Computerised support for the management of buildings in service

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Computerised Support for the Management of Buildings in Service

Support informatique pour la gestion des bâtiments en service

Ein Computerprogramm für die Erhaltung von bewohnten Gebäuden

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SUMMARY
A system is presented which supports the knowledge process of a building and manages not only ways for setting the knowledge but also the knowledge itself; thus it is a system that assists the operator responsible for the maintenance of the building. In its general configuration, it is a complex system made up of multiple hardware and software interacting one with another. The main core comprises a software system which assists the expert in three fundamental activities: 1) Consultation of the characteristic elements of the domain (activities, agents, information, tools, archives) and of their relations; 2) Preparation of the Building Computerised Card through retrieval and elaboration of information relative to buildings under investigation; 3) Consultation of the card containing information relative to specific buildings.

RÉSUMÉ
Le résultat de la présente recherche est un système à base de connaissance pour un bâtiment; il gère aussi bien les modalités nécessaires pour obtenir la connaissance que la connaissance elle-même. Le système assiste le spécialiste responsable d'une maintenance correcte. Ce système complexe se compose de différents matériels et logiciels interactifs. Le noyau principal se compose d'un système logiciel qui assiste le spécialiste dans les trois activités fondamentales suivantes: 1) consultation des caractéristiques du domaine (activités, agents, informations, instruments, archives) et leurs relations; 2) préparation de la fiche informatique du bâtiment par la recherche et l'élaboration des informations concernant les bâtiments étudiés ; 3) consultation de la fiche d'information sur les bâtiments-types.

ZUSAMMENFASSUNG
Die komplexe Systematisierung des Erhaltungsprozesses führte zu einem Computersystem, das den Kenntnisprozess eines Gebäudes unterstützt, indem es sowohl die Erkenntnisgewinnung als auch die Kenntnisse selbst verwaltet. Der Hauptkern besteht aus einem Softwaresystem der Originalplanung, das den Fachmann bei folgenden drei grundlegenden Tätigkeiten unterstützt: 1) Beim Nachschlagen (Konsultation zur Kenntnisnahme) der charakteristischen Elemente dieses Sektors (Tätigkeiten, Agenten, Informationen, Instrumente, Archive) und ihrer Beziehungen; 2) Erstellung der Computerkarte des Gebäudes mit Hilfe der Einholung und Ausarbeitung von Informationen über die zu untersuchenden Gebäude; 3) Das Nachschlagen der Karte, die die Informationen über spezielle Gebäude enthält.

1. INTRODUCTION

In the last few years, the rescue interventions on the existing, deeply degraded building patrimony have increased as a consequence of the consciousness of its historic, artistic, environmental and economic value [1]; this has brought about a strong thrust to the research field concerning techniques and diagnostic tools to be used in order to reset the prefixed quality levels of the building; on the contrary, the methodological aspects of the rescue have not been developed likewise. The interventions of building rescue must be considered as processes in which are to be defined all those activities to be carried out, their temporal sequence, tools to be used, involved operators, i. e., methodologies to be applied for the rescue and/or building *maintenance*.
The present work [2] puts forward, in the very general context of the BUILDING RESCUE (Fig. 1), a system analysis of the **Recovery** process as defined by the Italian law no. 457/1978 [3].

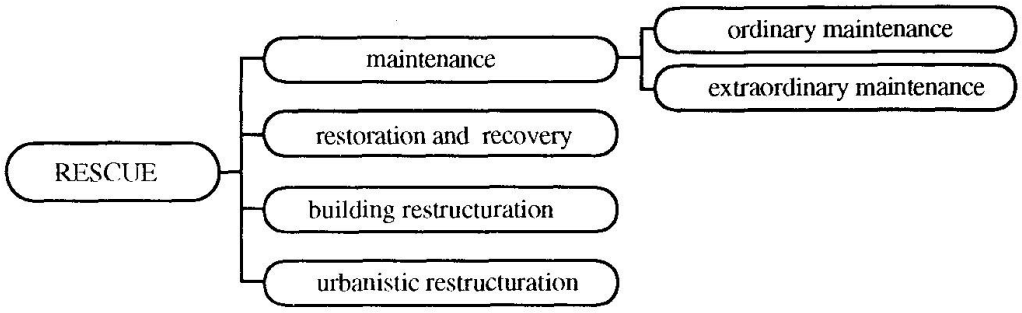

fig. 1 The rescue process

The four foundamental stages which constitutes such a process have been singled out, defined and are as follows:
A- Pre-project stage: the building knowledge.
B- Planning stage: the project of interventions for building recovery.
C- Implementation stage: the interventions for building recovery.
D- Building maintenance stage.
The present research has investigated the *knowledge stage* which is deemed essential for the proper implementation of the recovery process. Moreover, a computerized system, referred to as SMIRNE with the italian acronym (System for Intelligent Methodological Support of Building Rescue) has been set up. The system supports the knowledge stage of building by handling both the modalities to obtain the knowledge and the knowledge itself: thus, it is a system that assists the expert who is involved in the pre-project stage of the building knowledge and must either carry out recovery interventions or operate for the proper building maintenance.

