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Applying the Chronographical Approach to the Modelling of Multi-storey Building Projects

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Abstract: Graphical scheduling methods are often considered to be one of the points of failure in the planning and monitoring of construction projects. The Chronographic Approach analyses the layout of the user interface in the spatial dimension and discusses the suitable visual parameters and their associated values. The main goal is to propose a visual graphical representation of the schedule. The present paper discusses the application of the Chronographical Approach to the modelling of multi-storey building projects and describes how the schedule information can be communicated using tabular and graphical interfaces. The proposed model is able to manage floors, specialities, data and constraints on different strata and show them either separately or combined using multiple sheets, sub-sheets, layers and tabs. The result is the presentation of the same project schedule through different compatible approaches. The planner has the ability to switch from one approach to another by changing the graphical parameters. Each approach can help to schedule a certain project type, show valuable information in a clear and comprehensible manner, visually facilitate the identification of problems, and assist the manager in solving problems of a variable nature while simultaneously simplifying site management.

1 Background

Current project scheduling methods seem to be unable, individually, to meet all of a project planner's needs. Each possesses its advantages and disadvantages.

Graphical approaches for non-repetitive projects have traditionally been scheduled using bar charts or networks. Bar charts feature many known weaknesses already discussed in numerous studies. Networks were originally developed to model non-time-scaled schedules, thus limiting their use in the construction planning domain.

Repetitive and linear graphical approaches provide work continuity for crews and resources. These methods are well-applied to horizontal linear projects, such as road projects, and easily allow progress variation rates through the Linear Scheduling Method (LSM) (Harris and Ioannou, 1998). However, their applications to repetitive or vertical projects present some limitations, such as the inability to graphically show task relationships and parallel activities.

Simulation techniques initiated by CYCLONE provide production-based linked structures for representing activity relationships and were used to simulate and optimize a repetitive cycle of construction operations. However, they can hardly represent complex project schedules, since they can show only a limited amount of information clearly, and are a non-time-scaled model.



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Planners must deal with various project types, and they are confronted with a variety of problems. Modelling information at different point of views and displaying them under numerous approaches seems to be appropriate as a decision-making tool. Many current scheduling methods are criticized because of the lack of compatibility between them. Therefore, a complete model, which could present information in different, compatible representations, is considered to be the optimal solution.

Practically, the majority of the most recent projects are represented graphically by a Bar Chart diagram which shows precedence dependencies among activities. However, the main concern with this process is the difficulty in reading the dependency lines, which are often very dense, cutting amongst themselves as well as crossing the activity lines. Consequently, project scheduling on a computer screen becomes a difficult task (Fisk and Reynolds 2010).

Numerous others weaknesses are also associated with commercial scheduling software. The majority of these programs are not intended for the planning of all types of projects, unlike the proposed graphical schedule which is global. These systems do not use other features to improve the visual clarity of the schedule, such as, for example, the use of multiple sheets, like spread sheets, and sub-sheets in order to manage project phases or lots separately; the entire project is presented only on one unique sheet. The software does not use multiple layers, as CAD does, in order to show or hide data and constraints on different layers. Furthermore, the software also applies a consistent time scale to the entire scheduling diagram and therefore does not allow the planner to define a variable time-scaled interval, in order to hide or decrease scale for unproductive phases, or to increase scale and focus on a selected period (Francis and Miresco 2006b).

A review of the recent literature shows that most of the scheduling work entails the optimization of construction operations and involves algorithmic methods. These methods are generally based on mathematical concepts and hardly involve site conditions. The use of simulations also requires comprehensive information, which is relatively complex especially for building projects. For this reason, reliable results cannot be easily obtained.

Research related to the modelling of construction operations based on a graphical approach has only been addressed in some specific cases, particularly for linear and repetitive projects, introducing site layout management to the project schedule, and for simulation techniques.

However, managers still face several problems related to the management of partial and heterogeneous data and the manipulation of information as a consequence of incomplete and incompatible methods and systems, and most surveys (Choo et al., 1999, Liberatore et al., 2001, Galloway, 2006) concerning scheduling methods, software or practice applications have shown that construction professionals continue to have an interest in developing better methods for planning and project control.

