# AASE - Actor-Actor Systems Engineering Theory & Applications Micro-Edition (Vers.3)

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**Abstract**

This text is based on the the paper ”AAI - Actor-Actor Interaction. A Philosophy of Science View” from 3.Oct.2017 and version 11 of the paper ”AAI - Actor-Actor Interaction. An Example Template” and it transforms these views in the new paradigm ’Actor- Actor Systems Engineering’ understood as a theory as well as a paradigm for and infinite set of applications. In analogy to the slogan ’Object-Oriented Software Engineering (OO SWE)’ one can understand the new acronym AASE as a systems engineering approach where the actor-actor interactions are the base concepts for the whole engineering process. Furthermore it is a clear intention to view the topic AASE explicitly from the point of view of a theory (as understood in Philosophy of Science) as well as from the point of view of possible applications (as understood in systems engineering). Thus the classical term of Human-Machine Interaction (HMI) or even the older Human-Computer Interaction (HCI) is now embedded within the new AASE approach. The same holds for the fuzzy discipline of Artificial Intelligence (AI) or the subset of AI called Machine Learning (ML). Although the AASE-approach is completely in its beginning one can already see how powerful this new conceptual framework is. [1]

1. This text has a long ’conceptual history’ leading back to the Philosophy-of-Science studies of Doeben-Henisch 1983 - 1989 in Munich under the guidance of Peter Hinst, many intensive discussions between Doeben-Henisch and Erasmus about Systems engineering since 1999, a paper written by Doeben-Henisch and Wagner 2007 [1] with ongoing discussions since then, a lecture by Doeben-Henisch about formal specification and verification in 2010 [2], two papers by Erasmus and Doeben Henisch in 2011 [3], [4], about 20 regular semesters with the topic Human-Machine Interaction by Doeben-Henisch at the Frankfurt University of Applied Sciences (Frankfurt, Germany)(unpublished) in the timespan 2005 - 2015, two regular semesters with the topic HMI together with Tuncer in SS2016 and WS2016 at the Frankfurt University of Applied Sciences (Frankfurt, Germany) (unpublished), and two workshops with Erasmus in summer 2016 and Spring 2017 (unpublished). Additionally many discussions between Doeben-Henisch and Idrissi about AI and HMI since 2015.

## 1 History: From HCI to AAI

To speak of 'Actor-Actor Interaction (AAI)' instead of 'Human-Computer Interaction (HCI)' is rooted in the course of history. When the World War II ended several advances in technology and software gave raise to great expectations and visions what the future can bring mankind to improve life.[2]

Looking to the course of events between 1945 and about 2000 one can observe a steady development of the hardware and the software in many directions. This caused an explosion in many variants of new applications and usages of computer. This continuous challenge of how human persons can interact with this new technology provoked a rapid development what has been called in the beginning 'Human Computer Interaction (HCI)'. But with the extension of the applications in nearly all areas of daily live from workplace, factory, to education, health, arts and much more the interaction was no longer restricted to the 'traditional' computer but interaction happened with all kinds of devices which internally or in the background used computer hardware and software. Thus a 'normal' room, a 'normal' street, a 'normal' building, a toy, some furniture, cars, and much more turned into computerized devices with sensors and actuators. At the same time the collaborators of human persons were not only other human persons or certain animals but more and more 'intelligent' machines, robots, smart interfaces. Thus to speak of a 'human user' interacting with a 'technical interface' was no longer appropriate. A more appropriate language game is the new talk of 'interacting actors', which can be sets of different groups of actors interacting in some environment to fulfill a task. Actors are then biological systems (man as well as animals) and non-biological systems.

This new perspective is guiding the following considerations.

## 2 Different Views

If one wants to deal with the development of optimal interfaces within certain tasks for executing actors[3] one can distinguish different *views* onto this problem (see figure 1).

The common *work view* in systems engineering is an *expert (EXP)* as part of a *systems engineering process (SEP)* who takes a *problem description* $D_p$ and does some analysis work to find an *optimal solution candidate (OSC)*.

