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TWO SPECIAL CASES OF THE HOLONIC MANUFACTURING SYSTEM

K. BÁNYAI, Z. MÁNDY, I. DUDÁS

Department of Production Engineering, University of Miskolc, HUNGARY
e-mail: karoly.banyai@uni-miskolc.hu, mandy.zoltan@freemail.hu, illes.dudas@uni-miskolc.hu

The concept of holonics manufacturing systems (with divided intelligence) is the most intelligent, autonomous, elastic, units collaborating with each other. The idea takes as a starting point the fact that the today's environmental circumstances are exceptionally unsettled; there is need for companies with the ability to respond quickly to maintain competitiveness. Holonic manufacturing systems (HMS) have been recognized as a paradigm to accommodate changes and meet customers' requirements flexibly based on the notion of the holon, flexible and decentralized manufacturing architecture. Koestler proposed the word "holon" to describe a basic unit of organization in biological and social systems. A holon is an autonomous, co-operative and intelligent entity able to collaborate with other holons to process tasks. Autonomy and cooperation are two important characteristics of holons. In this study, we investigated a Holonic Manufacturing Systems for dry-working machine group.

Keywords: holon, autonomy, holarchy, CIM, HMS

Introduction

Firstly, we have to define what the word "holon" means. It is from Greek, means whole and part. Another name for a holonic manufacturing system is "divided intelligence". The word "holonics" was introduced by the Japanese (the name is from A. Koestler), who began worldwide development in this field. They started to co-operate in 1992 to form intelligent and flexible manufacturing systems become and the Holonic Manufacturing Systems (HMS) [1, 5].

Autonomy allows holons to decide the actions needed to be taken to accomplish the objectives without consulting any supervisory entity. Cooperation makes it possible for holons to agree on common plans and mutually execute them. The distributed architecture of multi-agent systems (MAS) and the agents' characteristics of autonomy and cooperation make MAS a potential model for the analysis and implementation of HMS. However, the aggregation relation of holons allows a holon to be part of another holon in the holonic architecture, which makes holonic systems different from MAS and reflects the difficulties of modeling and analysing HMS with existing MAS theory. To lay a theoretical foundation for the design and analysis of HMS, an available approach is to combine MAS architecture with suitable models. Van Brussel proposed the reference architecture PROSA for HMS and paved the way for further study and design of HMS. In existing literature, surveys of multi-agent manufacturing systems can be found in Shen and Norrie (1999), Monostori et al. (2006)) Contract net protocol (CNP), is a well known protocol for distributing tasks in multi-agent systems [6].

The holonic conception of manufacturing is that of intelligent, autonomous, elastic system capable of cooperating with other units. The concept arises from environmental circumstances, which are extraordinarily changeable, so that we need much more flexible, quicker facilities to maintain competitiveness. To better understand the whole concept here are given briefly a few definitions [1]:

HOLON: Autonomous and co-operatable unit in the manufacturing system, that transforms, carries, storing physical objects. A holon can be a part of other holons.

HOLARCHY: The system of the holons is able to co-operate, which works in the interest of the achievement of a given aim. The holarchy defines the co-operation from the fundamental rules.

HOLONIC MANUFACTURING SYSTEM: Holarchy that coordinates all of the phases of the production processes, because of the order and the planning of actual production through assembly to marketing.

HOLONICS CHARACTERISTICS: The band of those characteristics that makes a holon a unit. The minimal requirement is autonomy and the cooperation in one ability [1].

The structures and principles

The holonic manufacturing system (HMS) is built up from three elemental holons: an order holon, product holon and a source holon. The first holon is responsible for production, the second for the technological planning and the third one for material transport.

The elemental holons

There are two aspects of the independent principle of the HMS:

- the source aspect is trying to control the machine, with optimal velocity and max. capacity,
- the requirements of the customers, logistics and marketing.

Every HMS contains the source, product and order holons.

The source holon implies the physical part in the manufacturing system and the information from the parts of the process. This product offers the capacity and the functionality for the holons. The source holon is an abstract form for the product. The HMS is not separate from the manufacturing system.

The product holon manages the process and provide the capability to reach the suitable quality. Actually the producer holon is an informational server between the other holons in HMS. The product holon includes the functionality which covers the planning, operation planning and quality assurance [3].

The order holon represents the task in the production. It is responsible for ordering the work to happen in time. The order holon organizes the physical processes with all of the logistics paths. It may represent the customers' claims and the sources of correction. As *Fig. 1* shows there are three types of the holons with information in the manufacturing system.

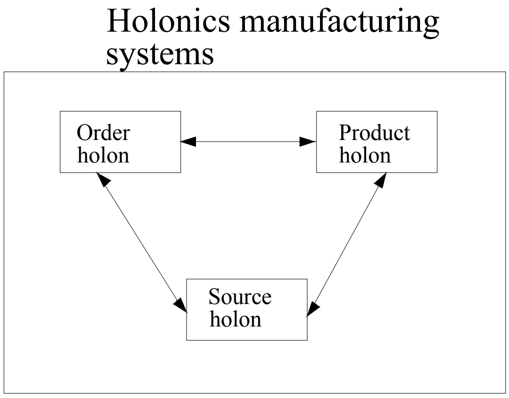

Figure 1: The elemental holons

The central holon can be the bottleneck if it gives up a task. The autonomy can be injured because the hierarchy among the holons becomes stronger with co-operation. The HMS is more developed than the computer-integrated manufacturing (CIM) structure.