To that end, a schedule capable of providing a user-friendly tabular and graphical interface, able to easily structure project information, able to adapt to work in an interactive, changing environment, and accept productivity variation is necessary for everyone on the site, especially the foremen and superintendents.

This paper discusses the application of the Chronographical Approach for modelling multi-storey building projects and describes how the proposed tabular and graphical interface addresses these concerns. The goal is to help to schedule a certain project type, show valuable information in a clear and comprehensible manner, visually facilitate the identification of problems, and assist the manger in solving problems of a variable nature while simultaneously simplifying site management.



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2 The Chronographic Modelling Approach

The Chronographic Approach (Francis 2004 and 2013; Francis and Miresco 2006 and 2011) is a graphical scheduling method that is able to represent a multitude of planning approaches and provide a comprehensive visual appearance, along with a more adaptable representation of the project information. This method analyses the graphical representation of the schedule and proposes suitable visual parameters and approaches for scheduling each project type, for scheduling a certain speciality, for viewing the needed information or for solving a certain problem.

The Chronographic graphical parameters model the construction operation, establish constraints, and determine directions and scales. The approach uses five (5) graphical parameter types:

- 1- Physical Entities, which represent the production tools that simulate the construction operation;
- 2- Associative Entities, which indicate the dependencies between the Physical entities (for example, relational, hierarchical, grouping, layering, sheeting and attributing constraints);
- 3- Functional Entities, which characterise the Physical or Associative Entities and denote decisional or probability functions;
- 4- Scale Entities, which designate external or internal measuring units;
- 5- Directional Entities, which define the Cartesian axes for the graphical representation.

The Chronographic Approach can help the planner to model the information using different approaches. Each approach is constructed by assigning different parameters to the Physical, Associative, Functional, Directional, and Scale Entities.

The Chronographic Approach can help the planner to display the project schedule using multiple, compatible representations. The planner can switch between representations in order to verify the different constraints, for example, verify if more than one crew occupies the same work location at the same time.

Using a multitude of representations can help the planner to analyse the same project from many different angles, to present various project types, and show the required information in a form which is easy to interpret. With this multitude of approaches, the planner would be able to observe the same project from different angles.

3 Modelling Multi-storey Building Projects

3.1 Issues in the planning of multi-storey building projects

Multi-storey building projects are complex and involve many phases and specialities. Most of the project activities are carried out by subcontractors. As a result, the majority of project resources are assigned to subcontractors who are responsible for the planning and management of their work programs. Thus, the project planning complexity is generally related to the coordination of the subcontractors' work.



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The planners of multi-storey building projects also face many other difficulties such as avoiding conflicts of use within limited workspace, the organization of on-site traffic to avoid congestion, the supplying, handling, and storage of project materials, and waste management and recycling.

Despite this, most recent research and commercial software are mainly interested in the representation of the activity relationships and constraints and for optimizing and levelling the limited resources of the project, which only partially solves the real needs of the planners of multi-storey building projects.

In addition, trying to represent project planning through a single detailed traditional schedule on one layer and one sheet is considered a complex task. It is obvious that no designer would choose to view all the project specialties, plan views, sections and details on a single plan and a single layer. As mentioned above, the issue with existing planning methods is the difficulty in reading the dependency lines, which are often very dense, cutting between themselves and crossing activities lines. Consequently, project scheduling on a computer screen becomes a complex task.

3.2 The schedule module of a multi-storey building project

The present paper discusses the application of the Chronographical Approach to the modelling of multi-storey building projects. Figure 1 shows the schedule module of a multi-storey building project and describes how the schedule information can be communicated using tabular and graphical interfaces. The proposed model is able to manage floors, specialties, data and constraints on different strata and show them either separately or combined using multiple sheets, sub-sheets, layers and tabs.