One *level above* we have the *manager (MNG)* of the systems engineering process, who is setting the *framework* for the process and has to *monitor* its working.

Another upper level is the *philosopher of science (POS)* who is looking onto the managers, processes, and their environments and who delivers *theoretical models* to

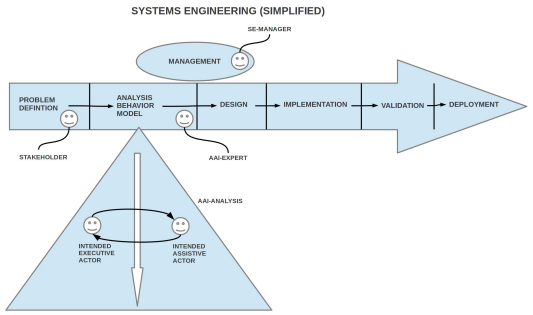


Fig. 1. Overview Systems Engineering Process - participating actors

*describe* these processes, to *simulate* and to *evaluate* these.

In this text the *Actor-Actor Interaction (AAI)* is the main focus, embedded in a *Systems Engineering Process (SEP)*, all embedded in a minimal *Philosophy of Science (PoS)* point of view.

For this the following minimal SEP-structure is assumed[4]:

$$\begin{aligned} SEP(x) \quad & iff \quad x = \langle P, S, Sep \rangle \\ Sep \quad & : \quad P \longrightarrow S \\ Sep \quad & = \quad \alpha \otimes \delta \otimes \mu \otimes \upsilon \otimes o \\ \alpha \quad & := \quad Analysis\ of\ the\ problem\ P \\ \delta \quad & := \quad Logical\ design \\ \sigma \quad & := \quad Implementation\ of\ S \\ \upsilon \quad & := \quad Validation \\ o \quad & := \quad Deployment \end{aligned} \tag{1}$$

The outcome of the analysis of an AAI-expert is an *optimal solution candidate (OSC)* for an interface of an assisting actor embedded in a complete *behavior model* $M_{SR}$ given as an *actor story (AS)* combined with possible *actor models (AMs)*. This output provides all informations needed for a following *logical design*. The logical design provides the blue-print for a possible *implementation* of a concrete working system whose behavior should be in agreement (checked through a *validation* phase) with the behavior model provided by the AAI-analysis.

## 3 Philosophy of the AAI-Expert

Before digging into the details of the following actor-actor interaction (AAI) analysis done by an AAI-expert one has to consider the conditions under which the AAI-expert is doing his job. These considerations are done in a separate paper

2. For some 'bits of history' see Doeben-Henisch (2018) [5]
3. Today still mostly human persons.
4. For the first paper of Erasmus together with Doeben-Henisch about this subject see [3]

called 'Philosophy of the AAI-Expert' (see Doeben-Henisch (2018) [6]).

The main topic in the philosophy paper is centered around the findings of modern biology and psychology that the ability of human persons to use a set theoretical language $L_\epsilon$ to talk about the experiences with the world is grounded in the cognitive machinery of human persons including complex processes related to perception, memory, spatial and temporal thinking, embedding of languages and others. Because the human brain in the body is not directly interacting with the outside world but mediated by sensors and actuators it is this complex cognitive machinery which constructs an inner model of the outside world. And it are exactly the properties of this 'inner model' which provide a 'point of reference' for all our thinking and talking.

One conclusion from these considerations is that reality is basically perceived as a stream of events, which can be divided in distinguishable situations, called states. A state is understood as a set of properties embedded in a three-dimensional space. If at least one property changes a state changes. Subsets of properties can be understood as objects, which in turn can be subdivided into 'actors' and 'non-actors'. Actors can 'sense' their environment and they can 'respond'. More distinctions are possible as needed.

To understand how an AAI-expert perceives his world, generates internal models, and how he is communicating with others, one has to clarify these philosophical groundings.

