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A Process Time Information System (PTIS) for Productivity Improvement

Système informatisé de temps d'exécution pour l'amélioration de la productivité

Ein Vorgangszeit-Informationssystem zur Produktivitätssteigerung

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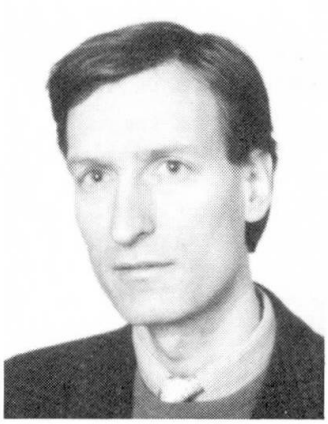

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SUMMARY

The fast development of electronic data processing makes it possible to develop a process time information system for the construction industry. This system under development, calculates process times in the project preparation phase and the construction phase and will contribute to productivity improvement. This paper gives an expose of research being undertaken.

RÉSUMÉ

Les développements rapides dans le traitement électronique des donnés rend possible la réalisation d'un système informatisé de temps d'exécution dans l'industrie de la construction. Ce système, en cours de développement, calcule les temps d'exécution dans la phase de préparation du projet et dans la phase de construction, et contribue ainsi à l'amélioration de la productivité. L'article présente les recherches entreprises actuellement.

ZUSAMMENFASSUNG

Die rasche Entwicklung der elektronischen Datenverarbeitung hat die Möglichkeit für die Anwendung von dynamischen Planungssystemen im Bauwesen geschaffen. Das hier beschriebene System berechnet Vorgangszeiten in der Arbeitsvorbereitung und während der Ausführung von Bauprozessen. Damit kann eine erhebliche Produktivitätssteigerung auf der Baustelle erzielt werden.

1. INTRODUCTION

The Netherlands Government has embarked on an extensive programme for the promotion and development of technological innovations in all important industries. Through an innovative research programme (so called IOP) the government subsidizes since 1979 those research projects in universities and other institutes which are of importance for industrial development.

The IOP research for the construction industry (IOP-Bouw) started in 1983. The basic idea is that a good and generally accepted information technical infrastructure for the construction industry is an important condition for optimum innovative development. Herewith the fast developments of automation tools can provide excellent opportunities.

An information technical infrastructure is meant to be a system of conventions which enables the various parties in the building process to communicate with each other, with the support of automated information systems.

In the field of electronic data processing (EDP) the three main fields for research and development are:
* coordination and communication;
* information transfer, instruction and education;
* socio-economic aspects.

One of the research projects is the development of a process time information system (PTIS) for the construction firm.

2. BACKGROUND

Due to changing market conditions and other ways of execution of building projects, contractors in particular, have a growing demand for specific information. An important part is specific information on time data of all activities -in general and in detail- during the realization process. Some of the reasons are:
- There is a move from new construction towards town rehabilitation, renovation and maintenance. This causes a different task content for the craftsman. The number of operations to be performed by a person or a gang is generally growing; A task used to be performed by one person/gang; we now see more activities are brought under one task. We speak of the creation of so called "intelligent gangs" and the use of "multi-functional" craftsmen.
- The building process can develop more smoothly when technical and organizational relations can be disconnected. For example the support & infill concept shows a "layering" during the design phase but also during the realization phase. The support is manufactured separately from the infill. This requires also a different work preparation of the realization phase.
- The introduction of EDP provides possibilities for improving and speeding up the information processing. It is possible to store information, to retrieve information, to compare alternatives and to arrive at better decisions (i.e. decision support system). Also the access to the process information is easier for

other 'levels' in the organization and for other partners in the building process.
- In the construction industry the productivity is lagging behind compared with other industries. There is a wish to measure and to influence the productivity development. At project level this can be obtained by a better registration of all inputs and outputs. This is part of a research project undertaken by this university (see also [1]).

3. PTIS IN GENERAL

The aim of the research project PTIS is the development of a process time information system, which can be used during the building project preparation and realization. This provides the possibility that decisions related to time can be taken in a better way.

A process time is defined as the progress time of a building process at a low or an aggregated level. It is a function of capacity, allowances and building process volume (e.g. man-hour).