2. THE BUILDING KNOWLEDGE STAGE

The *knowledge stage* is becoming essential also in the new building processes, because it is recognized that important information on the building is not to be lost even in the constructive stage.
The knowledge stage makes possible to elaborate, at the same time, the various stages (planning, implementation and building maintenance) and the complex of structured information, which constitutes the Building Computerized Card (B.C.C.). Only the exact knowledge of the building in its historical, technological and functional specificity (constructive techniques, materials, technological systems, construction age, destination, alteration, urbanistic bounds, etc.) allows properly oriented interventions, when necessary, and timely arranged interventions for the maintenance. It is a straightforward building anamnesis [4] which becomes a methodological tool of analysis.
Information is thus used in relation to specific goals to be attained, the knowledge goals being different and various:
- historical and cultural goals (catalog of buildigs and architectural masterpieces, etc.);
- fiscal goals (cadastral enrollment, real estate taxes, solid waste disposal taxes, etc.);
- public administrative goals (rescue plans, construction authorizations, adjustment to safety codes, etc.);
- maintenance goals (maintenance booklet, calculation of millesimal portions, etc.);
- others.

The building knowledge stage unfolds into planning of activities to be carried out and into definition and execution of corresponding actions:
- planning makes use of description or selection of activities and definition of archives, agents and information to be gathered:
- execution makes use of a series of activities, managed by specific professional profiles and aimed to collect, elaborate and retrieve documents and data from the various available information sources (archives).
The main information sources are the building itself and all documents that accompany the building from its inception until its demolition, a life cycle that may last centuries. All pertinent, documental information deserves to be searched, collected, organized and stored.
The knowledge objective is the preparation of an information assembly (BUILDING COMPUTERIZED CARD-B.C.C.) **made up by the totality of information (documents and data [5]) relative to the investigation object, which can be aggregated in distinct cards, and which are related to defined levels and specific investigation spheres.**
Two levels, often interrelated, are to be considered: the territorial level (urban context, environmental conditions, etc.) and the building level (morphology, constructive techniques, etc.).
The essential investigation spheres are locational, juridical-urbanistic, historical, geo-topographical-cadastral, typological-morphological, tecnological-constructive, tecnological-plants, functional-environmental.
- Data relative to the individual building are gathered from the locational sphere and allow its immediate location with respect to the administrative-territorial organization.
- Data relative to the building property and regulation bonds, and to the operators responsible for its planning, construction and management in service, are gathered from the juridical-urbanistic sphere.
- Data relative to the construction cronology *from a remote limit to the recent limit* [6] are gathered from the historical sphere.
- Data relative to the building location on the territory and to the cadastral division, are gathered from the geo-topographical-cadastral sphere. Such data are also useful for the evaluation of the urban context.
- Morphological-dimensional data for a type classification, relative to predetermined typological classes, are gathered from the typological-morphological sphere.
- Data relative to the physical elements of the building tecnological system, i.e., constructive systems, components, semicomponents as well as materials, are gathered from the tecnological-constructive sphere.
- Data relative to the mechanical and electrical systems (heating, lighting, ventilation, electric, waterworks, sanitary fittings, etc.) are gathered from the tecnological-plants sphere.
- Data relative to the qualitative and quantitative status of spaces and their use are gathered from the functional-environmental sphere.
The knowledge stage articulates within such spheres in activities and subactivities (Fig. 2), carried out by agents, by means of specific tools, aimed to the singling out, retrieval and/or elaboration of information useful to create what we have called the Building Computerized Card (B.C.C.). The research unit, after having singled out the activities to be performed, has deemed essential to elaborate, with the support of computerized tools, a system able to handle activities aimed to acquire knowledge, in order to prepare the Building Computerized Card (B.C.C.).
The activities planning requires, first of all, the identification of:
- information to be retrieved (documents and/or data),
- archives to be consulted,
- agents with specific professional expertise.
These concepts: Activities, Agents, Tools, Information (Document and Data) and Archives are linked by relationships as follows:
the Activities are processes capable of accepting Data and/or Documents, manipulating them and outputting again Data or Documents;
the Agents are, in general, people (e.g. the user, the planner, the historian, the physicist, etc.), and have the task to carry out the Activities;
information is any set of information which must be found or produced during the various Activities. Certificates, cartographies, regulations, to be found in agencies and libraries, as well as papers elaborated by the planner or by any other agent, fall within this concept;
the Archiv is the original source of information (Documents and Data). For example, it can be either a traditional archiv, (as Municipal Archiv, General Land Office Archiv, etc.), a data processing center, or a library. A peculiar Archiv and always at hand is the building itself;