## 4 Problem (Document)

1) The *problem document* $D_P$ is the result of a communication between some *stakeholder (SH)* and some *experts*, which have discussed a *problem* $P$ which the stakeholder wants to be solved. In this context it suffices to describe shortly in the introduction of the problem document which persons have been participating in the communication with their communication addresses for further questions.

2) Due to the fuzziness of human communication one has to assume to a certain degree a *semantic gap* with regard to the participants of the communication which generated the problem document as well as for potential readers of the problem document.[5]

3) Additionally to the general problem a finite set of special *constraints (C)* can be given, which correspond to the traditional 'non-functional requirements'. To do this in the right way one has to describe the 'intended meaning' of these constraints in a way that it is possible either to decide, whether this intended meaning is fulfilled by the following actor story and actor models or that these constraints pointing to the follow up phases of the systems engineering process.

5. For an early discussion of one of the authors about the semantic-gap problem see Doeben-Henisch & Wagner (2007) [1].

## 5 Check for Analysis

Within the general analysis phase of systems engineering the AAI-perspective constitutes a special view. This implies a check of the *occurrence* of the following aspects:

1) At least one *task (T)* and
2) an *environment (ENV)* for the task and
3) an *executive actor (ExecA)* as the intended user.

## 6 AAI-Analysis

The goal of the AAI-analysis is to find an optimal *assistive actor (AssA)*[6] to support the *executive Actor (ExecA)*[7] in his task. For this to achieve one needs an iterative application of the whole AAI-analysis process whose results are evaluated for an *optimal solution*.

To analyze the problem $P$ one has to dig into the problem $P$ so far that one is able to *tell a complete story*, how to *understand* and later to *realize* the task.

It can be some work to *investigate* the details of such a story. The investigation is complete if the resulting story is *sound*, that means all participants agree that they *understand* the story and that they *accept* it.

To *communicate a story* we assume the following main modes: *textual*, *pictorial*, *mathematical*, as well as *simulated*.[8]

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### 6.1 Actor Story (AS)

To *communicate* a story in the main modes textual, pictorial, mathematical as well as simulated one has to consider the above mentioned epistemological situation of the AAI-expert.

The *point of view* underlying the description of an actor story AS is the so-called $3^{rd}$-person view. This means that all participating objects and actors are described from their *outside*. If an actor *acts* and changes some property through it's action it is not possible in a $3^{rd}$-person view to describe the inner states and inner processes, that enabled the actor to act and why he acts in this way. To overcome the limits of a $3^{rd}$-person view one has to construct additional models called *Actor Models (AMs)*. For more details have a look to the section 6.2.

The relationship between the traditional 'functional requirements (FR)' and the 'actor story' is such, that all necessary functional requirements have to be part of the

6. Traditionally understood as the technical interface.

7. Traditionally understood as the human user.

8. For an extended explanation of the formalisms used in this document see the web-page https://uffmm.org/2017/12/27/formal-appendix-for-the-aai-case-studies/

actor story. The 'non-functional requirements (NFR)' have to be defined in their intended meaning before the actor story and then it must be shown, how the structure of the actor story 'satisfies' these criteria. In this sense are the 'non-functional requirements' presented as 'constraints' which have the status of 'meta-predicates', which have to be designed in an appropriate 'control logic' for actor stories.[9]

#### 6.1.1 Textual Actor Story (TAS)

An actor story AS in the *textual mode* is a *text* composed by expressions of some *everyday language* $L_0$ – default here is English $L_{EN}$ –. This text describes as his *content* a sequence of distinguishable *states*. Each state $s$ – but not an *end-state* – is connected to at least one other follow-up state $s'$ caused by the *change* of at least one *property* $p$ which in the follow up state $s'$ either is *deleted* or has been *newly created*.

Every described state $s$ is a set of properties which can be sub-distinguished as *objects (OBJ)* which are occurring in some *environment (ENV)*. A special kind of objects are *actors (As)*. Actors are assumed to be able to *sense* properties of other actors as well as of the environment. Actors are also assumed to be able to *respond* to the environment without or with taking into account what *happened before*.