The University works on this project together with the Research Institute for Labour Economy in the Building Trade (SAOB). This Institute has numerous time-motion data available from building site activities. However these data are not easily accessible. Due to technical developments in the field of EDP it is now possible to structure and to combine these data for interactive use even at the building site.

The PTIS system will function as a decision support system. Van Hee [2] gives the following characteristics of such a system:
- 1. Upon actions as chosen by the user, the system calculates the consequences in the form of ratios which provides the user a better insight in the production process.
- 2. Upon a criterion as chosen by the user, the system optimizes actions and calculates related ratios.
- 3. Once certain actions are chosen, the system determines the sensitivity for variations in parameter values. It represents in the ratios the effects of these variations.

The research approach is the following: firstly the available information has to be identified, structured and completed. For this purpose accessible data bases have to be created and also proper working definitions are required. Secondly procedures have to be developed for quick, effective and interactive use of structured process time data. The data bases and the information processing procedures are the main components of PTIS (see Fig. 1). This system can be integrated in a more complex building process information system, to be developed at a later stage, which is also related to cost and quality.

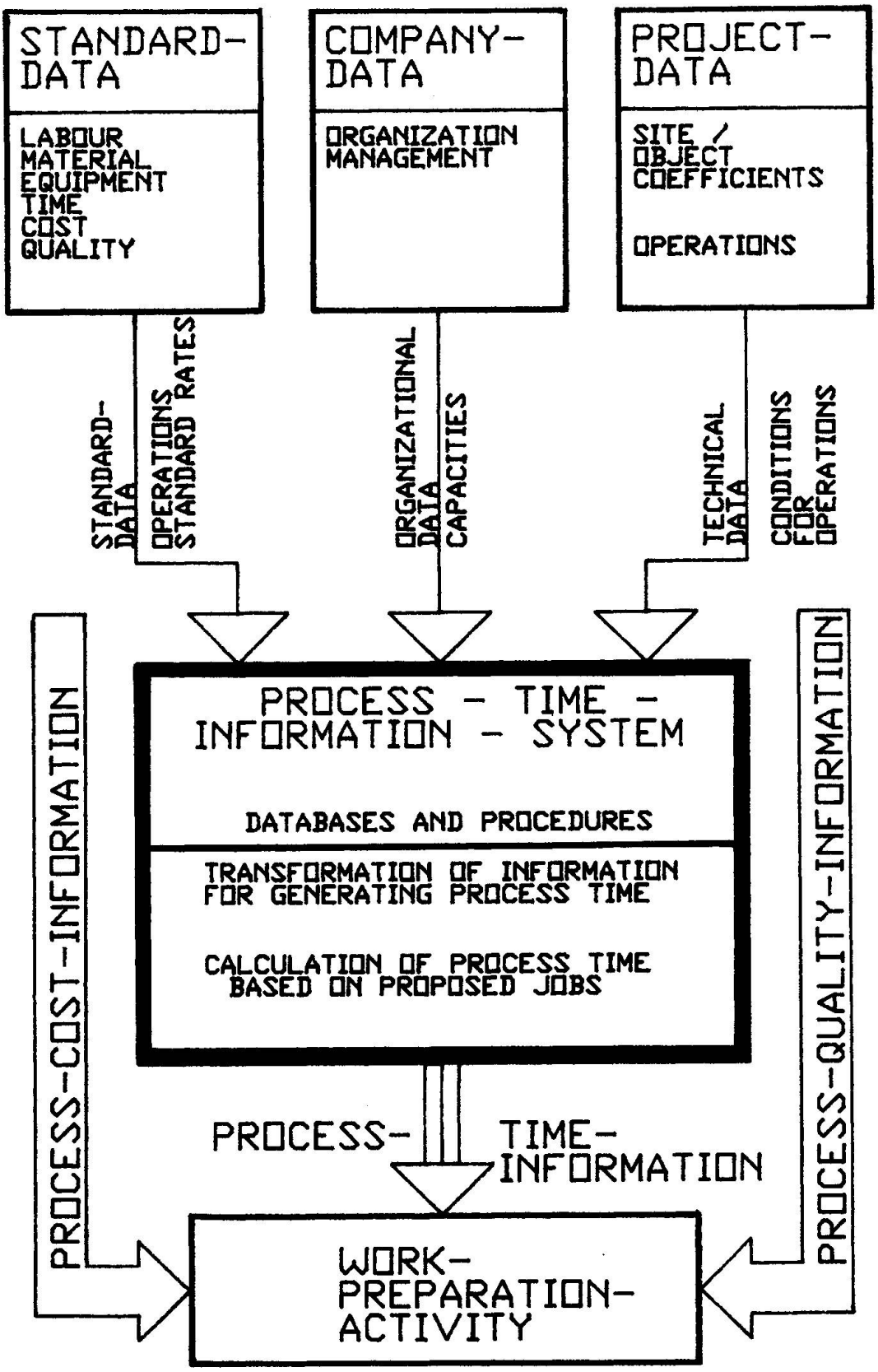

Fig. 1 The PTIS concept

4. INFORMATION ORDERING

4.1 Activity Groups and Mile Stones

The materialization sub-phase forms together with the commercial phase (project tendering etc.) the realization phase (Fig. 2). This phase has three groups of activities:

- Work preparation activities: These are considered to be information transforming processes. The results are decisions and/or descriptions for specific execution activities. Information from contract documents, work organization and site data are combined and transformed into plans such as a material planning, personnel planning etc.The execution activities are simulated as accurate as possible.
- Execution activities: These are considered to be material transforming processes. The quality of the execution activity is mainly determined by the preparation- and control activities.
- Control activities: The execution activities are checked by comparing the information from the execution with relevant information from the work preparation and then generates control information. It is therefore an information comparing process and control information generating process.

