PROCESS VIEW FOR ACTIVE AND HEALTHY AGING

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ABSTRACT

Active and Healthy Aging (AHA) is one of the growing concerns and aims of a sustainable society and thus a focus of the European Union. The adoption of a process view and the analysis of the processes to be performed has brought about numerous advantages to business organizations and industrial enterprizes. Advantages range from clarity, understandability, and teachability to increased efficiency due to assessment and measurements of quality and capability.

The basic idea of the process view is to describe necessary activities on an abstract level (i.e. as activity types) and organize these abstracted activities (together with abstracted work products) in a process model. Individual processes are derived (instantiated) from the process model to be enacted.

In this paper we investigate, as a continuation of (Chroust, 2017) and (Chroust and Aumayr, 2017), the challenge of applying a process view to health support for elderly persons ("AHA", Active and Healthy Aging (Univ.Torino, 2016)) and identify the differences from classical applications (software engineering, office automation, business intelligence, ...).

We will turn our special attention to activities which can be designed to be performed by a Senior himself/herself, by helpers from different professions, and by machines (computers) of varying capability and diversity. The variability of the capability of elderly people obviously has to be taken into account by the support system by providing alternative implementations of the same support activity task depending on the capability of an individual Senior.

A discussion about the possibilities to assess the quality of AHA-processes and their support by a Model Interpreter closes the paper.

Keywords: aging, health, senior, process view, process model, process capability, AHA

1 INTRODUCTION

Many people, especially in the Western world, enjoy now a much longer life under better conditions. This trend, however, is also one of the growing concerns of the European Union when considering the demographic changes in the Western World and their effect on a sustainable society. Active and Healthy Aging (AHA) is therefore a central theme of the EU Project My-AHA (Univ. Torino, 2016). Most Seniors will experience an active and/or passive roles in their strife for healthy aging, if they like it or not. Supporting active and healthy aging is an ethical, an economic, and an organizational issue, calling for systemic, interdisciplinary answers. In most cases, support is needed to compensate for lack of Seniors' capability to perform simple or complex necessary processes on one's own. This deficit in capability has to be overcome by a human support environment (consisting of persons from many different disciplines: family, doctors, nurses, service personal, helpers, etc.) and a technological support system (consisting of gadgets, tools, computers, robots, etc.). The current and growing lack of sufficient human personal makes shifting suitable tasks from human to machines (computers, robots) a key factor in providing an effective and also economic support for Seniors.

In the classical industry automation was able to boost productivity, reduce human labor, and increase efficiency and quality. This trend is essentially based on adopting a process view, today marketed under the label of "Industry 4.0". Its basic paradigm is an increased autonomous interactive behavior of multiple machines, each performing specialized tasks.

We suggest to adopt a process view of supporting AHA. In analogy to the classical production industry it will be a long way from initial automation steps to large scale automation. The process view will be a good basis for including technological means and tools in support of AHA. We believe that applying a process management approach can help to improve the quality, efficiency and cost of AHA-projects and will make the technology available to more Seniors. We will use the terminology and concepts of system development processes, e.g., ISO/IEC (International Organization for Standardization / International Electrotechnical Commission) 12207 (ISO/IEC, 2016) and ISO/IEC 15288 (ISO/IEC, 2006) for describing the AHA-support processes, their interfaces and the necessary requirements. Quality assessment will be based on the ISO/IEC 33000 family of standards (ISO/IEC, 2015).

In this adoption process, we have to be aware that an obvious key difference is that the 'objects' of software processes are innate artefacts and not living beings, human Seniors. This will impose strong implications and limits on AHA with respect to aspects of humanity, morality, ethics, and risks. While on the one hand humans are eliminated from the service processes (automation!) the AHA-processes will involve more and more humans and also in more intensive ways.

