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Automotive Vehicle Data Management Based on Holon-Product Paradigm

F. Chaxel, E. Bajic, J. Richard
CRAN-GGP, CNRS UPRESA 7039

Nancy I University, BP 239, 54506 Vandoeuvre lès Nancy, France
Frederic.Chaxel or Eddy.Bajic or Jacques.Richard @cran.u-nancy.fr

ABSTRACT

This paper describes research currently being carried out in the area of Holonic Manufacturing Systems especially for Automotive vehicles data management. The originality of the presented work deals with the idea that process control may be achieved by machines, but also by the product carrying and managing its own information. Distribution of the information system onto each individual product requires tools and methods to manage and provide access to product related information for both automated systems and human operators. Automatic identification technology using electronic data carriers can provide such functionality and act as product information vectors. Our approach is based on STEP technology to define computer-aided tools for data structuring and management of product knowledge implemented on mobile database nodes circulating in an open environment (from manufacturing to recycling).

1. INTRODUCTION

Added value architectures (manufacturing, after sales services, ...) are now often proposed more and more distributed [1]. This distribution is done by splitting both decision algorithms and information into several small sub-systems cooperating with each other. Each highly decentralized, modular, autonomous and cooperative sub-system supports a part of the global system. This paradigm is developed by the scientific community [2] under the words heterarchical [3], multi-agents, bionic[4] and more recently holonic [5].

Comparing to hierarchical architectures, expected advantages are [3] :

- robustness due to the high degree of distribution
- simplicity of each agents or holons because they just have to manage small systems
- possible application of the "plug and play" concept with the agents in the system

The three types of basic building blocks in an holonic manufacturing system (HMS) are: resource holons, order holons also call task holons and product holons [5].

A resource holon consists of a physical part, namely a

production resource in the HMS. It is an abstraction for the production means such as machines, conveyors, human operators, ...

An order holon is an entity responsible for performing the work in a satisfactory way. It captures all information related to a job [5].

Finally product holon is an entity created by real or forecasted market demand. It holds all the necessary knowledge to assure the realisation and the maintenance of a product. This holon is an information and communication entity (Fig 1).

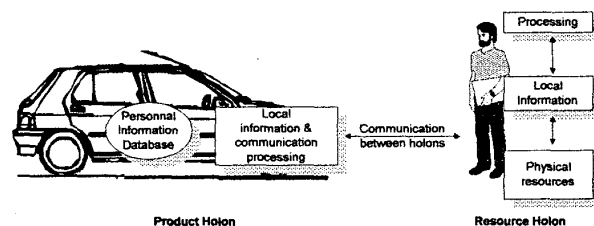


Fig 1. Resource and Product Holons structure.

Our research work is particularly focused on this last holon: the product holon considered has an entity without any physical capability (information, communication and local processing capabilities only). Our contribution, showed in this paper, presents a framework which allows an implementation of the product holon in an open environment. Application case is focus on an automotive vehicle circulating in the manufacturing and then in the after sales environment.

2. CONCEPT

Product knowledge is basically defined at the design level in words of functionality, shape, quality, manufacturing operations sequency, ... This knowledge is constructed step by step and structured through a life cycle product information model as shown in Fig 2 [6].

This product knowledge has to be shared by all the computer tools used for the product design. In this field some work has be done in order to define both standardised product model, like STEP for instance, and integrated information infrastructure like AIT Integration Platform or Esprit

NEUTRABAS platform.

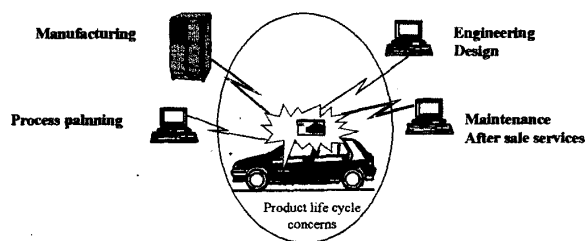


Fig 2. Some product life-cycle concerns.

At the manufacturing stage, this knowledge is conceptually duplicated to fit to each individual product or holon. One can say that product definition data set is cloned, and then follow it's own life.

One of the major problem lies in the management of this information set associated to each holon. For instance Duffie [3] proposed some computers, connected with each others, in order to play the role of products data manager. Some other authors [7] [8] are proposing the use of electronic tags, but without any regards about integration problems.