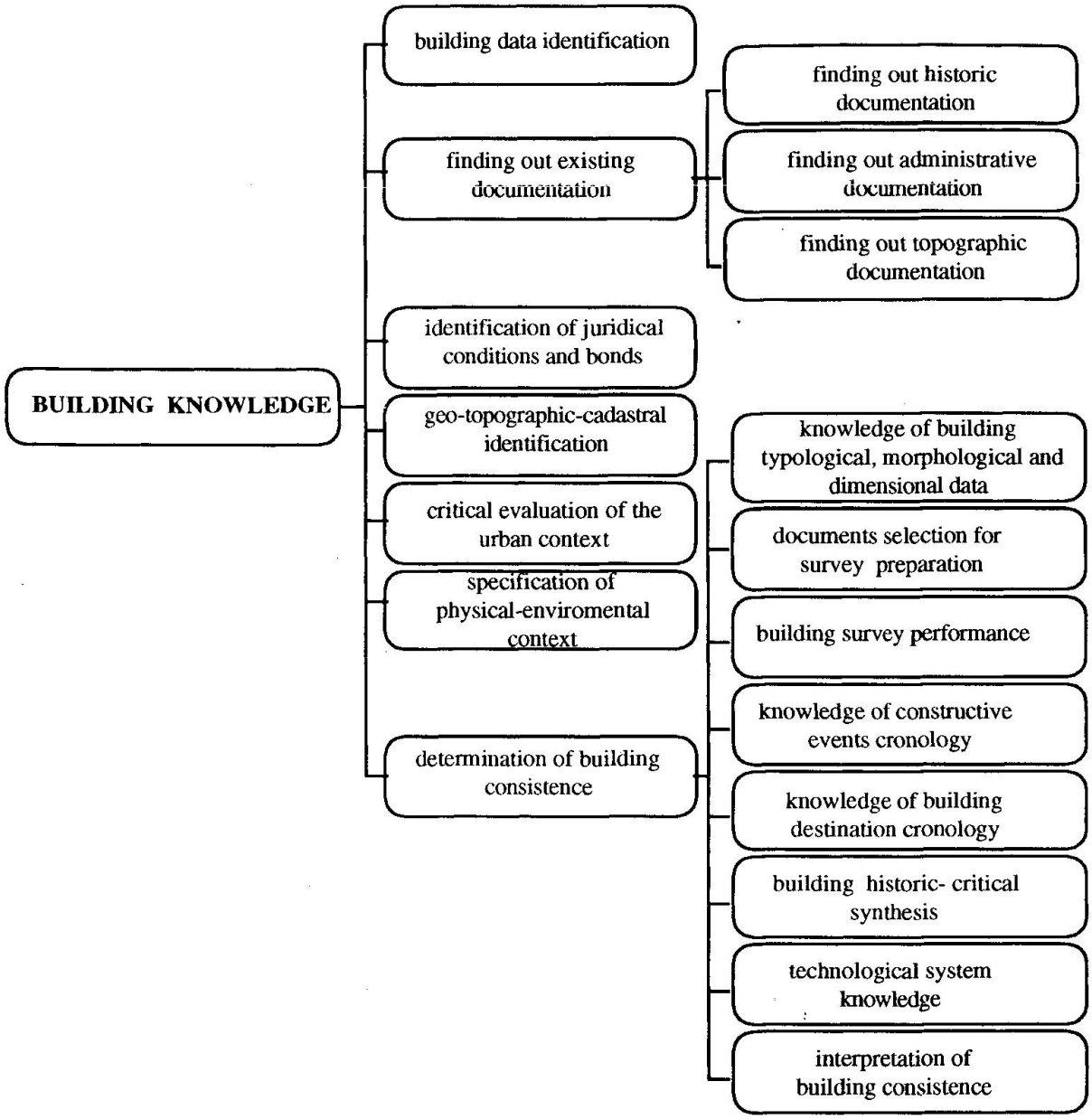

Fig. 2 Taxonomy of activities aimed to knowledge acquisition

the Tools support the Activities. They can be of various types, and can be classified either as traditional tools and innovative tools, or as mechanical tools, electronic tools and computerized tools.