Actors are further sub-divided into *executive* actors as well as *assistive* actors. Assistive actors $A_{assist}$ are those who are expected to support the executive actors $A_{exec}$ in fulfilling some *task (t)* (with $t \in T$).

A *task* is assumed to be a sequence of states with a *start* state $s_{start}$ and a *goal* state $s_{goal}$, where the goal-state is an end state. The set of states connecting the start and the goal state is finite and constitutes a *path* $p \in P$. There can be more than one path leading from the start state to the goal state. The states between the start and the goal state are called *intermediate* states.

Every finished actor story has a least one path.[10]

9. This topic of 'Non-Functional Requirements (NFRs)' as well as 'Functional Requirements (FRs)' and their relationship is a hot topic in systems engineering and has not yet a complete solution. The general problem is how to 'represent' the NFRs in a way, that these can be handled in the overall system. The following selected papers (only a subset of thematic related papers) can illustrate the discussion: dealing mainly with NFRs see Khalique et.al. (2017) [7], Fellir et.al. (2015) [8], Mairiza et.al. (2013) [9], Suhr et.al. (2013) [10], Yin et.al. (2013) [11], Zhang et.al.(2013) [12], Menzel et.al. (2010) [13], Liu et.al. (2012) [14], Kassab et.al. (2009) [15]. Dealing mainly with FRs see Lian et.al. (2017) [16], Abrahão et.al (2013) [17]. The big advantage of the AASE paradigm in this context is that the mathematical version of the actor story provides a formal structure which allows to describe all functional requirements (FRs) in a formal way which allows the annotation of non-functional reuirements (NFRs) easily.

10. To turn a textual actor story into an *audio* actor story (AAS) one can feed the text into a *speech-synthesis* program which delivers spoken text as output.

#### 6.1.2 Pictorial Actor Story (PAT)

In case of an textual actor story (TAS) – as before explained – one has a set of expressions of some common language $L_0$. These expressions *encode a possible meaning* which is rooted in the *inner states (IS)* of the participating experts. Only the communicating experts *know* which meaning is encoded by the expressions.

This situation – labeled as semantic gap – can cause lots of misunderstandings and thereby *errors* and *faults*.

To minimize such kinds of misunderstandings it is a possible strategy to *map* these intended meanings in a *pictorial language* $L_{pict}$ which has sufficient resemblances with the intended meaning. Replacing the textual mode by a story written with a pictorial language $L_{pict}$ can *show* parts of the encoded meaning more directly.

As one can read in the section 3 'Philosophy of the View-Point' the world of objects for a *standard user* is mapped into a spatial structure filled with properties, objects, actors and changes. This structure gives a blue-print for the *structure of the possible meaning* in an observer looking to the world with a $3^{rd}$-person view. Therefore a pictorial language can *substitute* the intended meaning to some degree if the pictorial language provides real pictures which are structurally sufficient similar to the perceived visual structure of the observer.

To construct a *pictorial actor story (PAS)* one needs therefore a mapping of the 'content' of the textual actor story into an n-dimensional space embedded in a time line. Every time-depended space is filled with objects. The objects show relations within the space and to each other. Objects in space, the space itself, and the changes in time are based on distinguishable properties. To conserve a consistency between the textual and the pictorial mode one needs a *mapping* between these both languages: $\pi : L_0 \longleftrightarrow L_{pict}$.

#### 6.1.3 Mathematical Actor Story (MAS)

To translate a story with *spatial structures* and *timely changes* into a mathematical structure one can use a *mathematical graph* $\gamma$ extended with *properties* $\Pi$ and *changes* $\Xi$ for encoding.

A *situation* or *state* $q \in Q$ given as a spatial structure corresponds in a graph $\gamma$ to a *vertex* $v$, and a *change* $\xi \in \Xi$ corresponds to a pair of vertices $(v, v')$ which is directly connected by an *edge* $e \in E$.