Unfortunately, electronic tags are by now not easy to integrate in an enterprise information system. It is for instance impossible to read or write structured information on these systems because they use elementary data handling protocol instead of high level and semantic information manipulation dialogue. In this field, the MONOLIN project (MOBILE Node Logistics and Industrial Network, ESPRIT 6936) develops the basic requirements for a standard identification systems network interconnection interface allowing integration : the Escort Memory System-Application Program Interface so called EMS-API [9].

The proposed concept is a logistic support to product holon data management and integration in order to solve both the vertical integration problem (link with the design level) and the horizontal integration problem by supplying a method and a tool where each electronic tag has to play the role of a vector of the information system which is in charge of the overall application management, and information coherency, consistency and reachability.

3. PRODUCT HOLON INFORMATION MODELLING

One of the most significant approach today in product modelling is the development of ISO 10303 standards called STEP [10] (STandard for Exchange of Product model data) which define models, database access and neutral data files format for representation and exchange of product data [11]. The goal is to define complete models for product life-cycle in a CIM context, as well as the means for exchange of data between enterprise functions along a product life-cycle definition (from CAD to production, maintenance, ...).

In this project, a now well known data object-oriented modelling language has been defined. EXPRESS is a formal language that models the knowledge about information used by an information system. EXPRESS provides the words, syntax and grammar needed to describe a universe of discourse in an uniform, precise and compact manner. An EXPRESS grammatical analyser could be simply programmed with standard Unix tools like LEX and YACC.

EXPRESS is designed to satisfy the five basic requirements [11]:

- modelling the things of interest;
- defining the constraints that are imposed upon those things;
- defining the operations in which those things participate;
- readable by a human operator;
- modelling in a computer sensible manner.

For data exchange (one product model) between CIM modules two methods could be used, via a neutral file (STEP part 21) or via a STEP database interface SDAI [12] (Simple Database Access Interface).

The STEP project presently only specifies data modelling language, files format and data models with no considerations to implementation infrastructure. In this field, projects like Esprit IMPACT [13] and Esprit NEUTRABAS [14] or CIM BIOSYS [15] have already obtained significant results re-used in project Esprit AIT (Advanced Information Technology in Design and Manufacturing) which is a European "user-pool" program.

These researches are the basis of our work, where we consider that product holon definition could result of a first phase suppling both a product holon data model and holon data in the form of an EXPRESS data model and STEP files.

4. PRODUCT-DRIVEN ENVIRONMENT

Product/Process Interrelationship

In our model, every product is a real actor within its process able to :

- manage itself its characteristics like shape, design version, ...
- has knowledge of its evolution through its operation sequency
- store its history in the holonic process.

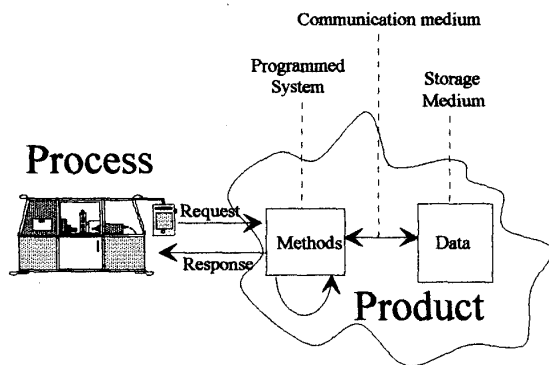


Fig 3. Process/product relationship based on the client/server model.

The schema Fig 3 points out the concept adapted from the client/server model we chose in order to respond to these objectives. In such a case each product is the manager of its own information and gives them to the process after it received a service request ("What is the next operation to be proceed on yourself" for example).

On the basis of a client/server relationship between product and process, user requests (i.e. process requests) are sent to an interface supporting product access methods in an object-oriented interrogation form such as *Object_Selector.Message (Parameters)* or *SystemMessage (Parameters)* :

- COLOR.GETVALUE ();
- COLOR.PUTVALUE (Red);

The data storage medium, in our case, consists of identification tags carried by products or by pallets and also some optional network databases.