3. GENERAL CONFIGURATION OF THE SMIRNE SYSTEM

The SMIRNE system, in its actual configuration, is a complex system made up by multiple hardwares and softwares interacting one another (Fig. 3).

The main core of SMIRNE is made up by a software system, developed by us with a Prolog language, which runs on a Macintosh PC; the SMIRNE System and assists and guides the expert in three foundamental activities:

1) Consultation (to obtain information) of the characteristic elements of the domain (Activities, Agents, Information, Tools, Archives) and of their relations.
2) Preparation of the Building Computerized Card (B.C.C.) through retrieval and elaboration of information relative to buildings under investigation.

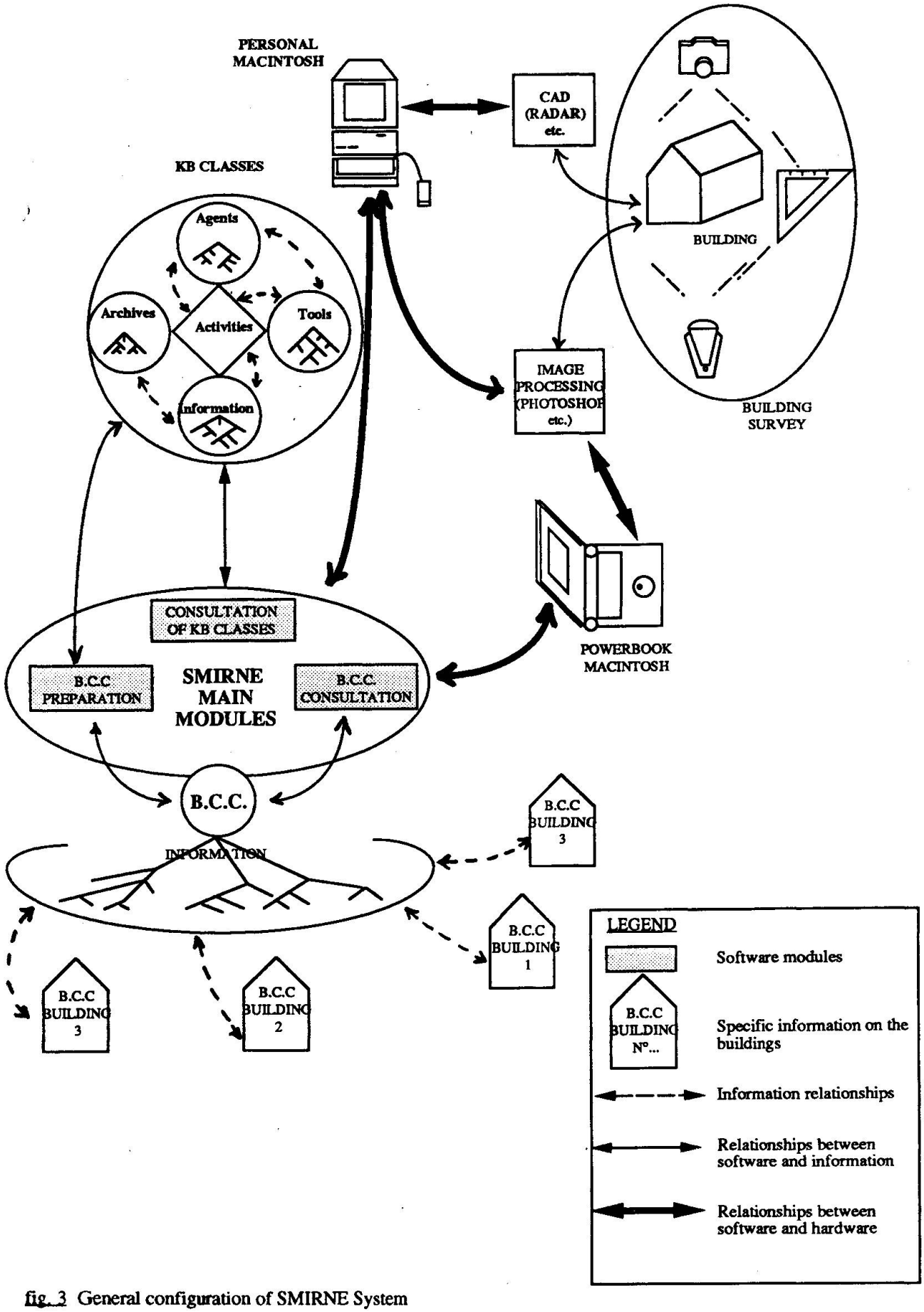

fig. 3 General configuration of SMIRNE System

3) Consultation of the Building Computerized Card (B.C.C.) containing information relative to specific buildings.