If one maps every vertex $v \in V$ into a set of property-expressions $\pi \in 2^{L_\Pi}$ with $\lambda : V \longmapsto 2^{L_\Pi}$ and every edge $e \in E$ into a set of change-expressions $L_\Xi$ with $\epsilon : E \longmapsto 2^{L_\Xi}$ then a vertex in the graph $\gamma$ with the associated property-expressions can represent a state with all its properties and an edge $e$ followed by another vertex $v'$ labeled with a change-expression can represent a change from one state to its follow-up state.

A graph $\gamma$ extended with properties and changes is called an *extended graph* $\gamma^+$.

Thus we have the extended graph $\gamma^+$ given as:

$$\gamma^+(g) \quad iff \quad g = \langle V, E, L_\Pi, L_\chi, \lambda, \epsilon \rangle \tag{2}$$
$$E \quad \subseteq \quad V \times L_\chi \times V \tag{3}$$
$$\lambda \quad : \quad V \longrightarrow 2^{L_\Pi} \tag{4}$$
$$\epsilon \quad : \quad E \longrightarrow 2^{L_\Xi} \tag{5}$$

Every assumed *object* $o \in OBJ$ attached to a vertex represents a sub-set of the associated properties. An *actor* $a \in A$ is a special kind of object by $A \subseteq OBJ$.

Some more remarks to a *change-event*:

The occurrence of a change is represented by two vertices $v, v'$ connected by an edge $e$ as $e : \{v\} \longmapsto \{v'\}$. The follow-up vertex $v'$ has at least one property-expression less as the vertex $v$ or at least one property-expression more. This change will be represented in a formal *change-expression* $\epsilon \in L_\chi$ containing a list of properties to be *deleted* as $d : \{p_1, p_3, ...\}$ and properties to be newly *created* as $c : \{p_2, p_4, ...\}$.

The *deletion-operation* is shorthand for a mapping of subtracting property-expressions like $d : \{s\} \longmapsto s - \{p_1, p_3, ...\}$ and the *creation-operation* is shorthand for a mapping of adding property-expressions like $c : \{s\} \longmapsto s \cup \{p_2, p_4, ...\}$. Both operations are processed in a certain order: first deletion and then addition, $change = d \otimes c$.

To keep the consistency between a textual and a pictorial actor story one needs a mapping from the pictorial actor story into the mathematical actor story and vice versa, $m_{p.m} : L_{pict} \longleftrightarrow L_{math}$.

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#### 6.1.4 Simulated Actor Story (SAS)

A *simulated actor story (SAS)* corresponds to a given *extended graph* $\gamma^+$ by mapping the extended graph into an *extended automaton* $\alpha^+$.

The usual definition of a finite automaton is as follows: $\langle Q, I, F, \Sigma, \Delta \rangle$ with

1) Q as a finite set of *states*
2) I $\subseteq$ Q as the set of *initial states*
3) F $\subseteq$ Q as the set of *final states*
4) $\Sigma$ as a finite input *alphabet*
5) $\Delta \subseteq$ Q $\times \Sigma^* \times$ Q as the set of *transitions*

If one *replaces/ substitutes* the *states* by *vertices*, the *input expressions* by *change-expressions* and the *transitions* by *edges* then one gets: $\langle V, I, F, L_\chi, E \rangle$ with

1) V as a finite set of *states*
2) I $\subseteq$ V as the set of *initial states*
3) F $\subseteq$ V as the set of *final states*
4) $L_\chi$ as a finite set of *input expressions*
5) $E \subseteq V \times L_\chi \times V$ as the set of *transitions*

Finally one extends the structure of the automaton by the set of property-expressions $L_\Pi$ as follows: $\langle V, I, F, L_\chi, L_\Pi, E, \lambda \rangle$ with $\lambda : V \longrightarrow 2^{L_\Pi}$.