The paper will be structured as follows: In section 2, we will describe the basic concepts and terminology of a process view, i.e., the structure of processes with activities and tasks and their interrelations and the process models. While this discussion is applicable essentially to all processes, we will in section 3 specifically discuss the requirements, challenges, and differences introduced by considering AHA, especially in comparison with 'pure' technical processes. In section 4, we will again be inspired by software engineering with respect to discussing means to measure, control and even improve the quality of AHA-processes. At last, section 5 will be devoted to the technological support for enactment, assessment, and control of AHA-processes, leading to concepts for an AHA-Process Interpreter.

Statements and observations specific to AHA will be emphasized by using an italic font and preceding them by "AHA:".

2 WHAT CHARACTERIZED A PROCESS VIEW?

2.1 Activities and Tasks

The process view decomposes a complex undertaking into a set of processes. Each process is seen as a sequence of pre-defined tasks ('activities') which exchange information and work products ("inputs" and "outputs"). In this way the complete process is made transparent, can be easier taught to others and can be improved for the future. The Software Engineering Standard

ISO/IEC 12207:2017 (ISO/IEC, 2016) defines:

- process : set of interrelated or interacting activities that transforms inputs into outputs.
- task : a requirement, recommendation, or permissible action, intended to contribute to the achievement of one or more outcomes of a process. (In the management literature a task is often considered as an uninterruptedly unit of doing to be performed in one step.)
- activity : a set of cohesive tasks of a process. Despite the fact that the above distinctions are important for the structuring of process models, we will in most cases simply speak of ’activities’, encompassing also tasks and sometimes also processes.

The division of an activity into different tasks (the granularity) will depend on the nature of a task and also on the capability/knowledge of the performing person (Milani et al., 2016; van der Alst and Dustdar, 2012). A process model designer must strike a good balance between too coarse a granularity (leaving too much open and making some users helpless) and too fine a granularity (boring some users with unnecessary and/or ’obvious’ details of tasks).

AHA: *This issue will receive special attention in this paper (see section 3). Activities can be assigned to be performed by the Senior himself/herself, by various helpers from different professions, and by machines (computers) of diverse capability and diversity. One consequence is that the same support activity has to be divided differently depending on the capability of the individual Senior.*

2.2 What is a process model?

A process model defines and describes the activities, their contents, their meaning, and their interaction (via workproducts as input and output) with other activities. For Software Engineering, key documents are ISO/IEC 12207 (ISO/IEC, 2016), ISO/IEC 15288 (ISO/IEC, 2006), and ISO33000 (ISO/IEC, 2015).

The process model *abstracts* from idiosyncrasies of a single process and describes the process ’in general’, independent of the enacting person or the object of the activity. It describes in an abstracted form the necessary activities (e.g., ’evaluate health status’ or ’perform operation’) and their logical dependencies (e.g., ’measure blood pressure’ precedes ’perform operation’) and the necessary work products (e.g., ’blood pressure value’, ’description of previous treatments’) to be produced and used by these activities. When modelling a process, all semantically equivalent activities are abstracted into one "activity type" (Chroust and Aumayr, 2014), e.g., measuring blood pressure in the morning, the afternoon and the next day are abstracted to one activity type ’measure blood pressure’ (Figure 1). Similarly, the work products are abstracted into "work product types", e.g., to a work product type "blood pressure".

When a new project is started, the actual activities and/or workproducts are modelled (’instantiated’) after the respective activity types/work product types.

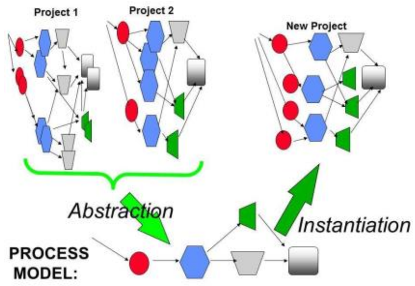

Fig. 1: Process Abstraction and Instantiation (Chroust et al., 2011)

The logical dependencies between activities are also expressed on the ’type’-level and have to be applied to the individual activities (instances). This leaves still considerable freedom to "navigate", i.e., to choose the next task (Chroust, 2000, 1994), see also Figure 2. A process model contains therefore in abstracted form the experiences of many previously executed processes combined with theoretical considerations and desirable improvements. By adding new experiences and best practices the process model will be modified and improved. Different methods and strategies for performing a given functionality will distinguish themselves, both in the activities and work products, but especially in the sequence the various activities are to be performed in (Chroust, 1994).