The software implemented in Prolog allows:

1. Navigation in the semantic network of concepts (Activities, Agents, Information, Tools, Archives) and of their relationships.
2. Navigation in the information archiv of the Building Computerized Card (B.C.C.).
3. Management of the various phases involved in the execution of activities for the building knowledge (information retrieval, agents and tools collection, activities elaboration, storage of information in the Building Computerized Card (B.C.C.).

The SMIRNE core is made up by an 'inferential system' ('inferential motor') and a knowledge basis of the domain elements (Building knowledge for its rescue) and their relations.

Additional software and hardware elements, supporting the principal core, are used for the filing of physical information (texts, bidimensional images as either ruster or bit maps) as well as for information retrieval. CAD softwares (Radar, etc.) residing in the personal computer, are used to develop tridimensional models of the building under consideration.

Additional softwares which handle bidimentional image (Photoshop, etc.) are used, with cameras, videocameras and scanners, to develop bidimentional images of the building or digitize hardcopies drawings.

Such programs which handle bidimentional image are also used to convert tridimensional and bidimensional drawings in unified formats for filing in the Building Computerized Card (B.C.C.).

For retrieval of various information filed in the Building Card are needed hardwares such as printers and plotters.

In summary, the SMIRNE core is used as a support (supervisor) to all activities in preparation of the Building Card and in consultation of the domain elements of information contained in the card itself; specific softwares (Radar, Photoshop, etc.) are needed to develop tridimensional models of the building and for the high quality visualization of images (colour, high definition, etc.) and, in general, for manipulation of tridimentional models.

3.1 Development modalities of SMIRNE system

The actual version of the system has been developed in the following stages:

stage1: theoretical development of the model of the Building Knowledge System (inferences on network classes, preparation of the Building Computerized Card B.C.C., consultation of the Building Computerized Card B.C.C.);

stage 2: complete taxonomic description of activities for the building knowledge;

stage 3: complete description of the concepts of Information, Agents, Tools, Archives;

stage 4: Prolog implementation of the concepts description and of the concepts relation;

stage 5: examination of the building as a typical example; retrieval of textual and graphical information and their filing;

stage 6: Prolog implementation of the system for the building knowledge in its three articulations (Inferences on classes network, preparation of B.C.C., consultation of B.C.C.).

Such stages are developed by specific figures of the research staff:

- the domain expert, i. e. the expert in the recovery field,
- the system expert, i. e. the expert in the planning of computerized knowlwdge systems,
- the graphic expert, i. e. the expert in the computerized preparation and handling of graphical systems.

Each stage is developed by only one, or more, of the mentioned experts.

4. THE SYSTEM MODEL

The model of the building knowledge system is made up by three main inferential modules (Fig. 4):

1 - the module of INFERENCE ON THE NETWORK OF CLASSES OF CONCEPTS (Activities, Agents, Information, Archiv, Tools), that consists in a 'navigator' of the semantic network whose nodes are: Activities, Agents, Information, Archiv, Tools;

2 - the module of the Building Computerized Card (B.C.C.) PREPARATION, that consists in the overall procedures for performing activities linked to the building knowledge, therefore, retrieval of given information, its elaboration and filing in the Building Computerized Card (B.C.C.);

3 - the module of the Building Computerized Card (B.C.C.) CONSULTATION, i.e. retrieval or either simple or