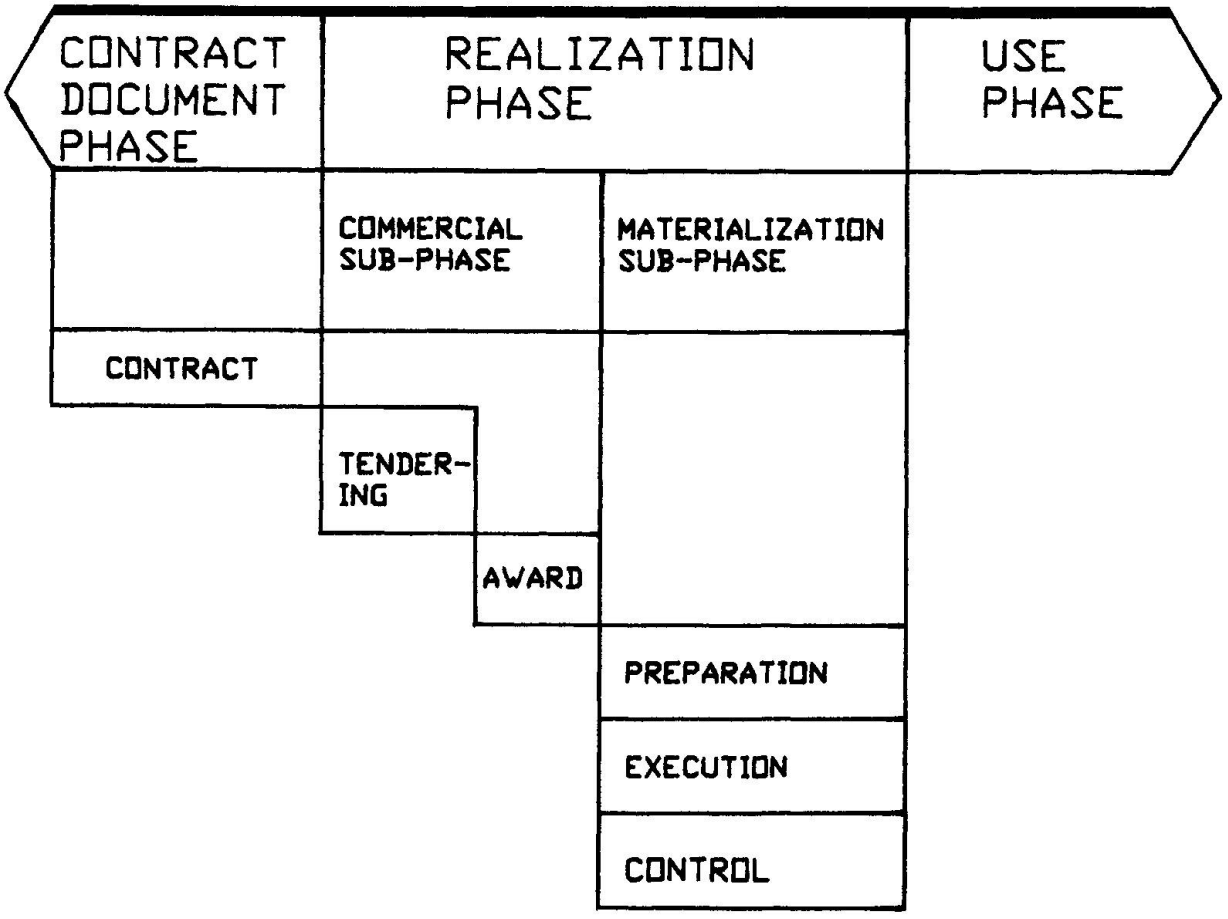

Fig. 2 Project phases, detailed realization phase

Currently there is no suitable method available for the classification of information on activities in the materialization phase. The planning of the sequence of building activities is in general the guiding principle. Though experiences and possibilities for information processing may differ by contracting firm.

The information in this phase is ordered in a process oriented way. This is contradictory to the object oriented ordering during the design phase. The basis for the ordering principle is the hierarchic structure: processes are top down sub divided in smaller processes.