With this definition one has an extended automaton $\alpha^+$ as an automaton who being in state $v$ *recognizes* a change-expression $\epsilon \in L_\chi$ and generates as follow-up state $v'$ that state, which is constructed out of state $v$ by the encoded deletions and/ or creations of properties given as property-expressions from $L_\Pi$. All state-transitions of the automaton $\alpha^+$ from a start-state to a goal-state are called a *run* $\rho$ of the automaton. The set of all possible runs of the automaton is called the *execution graph* $\gamma_{exec}$ of the automaton $\alpha^+$ or $\gamma_{exec}(\alpha^+)$.

Thus the *simulation* of an actor story corresponds to a certain run $\rho$ of that automaton $\alpha^+$ which can be generated out of a mathematical actor story by simple replacement of the variables in the graph $\gamma^+$.

#### 6.1.5 Task Induced Actor Requirements (TAR)

Working out an actor story in the before mentioned different modes gives an outline of *when* and *what* participating actors *should do* in order to *realize* a *planned task*.

But there is a difference in saying *what* an actor *should do* and in stating *which kinds of properties* an actor *needs* to be able to show this required behavior. The set of required properties of an actor is called here the *required profile* of the actor A $RProf_A$. Because the required profile is depending from the required task, the required profile is not a fixed value.

In the general case there are at least two different kinds of actors: (i) the *executing* actor $A_{exec}$ and (ii) the *assistive* actor $A_{assis}$. In this text we limit the analysis to the case where executing actors are *humans* and assistive actors *machines*.

#### 6.1.6 Actor Induced Actor Requirements (UAR)

Because the required profile $RProf_{requ}$ of an executive actor realizing a task described in an actor story can be of a great variety one has always to examine whether the *available executing actor* $A_{exec}$ with its *available profile* $RProf_{avail}$ is either in a *sufficient agreement* with the required profile or not, $\sigma : RProf_{requ} \times RProf_{avail} \longmapsto [0, 1]$.

If there is a *significant dis-similarity* between the required and the available profile then one has to *improve* the available executive actor to approach the required profile in a finite amount of time $\chi : A_{avail,exec} \times RProf_{requ} \longmapsto A_{requ,exec}$. If such an improvement is not possible then the planned task cannot be realized with the available executing actors.

#### 6.1.7 Interface-Requirements and Interface-Design

If the available executing actors have an available profile which is in sufficient agreement with the required profile then one has to *analyze the interaction* between the executing and the assistive actor in more detail.

Logically the assistive actor shall assist the executing actor in realizing the required task as good as possible.

From this follows that the executing actor has to be able to *perceive* all necessary properties in a given situation, has to *process* these perceptions, and has to *react* appropriately.

If one calls the sum of all possible perceptions and reactions the *interface of the executing actor* $Intf_{A,exec}$ and similarly the sum of all possible perceptions and reactions of the assistive actor the *interface of the assistive actor* $Intf_{A,assis}$,then the interface of the assistive actor should be optimized with regard to the executing actor.

To be able to know more clearly how the interface of the assistive actor $Intf_{assis}$ should look like that the executive actor can optimally perceive and react to the assistive interface one has to have sufficient knowledge about how the executive actor *internally processes* its perceptions and computes its reactions. This knowledge is not provided by the actor story but calls for an additional model called *actor model*.

### 6.2 Actor Model (AM)

While one can describe in an actor story (AS) possible changes seen from a $3^{rd}$-person view one can not describe *why* such changes happen. To overcome these limits one has to construct additional models which describe the internal states of an actor which can explain why a certain behavior occurs.

To enable such a *transparent interaction* between actor and environment it will be assumed that an actor is generally an *input-output system (IOSYS)*, that means that an actor has *inputs (I)* allowing some kind of *perceptions* of his environment as well as *outputs (O)* allowing changes, modifications in the environment. The sum of all inputs and outputs defines the *interface* of an input-output system, written $Intf(x)\ iff\ x = \langle I, O\rangle$. Furthermore it is assumed that every actor has some *behavior function* $\phi$ which determines how the actor will respond with an output given some inputs. More formally this can be written as follows:

**Def: Input-Output System (IOSYS)**

$$\begin{aligned} IOSYS(x) \quad & iff \quad x = \langle I, O, IS, \phi\rangle \\ I \quad & := \quad Input \\ O \quad & := \quad Output \\ IS \quad & := \quad Internal\ states \\ \phi \quad & : \quad I \times IS \longmapsto IS \times O \end{aligned} \tag{6}$$

and with explicitly mentioning the *interface*:

**Def: Input-Output System (IOSYS)**

$$\begin{aligned} IOSYS(x) \quad & iff \quad x = \langle I, O, INTF, IS, \phi\rangle \\ I \quad & := \quad Input \\ O \quad & := \quad Output \\ INTF(x) \quad & iff \quad x = \langle I, O\rangle \\ IS \quad & := \quad Internal\ states \\ \phi \quad & : \quad I \times IS \longmapsto IS \times O \end{aligned} \tag{7}$$

Thus the behavior function $\phi$ generates an output O depending from the actual input I and some internal states IS, and – this is reflexive – the behavior can again change the internal states IS such, that these are in another shape for a next response. This means that the same input can be followed by different responses depending from the internal states. This includes properties which often are called *learning* and *intelligence*.

Because the *inner states (IS)* of every real system are *not* directly observable it follows that all assumptions about possible inner states as well as about the details of the behavior function $\phi$ represent nothing else as a *hypothesis* which is given in the format of a *formal model*. The formal space for such hypothetical models is *infinite*.

The only *constraints* for some kind of *plausibility/ soundness* of such formal hypothetical models is given by the actor story which is defining a framework within which the hypothetic model has to be embedded.[11]

#### 6.2.1 Design Principles; Interface Design

Given the actor model AM of an executive actor $A_{exec}$ one can derive some *actor-based principles* $Ax_{A,exec}$, how the interface $Intf_{assis,B}$ of an intended assistive actor B should look like to enable an optimal performance with the executive actor A. To make the actor-based principles $Ax_{A,exec}$ as empirically sound as possible one needs sufficient empirical research of real actors doing jobs like those required in the actor story.

From the dependency of the executive-actor-based principles for the design of an assistive-actor interface it follows that the principles can only be as good as the presupposed model.

11. The modern tool of *Neuroscience* can measure many real properties of real neurons, whose activity is assumed to underly the observable behavior. But the limits of these measurements combined with the still unknown complexity of the mapping between neural activity and observable behavior are not allowing today a completely defined empirical mapping. This weakness is even more amplified by the fact, that the factor of the *consciousness* filtering a small subset of practical helpful phenomena out from the complexity of the body is today also not yet sufficiently understood.

### 6.3 Simulation of Actor Models (AMs) within an Actor Story (AS)

Programming a real computer with actor models and an actor story allows the simulation of actor models embedded in an actor story.

### 6.4 Assistive Actor-Demonstrator

Given the design of the interface of an assistive actor one can realize a *demonstrator* based on such a design called $Demo(Intf_{assis,B})$. Every created demonstrator is a possible *candidate* for the optimal solution. To check it's 'value' one uses the demonstrator within an usability tests.

### 6.5 Approaching an Optimum Result

To approach a possible optimum for a finite set of demonstrators one applies a set of usability measurements – called 'usability test' – in an iterative process. A *usability test* $UT$ realizes a mapping of given *demonstrators* $D$ into a set of *usability values* $V$ as follows $\upsilon_{UT} : D \longmapsto D \times V$. A usability test includes a finite set of objective as well as subjective sub-tests. The values $V$ of one usability test are usually given as a finite set of points in an n-dimensional space $V^n$. Thus after a usability test $\upsilon_{UT}$ has been applied to a demonstrator one has an ordered pair $(D, V)$.

To find the *relative best* demonstrator in a finite set of candidate demonstrators $\{(D_1, V_1), (D_2, V_2), ..., (D_m, V_m)\}$ one has to define a *measure* $\mu : 2^{V^n} \longmapsto V^n$ for the assumed finite many n-dimensional values $\{V_1^n, V_2^n, ..., V_m^n\}$ to compare these values and identify for this set an optimal value. Thus $\mu(V_1^n, V_2^n, ..., V_m^n)$ computes a certain $V_i^n \in \{V_1^n, V_2^n, ..., V_m^n\}$.