Figure 3 shows the extended meta-model of a software process model, also showing additional components: tools, roles, input/output relations, and structural information (Chroust, 2000).

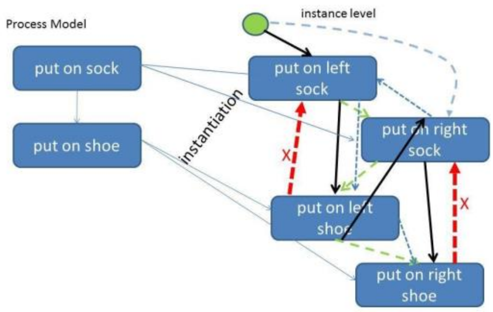

Fig. 2: Instances of activity-types, work-product-types for AHA

2.3 Advantages of the Process View

Key advantages of a formal process model are (Chroust, 2000; SPIRE Project Team, 1998) :

From an implicit to an explicit description :

Without a written-down process the knowledge about the processes to be performed rests only in the head of the engineers. A written process model can be shared with others and thus improves teachability of the processes. It can be recorded, standardized, transmitted to others, stored and taught, thus converting implicit knowledge into explicit knowledge (Nonaka and Takeuchi, 1995).

Storing Best Practices :

It also acts as a repository for new best practices, thus accumulating experience, but also allows audits and recording of inadequacies. One can also identify essential or useful subprocesses by ex-post analysis (van der Alst and Dustdar, 2012).

Standardization :

The model provides standardization across different persons, projects and applications. This is of special value for the cooperation of heterogeneous teams.

Quality assessment :

The process can ex-post be evaluated, improved (van der Alst et al., 2016), its capability and maturity assessed (e.g., by the approach of the ISO/IEC 33000 family (ISO/IEC, 2015). For details see section 4.

Quality Assessment of Process enactment :

Observing and the (automatic) recording of the enactment of a process allows to check the compliance with described process steps and legal requirments and accounting of used resource (personnel, volunteers, operational material, etc.).

Computer Support :

A formally described process model can be supported by a Process Interpreter, see section 5.

2.4 Enacting a process model

When performing a project (or actually any activity based on the process model, Figure 3) the model has to be interpreted and followed as a guideline. For every individual activity type the corresponding activities have to be created ('instantiated') and performed ('enacted') according to the sequencing prescribed by the model. An 'interpreter' of the process model (Figure 4) can be a human (like when you follow a cooking recipe), a computer program, or a combination of both.