The relation between the processes at all levels is indicated by a code. Also the mile stone concept, as being used for network planning, shows such a top down structure (Fig. 3 [3]). In this way building processes can be structured top down.

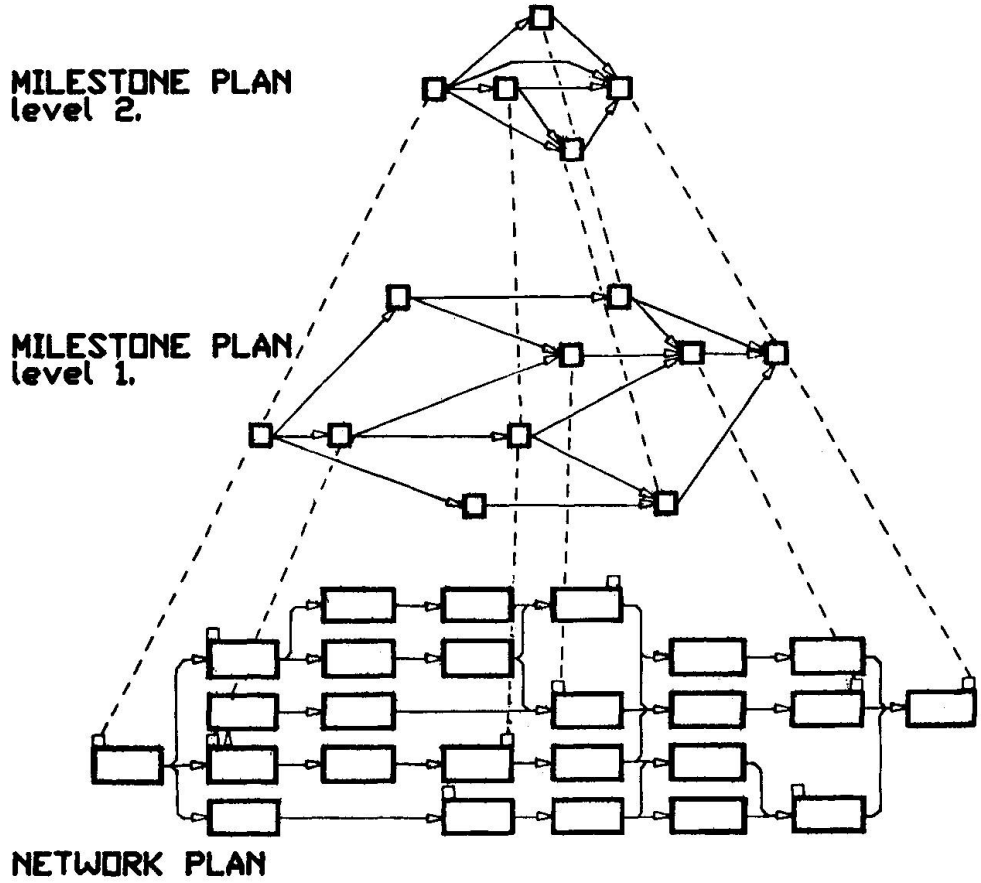

Fig. 3 The mile stone concept

It is also necessary to structure the building process in a chronological order. The proposed phasing of the so called main building processes is:
- start;
- substructure;
- superstructure: frame;
- facade;
- roof;
- infill;
- finishing;
- end.