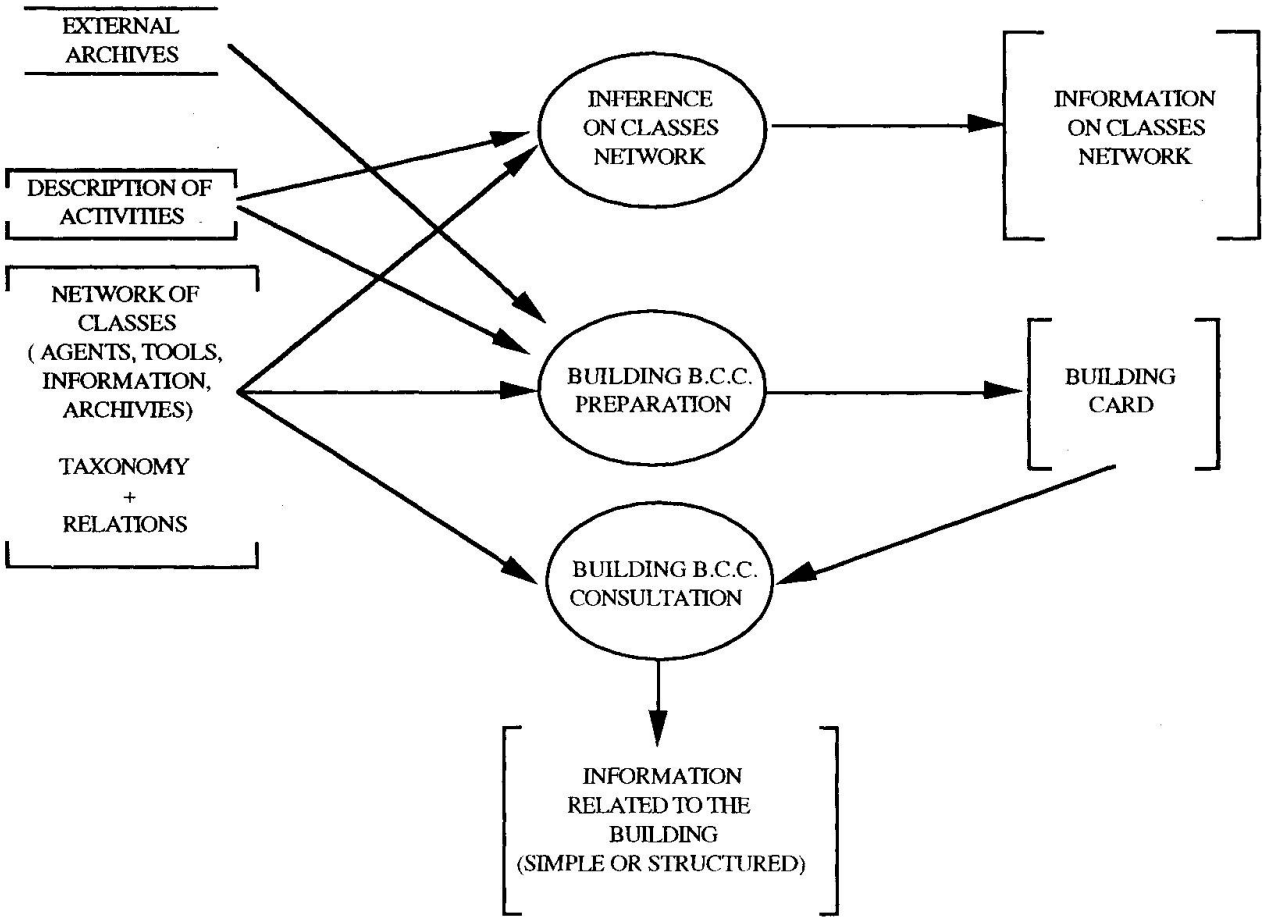

fig. 4 Main inferential cores of the system model

structured information of the building knowledge in order to prepare specific documentation useful for the subsequent recovery phases.

The *knowledge sources* that support such inferences are:

1 - the EXTERNAL ARCHIVES which provide information required for the preparation of the building card;

2 - the DESCRIPTION OF THE BUILDING KNOWLEDGE ACTIVITIES required for the inferential module on the network of classes and for the module of building card preparation;

3 - the NETWORK OF THE BUILDING KNOWLEDGE CLASSES, or else the description of the classes of agents, tools, information, archives, in their taxonomies and relationships, required for the module of network inferences, for the module of the building card and, in one of its subsystems, for the module of card consultation;

4 - the BUILDING COMPUTERIZED CARD (B.C.C.) produced by the central module of the knowledge model and required for the consultation stage on the building information.

In the preparation of the Building Computerized Card (B.C.C.), each single action is made up by three substages:

1 - preparation

2 - elaboration

3 - filing

In the **preparation stage** one or more agents are involved, one or more tools are recalled and the information required for the elaboration is retrieved, trough a given archiv.

The **elaboration stage** is the fundamental core of the action execution: the input information is manipulated by the agent by means of tools and additional information is produced as result of the elaboration.

The **filing stage** consists in the filing of produced information into the Building Card archiv and in the update and of the system advancement status (list of the actions carried out at that time).

4.1 The structure of the Building Computerized Card (B.C.C.)

The structure of the Building Computerized Card B.C.C. is a tree structure having the information concept at the root and taxonomic branching of this concept (from classes to subclasses) (Fig. 5).