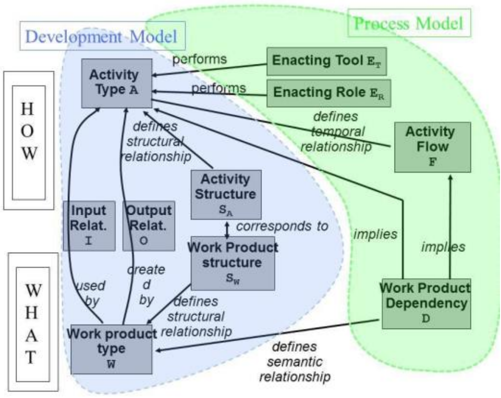

Fig. 3: A Process meta-model

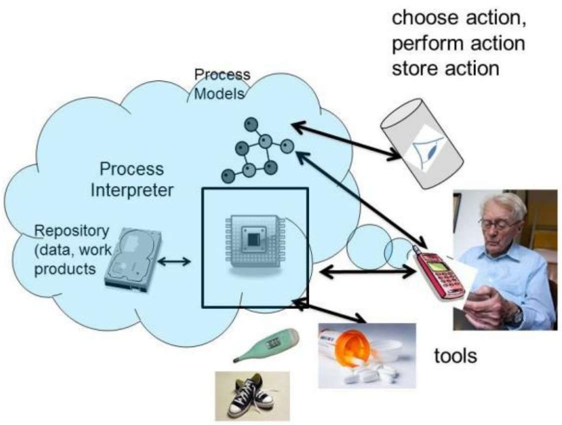

Fig. 4: Interfaces for AHA

Key actions of the interpreter are:

Instantiation and administration of activities :

For each activity types appropriate activities must be initiated, shown to the user, worked on by the user, and their status remembered (planned, started, in work, finished, in rework, etc.). Access to the needed inputs must be provided, outputs identified.

AHA: *Some activities can be initiated automatically, but in many situations a Senior has to initiate and/or perform specific activities. The Process Interpreter can ask the Senior to do so.*

Status of an activity AHA: *Many activities have actually be performed* outside *the computer system proper, e.g. cleaning teeth). It is difficult (impossible?) to check whether the action has actually be performed or completed, see section 3.2.*

Instantiation and administration of work products :

All work products (documents or pointers to external artefacts) must be created, i.e., instantiated as often as necessary (Figure 2)), administered and related to the appropriate activities.

Navigation :

The enactment of an activity (an instance) must honor dependencies and restrictions between all other activities (Chroust, 2000) (e.g., sequence constraints between activities, common start or end of activities, exclusion of parallelism between them, etc.). The sequence in which activities are to be performed (the 'navigation information') is partially defined in the process model. However, the model (since it is a construct on the 'type' level) leaves considerable freedom.

AHA: *For example, a process model for a Senior might contain two activity types "put on socks" and "put on shoes" (see Figure 2). Actually, each of these two activity types identifies two activities (one for the right and one for the left foot). Theoretically there are 24 possible sequences. However, given that a sock has to be put on before a shoe and that left and right must be matched, it leaves only 6 different acceptable activity sequences.*

Pre-emption and resumption :

Sometimes processes have to be urgently interrupted in order to assign resources to other activities, typically for emergencies.

AHA: *An unexpected heavy bleeding has to be handled immediately, probably preempting another activity. After the emergency has been taken care of it is often difficult to decide how to handle the interrupted activity (start anew, continue at point of interrupt, abandon the rest of the activity). In all cases the process model Interpreter has to be informed and the necessary status set.*

3 SYSTEM DEVELOPMENT AND SUPPORTING AHA

In this section, we will expand on the use of the process view in AHA and use the experience and know-how from Software Engineering. See also a similar comparison between Software Engineering and Disaster-Management in (Chroust et al., 2016).

3.1 AHA as a Collection of Processes

The processes performed in AHA are in many aspects similar to maintenance process in systems engineering. A Senior himself/herself is a very complex system. The processes, which try to improve his/her status and/or situation must - as consequence - also be very complex, as the Law of Requisite Variety postulates (Ashby, 1958). Support for Seniors by humans and machines (including computers) must provide a large variety of support processes.

Health care processes diverge in their properties in several ways from the classical systems engineering processes. The reason lies in the different focus: the ’objects’ of AHA are living humans with their will, individuality, personality and idiosyncrasies while the objects of systems engineering processes are usually inert software objects. Humans are flexible, variable, sometimes irrational, and provided with a free will, with moods and variations. This has to be considered when planning the various components of the AHA-process, i.e., supporting individuals in living through their aging process in an acceptable and healthy status.