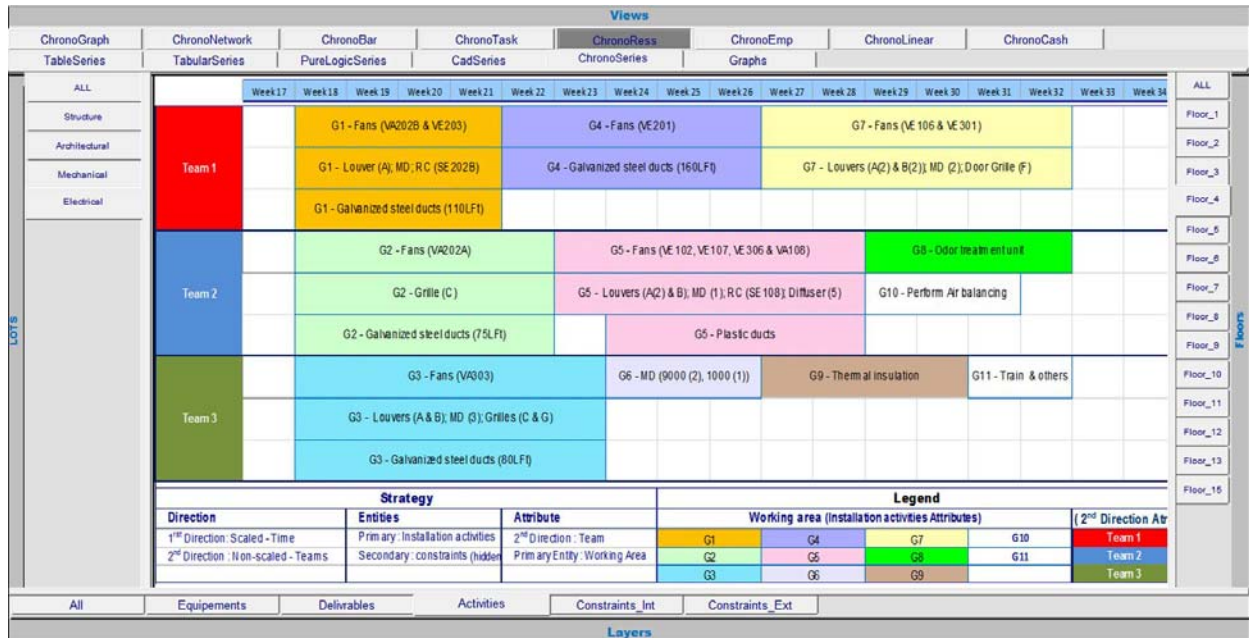


Figure 1: The schedule module of a multi-storey building project



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The module presented in Figure 1 uses multiple sheets, sub sheets, layers and tabs:

- The **Left Tab** manage specialities separately (Structural, Architectural, Mechanical, and Electrical work) or combined (more than one or All). Each speciality is presented on a different sheet. Sheets can also be composed of several sub-sheets (more levels will be permitted) that define the different lots. For example, the mechanical sheet can be detailed for to four (4) sub-sheets: Plumbing, Ventilation, Heating and Air-Conditioning.
- The **Right Tab** can show one or more floors separately or combined (Floor 1 to 15; All). Each floor is presented on a different sheet. Sheets can also be detailed into sub-sheets to define different zones.
- The **Upper Tab** shows six (6) different modelling strategies. The ChronoSeries strategy present eight (8) different approaches. Each presents the information using different and compatible angles in order to help the manager solve various problems, represent different types of projects, and allow the decision-maker to analyze the schedule according to his/her level of responsibility in the project.
- The **Lower Tab** uses multiple layers; in order to put data and constraints on different strata and show them separately or combined. The activities, and other constraints, are arranged on these layers according to the user's needs in order to help the manager improve the graphical visualization of the schedule.

3.3 The Chronographic layout for planning multi-storey building projects

The central part of Figure 1 shows the Chronographic Approach graphical planning for the project's mechanical works. This approach analyses the mechanical works schedule layout and proposes suitable visual parameters and their associated values. The main goal is to propose a visual graphical representation of the schedule.

To prepare the project schedule, we define the Physical, Associative, Functional, Scale and Directional Entities that simulate the construction operation.

The chosen approach uses two axes. The principal direction uses Weeks as scale. The second direction is grouped as a function of Teams. The activities are symbolized within the Physical Entity. The placement of these activities are presented in this figure with different colours.

Constraints (Functional Entities) among activities are not shown on this representation in order to improve visual clarity. These constraints are modelled on different hidden layers using the Lower Tab.