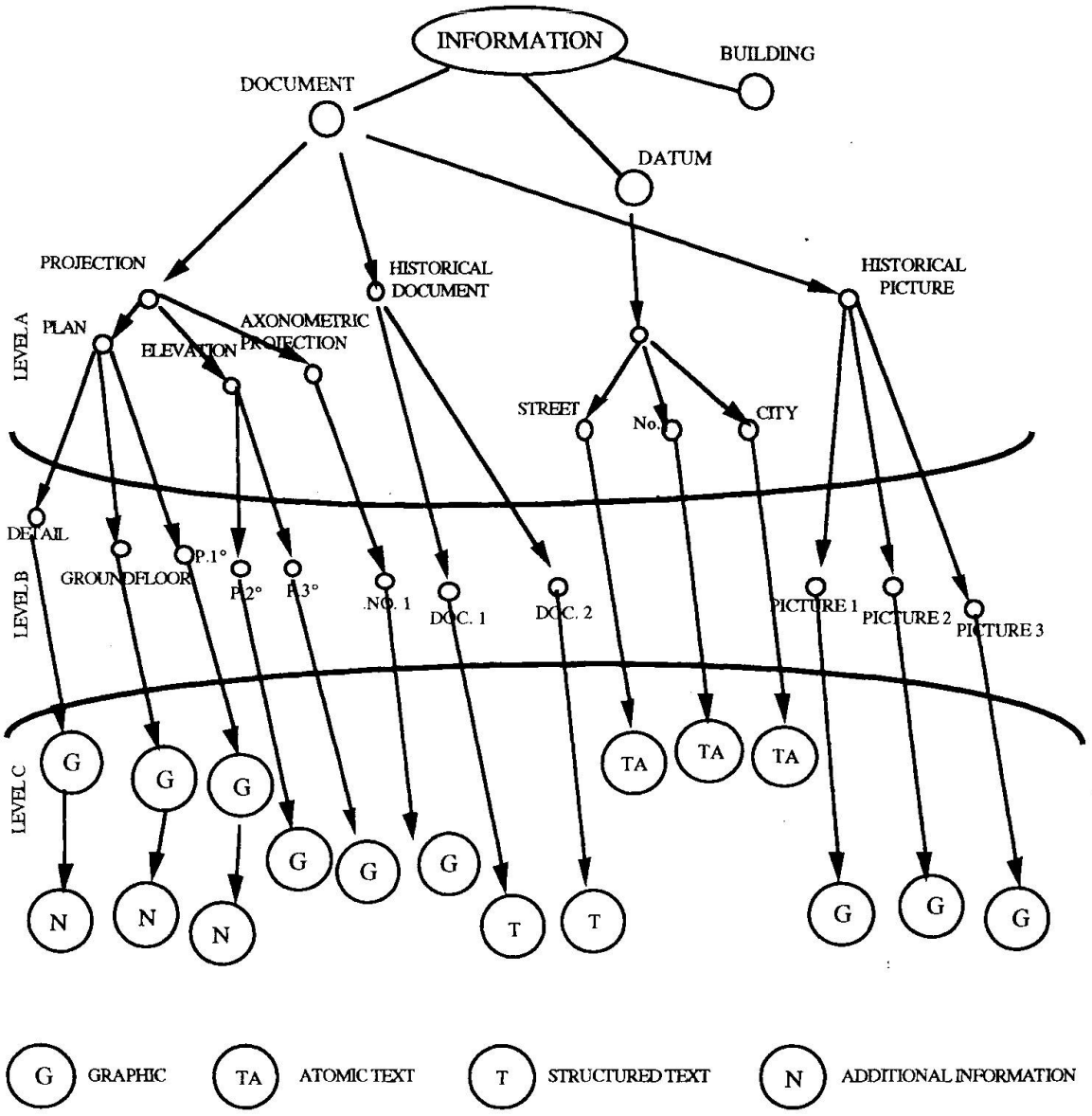

fig. 5 Tree structure of the Building Computerized Card (B.C.C.)

Such a branching begins with the 'generation', from the 'information' concept, of the two descending concepts 'document' and 'datum', and goes on, from primary concepts to descending concepts, until it reaches the leaves ('terminal' information). This part of the card structure (always present) is common to each building and constitutes the first level (starting from the top) of the structure itself (in an ideal division through levels, from general to particular). General 'Terminal' information, in general, terms may give origin to specific information which may vary for each given building; or else they can be related directly to 'physical' information. That part of the card structure which corresponds to 'specific' information constitutes the second level of the structure itself. 'Comment' information may be related to phisical information. Both 'physical' information and 'comment' information are situated to the third level of the card structure.

5. IMPLEMENTATION CHOICES

Smirne is made up baisily by three parts (foundamental functions):
I. Management of a semantic network of concepts and relationships on the knowledge for the building recovery.
II. Management of a collection card of the building information, structured as a tree.
III. Management of the preparation of the building information card (prepared through the activities development).
These three parts are implemented in Prolog.
For the fullfillment of parts I and II, we could have also used either a relational DBMS (Data Base Management System) or an ipertextual environment; on the other hand for the fullfillment of part III, it was necessary the use of a programming language with procedural characteristics.
It has not been possible to interface properly a DBMS or an ipertext with the procedural program required for the part III.
Therefore, Prolog has been the optimal solution in this case.