Each building main process can be defined by its start-point and end-point. This is similar to the way an information process is defined by its inputs and outputs. The start and the end of each building main-process can be identified as a mile stone. This is also a measure point (see Fig. 4).

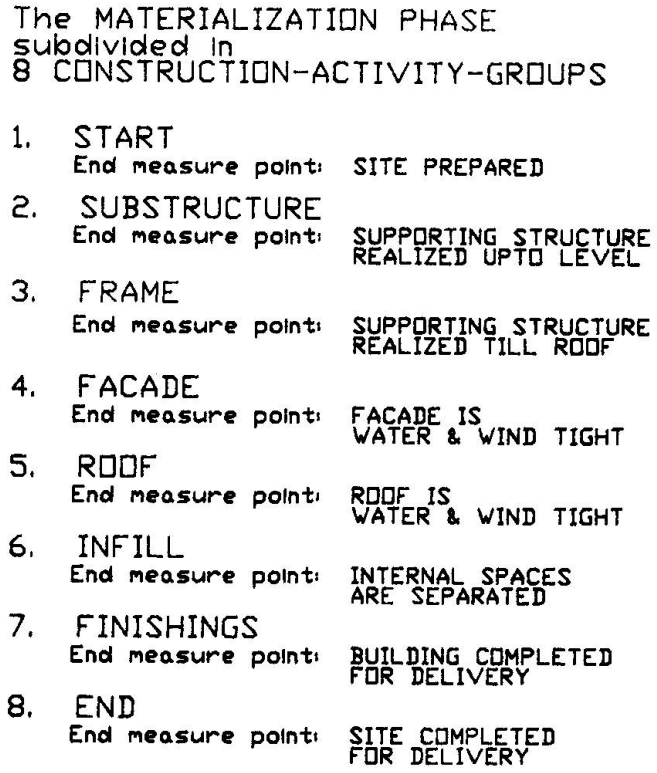

Fig. 4 Building phases and mile stones

4.2 The Building Sub-Process

For a top down structure of the building process, we can distinguish the following classes of building processes:
- building main processes of the materialization phase;
- building sub-processes as a part of one main process;
- operations as a part of more sub processes;
- actions as a part of more operations;
- movements as a part of more actions.

Fig. 5 shows the complete picture. The processes are disconnected. This allows for another ordering of the building process, reconstruction etc.

