Explicit representation of function allocation and authority sharing (initiative and responsibility)

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Abstract
Automation can have a huge impact on the overall performance of the couple operator/system. Function allocation and authority sharing are key elements of the design of automation; there is thus a critical need for methods and tools to support the design and assessment of these elements while developing autonomous systems. In this position paper, we discuss the benefits of embedding those concepts as first class citizens in a notation and its associated method building on earlier work on operators' tasks descriptions and system behavior modeling.

Author Keywords
Automation Design and Assessment; Tasks description and modelling; Usability and Reliability of partly autonomous systems.

ACM Classification Keywords
D.2.2 [Software] Design Tools and Techniques, H.5.m. Information interfaces and presentation (e.g., HCI).

Introduction
Currently, automation is one of the main means for supporting operators using systems with increasing complexity. Automation makes it possible for designers to transfer the burden from operators to a system.

Table 1. Levels Of Automation (**LOA**) from [13]

HIGH	10. The computer decides everything, acts autonomously, ignoring the human
	9. informs the human only if it, the computer, decides to
	8. informs the human only if asked, or
	7. executes automatically, then necessarily informs the human, and
	6. allows the human a restricted time to veto before automatic execution, or
	5. executes that suggestion if the human approves, or
	4. suggests one alternative
	3. narrows the selection down to a few, or
	2. The computer offers a complete set of decision/action alternatives, or
LOW	1. The computer offers no assistance: human must take all decisions and actions

Parasuraman et al. have defined a classification [13] of different levels of automation (LOA). These LOA (see **Table 1**) have been extensively used for assessing the automation level of command and control systems such as Air Traffic Management applications, aircraft cockpits or satellite ground segments (also called human in-the-loop systems). Current push in automation is towards fully autonomous systems (such as google cars or a wrist watches) raising critical issues such as: how to ensure dependability of fully autonomous systems, how to make it possible to users to foresee future states of the automation, how to engage/disengage automation (hand over) or how to address legal issues raised by safety-related concerns (both for users and the environment), just to cite a few. Two main aspects of automation at design time lay in describing which functions/tasks are allocated to the system and the human and who is in charge of triggering the execution of functions (authority sharing).

Because increasing/decreasing automation can have a huge impact on human performance, workload, team size and human error, there is a need for methods and tools making it possible to assess the impact of automation design in early stages of the development process. In this position paper, we highlight the benefits of having a notation making it possible to describe in a complete and unambiguous way both function allocation and authority sharing. We argue that a dedicated notation provides support during various stages of the design and development of an autonomous or partly autonomous interactive system.

Methods and techniques for the design and assessment of function allocation and authority sharing

Increasing automation corresponds to migrating functions previously performed to the operator to the system, while allowing the system to trigger a function on its own increases system' authority. Designing partly-autonomous systems requires identifying the best distribution of both functions and authority with respect to the work context. Existing approaches dealing with automation design usually focus on identifying functions that should be allocated to either the operator or the system as presented in [3] and [5].

Beyond that, this distribution of function and of authority can be static (identified at design time and not modifiable at operation time) or dynamic (altered at design time). Dynamicity can be also defined at design time where various distribution of functions and authority can be considered according to, for instance, context of use. In such a case, the allocation of function could be different at night and at daytime. If this change is triggered automatically, the automation is called adaptive [14] while if the operator triggers it, it is called adaptable. between an operator and the system could change The allocation is static once deployed, which means that it can be changed several times during the design and development of the system but not at runtime. The same holds for authority that can be static or dynamic [10], adaptable or adaptive.

Table 2. Number of user tasks and system functions per types for each LOA depicted in **Figure 1.**

Type of user task or system function	LOA 1	LOA 7
User Perception	2	1
User analysis	2	1
User decision	1	0
User action	1	0
System info. Acquisition	0	1
System info. Analysis	0	1
System decision selection	0	1
System action impl.	1	1

