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NFC-based Task Enactment for Automatic Documentation of Treatment Processes

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Abstract. In nursing homes documentation is a mandatory yet time consuming task: typically, nurses document their work after performing the treatments at the end of their shifts which might lead to a decline in the quality of the documentation. The utilization of process-oriented technology in the care domain has already been shown to have high potential in support for documentation of treatment tasks. We want to further this idea, by transforming physical objects into smart objects through equipping them with NFC tags. They can then be used to automatically register their usage with NFC readers specific to care residents. Our analysis shows that many treatment tasks are using care utilities and are candidates for automatic task documentation. We present three scenarios for automatic documentation in nursing homes, an implementation through a proof-of-concept prototype, and an evaluation through expert interviews in the care domain. The interviews indicate an average decrease in documentation time per shift of more than 60%.

Keywords: Business Process Ecosystem, Transformative Technologies, NFC, Automation, Care Domain

1 Introduction

High quality documentation is not only a requirement by legislators, but also a much discussed topic for nurses in general [12]. Documenting every interaction with a patient, from administering drugs to cleaning patients to hydrating them, is very time-consuming and decreases the time spent with a patient. Additionally, the documentation is often conducted at the end of shifts, which leads to missing entries and even wrong entries as documentation is created from memory. Thus enhancing the documentation process is a top priority for nurses and care homes:

1. Continuous documentation: documentation steps should be conducted when a care activity is done, to not miss any details. This can include reminding the nurse that she should take audio notes.
2. Automatic documentation: for many steps, especially when a detailed care process is available for every patient, only its completion has to be documented, no further details are needed.

This paper elaborates the second aspect, the automatic documentation through monitoring physical objects. Automating the documentation of steps that require physical interaction leads to both (1) a reduction of time and effort for care takers, and (2) an improvement in documentation quality (as automatic documentation is always consistent and complete), without any downsides.

In order to understand the idea of automatic documentation support a typical care process is described in the following. Figure 1 depicts the morning routine of nurses (as delineated by international nursing guidelines[1] and national laws) and modeled in a process-oriented way (cf. [22]). It was interesting to learn that for each of the morning routine tasks a physical object was utilized such as a comb.

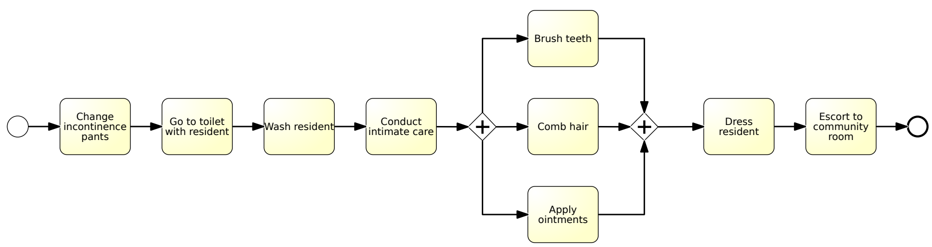


Fig. 1. Daily Morning Care Routine (BPMN Notation Using Signavio)

The following physical objects (denoted as *care utilities*) are used during morning routine:

- Change incontinence pants: Pants
- Go to toilet with resident: Toilet paper
- Wash resident: Washing cloth
- Conduct intimate care: Washing cloth
- Brush teeth: Toothbrush
- Comb hair: Hair brush
- Apply ointments: Ointment package

For task *Change incontinence pants*, e.g. *pants* are employed as care utility. Moreover, all these tasks are manual tasks conducted by the nurse and do not require extensive data input. Consequently, the documentation of these steps includes merely a confirmation that the task has been done, equipped with information on the patient, the actor (nurse), time when it was conducted, and possibly some limited data (e.g., dosage of a drug).

To accomplish a reduction of time committed for tasks involving the documentation of care activities, this paper outlines a way to document steps connected to physical objects automatically, without disturbing nurses or residents. In order to achieve this, each physical object has to provide information about it's existence (and potentially its state).

Several technologies were compared and it was decided to use *Near Field Communication (NFC)* due to reasons such as availability and security[1]. In detail, care utilities are equipped with NFC tags storing precise information about the care utility. Figure 2 shows a resident bed equipped with NFC reader in the lab at the Research Group Workflow Systems and Technology.

