostic procedure. This can, for example, be necessary if a malfunction in the system is not clearly mapped or not registered. In this case, no service process models are available, but technical documents can still be accessed for the individual assembly groups.

Post processing the troubleshooting

After the repair of the malfunction, an evaluation of the IT-support by the customer service technician is intended. Feedback won here is integrated into the repository via the PIPE portal server for example, through the constant maintenance of meta-data from the service process models. The manufacturer can later consult the aggregated feedback pertaining his devices to improve his service processes. If for example, the failure probability of a certain assembly group is significantly high, then a change in its construction can be considered.

SUMMARY OF THE RESULTS AND OUTLOOK

Technical customer service in machine and plant construction must meet the challenge of providing their services more efficiently despite the constantly increasing complexity of technical products. Our approach presented here is based on models for the efficient description of service processes, which can be communicated mobile. This IT-support via mobile application systems allows the technical customer service to, for the first time, continually improve and store service knowledge. A multitude of closely connected technologies and services are necessary for realizing this concept. Therefore, an approach using hybrid added value was selected. Its core is a product service system pertaining to aspects of service information. System architecture was presented from the technological perspective that is suitable for realizing the concept, as well as a structure for modeling service information. These points were then summarized on the basis of a mobile application scenario.

The question as to whether a solution is contribution in kind, services rendered or a combination of both will become more and more difficult for the customer to answer in the future and take a back seat in importance – the borders between contributions in kind, services rendered have become blurred. Therefore, our central challenge in the future is to support hybrid added value by designing adequate information systems.

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