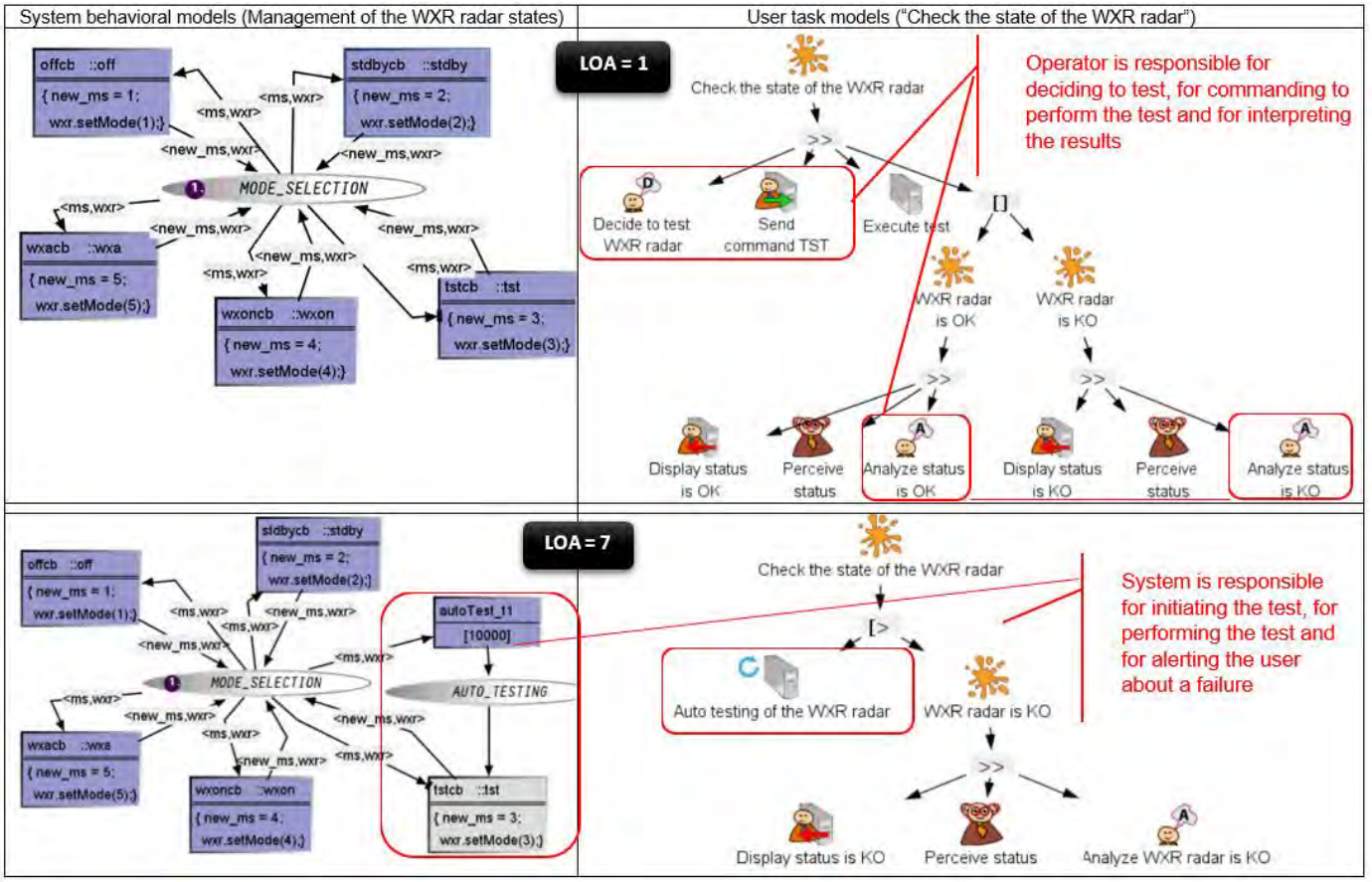

Figure 1: Two versions of the models of the system behavior and of the user tasks for function "Check the state of the WXR radar" (two different automation levels according to the classification of Parasuraman [13])

The benefits of describing function allocation

Automation design activity requires at first a complete understanding of operators tasks and of functions that can be executed by the system. The benefits of using a notation are:

- to identify and describe all of the possible operator tasks and all of the possible system functions [8] [9]
- to identify which tasks are good candidate for automation and which ones should remain operator driven [2], [8] and [9].

- to assess the impact of allocation options on number and types of user tasks [8] [9] and to identify potential automation surprises [1].

Figure 1 depicts an example of user tasks models and system behavioral models for two given levels of automation for the function. **Table 2** presents the data that can be collected from the models.

Assessment of authority sharing

The design and assessment of authority sharing requires to identify the roles, the associated responsibilities [6] [10] and initiative. Responsibility defines who is liable for the outcome of the task. Initiative defines who triggers the execution of the task. It is then also required to identify and describe the possible handovers of authority (rules for transfer of authority: triggering, stopping and transferring). The identification and description of the authority sharing between user and automation provides support for analyzing, at design time and at runtime:

- static and dynamic explicit representation of who triggers a task/function and of who is responsible for the consequences of the triggering of this command,
- impact of the type of automation (static versus dynamic) on the performance of the operator,
- workload of the operator and of the system for each option of allocation,
- temporal issues regarding the transfer of authority.

During this workshop, we would like to discuss how techniques and tools for precise and unambiguous description of allocation and authority sharing can complement approaches for the design and evaluation of interaction with autonomous systems. Furthermore, we will be interesting in discussing the specificities of other application domains and the need (or not) for transversal or tuned notations.

Monitoring and managing automation

A video player can be considered as an autonomous system in which the entire activity (displaying images at a given rate) is performed by the system. Authority is in the hands of the user who is the only one able to start a video. The control panel below the video (see **Figure 2**) allows the user monitoring and managing automation. Thanks to that control panel, authority remains all the time in the hands of the user who can pause the video, move the cursor on the bar to see future images of the video, identifying time left until the end of the video ….

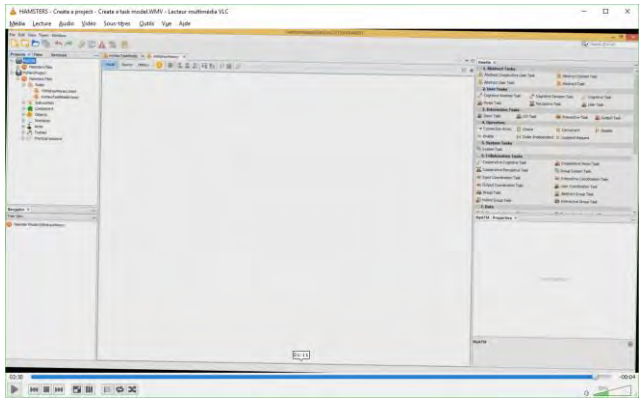

Figure 2. A video player as an autonomous system

Such monitoring allows keeping the operator/user in the loop even though the system is fully autonomous. Designing and assessing the interaction with automation then requires to handle the usability of such monitoring. This is also a challenge that has to be addressed at design time thanks to the identification of additional tasks related to the monitoring and management of automation. Furthermore, the monitoring and management of automation is a responsibility that may be assigned to the operator, to the system or transferred between both at runtime.

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