Product Model Translation for Manufacturing Control Services

The major problem, related to this model (Fig 3.) is the integration of tags in the information system which necessitates :

- reference conceptual models to put the information about the products themselves on tags;
- tools to implement these models and to access the information.

For the purpose of our work, we assume that a logical data model of product for manufacturing operations exists and is defined in the EXPRESS language (this model could be a STEP application protocol or a specific model)

Fig 4 [16] shows the STEP-based methodology allowing translation of product model, described in the EXPRESS formalism (entities, attributes, functions, rules) :

- to a product-information access library supporting a direct requesting of target application on the EXPRESS schema data;
- to the optional database structure definition.

The product definition within the STEP neutral file is used :

- to create the tag memory image, for the first state of a product associated to the current phase of its life cycle in the manufacturing environment;
- if needed, to populate the previously created database EXPRESS

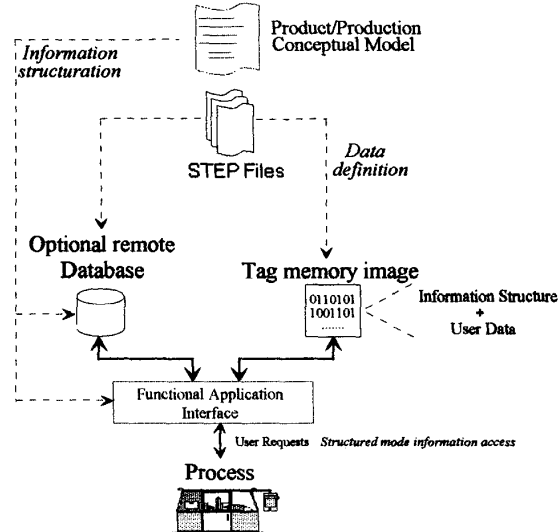


Fig 4. From EXPRESS schema to users requests. schema.

A short example of the functional application interface configuration (i.e. programming) is shown next page in Fig 5. The program code (in C and Java) is obtained by an automatic translation from the EXPRESS schema through a meta-translation model identifying semantic losts.

The resulting code has to be linked with a library providing the basic tags oriented functions like *LockInst()*, *TAGS_Int()*, *TAGS_Str()*, ... and all the communication oriented functions like *Send_Value()*, *Send_Error()*, ... in order to generate the Functional Application Interface.

Remote Database Reachability

Tags are of course limited in capacity, and storing complex structures (ENTITY) needs more memory than only storing the contents (Attributes value). Today, tags tend to have higher storage capacity (up to 128 KBytes) but in some cases (like automotive industries) this may not be enough, so if it is relevant for the application a part of the data could be stored on other medium.

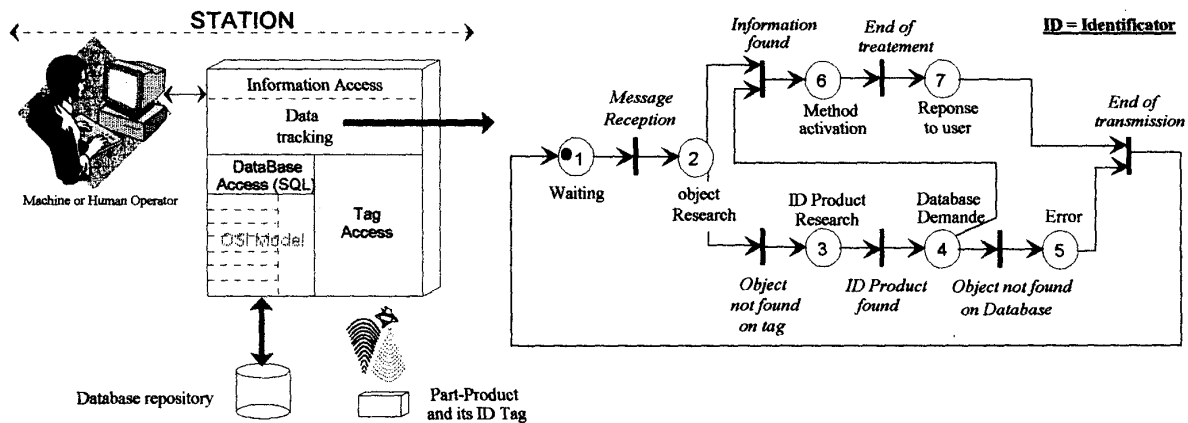


Fig 5. State graph of product data remote access from a process point.