Fig. 2. NFC Reader Integrated into Resident's Bed

For not changing the daily routine of nurses too much, a way to unobtrusively register these tags with a process management system during care activities is needed. Additionally reading the tags is not intended to take longer than a few seconds and should happen right at the moment the care task is finished.

To realize this, we decided to build tag readers into the nursing home residents' beds. Every tag reader is connected to one specific resident. Every time the reader detects a tag, it tries[2] to find a matching active task in the residents treatment process, marks it as finished and documents the occurrence with a timestamp and the care utility. This can effectively reduce the time a nurse needs for the documentation of a resident and improve the quality of the documentation at the same time.

In order to achieve the results presented in this paper, we used the design science research methodology[24]. This paper is structured as follows: we start by presenting the scenarios for the solution design derived from literature in Sect. 2. Sect. 2 also presents the solution design itself. The evaluation of the solution is two-fold: Section 3 presents the implementation of the solution and explains technical design choices such as using NFC. In Sect. 4, the solution is evaluated with nurses from two nursing homes by analyzing their working processes, i.e., morning, lunch, and afternoon/evening routines. The initial solution has been designed and realized for the care domain, however, as discussed in Sect. 5 can be transferred to other application domains such as manufacturing and logistics. Related work is discussed in Sect. 6. Sect. 7 provides a summary and outlook to future work.

Overall, the results are promising. The evaluation indicates that automatic task enactment and documentation can be widely applied in the care domain.

[1] e.g. no accidental triggering due to low range

[2] if no task is found, the activity for the resident is logged with a note that it was either an emergency or an error.

Moreover, based on the assessment of the experts, the documentation time per nurse can be decreased by more than 60% on average.

2 Solution Design

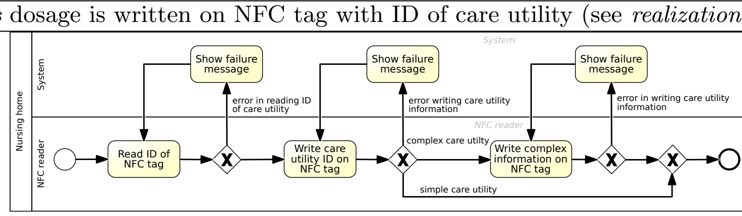
The solution design covers nine scenarios that are relevant for sensor-supported enactment in treatment processes. These scenarios are derived from interviews with experts in the care domain and IT experts and created following the guidelines of [20] and aim for an easy to integrate system. Particular focus is on the automation of documenting the tasks. Due to space restrictions, in the following, a selection of three scenarios will be presented. The entire set of scenarios can be found on `http://cs.univie.ac.at/project/ants`. Note that the scenarios are described for treatment processes, but can be easily adapted for other domains (see Section 5).

In order to connect a physical object to our system, we have to write information to a NFC tag connected to the object. Two types of objects are possible: *simple* and *complex*.

Simple care utilities just have have function (like hair brushes, tissues) thus only their application or hand over is relevant. Thus only the ID of the care utility is relevant.

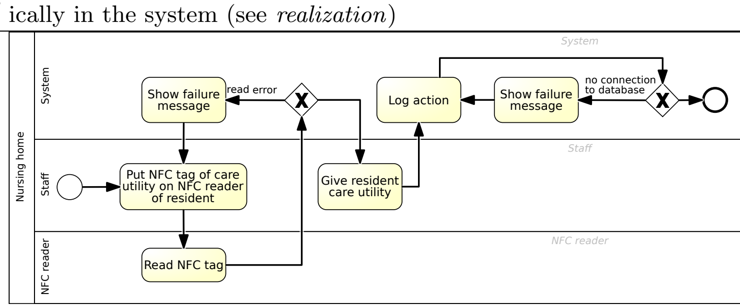
For **Complex** care utilities the NFC tag holds additional information, e.g., the dosage for utility drug (for example see Scenario 1). An example is the painkiller Parkemed which can be administered in dosages $250mg$ and $500mg$. Dosage is a critical parameter in the context of care utilities due to the prevention of misuse. Scenario 1 can be generalized to other parameters. Nested information can be stored on a NFC tag as well, i.e., using containers. Containers also enable to store the information of more than one care utility on the NFC tag. The NFC tag writing of a container, can be done via a NFC tablet in the nurses room for example.