All activities must be designed with strong consideration of human factors with respect to all involved persons (McEntire, 2007)(ISO, 2011). This includes observation of national and cultural differences between ethnic groups (McEntire, 2007) with respect to contents, form, adressee, including a concern whether the recipients are willing to follow warnings and instructions (Haddow and Haddow, 2008)

3.2 Challenges in AHA

Considerable differences exist between the situation in a system engineering situation as compared to an AHA-situation, see also (Chroust et al., 2016) . Many of these differences challenge the creativity of architects of AHA-processes.

- Completion Control :
  In a ’regular’ system development project guided by a process model each task or activity has at least one outcome in tangible form (a piece of document, finished intermediate product, etc.), which is expected (and needed) by a successive task. In most cases somebody will be in charge of the successor task(s) and therefore will ’ask for’ the work product, the quality might be lacking, but the work product is expected to be delivered.

AHA: *The situation with AHA is different. Most 'outputs' of an AHA-process are triggers for a Senior to initiate an 'outside action'('take medicine XYZ' , 'drink a glass of water', ...). In the process model only messages as surrogates for these 'work products' are created. Whether the Senior has actually cleaned his/her teeth, or drank enough liquid is very difficult to control. The simple solution that the Senior has to acknowledge the completion of the task is of little use since a Senior can (and often will) easily fake the acknowledgement.*

Two approaches are promising:

Internet of Things: Utilizing the concept of the Internet of Things (Schultz, 2016) one can equip essential gadgets (e.g., the tooth brush or the jug) with active sensors and thus recognize the completion of an activity (at least to a certain extent).

AHA: *Experience shows that Seniors dislike this type of control and are very creative in circumventing and faking completion (e.g., watering the flowers instead of drinking, etc.)*

Gamification: A more promising approach seems to be the concept of Gamification (Deterding et al., 2011): the recognized successful completion of an activity will produce of visible 'achievement marks' on a prominently visible display. Psychologically this is more promising, but can only be used in certain environments.

- Misplacing and Searching :
  In a Software Engineering Environment the Process Interpreter stores, administrates and makes available the work product.

  AHA: *Seniors are generally plagued by misplacing things and having problems finding them later. To a certain extent an Internet of Things approach (see above) could help: one would need to equip all important object with sensors. In this case the system could indicate where to find the desired objects.*

- Forgetfulness :
  Depending on the specifics of the chosen project interpreter, users will be reminded of pending activities and deadlines.

  AHA: *Seniors tend to become forgetful. A Process Interpreter can bridge and alleviate much of this forgetfulness by registering activities and dates to remind the Senior.*

- Time variability :
  While mechanical systems show a reasonable predictability and stability this is not true of Seniors.

  AHA: *This means that one cannot make reliable assumptions about the physical or mental status of a Senior. It can change any time. Therefore the AHA-processes must be carefully double checking the situation etc.*

- Lack of full knowledge of the history :
  In Software Engineering lots of the information is not provided explicitly but hidden in the code and documentation (as far as trustworthy).

  AHA: *Similarly, historical data documented about a Senior is full of hidden facts, omissions, mistakes, misunderstanding and unknowns - often due to privacy considerations. Treatment has to take this into account, especially if certain activities are performed by computers.*

- Pre-emption of activities :
  One often has to interrupt an activity in favor of performing another one.

  AHA: *A well-ordered enactment of a process model is often not possible. Activities have to be started suddenly due to an emergency (e.g., "severe coughs"). Other activities have to be interrupted and later abandoned, taken up at the point of interrupt, or repeated.*

- Pressure of Time and Success :
  The production of software seems to be notoriously under performance pressure.

  AHA: *For Seniors the time very often 'runs away'. Hazards appear suddenly and have to be taken care of immediately. Life-saving activities often have a very narrow time window to be successful.*

- Stress and psychological pressure :
  Unclear situations are always a cause of stress in view of the responsibility to take a correct action (Duckworth, 1986; Bundesamt f. Bevölkerungsschutz und Katastrophenhilfe, 2011).