- Contact-Autonomy: For a given unit it has characteristics for which it uses plans created by itself.
- Co-operation: Important between the holons.

The concept is sketched in *Fig. 2*. The example serves the aim to answer the question of how much central holons should be burdened.

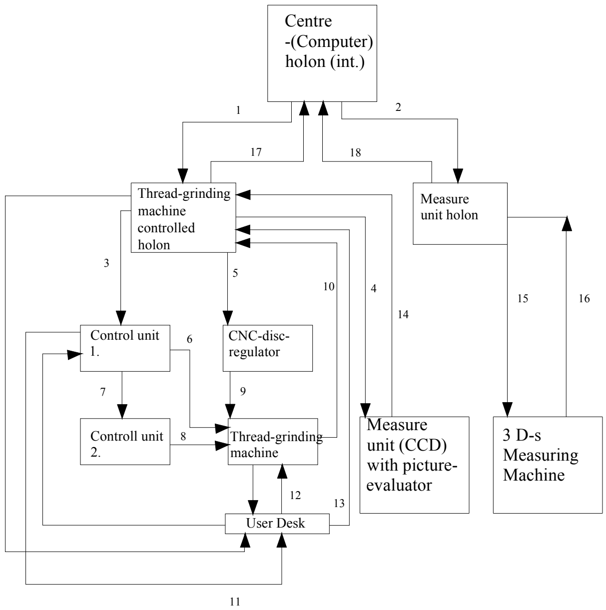

Figure 2: A holonic manufacturing system [5]

Case 1

Here we present how a screw surface can be ground with HMS. The HMS is built up from the following elements: (1) NCT90 RAMDISC, a hard drive to contain the input programs, (2) CNC machine with Hunor language, which has been connected to the RAMDISC, (3) a disc-regulator, (4) a thread-grinding machine, (5) a picture evaluator unit with CCD camera, (6) a 3D measuring machine (DEA type), and finally (7) a modern PC. The PC acts as the central holon, meaning that it controls everything. The connection between the PC and the grinding machine is developed by NCT Technic Ltd. These are the HMS. The other parts are the subordinated holons. It is very important to use the suitable cooling fluids, which can actually be considered another subordinate holon, but can be used just manually. When we turn on the machine, it is visible in the display that the grinding disc can move foreward or backwards.

The setup of the divided intelligence

The system gives all of the information that the subordinate holons can endure because of subordinate autonomy. The insurance of co-operation of the subordinate holons is important because we have to help the subordinate holons communicate with the central holon. If the environmental effects change, the system will respond cooperatively. The main parts of the connection of the holons are important to hold the relationship of the static and the dynamic information. This depends on whether the information flow serves the survival of the structure, and whether it follows the environmental effects for the holonic system for the viewpoint of survival. Static information can be the transmission of the geometrical parameters. An example of dynamic information can be the handling of transport.

Case 2

In order not to overcomplicate the structure we wish to present our ideas for a small factory as an example. The first consideration is input substance and energy.

The small factory has one dry-working machine group furthermore men who are hand-assembling in a small group (in the holon the men represent the intelligence). The measure unit holon contains a PC with data evaluating CCD camera and a gauge machine with a DEA type 3D measuring machine. A portable ROMER machine can be an arm type gauge machine. The software being used for monitoring may be a holon, for example the software of STATISTICA with evaluating function.

The third (subordinate) holon is the measure unit holon and its structure. It consists of four parts: a PC with data-evaluating single CCD camera for the abrasion examinations, CNC disc regulator, and a portable gauge machine. Defective products are avoidable using the measure holon which diagnoses and notices mistakes with feedback. Although the measure holon is shown as one piece it actually exists at several workplaces physically.

The fourth (likewise subordinate) holon is the holon for carrying a load. It is responsible for the transport of the semi-finished products.

It is possible to logically handle the distribution of the tasks from the central one and among the subordinate holon(s). There may be some other kind of solutions in this actual production case, naturally, as the process follows changes. The change is an important question in understanding the concept and the priorities in the process.

Information from outside and from the totality of the informational/material contacts among the holons defines the number of the elements and the structure of the manufacturing system. The aim is the hierarchy and the formation of the cooperation of the autonomy.

When there is a change in the input resources, the holons need more autonomy. If the environment changes in other parts, the inner environment reacts by self-learning and with self-organization. This is shown in *Fig. 4*. The strategic features of the holons are important. There is a continuation in the development chain: automation systems → intelligent systems → multi-agent systems. It is necessary to be able to translate the incoming information concerned in order to make changes in the conditions for the system in order to define the autonomy.