Table 1. Write utility information

primary actor	care staff
stakeholders and interests	staff member (stakeholder 1) wants to connect a care utility to a specific NFC tag; resident (stakeholder 2) wants care with high quality
preconditions	utility type is complex; dosage needs to be specified (see *realization*)
postconditions	dosage is written on NFC tag with ID of care utility (see *realization*)
realization	
frequency	often

Scenario 2 *Give Utility to Resident* realizes the automatic documentation of a care task. The care utility carries a NFC tag which is placed on the NFC reading device of the resident. Doing so the connection between resident (specifying the treatment process instances) and care utility (specifying the care task) is made. The NFC reader decodes the information read from the NFC tag. The system automatically documents that the care task has been completed for the resident with all necessary information such as timestamp and possibly dosage. Looking at the morning care shown in Fig. 1 together with care utilities, the automatic documentation would be conducted, e.g., when the staff member hands the toothbrush to resident *Smith*. The system would then automatically document that task *Brush teeth* has been completed for process instance *Smith*.

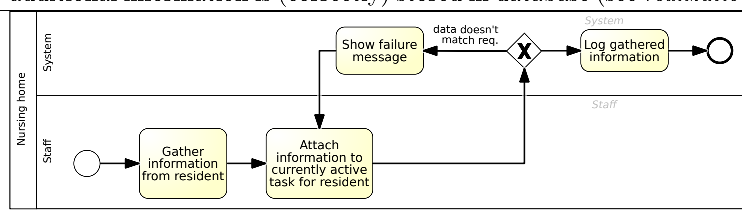
Table 2. Give Utility to Resident

primary actor	care staff
stakeholders and interests	staff member (stakeholder 1) wants automatic documentation of care utility given to resident; resident (stakeholder 2) wants care with high quality
preconditions	resident is ready to receive care utility; NFC reading device for resident is registered; NFC tag of care utility is registered and has necessary information stored (e.g., dosage)
postconditions	resident successfully receives care utility; this is documented automatically in the system (see *realization*)
realization	
frequency	often

For some tasks the automatic documentation that the task was completed using the care utility is not sufficient, e.g., if further relevant information is created and to be documented as well. An example is a discussion about the health status of a resident between staff member and resident. Scenario 3 summarizes the necessary steps, i.e., the documentation of the additional information by the staff member using a form which is stored in the system.

The provided scenarios cover the entire spectrum of automatic task documentation based on NFC technology for treatment processes (see Section 4).

Table 3. Document Further Information

primary actor	care staff
stakeholders and interests	staff member (stakeholder 1) wants to document further information, e.g., the health status of a resident; resident (stakeholder 2) wants care with high quality
preconditions	additional information cannot be stored on NFC tag
postconditions	additional information is (correctly) stored in database (see *realization*)
realization	
frequency	often

3 Implementation

In order to prove the viability of the solution design, a prototype implementation supporting the scenarios above was conducted. As mentioned above the implementation uses NFC as means to connect care utilities to the system (see rationale below). The implementation has the following properties:

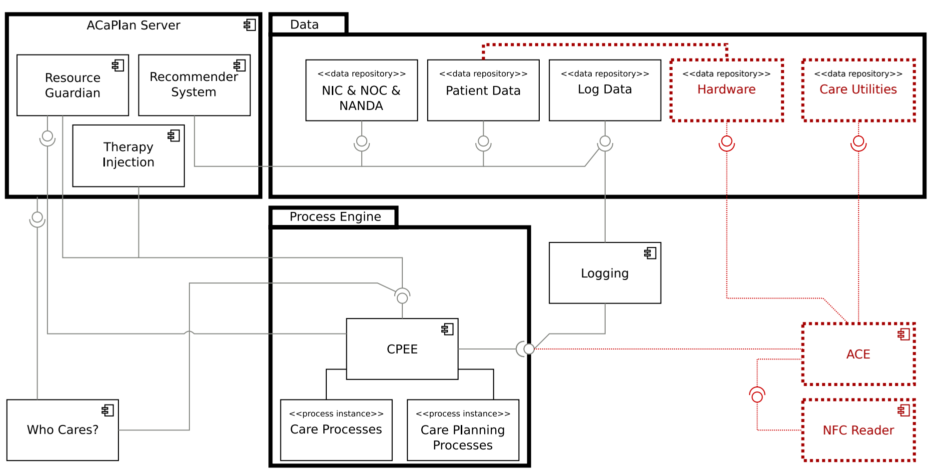


Fig. 3. System Architecture, taken from [22]. The red dotted components are new components, developed in this work.

