

Touch and Mobile Devices to Support Construction Process Management: Bachelor and Master Thesis

There are several factors that make process management in construction a challenging activity. Among these there are the needs to coordinate a number of different companies involved in the construction process, to manage a high number of tasks to be performed and to recover from the occurrence of unpredictable events (like bad weather conditions).

To satisfy these needs and to guarantee an high quality of the process execution, a group of researchers at the Fraunhofer Italia institute has developed the *PRECISE* methodology. This methodology, based on principles and techniques adopted in the manufacturing industry, foresees three phases:

1. *modeling* of the process in terms of tasks to be executed, precedence dependences among them and resources needed;
2. daily/weekly *scheduling* of the activities to be performed on-site, supplying details on where to perform them and who will execute them;
3. *monitoring* of the actual progress on-site, to be compared with the scheduling.

The three phases are tightly connected one another: the scheduling needs to be performed according to what is defined in the process model; the process monitoring is important to align the scheduling with the actual progress of the work on-site and to understand whether the project deadlines can be met.

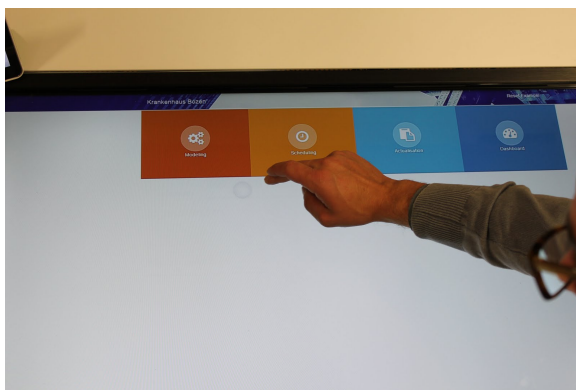


Figure a. Process management on a touch table

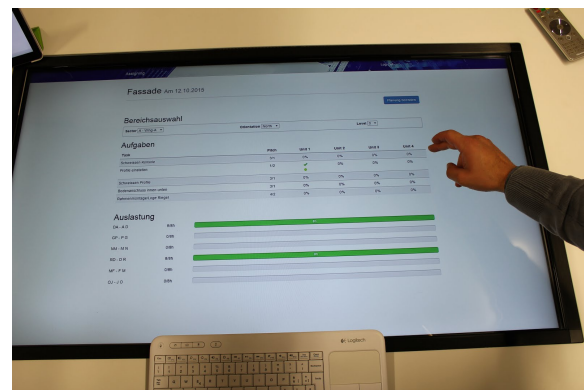


Figure b. Daily scheduling performed on a touch table

In the context of a running collaboration and a running project between the Fraunhofer centre and the Faculties of Computer Science and Science and Technology of the Free University of

Bozen-Bolzano, we are proposing bachelor and master thesis with the aim of developing IT tools to support the application of the PRECISE methodology. In particular, we want to develop a web application that is able to support all of the three phases of the methodology. The application should be accessible both with "traditional devices" (e.g. laptops) and with touch and mobile devices (e.g. touch tables, tablets, phones). In this context, a set of requirements have been already collected and preliminary prototypes for supporting the process modeling and scheduling phases have been developed and tested on a digital touch table (see Figures *a* and *b* above).

Below we list proposals for bachelor and master thesis. Students are also encouraged to propose different ideas they would be interested to work on. The activity will be carried on with the support and collaboration of the researchers working in this area. The developed solutions will be tested on a digital touch table (as in the pictures above) and, in accordance with the progress of the running projects and the time needed to develop the thesis, they might be tested on-site on real construction processes.

Topics of interest.

Process modeling.

- **[Bachelor Thesis]** The PRECISE methodology foresees a graphical language for process modeling. This has been tested in actual construction processes but without the use of IT support. We are looking for a student that implements a module of the web application that allows one to draw process diagrams, store and reuse them.

Together with the supervisors, an interested student will: *i*) understand the requirements for the development of such a module; *ii*) define a possible interface that aims at maximizing usability by non IT-experts; *iii*) implement a demonstrator using technologies such as JavaScript, jQuery.

Further extension could be the definition of composite tasks, i.e. tasks which are defined in terms of subtasks and dependences among them. In this case, the interface would need to allow a user to zoom into a composite task to define and visualize the subtasks it is composed of.