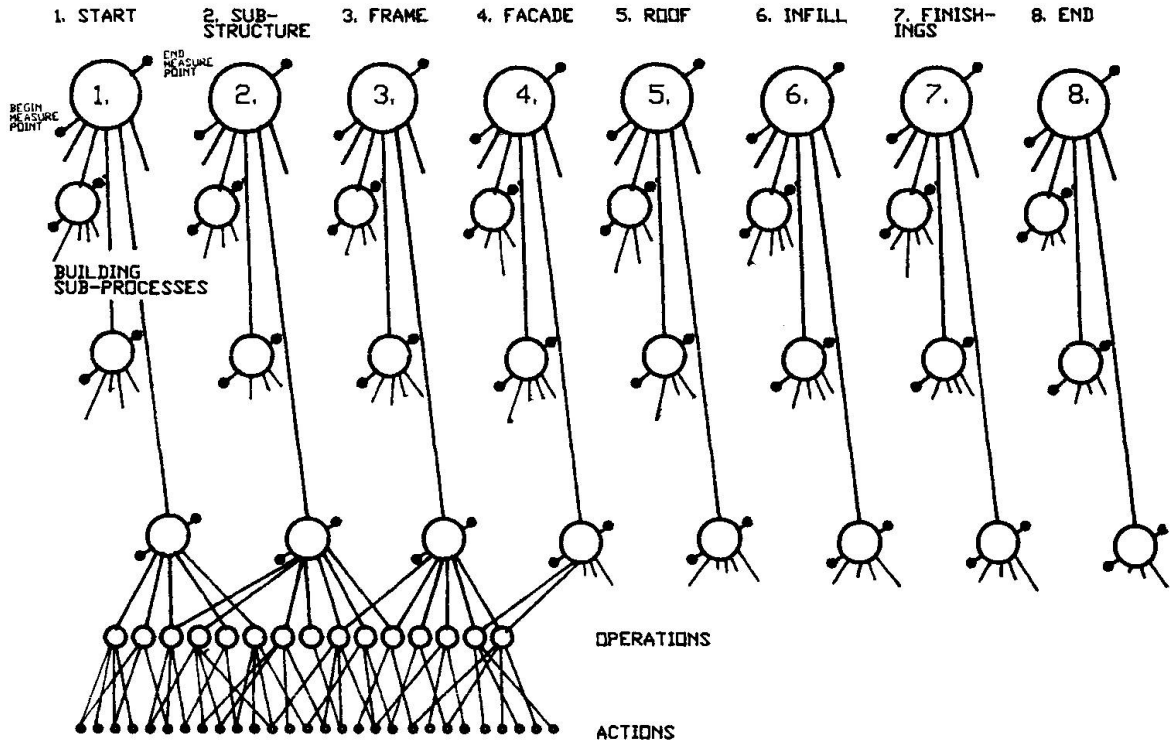

Fig. 5 Hierarchy of building processes

The level of sub-processes, is in practice the level for generating work-tasks. This will also be the level on which work preparation and execution are focused within this research project. This level will therefore be considered in more detail. The following information is required:

- Labour economical information coming from information on operations (standard data);
- Building technical information coming from the object to be realized (project dependent) and from the available techniques (contractor dependent);
- Building phase information dependent of the object to be realized (project dependent) and the available techniques (contractor dependent).

The time data of the actions are inclusive productive, indirect productive and improductive time: a nett time with allowances. Theoretically time data of operations can be built up from time data of actions. However most of these operations are complex and the usual tuning losses at this level are not included then. Most of the time data measured on site are at the operations level.

4.3 Grouping Technology

Each craftsman has a (limited) field of experience and expertise (carpentry, masonry etc.). Each piece of equipment has its own working characteristics. When we make a planning for example for a sub-process) the computer can optimize the composition of a gang by a clustering strategy and takes into account the various fields of expertise of the workers and the characteristics of the equipment. This can be worked out in two ways (i) bottom up and (ii) top down:
(i) Often sub-processes can be executed in different ways with different combinations of actions/operations. By analyzing at a low level the requirements (expertise, characteristics), the next higher level can generate a number of alternatives.
(ii) Actions/operations have a certain degree of relationship. Partly they have a number of the same movements and they may require the same skills, tools and equipment. By breaking down sub-processes the computer may try to combine those actions/operations which have a certain relationship. These combined actions/operations require common skills, tools and equipment. This can be the basis for the planning of gangs and individuals. The user can select one of the presented possibilities.

5. PTIS SYSTEM DEVELOPMENT

5.1 Introduction

A number of methods are available for the development of a computer based information processing system. The differences between these methods are essentially marginal. The applied method is developed by DeMarco- Yourdon [4] and is used by many multi- nationals. The characteristics of the method is the top-down analysis whereby a distinction has to be made between data and process [5]. Processes are indicated with bubbles; input- and output data flows with arrows relating the bubbles (Fig. 7).

For the development of the system it is required to interview contractors for their ideas on the output of PTIS: How do they want to use the system. The output descriptions will be the basis for the input organization.

5.2 System Component: Time Data

The ordering of data belonging to process time and process time variables, is in accordance with the ordering of building processes as shown in Fig. 5. The ordering of the time data within a building main process is similar to these process classes (Fig. 6):
- time data of a main process built up of time data of one or more sub processes;
- time data of a sub process consisting of time data of one or more operations;
- time data of an operation consisting of time data of one or more actions;
- time data of actions.