- We extended an existing solution called Adaptive Care Planning (ACaPlan)[13] that realizes therapy processes for nursing homes. I.e. based on the list of residents stored in the system we store NFC readers for each residents.
- We utilize event streams from process engine that is utilized by ACaPlan: i.e. notifications are received whenever a task becomes active or is finished. ACaPlan uses CPEE[3][16] as its process engine.
- We store all possible care utilities.
- Based on events and data from the NFC readers we can find out which task for which residents can be marked as finished. For ACaPlan all tasks had to be marked as finished manually.
- ACaPlan already provides a custom logger that saves XES[4] files containing the full information about all aspects of running therapy processes[5]. The XES files are transformed to written documentation through XSLT. Thus no implementation in the context of this paper was necessary.

The overall architecture is depicted in Figure 3. Components or implementing the ideas in this paper are modeled with dotted outlines (red). All other components (black) are part of the solution we built our implementation on, and are explained in [13].

In the remainder of this section we will detail the components specific to them implementation in this paper. Furthermore we show how the components interact during the enactment of one of the above scenarios.

3.1 Contribution - Data Repositories: Hardware & Care Utilities

In the hardware repository, all residents are stored with the ID of the related NFC reading device which is a prerequisite to relate events and residents.

The care utilities repository contains all data about the care utilities used during treatment, i.e., care utilities and their encoding, their type (simple or complex), interrelations with other care utilities such as side effects of drugs, and defined breaks between using the utilities (mainly relevant for drugs again).

Therapy process often contain many tasks in parallel. E.g. a resident has to be medicated, but also a proper level of hydration (periodic liquid intake) has to be maintained.While assigning the intake of a certain drug to a task might be unambiguous, proper hydration might be a side effect of different tasks. E.g. serving the resident a cup of coffee, serving a glass of lemonade with the lunch, as well as the glass of water that is part of the medication intake all count towards the goal of proper hydration.

When hydration is seen as task in the therapy process that (in a loop) collects the quantities of liquid that has been consumed over the course of a certain time period, it becomes clear that whenever one of the above (separate) tasks happen, the hydration task additionally has to be provided with the correct information.

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[3] `http://cpee.org`
[4] `http://www.xes-standard.org`
[5] Extensions to the format are utilized to store all information available in certain tasks

Thus the care utility repository does not merely contain a list of data, but a flexible ontology that contains all facts connected to a certain care utility. Thus it becomes possible to identify the correct hydration task from a multitude of care utility applications. All facts in the ontology are described as turtle triplets and can be queried through SPARQL[19].

3.2 Contribution: NFC Reader

Whenever a NFC reader sends information about a care utility, with the help of the repositories above the following information can be deducted:

- Which patient is affected and thus: which therapy process is affected?
- What additional information about this care utility is available?

3.3 Contribution: Automatic Care Enhancement (ACE)

ACE as the main component has the following functionalities:

- Collection of events from the process engine implementing the therapy processes. It knows all currently active tasks for all residents.
- Collection of events from the NFC readers. It knows all care utilities and the properties that have been used for each patient.
- Enactment on active tasks. ACE selects all tasks that are potentially affected by a care utility and supplies it with information found on the NFC tag and allows the process engine to finish this task. Alternatively it notifies the care taker that additional (manual) input is necessary. We envision that in future revisions of the system, care takers are prompted to record voice messages which are automatically assigned to the correct task.

3.4 Implementation of Scenario: Give Care Utility to Resident

As an example the implementation of Scenario 2 is provided[6]. In order to register the usage of a care utility, the NFC tag attached to the utility has to be moved near the NFC reader. Using a care utility can inhibit other utilities or suggest alternative ones. Inhibiting other utilities can become necessary in order to, for example, prevent undesired side effects between drugs. Suggesting other care utilities can be also important in the context of drugs, for example, if a gastric protection drug is suggested for accompanying another drug that is aggressive to the stomach. Finally, for complex care utilities information such as dosage and time interval (e.g., for administering drugs) have to be stored.