The Chronographical Approach can present the same project schedule through different compatible approaches. For each representation, the suitable modelling parameters (Physical Entity, Attributes, Directions or Scales) would be defined. The planner has the ability to switch from one approach to another by changing the graphical parameters. Each approach can help to schedule a certain project type, show valuable information in a clear and comprehensible manner, visually facilitate the identification of problems, and assist the manager in solving problems of a variable nature while simultaneously simplifying site management.



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Commercial software which use traditional scheduling, have difficulty in presenting graphical information clearly. These limitations include the non-optimal utilization of the graphical scheduling presentation area, the complexity of following the scheduling constraints on screen, the inability of the model to adapt to all types of projects and the utilization of activity as the only option for presenting the production scheduling tool.

Furthermore, the entire project is presented on one sheet as one entity and not as independent lots that are managed separately. Because of this, these systems do not use multiple sheets, such as spreadsheets. They also do not use multiple layers, like CAD, in order to show data and constraints on different layers and help the manager to improve the graphical visualizations of the schedule. The planner should, from the beginning of the project, detail all the activities in order to calculate with accuracy the critical path; not taken into consideration is the fact that each department, team or subcontractor must manage their respective activities within some objective of budget, duration and milestones in order to realize certain deliverables.

3.4 The proposed integrated scheduling system

The proposed project management system is based on an integrated approach that favours information sharing between different phases and functions. This integrity should not affect the flexibility and the adaptability of the system. In order to respond to these needs, the system is arranged as independent modules that can be connected to the project database.

Figure 2 demonstrates a proposed integrated scheduling system. The interface shows that the screen is split into five (5) independent modules.

The lower right module displays three layers: i) the lower layer shows the architectural plan for the repetitive floor; ii) the middle layer shows the particularity of the 4th floor; and iii) the upper layer divides the floor into different zones, each identified with a different color ;

- The two lower left modules show the overall S curves (planned, revised, actual and EV) and the schedule and cost performance index graphs ;
- The upper right module presents the summary table for the construction modifications and claims ; and
- The upper left module illustrates the schedule module of the multi-storey building project and presents the schedule approach shown in Figure 1. The schedule module presents an approach with two directions. The principal direction is scaled by Time. The second direction is grouped by teams. The activity attributes (color) identify different zones.



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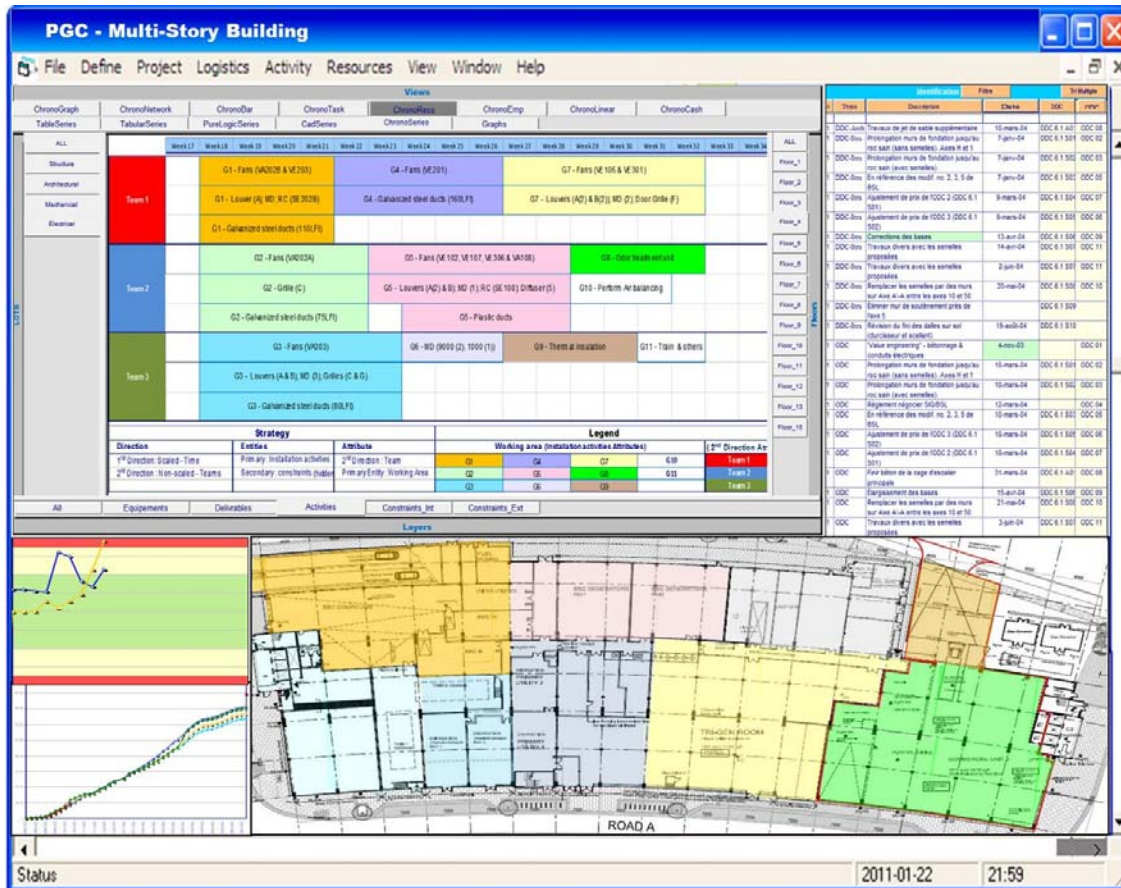