- **[Bachelor Thesis]** Existing tools for process scheduling allow one to have a graphical representation of the building. This allows a user to select the construction area where a task needs to be performed, directly on the graphical representation. Additionally, once a scheduling is defined, many tools support a graphical simulation of the construction process of the building.

We are interested in understanding how the representation of the construction areas we are currently adopting, can be used and extended to make it compatible with those adopted with these tools.

An interested student will *i)* understand the format used by these tools; *ii)* investigate how the representation of the construction areas we are using can be extended so as to be used in one of these tools; *iii)* understand how this tool can be used with our representation of a scheduling so as to simulate the construction process.

- **[Master Thesis]** A process model foresees a number of tasks, related one another by precedence constraints (e.g. painting should be done before the installation of window frames). These constraints should then be satisfied by a process scheduling. Researchers from the Faculties of Computer Science are now investigating how to check the compliance of a process scheduling represented as a Gantt Chart, with respect to a process model. In this context, we are looking for a master student interested in developing further and implementing the compliance check. Further extension may be the development of the satisfiability check, that aims at determining whether, given a process model, there exists a possible scheduling that satisfies all the constraints. Additionally, an interested student may investigate the same problems on other representation for the scheduling, like the flowline charts.

Process scheduling.

- **[Bachelor Thesis]** Activities to be performed on site are scheduled on a daily or weekly base. A scheduling consists in defining the tasks to be performed, the location and a crew of workers to perform it. We developed a first prototype supporting some basic functionalities and we are now looking for a student that can further develop it. In particular, in a process model the tasks are related by precedence dependences. A warning message should inform the user when he is scheduling a task whose predecessors from the process model are not all completed yet. Additionally, we are interested in developing the following functionalities: export/import of a scheduling into a suitable format (e.g. csv or Gantt charts), edit and delete of an existing scheduling, possibility to undo changes.

An interested student will: *i)* familiarize with the existing prototype; *ii)* define with the supervisors possible improvements and how to implement the possible extensions; *iii)* implement the changes and possibly *iv)* test the usability of the developed application with construction companies or on real construction projects.

- **[Master Thesis]** Currently the scheduling of the activities to be performed on-site is a manual activity that is performed by relying on the experience of the project manager or the foreman on-site. We are interested in developing and implementing algorithms for the automatic generation of possible schedules starting from a process modeling. Together with the supervisors, an interested student will: *i)* understand the information coming from the process model (such as set of tasks, costs, duration of a task, dependences among the tasks); *ii)* understand the requirements that a scheduling that is generated automatically should satisfy, such as which are the aspects that a scheduling

should optimize (e.g. minimize costs and duration); *iii*) investigate existing techniques for planning and process optimization; *iv*) define and implement a possible algorithm for the generation of the schedules.

Process Monitoring.

- **[Bachelor Thesis]** Monitoring of the work on-site is important in construction processes to understand whether the project is running on time and whether the established deadlines can be met.

We are interested in developing a module of the web application that allows worker on site to mark a task as completed. In particular, we are interested in developing an interface that can be used with mobile devices, such as phones, that better suit this use on the construction site.

With the support of the supervisors, an interested student will *i*) identify the requirements for process monitoring; *ii*) design a suitable interface to be used with mobile devices; *iii*) implement a demonstrator.

A further extension would be the introduction of QR codes to support the process monitoring. The idea would be to use QR codes to ease the definition of completed tasks or completed areas on-site. Additionally, the interface could be extended to allow workers to point out possible problems on-site (e.g. to point out that a window has not been installed correctly and thus it needs to be fixed). Potentially, also in this case QR codes can be used.

- **[Master Thesis]** Delays in construction processes always result in budget overruns. For this reason, it is important to establish intermediate milestones and to monitor the progress of the work with respect to those. We are looking for a student to identify possible ways to represent milestones in construction processes and to understand whether a defined schedule will allow to meet them.

An interested student will: *i*) investigate existing techniques currently adopted in process management such as the CPM (Critical Path Method); *ii*) identify possible ways for representing deadlines in the existing representation for process modeling and scheduling; *iii*) investigate how to determine whether, given a snapshot of the current progress of the work, a deadline can be met or not.

Reference people: We invite all interested students to contact

Dr. Elisa Marengo, Prof. Werner Nutt (email: name.surname@unibz.it)

to further discuss thesis topics.

Requirements: Java Programming skills.