When the NFC tag is put close to the NFC reader of the resident, the NFC reader automatically scans the data of the NFC tag. The data of the NFC tag is then sent to a connected computer, running ACE. A local copy of the event will

[6] A detailed description of further scenarios and more technical details can be found in [22].

be stored and a matching active activity in the resident's process is searched. If the search is successful, the data of the NFC tag will be sent to the process engine, and the open event will be locally deleted on the ACE system. The activity is then marked finished in the process engine and the next task will be marked as active and the ACE system stores the new activity for future searches. The documentation is stored in XML files, containing timestamps of the events, the ID of a care utility with the described details, like inhibitors, suggestions and dosage. If the search fails, the event will be stored and put into the documentation with a warning. Note that for this prototype XML was used, because of the readability. For a real care home, a standard database approach is recommended, since XML parsing is usually slow.

3.5 Implementation Choice: NFC

NFC is one of the technologies for sending and receiving data wireless in close range. Alternative technologies would be Barcodes or RFID.

Barcodes: 1D barcodes store rather little information (13 digits) since usually additional information is then looked up in the database [14]. 2D barcodes, e.g., QR-Codes, can hold more information which can be decoded without accessing a database. Limitations of using barcodes are restricted usage ("line of sight" is needed), lack of reusability (barcodes are printed on the object), and that they cannot be edited. *Radio-frequency identification technology, RFID* [23] supports active and passive devices. Another advantage is that no "line of sight" is required. Moreover, RFID devices are cheap to produce, hence can be used at a large scale from an expenses point of view. *Near Field Communication, NFC* [2] is used in many applications and devices such as Smartphones, Debit cards, and tickets for public transportation. NFC builds upon the RFID technology [2] and communicates on a very short range below $10cm$. NFC can work with an active device, the NFC reader, and a passive object, like a tag or card. The reader can write and read information of the object. A big difference to RFID is the range. A RFID reader can create a larger electromagnetic field to automatically detect different objects going through it. Since the communication range of the NFC reader is quite low in comparison, there will not be any unwanted detection of different tags entering a room, which would create a flawed documentation. NFC tags are cheap to produce, very thin, and can be attached to any surface, like stickers. In conclusion, NFC was chosen because of three advantages:

1. *Ubiquitous availability:* NFC capable devices can be found everywhere nowadays. Smartphones, Toys, table computers and even watches. This allows for an approach which is feasible to acquire and relatively easy to learn, since the devices are used in everyday lives.
2. *Better security:* Since the distance to communicate is only about a few centimeters, it is safer to use than RFID. The short range does increase the level of difficulty to create unwanted detections and or malfunctioned detections.
3. *No unwanted detection:* Another advantage of the close communication range of the NFC technology is the elimination of unwanted tag detection. In a

room of a resident are many care utilities. RFID creates a large field, where every tag will be detected. This is very useful for warehouses, but in the nursing home we only want to detect the right NFC tag at the right time. The short communication range allows only one tag to be detected if it is right in front of the NFC reading device, thus allowing for a correct documentation.

For communicating with the NFC reader[7], a binary communication protocol is available, which was utilized in a C library, and made available in a high level language as open source [8].

4 Evaluation

The evaluation is based on two expert interviews with nurses from two different nursing homes. The nurses where asked, for each shift and for each task, how much time could be saved with the solution presented in this paper, taking into account that some tasks need additional information (i.e. comments by the nurses) that can not be automatically acquired. Thus the nurses, for each shift and each task, provided the following information:

- Potential physical objects and how practical it would be to use them for automatic logging.
- Current documentation effort, and estimated savings with the solution presented in this paper.

The overall savings (Tab. 4), as expected by the experts are rather encouraging: the total **expected saving** are about 60%.

Table 4. Possible improvements through automatic documentation

Task	Morning		Evening&Night		
Residents	14		70		
Tasks per resident	12		3-6 (4.5 avg.)		
Tasks total	168		370		
Worktime (nurses)	540 min.		420 min.		
Worktime per task	03:12 min.		01:06 min.		
Nurses	2		1		
Documentation	Manual	Automatic	Manual	Automatic	Improvement
per resident	07:30 min.	02:00 min.	03:00 min.	01:10 min.	68.00%
per nurse	52:30 min.	14:00 min.	210:00 min.	90:50 min.	64.87%
average per task	00:38 min.	00:10 min.	00:40 min.	00:10 min.	74.34%

The daily routines can be divided in morning routine, lunch, and afternoon & evening routine. Lunch mainly consists of two tasks, i.e., assist residents with

[7] http://www.kronegger.com/
[8] https://rubygems.org/gems/nfclib

intake and give drugs. For the intake a form has to be filled manually for documentation. Support for this documentation task has been outside the scope of this work so far. Giving drugs is supported by the system.