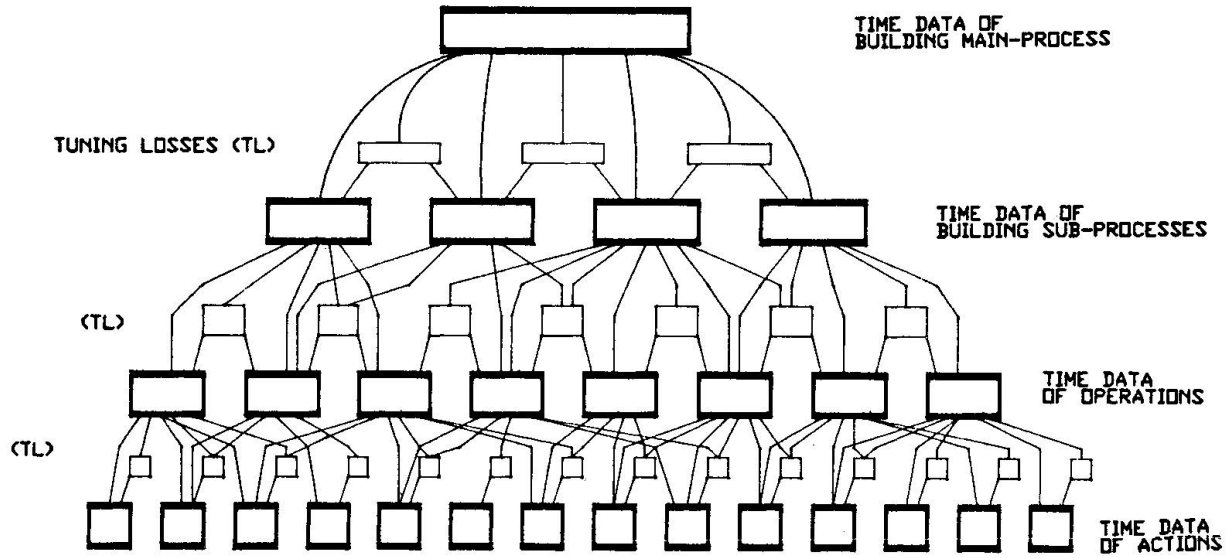

Fig. 6 The ordering of time within a building main-process

A first rough concept of the system requires the following data-bases:
- a data base of labour and equipment time. Based on information of action times and operation times;
- a data base with specific information of the company (time data etc.);
- a data base with information on recent projects.

A program can calculate all possible process time variations belonging to different methods of execution.

5.3 System Component: Processes

The lowest level of data (actions and also operations) is in principle manually loaded in the system and permanently stored in a data base. The data for a building process time at any level is generated through a procedure of information transforming activities. Hereby the lowest levels of data serve as the input for these activities.
The classes of information transforming activities are similar to the ordering of time data. The following process time data can be calculated for:
- operations based on time data of actions added with allowances;
- sub processes based on time data of operations added with tuning losses;
- main processes based on time data of sub processes and tuning losses;
- materialization phase based on time data of main processes, overlaps and tuning losses.

Fig. 7 shows in a schematic way these four levels of classes as analyzed with DeMarco - Yourdon method.