A network database in client/server mode seems to be the natural architecture to manage the overflow of data :

- we need to have a persistent computer storage in order to manage EXPRESS schema population and translation;
- it stores and manages high volume of data;
- time response is efficient for most of the applications;
- and enterprises are already trained with such an architecture.

Our approach has the same philosophy as distributed database [17] that is, "users do not have to know where data are stored to access to them". The system performs data locating, formatting and transferring through the structure (see Fig 5.). In fact, when we populate the schema, we specify where EXPRESS entities must be (on tags or remote database). Afterwards, the user can send a request to the system, without specifying the location of the objects he wants to access.

The search for physical storage of objects is made after each user request reception, as shown in the model exposed in the Fig 5 :

- if object attributes are stored on the tag (2), the message treatment is realised (6);
- if not, an identification of the product is made by reading its distinctive characteristics (product identification number, product type identification number) (3);
- after which, we get data from the database (4) and we realise the treatment (6).

Application Tool

Our prototype Tag-STEP (see Fig 6.), running under MS-Windows, uses a standard computer to generate the Mobile Database Nodes structure. It is connected to a relational network database management system (ORACLE 7) through SQL_NET-TCP-IP-Ethernet protocols.

The EXPRESS schema is converted in a relational schema which has to be put on the ORACLE database. In this case each EXPRESS entity is translated to a relational entity (a table) and to a view in order to manipulate sub-typing. Such a conversion has already been made by Eggers [18] at the National Institute of Standards and Technology.

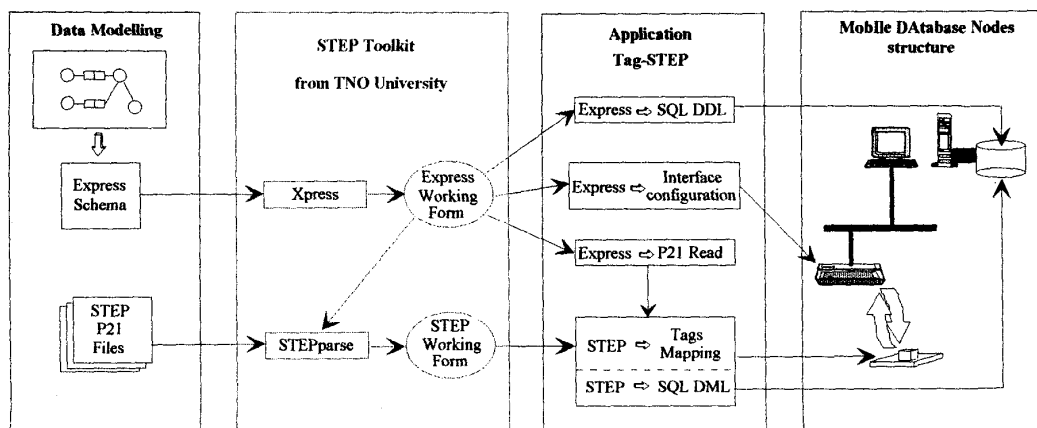


Fig 6. Structure configuration with EXPRESS schema and STEP P21 neutral files.

The schema is also converted as a C programme to generate the Functional Application Interface as explained before. This program is able to read or write data independently on tags or on the database. To populate the schema we use a STEP neutral file provided by the product definition phases.

5. APPLICATION

To validate our approach, we have design an application concerning automotive vehicle data management covering a part of the live cycle from the factory to recycling.

This application is based on five application scenarios describing an usage of different vehicles.

The target support escort memories supported by the present work are : (See fig 7.)

- Gemplus MPCOS 3DES 64Kbits Contact Card,
- Gemplus Gemeasy 64Kbits contactless Card 13.56 Mhz
- Philips HiTag 125 KHz RFID
- Balogh Inductive tag 1,5 Mhz

Due to the poor memory capacity of the currently escort memories, only a part of the overall information is used, when some Mega Bytes should be necessary ...