The time for using an physical care object is determined by three aspects:

- How long is the physical object used for the care purpose?
- How long does it take to bring the physical object next to a NFC reader (integrated into the bed)?
- How long has the physical object to remain next to a NFC reader, in order for the data to be read out?

While the duration of the first aspect is fixed, the two other aspects replace the manual documentation. They are assumed to take about 10 seconds in total per task[9].

4.1 Morning routine

The process model for the morning routine is depicted in Figure 1 together with the assigned care utilities. One nurse is typically responsible for 14 residents. The morning shift for a nurse starts at 7:30 am and he/she has to conduct the morning routine all by himself/herself within 2 hours. Afterwards a second nurse joins. The tasks for the residents are split evenly. The residents have different levels of care, i.e., are able to conduct a varying number of tasks in the morning routine themselves. Even though the independence of the residents is to be preserved as much as possible, each of the tasks has to be documented by the nurse. This results in a higher amount of time for residents with a low level of care. As there is a substantial time pressure to finish the morning routine for all residents before breakfast, often the documentation of the morning routine is postponed to the end of the shift from noon to 13:00 pm. This constitutes a risk of lowering the documentation quality (e.g., by forgetting tasks).

Assessment: 12 tasks have to be performed for 14 residents resulting in 168 tasks altogether. The average time per task is 03 : 12 min. The manual documentation time has been estimated as 07 : 30 min per resident, 52 : 30 min per nurse, and 00 : 38 min per task.

4.2 Evening and Night Routine

Figure 4 depicts the evening and night routine. For this shift a nurse is typically responsible for about 70 residents. During the night, additionally, a graduate nurse is present for emergency cases. The night shift runs from 8 pm to 7:30 am the next day. After handover of shift the general health status and clothes are checked. Repeating tasks of the night routine are changing incontinence pants and bed positions of the residents in order to avoid bedsore, typically performed

[9] It took about 2 seconds in tests with nurses, but we conservatively estimated 10 seconds to account for delays due to sloppy usage

every 2 to 3 hours. In quieter periods in between documentation is performed. In case of emergencies the nurse prepares the associated documents and calls the ambulance if necessary.

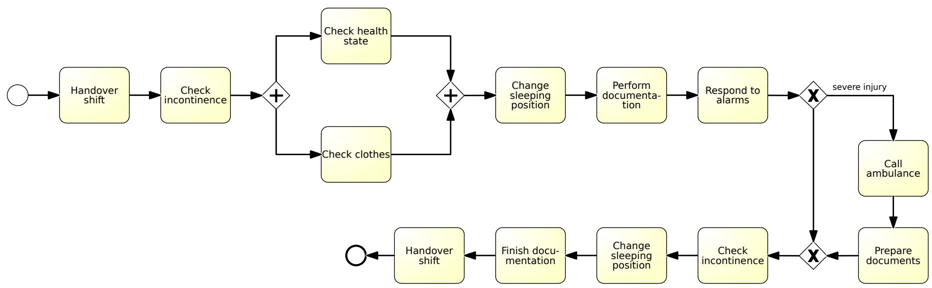

Fig. 4. Process Model for Afternoon / Evening Routine

Though the nurse is responsible for more residents the tasks are less intense and frequent. The shift handover takes about 30 minutes. On average, 370 tasks are performed by one nurse per night, taking 420 minutes of the shift. 210 minutes are left for documentation, resulting in an average documentation time of approx. 40 seconds per tasks. The experts were positive, that except for the health status check, all tasks contained in the process model in Figure 4 can be documented automatically. Again tests revealed a time of 10 seconds per task for automatic documentation under pessimistic assumptions. The documentation time per nurse will be reduced from 210 minutes to 90:50 minutes.

This means a reduction of 74.34% of time per documentation task, 68% per resident and 64.87% per nurse on average for both shifts. It should also be noted, that in this approach, the identity of the nurse fulfilling a task gets drawn out of the shift schedule. An adaption could be NFC tags placed on the clothes of a nurse as identifier.

5 Transferability to Other Domains

The evaluation indicates a high potential for sensor-based automatic task documentation for treatment processes. What are the preconditions for an application to benefit from automatic sensor-based task enactment and documentation?

