Lints, T. (2008). What is adaptation? In *Info- ja kommunikatsioonitehnoloogia doktorikooli IKTDK kolmanda aastakonverentsi artiklite kogumik, Voore, Estonia, 2008*, pages 133–135.

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What is Adaptation?

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***Abstract*—This short paper reports on the progress of my PhD studies, and very concisely reviews some possible ways of defining adaptation.**

I. Overview of My Research

A. Goal of the Project

The goal of my current research is to find out the properties and processes that make systems adaptive. My main motivation for this is my interest in Artificial Life and Artificial Intelligence, where making the systems adaptive is of utmost importance (it is difficult to imagine a lifeform whose internal processes and behavior would not depend in any way on the situation the organism is in). The topic, however, is of great interest to a large number of other fields of research as well, including engineering (e.g., creating systems that are able to reconfigure and repair themselves without costly human intervention), psychology, business research, military studies, biology, etc.

B. Project Status

Currently I am organizing and reviewing the information that I have collected so far. In a month or so the project is expected reach the phase of applying the gathered knowledge and of producing novel results.

II. Defining Adaptation

While finding out the properties and processes that make systems adaptive is definitely the main focus of my current research, it is first necessary to understand what the concept *adaptation* means.

The word *adaptation* and its various forms are abundantly used in many disciplines and also in everyday language. The exact meaning varies considerably in different contexts and there is no single definition of adaptation that would cover all those meanings. Even if it would be possible to construct such an overarching definition, it would likely be too general to have much practical use anyway. Thus, rather than trying to find an "ideal" definition, my approach has been to gather all kinds definitions and consider them to be either revealing different aspects of the more general concept or detailing the (possibly conflicting) differences between the contexts they are used in.

Although compiling a fully comprehensive list of all definitions and meanings of adaptation is nearly impossible, I have nevertheless put together a fairly extensive review. It is currently still a draft-in-progress and thus available by request only (feel free to contact me to get the draft). The following is an extremely superficial sampling of the review, but it should still give some sense of what the concept *adaptation* is about.

A. Dictionaries

Although dictionaries do not provide particularly deep definitions, they are still useful for a more general explanation. Dictionary.com Unabridged defines *to adapt* as [1]:

1) *(used with object)* to make suitable to requirements or conditions; adjust or modify fittingly: *They adapted themselves to the change quickly. He adapted the novel for movies.*
2) *(used without object)* to adjust oneself to different conditions, environment, etc.: *to adapt easily to all circumstances.*

and *adaptation* as [2]:

1) the act of adapting.
2) the state of being adapted; adjustment.
3) something produced by adapting: *an adaptation of a play for television.*
4) *Biology.*
   - any alteration in the structure or function of an organism or any of its parts that results from natural selection and by which the organism becomes better fitted to survive and multiply in its environment.
   - a form or structure modified to fit a changed environment.
   - the ability of a species to survive in a particular ecological niche, esp. because of alterations of form or behavior brought about through natural selection.
5) *Physiology.* the decrease in response of sensory receptor organs, as those of vision, touch, temperature, olfaction, audition, and pain, to changed, constantly applied, environmental conditions.
6) *Ophthalmology.* the regulating by the pupil of the quantity of light entering the eye.
7) Also, adaption.

B. Biology

Living organisms are probably the most notable examples of adaptive systems, so it is no wonder that biology uses the concept *adaptation* extensively. But even in biology no single universally accepted definition has developed. Not only do

the details of definitions differ, the same word *adaptation* is used by different authors, confusingly enough, either for the *process* through which adaptedness is acquired or the *result* of that process. In evolution theory, the process in question is evolution. In physiology, it is often some homeostatic process instead. A few examples of biological definitions are given in the previous section of this paper.

C. Human Research

As humans display a particularly wide range of adaptive behaviors, most of the research fields that study humans inevitably also deal with adaptivity to some degree. A psychologist O. J. Harvey, for example, provides the following definition [3]:

> In the ultimate sense, adaptability means the capacity to behave in ways maximally consonant with the attainment of ends or goals. Adaptable behavior thus becomes synonymous with appropriate behavior, "appropriate" defined as the degree to which a particular act facilitates or runs counter to the attainment of a sought end. Obviously behavior which is consonant with one end may be, and frequently is, incompatible with other, simultaneously extant, goals. Hence while responding adaptively in regard to certain ends, one may at the same time be behaving inappropriately or maladaptively in relation to other goals.