6. CONCLUSIONS

SMIRNE, in its actual configuration, can support the building knowledge stage which is made up by:
Activities: Activities to be performed for the building knowledge and the formation of the building card.
Agents: Agents that perform activities.
Tools: Tools (manual, mechanical, electrical and electronics, computerized) that, used by agents, support activities.
Information: Documents and data (textual or graphical) that are needed either to prepare the computerized card, or to flow directly into the card.
Archives: Sources of information (places where information is retrieved).
The SMIRNE system can be enlarged in order to favour a better articulation of building knowledge elements and a better articulation of the knowledge consultation, so that it may allow particular 'navigations' within such a knowledge and extrapolation of 'relational' knowledge (among different objects-buildings too).
Enlargement of the structural possibilities implies changes of the intrinsic SMIRNE structure in order to let SMIRNE handle not only support of knowledge (and executive) activities, document preparation (e.g. the Building Card) and document consultation but also the functioning of software and expert sistems.
SMIRNE, in its actual configuration, is ready to support the building knowledge stage and the building recovery; it will allow the preparation of computerized cards for the knowledge of different buildings.
SMIRNE can be also used for more general aims, i.e. for the building recovery and for any situation where it is needed the 'knowledge' of the building of a specific city (or province, region, etc.), regardless of aims of such a knowledge (e. g., description of the architectural patrimony of any type) or for specific aims such as building maintenance.
Nowdays the SMIRNE System users' could be the involved operators in recovery activity: designers, historians, technical-physicist, topographers, building administrators or owners; each one of them can, inside SMIRNE, enter or utilize information relative to the building under examination.

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NOTES

[1] The European Charter of the architectural patrimony, promulgated at the end of the European Architectural Patrimony Congress, held in Amsterdam in 1975, and adopted by the committee of the European Council Ministers, states: "The European building/architectural patrimony is formed not only by the most prestigious monuments, but also by all the

buildings which make up our cities and our traditional villages in their natural and constructed environment (...) For quite some time, only the most important monuments have been preserved and restored, regardless of their context. They may, however, lose a great deal of their value if their context is altered. Moreover, groups of buildings, even without outstanding architectural features, may have environmental qualities which contribute to give them a diversified and articulated artistic value. These groups of buildings must be preserved as such."
Such a principle is recalled by the Italian law 457/1978 which specifies in the Fourth Title the General Rules for the rescue of the existing urbanistic and building patrimony; in the article 31 of this act, ordinary and exstraordinary maintenance, restoration and recovery, building and urbanistic restructuration fall within the interventions aimed to the building rescue. They are not simple interventions but specific processes characterized by specific, common aspects: the preexistence of the constructed object which must be investigated, measured, checked, i. e. known in-depth, before starting any building activities.

[2] This paper is the second in a series. The first one was published in "Knowledge-Based Systems in Civil engineering", IABSE Colloquium, Beijing, 1993, pp. 301-310. (Reference no. 2)
This work is part of "Progetto Finalizzato Edilizia" (Targeted Project for Building), funded by the National Research Council, the main Italian Research Body. The research program, started in 1989 lasts five years. The Project articulates into an experimental area and three subprojects each pertaining to specific research fields. In the first subproject of this program, entitled "Process and Procedures", which addresses questions on the procedural context, and specifically in the section "Organization, management, maintenance and recovery", we have singled out our theme.

[3] In the article 31 of this act, ordinary and extraordinary maintenance, restoration and recovery, building and urbanistic restructuration fall within the interventions aimed to the building rescue.
Throughout the text we made use of several words whose meaning is detailed as follows: rescue refers to the global process, whereas maintenance, restoration, recovery and restructuration refer to different types of the rescue.
Restoration and recovery interventions are those addressed to mantain the building organism and insure its functions trough a set of homogeneus actions that allow a compatible use respectable of its typological, formal and structural elements. Such interventions include strenghthening, restoration and renewal of the building constitutive elements, introduction of accessory elements and if required technological plants, removal of not related elements (Fourth Title, article 31, 457/1978 Act).

[4] Anamnesis: reminiscence. In medicine, a preliminary case history of medical patient, referable both to the investigation of the specific pathological condition and to general and foundamental stages of the patient's life, i.e., physiology, remote and recent pathology.

[5] Datum is any elementary information, generally rapresented by aggregates and classified as documents. For example, identification data of the building and of people who are legally bound to it, as well as evaluations made by the planner on the building preservation state, fall within this concept.

[6] Terminology used in the Card A, "Structure of Precatalogue Cards Data", by Central Institute for Catalog and Documentation, Italian Minister for Cultural and Environmental Affairs.

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