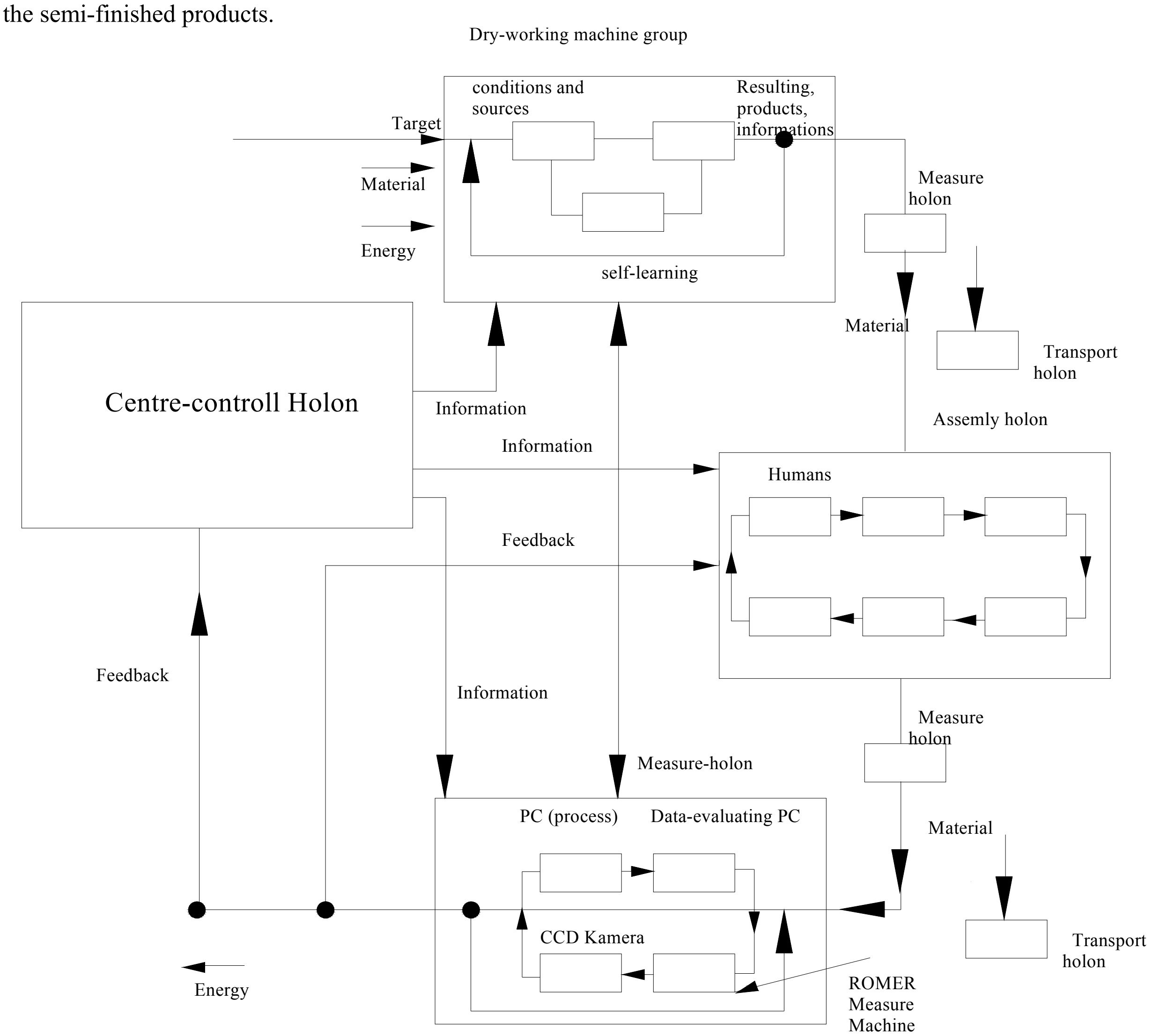

Figure 3: A dry-machining group

About the inner environment

As an example of a self-regulation measurable physical quantity, we may call it variable, mentioning for example the direction of the velocity, acceleration, and so on. The mechanism of the self-regulation is feedback:

- communication – the system is able to communicate with other systems;
- learning – the holonics system is able to develop its knowledge;
- self-development – the system can develop itself;
- anticipation – the system is able to forecast the changes in the near environment;
- creativity – the system is able to generate new concepts, plans, methods;
- reproduction: The system is able to plan itself again.

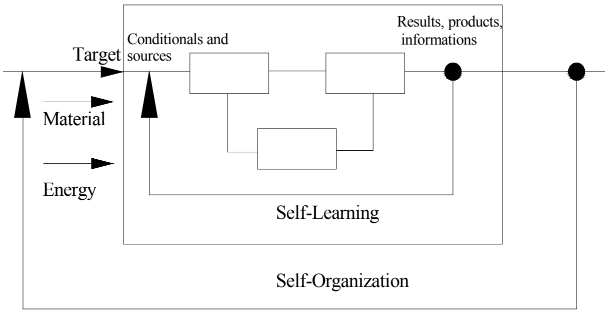

Figure 4: The self-organization

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