Figure 2: Proposed integrated scheduling system

The Chronographical Model permits the visualization of the project activities, resources, units, quantities, cost, and work space, through various graphical entities, attributes, directions and scales. This integrated schedule system permits the presentation of the project information using several graphical and tabular perspectives in the spatial dimension. The schedule can be modeled through different strategies, organized under levels of detail or using semantic zooming, optimizing the use of the presentation area. This model provides a user-friendly tabular and graphical interface which is able to structure project information, easily adjust in an interactive, changing environment, and accept productivity variation and the site conditions.

4. Conclusion

This paper discusses the application of the Chronographical Approach to the modelling of multi-storey building projects and describes how to address these concerns through the proposed tabular and graphical interface. The main concern is studying the modalities of information representation. The use of



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understandable visual communication methods will facilitate the sharing of information while helping to plan and control project activity, including the improvement of productivity, performance and effectiveness.

The research discusses several graphical perspectives which show the scheduling information in the spacial dimension and studies the representation of activities, resources, units, quantities, cost, and work space, through various graphical entities, attributes, directions and scales. Scheduling can be modeled through different strategies, organized under levels of detail or using semantic zooming, thus optimizing the use of the presentation area.

These advantages can help planners present valuable information in a clear and comprehensible manner, solve various problems, present a multitude of types of projects, phases or lots, and facilitate site management.

5. References

- Choo, H. J., Tommelein, I. D., Ballard, G. and Zabelle, T. R. 1999. Work plan: constraint-based database for work package scheduling. *Journal of Construction Engineering and Management*, ASCE, 125(3): 151-160.
- Fisk, R.E., and Reynolds, W.D. Construction projects administration. 9th edn. Prentice-Hall, N.J., 2010.
- Francis, A. 2004. *La méthode chronographique pour la planification des projets*. Thèse de doctorat (20), École de technologie supérieure, Montréal, Université du Québec.
- Francis, A. The Chronographical Approach for construction project modelling. *Management, Procurement and Law*, ICE, in print, 2013.
- Francis, A. and Miresco, E. 2006. Toward a new generation of project management software. *Icccbe '06'*, Montreal, Qc, Ca, 1: IC-553, 3558-3567.
- Francis, A. and Miresco, E.T. 2011. Improving the sharing of information on construction projects sites using a chronographical model. *CSCE '11'*, Ottawa, ON, CA, 1: CN-041, 1-8.
- Galloway, P. D. 2006. Survey of the construction industry relative to the use of CPM scheduling for construction projects. *Journal of Construction Engineering and Management*, ASCE, 132(7): 697-711.
- Harris, R. B. and Ioannou, P. G. 1998. Scheduling projects with repeating activities. *Journal of Construction Engineering and Management*, ASCE, 124(4): 269-278.
- Libratore, M., Pollack-Johnson, B. and Smith, C. 2001. Project management in construction: software use and research directions. *Journal of Construction Engineering and Management*, ASCE, 127(2): 101-107.