Applying this measure to the set $\{(D_1, V_1), (D_2, V_2), ..., (D_m, V_m)\}$ gives the best demonstrator of this set.

## 7 What Comes Next: The Real System

After the completion of the AAI-analysis after n-many iterations[12] one has an actor story AS in four modes {TAS, PAS, MAS, SAS}. Furthermore one has possibly different actor models $\{AM_{exec}, AM_{assist}, ...\}$, and one has a demonstrator $Demo$ with the best interface $(D_i, V^n)$. Between the assistive and the executive actor model exists a logical dependency as well as between all actor models and the actor story: without the actor story the actor models are underspecified. That means the *whole specified behavior* $M_{SR}$ is only given as the complex structure $\langle AS, AM_{exec}, AM_{assis}, \iota_{as,am-exec}, \iota_{as,am-assis} \rangle$ where the mappings $\iota$ connect the actor story with the embedded models.

12. It is actually not clear how 'big' this $n$ should be. Some research is needed.

### 7.1 Logical Design, Implementation, Validation

To *convert* these results *into a real working system* $SYS_{assis}$ one has to process[13] a *logical design phase* $\delta$ which takes into account the whole specified behavior $M_{SR}$ as requirements for the behavior of the intended system. The outcome should be a *blue-print* $M_{SR,design}$ for the implementation of a real system, written as

$$\delta \quad : \quad M_{SR} \longmapsto M_{SR,design} \tag{8}$$

Based on such a blue-print the *implementation phase* $\sigma$ translates these ideas in a physical entity $M_{SR,real}$, written as

$$\sigma \quad : \quad M_{SR,design} \longmapsto M_{SR,real} \tag{9}$$

Because the transfer from the AAI-analysis phase into the logical design phase as well the transfer from the logical design phase into the implementation phase can principally not completely be defined one has to run a *validation phase* $\upsilon_v$ which compares the *behavior requirements* $M_{SR}$ from the AAI-analysis phase with the *behavior* of the *real system* $M_{SR,real}$. The outcome will be some percentage of agreement with the required behavior, written as

$$\upsilon_v \quad : \quad M_{SR} \times M_{SR,real} \longmapsto [0, 1] \tag{10}$$

### 7.2 Conceptual Gap In Systems Engineering?

The theoretically required validation of the behavior of the real system $SYS_{assis,real}$ with the required behavior specified as whole behavior model $M_{SR}$ can not work out directly, as long as the specified behavior is not available in some *implemented* format.

Diverging from the usual processing of systems engineering it will be assumed in this text that the whole specified behavior $M_{SR}$ will be translated into a blue-print within logical design (cf. Formula 8) and similarly will the blue-print version of the whole behavior $M_{SR,design}$ completely be converted in a real version $M_{SR,real}$ including not only the intended assistive actor but also the complementary executive actor as well as the necessary actor story (cf. Formula 9).

One way to realize this concept is to implement real simulators to mimic the required behavior . Especially it should be possible that real users can take over the role of the simulated executive actors within such simulations or the real world is another actor which takes over the role of the simulated world of the simulated actor story.

13. For all assumed phases in a systems engineering process see formula 1 in section 2 and more elaborated in the paper Erasmus & Doeben-Henisch 2011 [4]

## 8 THE AASE-PARADIGM

The text so far gives only a very limited account of the whole *Actor-Actor Systems Engineering (AASE)* paradigm. We hope to be able to develop it further with many illustrating applications (case studies).

Everybody is invited to share the discussion of this new paradigm with questions, critical remarks, hints, examples, whatever helps to clarify this paradigm.

There exists a minimal project plan to finalize these ideas in a first booklet (theory and case studies) until April 2018 with a publication in May 2018. Then everything can happen.

## APPENDIX A
## FORMALISMS

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