  AHA: *This problem often is more pronounced because health situations are tend to be more difficult to understand. This is aggravated by the fact that the decisions often are a matter of life or death of a human being.*

- Systemic problems :
  Health problems are usually the result of several interacting causes.

  AHA: *Illnesses and hazards often have highly interrelated causes and reciprocal influences, often showing new (emergent) symptoms like allergic reactions against some medicine. Domino-effects of existing illnesses and side effects of medication need to be considered.*

- Cultural "blockages" and taboos :
  When treating Seniors, social taboos and conventions have to be kept in mind (no blood transfusion for Jehovah's Witnesses, no male personal for Muslim women, etc.).

  AHA: *Seniors often have their own mind, long established peculiarities and often no understanding for the necessities of treatment. They also often object to being 'led' by a 'machine' despite the lack of the capability to manage themselves.*

- Tailoring of Processes :
  When enacting a process often the need arises to adapt process models with respect to the needs and idiosyncrasies of a specific project (Broy and Rausch, 2005).

  AHA: *The individuality of Seniors is even more pronounced with respect to adaptability of processes. Flexibility is a must in AHA-situations.*

4 CAPABILITY ASSESSMENT OF THE AHA-PROCESSES

One of the key advantages of defining and following a process model is the possibility to assess the capability of the performing organization in providing the services and products intended to be provided based on a standardized and accepted process model, cf. (ISO/IEC, 2015).

In the 1980s, the Software Process Program was founded at the Software Engineering Institute (SEI) at Carnegie Mellon University under the leadership of Watts Humphrey. This program resulted in the development of the Capability Maturity Model (Humphrey, 1989; Humphrey, 1995; van Loon, 2004). A prerequisite is a comprehensive, generally agreed-upon process model containing all the key processes needed for software engineering. ISO/IEC (2016) identifies some 40 individual processes. These processes are rather comprehensive containing many individual tasks. Each process is evaluated to what extent it is performed by the organization (N..not performed, P..partially performed, L..largely performed, F..fully performed). This yields a profile as shown in Figure 5. This profile can be compared to other enacted processes, to an industry average and also compared with the profile needed for the specific project.

Having the overview over many previous processes allows to assess for any type of organization (be it a software house or - in our case - a senior home) its over-all maturity. This is of high relevance for current activities and future planning. The maturity can be measured. Figure 6 is the basis for assessing an enterprize. In software engineering the levels (see Figure 6) run from ’incomplete’ (where the process is mostly unsuccessful) up to ’optimizing’ (where the process is continually adapted to new needs and challenges). In a nutshell the maturity of an enterprize to produce good software can be assessed and measured using a two dimensional graph (capability versus individual relevant processes), see Figure 5. The assessment can also be used for the improvement of the processes (SPIRE Project Team, 1998; van der Alst et al., 2016).

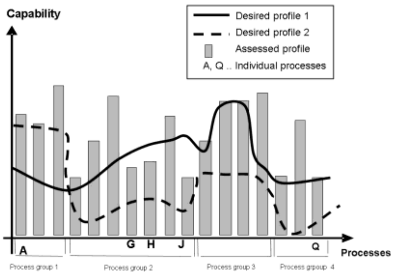

Fig. 5: Comparing different profiles

AHA: *One needs a comprehensive, agreed-upon process model and historical records of what has worked in the past. One can then identify deficiencies in the process model, compatibilities and differences of various processes (since not all Seniors need all processes), and identify the improvement potential.*