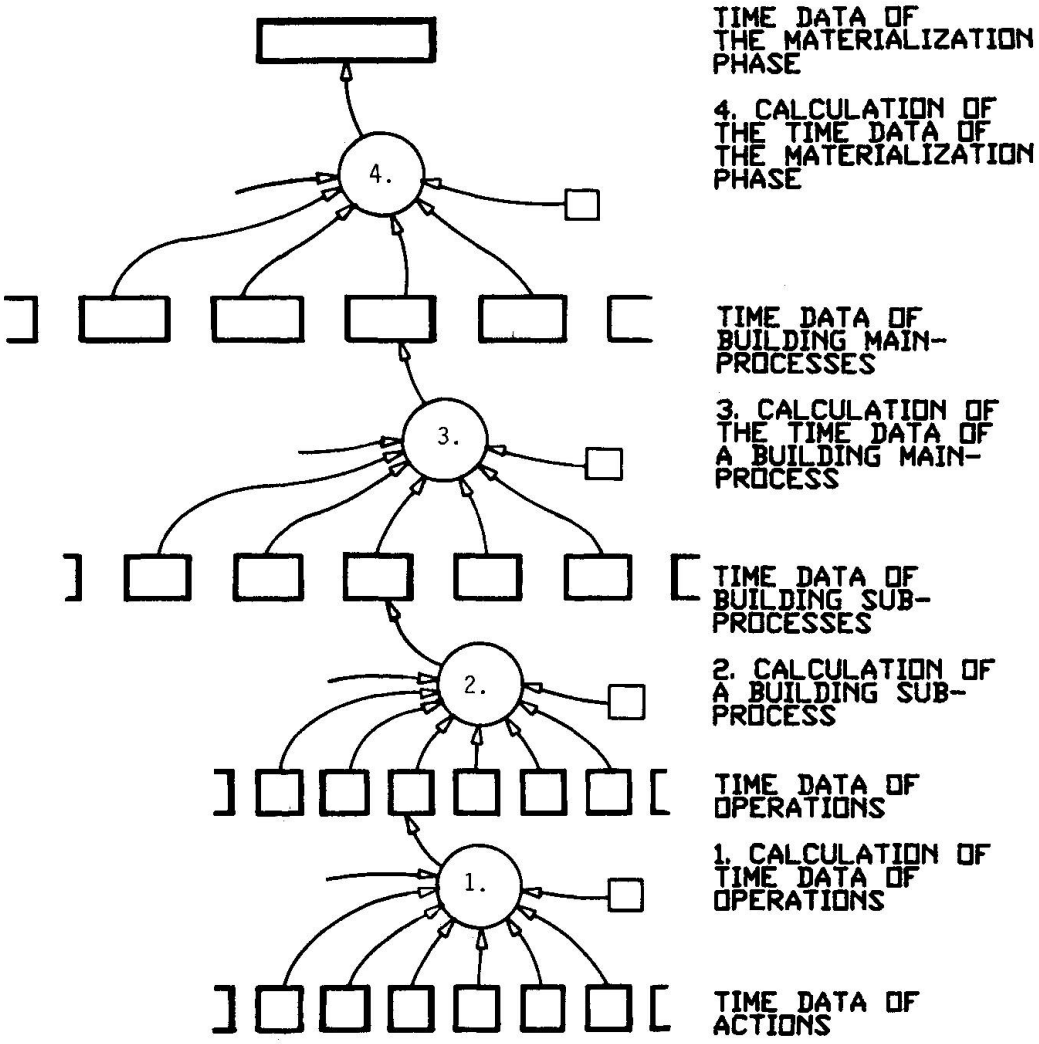

Fig. 7 Levels of classes of information

6. PRODUCTIVITY AND PTIS

Productivity in the building industry is an important area of research [1]. The definition for productivity is the ratio of output and input. Sofar no revolutionary ideas have come up. Production factors like men, money, machines and material can be expressed in terms of money, time or quantitities or related dimensions. The measurement of productivity and interpretation of ratios can be used as a management tool.
The determination of a process time can also be used as a tool for the determination of the productivity. We can think of the (single-)factor productivities like labour-, equipment- material-,capital-, and management productivity. The total productivity can be the total of the above. When we have calculated various process time possibilities for a building process the productivity of the applied production factors can be a yard stick for the selection of a process time variant.

7. HOW TO WORK WITH PTIS ?

At the highest level one is interested in a process time of a building main process or a sub-process time of the construction of a super-structure, a wall. For tendering purposes one may need a rough time schedule for the calculation of the time related cost. At the execution level one may be interested in time data for working plan schemes and for control of the project.

The work-planner makes an overall time plan with PTIS. The organizer/planner can make detailed plans and work schedules for the site: a rough planning 4 weeks ahead and a detailed plan 2 weeks ahead. When the contractor is introduced in an early stage of the project, the required planning is at a mile stone level: for main- or sub-process.
The selection of the type of planning is by means of a menu structured programme. The results can also be visualized on the screen in the form of schedules for labour, equipment, material, etc. Due to the interactive programme, it is possible to modify input at all levels and to ask for a calculation of the consequences.

8. RESULTS AND CONCLUSIONS

The results of this research are at this stage:
- a series of definitions for the labour economic aspects. Those definitions were not complete or very vague.
- a system design for a process time information system. The development of a steering programme to activate existing programme-modules as for example a network programme.
- a calculation method for process times for all the levels in the building process and for all types of construction.

Although this project has shown some fields which need further research, it will be feasible in the near future to develop a fully working PTIS. This can be extended with other programmes in the field of cost and quality. Also the designers can use this system for their preliminary considerations. They can get an indication of the time consequences of their design decisions.

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