In addition to individual adaptability, the flexibility of teams is understandably an active area of research, as it can directly benefit all kinds of existing organizations, be they business or academic or military. The definition of team adaptation by Stagl et al. [4] is a representative example of this research direction:

> Team adaptation is defined herein as a change in team performance, in response to a salient cue or cue stream, which leads to a functional outcome for the entire team. Team adaptation is witnessed in the functional innovation of new, or modification of existing, structures, capacities, or cognitive and behavioral goal directed actions.

D. Computer Systems

Both single computers and networks composed of them usually benefit from having a certain degree of adaptivity. Examples of definitions include Rohr et al.'s [5]:

> A software entity has the capability of self-adaptation if it can automatically change its structure or behavior, based on observations of its system or environment, with the goal to maintain or improve the Quality of Service.

and Laddaga et al.'s (as cited in [5]):

> Self adaptive software is software that monitors its own operation, detects faults and opportunities, and repairs or improves itself in response to faults and changes. It effects the improvement by modifying or re-synthesizing its programs and subsystems, using a feedback control-system like behavior.

E. Quantifiable Definitions

It would often be remarkably helpful if the adaptation or adaptivity of systems under study would be measurable in some suitable way. Finding appropriate metrics for various types of systems is an open area of research and a lot of work remains to be done. But luckily, a few approaches already do exist.

For example, in evolution theory, adaptive value of a genotype is typically defined as the average reproductional success of all individuals with given genotype relative to other genotypes of the population [6].

Although probably not very widespread, a possibly measurable definition for psychology is proposed by O. J. Harvey [3]:

> ... it makes some sense, from the stance of an outside judge, to define the total adaptability of a system as the largest number of goals or values it can move toward simultaneously without conflict between the goals or their means of achievement.

Other interesting measures are related to, e.g., entropies of the system and its environment [7], the speed of movements on a fitness landscape [8], and the size of the basin of the attractor the system currently occupies in its state space [9].

III. Your Help Welcome!

If you have any comments or ideas about my work and about the topic in general, or any suggestions about what I should read or whom I might find interesting to contact, then please let me know! There's no need to worry about the suggestions being too obvious or too obscure, too general or too specific. I would highly appreciate getting all of them! If you know anybody who might be interested in my research topic, then please encourage them to contact me and direct them to my homepage taivo.net!

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References

[1] "Adapt," Dictionary.com Unabridged (v 1.1). Retrieved February 02, 2008, from Dictionary.com website: http://dictionary.reference.com/browse/adapt.

[2] "Adaptation," Dictionary.com Unabridged (v 1.1). Retrieved December 28, 2007, from Dictionary.com website: http://dictionary.reference.com/browse/adaptation.

[3] O. J. Harvey, "Ends, means, and adaptability," in *Experience, Structure & Adaptability*, O. J. Harvey, Ed. Springer, 1966, pp. 3–12.

[4] K. C. Stagl, C. S. Burke, E. Salas, and L. Pierce, "Team adaptation: realizing team synergy," in *Understanding Adaptability, A Prerequisite for Effective Performance within Complex Environments*, E. S. C. Shawn Burke, Linda G. Pierce, Ed. Elsevier, 2006, pp. 117–141.

[5] M. Rohr, S. Giesecke, W. Hasselbring, M. Hiel, W.-J. van den Heuvel, and H. Weigand, "A classification scheme for self-adaptation research," in *Proceedings of the International Conference on Self-Organization and Autonomous Systems In Computing and Communications (SOAS'2006)*, 2006.

[6] M. Viikmaa, "Kohasus ehk genotüübi adaptiivväärtus," in *Adaptatsiooni teooria. Schola Biotheoretica XXVI*, I. Puura, Ed. OÜ Sulemees, 2000, pp. 22–29, in Estonian.

[7] M. Conrad, *Adaptability. The Significance of Variability from Molecule to Ecosystem.* Plenum Press, 1983.

[8] A.-M. Grisogono, "Success and failure in adaptation," in *Proceedings of the Sixth International Conference on Complex Systems*, A. Minai, D. Braha, and Y. Bar-Yam, Eds. New England Complex Systems Institute, 2006.

[9] A. Klyubin, "An organization-centric approach to viewing adaptation in complex adaptive systems," Master's thesis, Tallinn Technical University, 2002.