1. Process-oriented solution
2. Need for documentation
3. Process subjects and / or objects can be equipped with NFC tags and connected to NFC reading devices. Process subject [9] denotes the person or item that denominates the process instance, e.g., the resident or the product. Process objects describe in a broader sense data that is processed during process execution as well as physical objects that are utilized for conducting process tasks such as a vehicle, a comb, or an employee card.

4. Currently, only a restricted amount of data input can be processed through NFC technology, e.g., dosage. For future applications., extended solutions connecting automatic documentation with data input are conceivable as well.

Application areas that fulfil the above mentioned preconditions are, for example, manufacturing and logistics. Both crave for process support [21,4] and are prone to documentation for quality assurance and traceability [8]. Specifically in the logistics domain, sensor-based technology such as RFID is already in use [5]. Moreover, manufacturing and logistics processes employ process subjects, i.e., products and goods/cargo as well as process objects such as vehicles and machines that can all be equipped with NFC technology.

Manufacturing: The applicability of sensor-based documentation in the manufacturing domain was analysed in the experimental manufacturing environment LegoFactoryWST Lab[10] at WST research lab. In this setting, several sensors are integrated and utilized anyway. Here the product is the driving factor for the process execution, i.e., the product is to be equipped with a NFC tag and the different machines with readers in order to document automatically that a product has passed a certain machine.

Logistics: Similar to the manufacturing domain, the goods are the process subjects are drive the process execution. Hence, for logistics as already done in practice, goods can be equipped with NFC tags and the utilities for transportation, e.g., the truck, equipped with the readers. This would not only facilitate documentation, but also foster the traceability of the goods on the transport. An interesting question is whether single goods are equipped with NFC tags each or cargo, i.e., bundles of goods. This becomes particularly important for bundling and unbundling of cargo.

6 Related Work

AdaptFlow [7] enables the dynamic adaptation of medical processes, specifically to deal with exceptional situations. AGENTWORK [17] is similar in that it provides adaptive process technology equipped with reactive and predictive strategies for exceptional situations based on planning. OzCare [15] also deals with flexible support of treatment processes based on a declarative description of the processes. AdaptFlow, AGENTWORK, and OzCare do not support sensor-based task enactment and documentation.

Poulymenopoulou et al. [18] also focuses on emergency care, in particular on supporting the interaction between emergency services and hospitals. The standard exchange format used is CDA [6] employing a RESTful service orchestration. The latter is similar to ACAPLAN and ACE, however, no attention is paid to the automatic task enactment and documentation.

The approach presented by Anju et al. [3] aims at improving the medical documentation. The main application focus in on intensive care units (ICU)

[10] `http://gruppe.wst.univie.ac.at/projects/LegoIndustry/index.php?t=project`

where time management is crucial. Hence, this approach assumes manual data input and provides information management on PCs and tables used in the ICU based on apps. These are two major differences to the work at hand, i.e., automatic versus manual data input and web services versus apps.

Horsky [11] deals with computerized assistance for emergency facilities based on recommendations for process models. Specifically, it enables the usage of RFID tags in order to update patient records automatically. The work at hand advocates to use NFC instead of RFID due to reasons such as security and minimal invasiveness furthering the acceptance of end users. Gunter [10] also employs Bluetooth and WiFi as well as RFID for identifying patients and updating patient data, more precisely their electronic health records (EHR). The distinction to the work at hand is that this work does not only enable updates of measures for the patient, but documentation of entire tasks as well as opting for NFC instead of RFID for the above stated reasons.

7 Conclusion and Outlook

The sensor-based enactment and documentation of care process tasks constitutes a crucial edge for nursing homes by relieving the staff and providing a constant quality of the documentation. The paper has shown the potential of automatic documentation for a large share of routine tasks. The solution has been presented in its design and implementation. The results are very promising, i.e., more than 60% of documentation time per task could be saved as indicated by interviews with nurses. Moreover, the potential of automatic task enactment and documentation is interesting for other domains as well. The transferability has been discussed for manufacturing and logistics.

In future work, sensor-based task enactment and documentation will be applied to the manufacturing test lab setting for investigating and furthering the application in another domain. It will be also investigated how the sensor-based documentation can be utilized for purposes such as compliance checks.