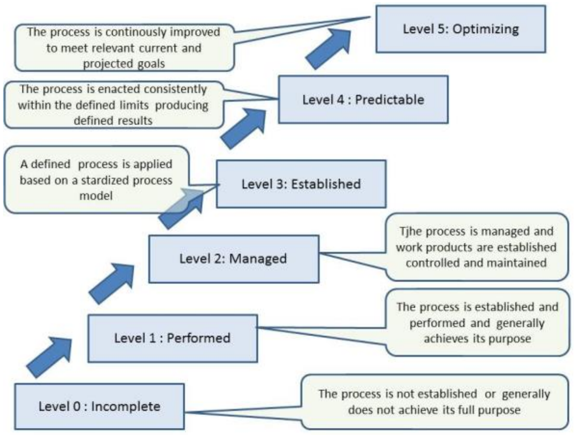

Fig. 6: Levels of Process Capability in ISO/IEC 33000 (ISO/IEC, 2015)/fl

5 A PROCESS INTERPRETER

Computer support is the key for efficiency and effectiveness of the AHA-processes. It has to show two different faces: One is directed to the Senior, the aging person. It has to be empathic, helpful and trying to explain/show the situation in a way a Senior can understand. The other one is technological and effective and provides a stable, effective infrastructure for the technical interface.

5.1 User Interface

The system helps the user to enact the processes he/she is supposed or intended to perform. It also allows the user enter processes of his/her own (things to do, things not to forget and be reminded, deadlines...). Considering the challenges listed in section 3.2 a Process Interpreter for AHA-purposes must fulfil several somewhat contradicting properties:

- strict :
  Certain activities must be performed exactly as prescribed, often even within a very narrow time window.

- robust :
  The system must be robust against disturbances of various kinds (be it erroneous inputs, changes in the well-being of the Senior, computer failures, cultural differences, sudden unexpected changes in the behavior or the situation, ...)

- agile :
  Handling of Seniors must be highly adaptible (especially due to the combination of inflexibility and volatility, which come with old age).

- tolerant/flexible :
  Some activities may be performed not at all or very loosely, depending on the specific situation, especially in view of the varying psychical and mental situation of a Senior.

  AHA: *A Senior who is able to walk alone, does not need certain processes irrespective of their performance level.*

- user-friendly :
  The interfaces must be easy to understand and show "good behavior with the sensitivity of an intuitive, courteous butler" (Miller, 2004). They should take into account the personal and cultural differences as defined in (Hofstede et al., 2010).

- unobtrusive and non-stigmatic :
  The Senior must feel confident, that his/her use of the assisting system is accepted by his/her peers and neighbors without negative feelings.

5.2 The Role of Tools, Machines and Robots

In many ways, robots can support or even perform human actions and perform similar tasks. Also some robots are able to augment the capabilities of humans (e.g. Vinci Robot for surgery). Thus it is possible to allocate processes to persons or machine (or an appropriate mix), whatever is the better choice. In this situation, we are referring to socio-technical systems. Process-related architecture has to reflect the usage of the system and the needed adaptation of systems by users. The integration of technology in a social context is providing the full system environment also in terms of usability and user acceptance.

For this to happen, it is necessary to have a clear, unambiguous and formal description of the processes to be performed (the process model), plus a description of the computers and tools of the environments. Robots can relieve helpers from chores, which do not really require human understanding and human empathy for the Seniors. A Process Interpreter (Figure 3) is an ideal tool and infrastructure to automatically include the access to tools into the AHA-processes.

6 CONCLUSION AND FUTURE WORK

Adopting a process view for supporting Active and Healthy Aging (AHA), like in other business and industrial areas, promises an improvement in clarity, understanding, and efficiency: The necessary processes are defined and documented in a process model, which is the basis for automatically guiding the execution of the individual processes by a so-called Process Interpreter. It helps all stakeholders, the Seniors, the human support personnel to follow the processes and to use technical support. This approach also allows a better control of the execution of these processes and enable assessment of the quality and capability of the defined processes. Implementing such a scenario requires a deep understanding of the behavior, the limitations and idiosyncrasies of Seniors.

Obviously, the work described here is only a beginning. More work has to be done to understand the requirements of Seniors with different social, cultural and economic background. This strongly affects the 'look and feel' of interfaces, especially with respect to ease of use and empathy. We hope that our contribution will trigger further research and useful result for Active and Healthy Aging of Seniors.

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