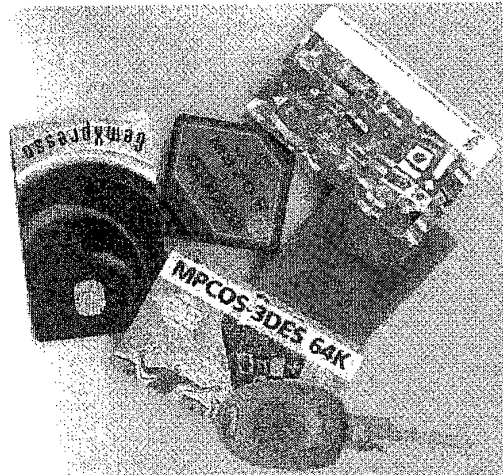


Fig 7. Target escort memories for Product life cycle management

Results from this application are :

- ISO-STEP based approach is coherent and pertinent with this framework;
- individual product management and transport is convenient for after sale services and can accelerate drastically maintenance operations because each product is always well known through its configuration data;
- new customer services can be added in product usage as for instance product self configuration (seat position in a car for example).

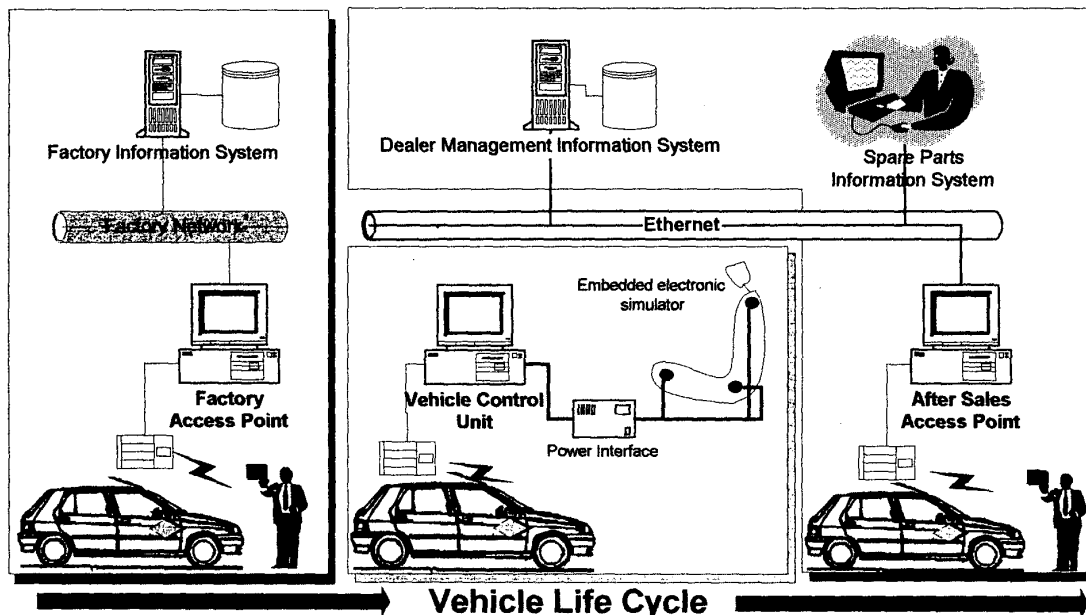


Fig 8. : Application platform.

6. CONCLUSION

Electronic data carriers for distributed manufacturing information management is taking more and more importance in industrial applications.

This new approach for information management necessitates methodological framework for Information System implementation as well as interfacing tools based on international standard definitions. Our proposal dealing with STEP formal models has demonstrated the feasibility of high level information structuration, based on product data definition, with advanced management technics on attached escort memories.

Attained benefits in CIM environments are :

- better data distribution in the overall plant allowing real time tracking of products. Each tag is an element of a distributed manufacturing database allowing immediate consultation by users (automated machine or human operator);
- simplification in the production machine structure and software capabilities. A generic interface is defined to link different kinds of users to the structure in the product coupled memory. There will be a gain in the production system modularity and modifiability, ...
- implicit fault-tolerance due to the data distribution on many media.

One of the most significant extension of this concept concerns its application to cover the full product life cycle data management from production to after sale services and recycling. This is actually done in the field of a research contract between the CRAN and a French cars manufacturer. Basically, STEP will be the general framework used for vehicle data management and the link between different phases - ie different data models - will be done through models described in EXPRESS-X [19] (creation of views on a model and mapping data from one model to another).

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