References

1. Implementation of NANDA nursing diagnose... [Comput nurs. 1998 Nov-Dec] - PubMed - NCBI. http://www.ncbi.nlm.nih.gov/pubmed/9844258, `http://www.ncbi.nlm.nih.gov/pubmed/9844258`
2. Agrawal, P., Bhuraria, S.: Near field communication. SETLabs Bridfings 10(1), 67–74 (2012)
3. Anju, K., Mathew, A., Antony, J., Joy, S., Vijayan, B., Santhoshkumar, G.: Business process reengineering of the workflows in intensive care unit supported with a tablet pc based automation system. In: Advances in Computing and Communications. pp. 265–268 (2013)
4. Baumgrass, A., Cabanillas, C., Di Ciccio, C.: A conceptual architecture for an event-based information aggregation engine in smart logitics. In: Enterprise Modelling and Information Systems Architectures. pp. 109–123 (2015)

5. Chow, H.K., Choy, K., Lee, W.: A dynamic logistics process knowledge-based system an {RFID} multi-agent approach. Knowledge-Based Systems 20(4), 357 – 372 (2007)
6. Dolin, R.H., Alschuler, L., Beebe, C., Biron, P.V., Boyer, S.L., Essin, D., Kimber, E., Lincoln, T., Mattison, J.E.: The hl7 clinical document architecture. Journal of the American Medical Informatics Association 8(6), 552–569 (2001)
7. Greiner, U., Ramsch, J., Heller, B., Loffler, M., Muller, R., Rahm, E.: Adaptive guideline-based treatment workflows with adaptflow. Studies in health technology and informatics pp. 113–117 (2004)
8. Grob, K., Stocker, J., Colwell, R.: Assurance of compliance within the production chain of food contact materials by good manufacturing practice and documentation part 1: Legal background in europe and compliance challenges. Food Control 20(5), 476 – 482 (2009)
9. Grossmann, W., Rinderle-Ma, S.: Fundamentals of Business Intelligence. Data-Centric Systems and Applications, Springer (2015)
10. Gunter, E.L., Yasmeen, A., Gunter, C., Nguyen, A., et al.: Specifying and analyzing workflows for automated identification and data capture. In: System Sciences, Hawaii International Conference on. pp. 1–11 (2009)
11. Horsky, J., Gutnik, L., Patel, V.L.: Technology for emergency care: cognitive and workflow considerations. In: AMIA Annual Symposium Proceedings. vol. 2006, p. 344 (2006)
12. Jefferies, D., Johnson, M., Griffiths, R.: A meta-study of the essentials of quality nursing documentation. International Journal of Nursing Practice 16, 112–124 (2010)
13. Kaes, G., Mangler, J., Stertz, F., Vigne, R., Rinderle-Ma, S.: Acaplan - adaptive care planning. In: BPM Demo. pp. 11–15 (2015)
14. Kato, H., Tan, K.: 2d barcodes for mobile phones. In: Mobile Technology, Applications and Systems, 2005 2nd International Conference on. pp. 8–pp (2005)
15. Lee, W., Kaiser, G.E., Clayton, P.D., Sherman, E.H.: Ozcare: a workflow automation system for care plans. In: AMIA Annual Fall Symposium. p. 577 (1996)
16. Mangler, J., Rinderle-Ma, S.: Cpee - cloud process exection engine. In: Int'l Conference on Business Process Management. CEUR-WS.org (2014)
17. Müller, R., Greiner, U., Rahm, E.: Agentwork: a workflow system supporting rule-based workflow adaptation. Data & Knowledge Engineering 51(2), 223–256 (2004)
18. Poulymenopoulou, M., Malamateniou, F., Vassilacopoulos, G.: Emergency healthcare process automation using mobile computing and cloud services. Journal of medical systems 36(5), 3233–3241 (2012)
19. Prud'Hommeaux, E., Seaborne, A., et al.: Sparql query language for rdf. W3C recommendation 15 (2008)
20. Robertson, S., Robertson, J.: Mastering the requirements process: Getting requirements right. Addison-wesley (2012)
21. Schulte, S., Schuller, D., Steinmetz, R., Abels, S.: Plug-and-play virtual factories. IEEE Internet Computing 16(5), 78–82 (2012)
22. Stertz, F.: Sensor Supported Automatic Workflow Enactment for Treatment Processes. Master's thesis, Medical University of Vienna (2016)
23. Want, R.: An introduction to rfid technology. Pervasive Computing 5, 25–33 (2006)
24. Wieringa, R.: Design Science Methodology for Information Systems and Software Engineering. Springer (2015)