Engineering Management Methods BMEVITMAK47
Electrical Engineering BSc and MSc Major
Computer Engineering BSc and MSc Major

Projectmanagement

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Definitions of project

- A project is a *temporary endeavor* with a *defined beginning and end* (usually time-constrained and often constrained by funding or products). /Harrison, 1993/
- A project can be defined as a *temporary endeavor* undertaken *to create a unique product or service*. /Stuckenbruck, 1993/

- *Project is a **unique process** consisting of a **set of coordinated and controlled activities** with **start and finish dates**, undertaken **to achieve an objective** conforming to specific requirements including **constraints of time, cost and resources**. /ISO 8402, 1994/*

A project

- For well-defined and documented *objectives (outputs)*;
- Has *influence on the resource portfolio* of the company;
- Utilizes (limited) *resources*;
- Causes *changes* in its environment;
- Not „daily routine” in the life of a company;
- *Unique* (probably never repeated);
- Has *given starting and ending dates*;
- Usually it is *late* to start,
- Often needs *new methodology* and technology;
- Well documented procedure.

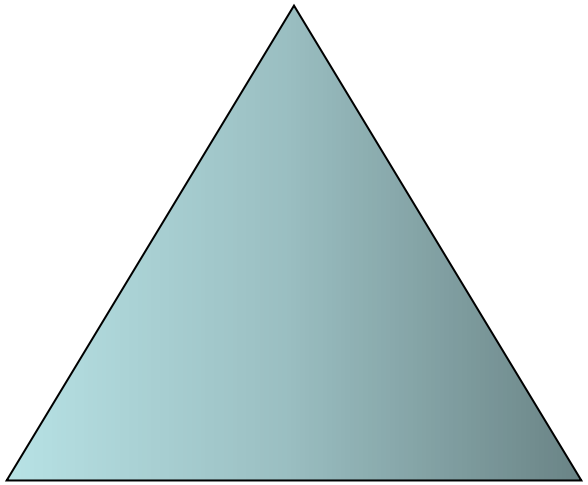
Resources of a project

A project is a set of activities utilizing **resources**:

- time,
- money,
- manpower (knowledge, experience),
- material,
- energy,
- place
- …

Project triangle

Scope (objectives, quality)



Time

Money

Items of project triangle

- **Scope:** requirements specified to achieve the final result (output). The overall definition of what the project is supposed to accomplish and a specific description of what the final result should be or accomplish.
  - **SMART** model: the aim should be **s**pecific, **m**easurable, **a**ttractive, **r**eal and **t**imed.
  - there are some crucial **success criteria** among others.

- **Time:** required to produce the outputs (products or services). It is estimated using several techniques. One method is to identify tasks needed to produce the outputs documented in the **work breakdown structure** (**WBS,** see later).

- **Money:** to cover (buy) fixed and variable amounts of other resources

From where do we have projects?

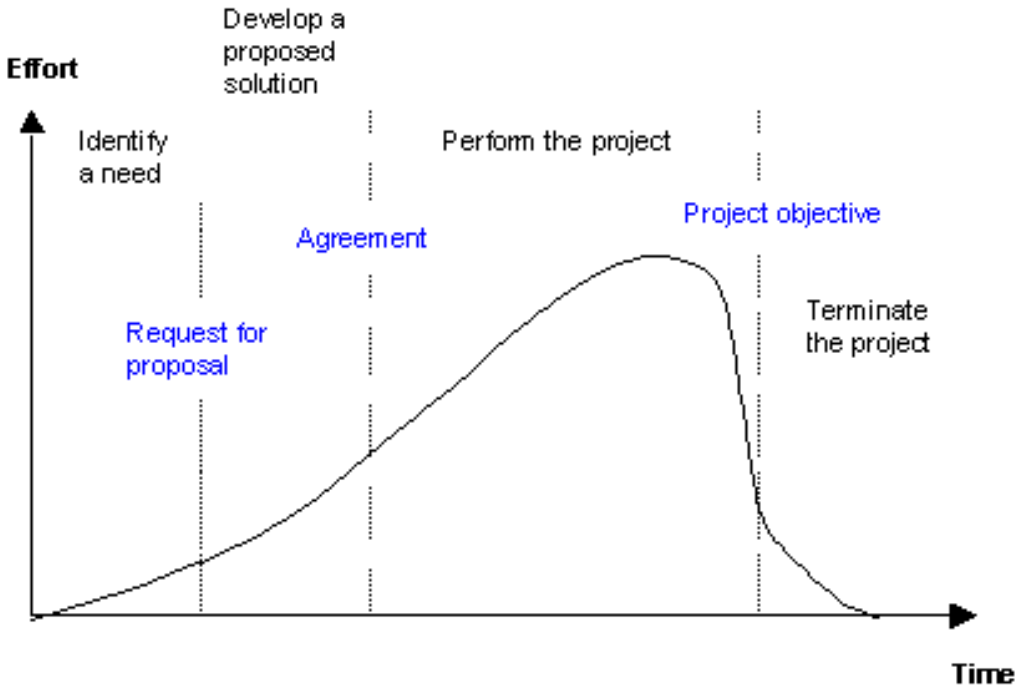
- Top - down: derived from strategy
- Bottom - up: development initiatives from the employees
- Out of the company:
  - from business partners,
  - obligation, charge laid by law, authority,
  - constraint by the environment.
- …

Project types

- PRODUCT DEVELOPMENT AND MANUFACTURING (if unique)
  - real estate development
  - machine manufacturing
  - service development
- ORGANIZATION, MANAGEMENT
  - functional planning
  - realignment
  - software installation
- RESEARCH, IMPLEMENTATION
  - fundamental research
  - applied research

Steps of projectmanagement

- Identify a need and/or purpose
- Develop the plan
- Perform and control the project
- Terminate the project



Approaches to manage projects

- **Traditional approach:** **five „classical" components** of a project can be distinguished (four phases plus control): initiation, planning, execution, completion and monitoring (control).
- **RUP method:** Rational Unified Process (RUP) is an **iterative software development process framework** created by the Rational Software Corporation, a division of IBM.
- **Gantt Diagram:** time planning technique for simple projects.
- **Network Planning Techniques (CPM, PERT):** time planning techniques for more complex projects.
- **Critical chain project management (CCPM):** method of planning and managing project execution **considering the limited availability of resources** (physical, human skills, as well as management and support capacity) needed to execute the project. Useful for **multi-project management** with resource leveling.

Determination of aim

1. Determination of problem definitely
2. Technical and functional goals definitely
3. Expected efficiency and economical results definitely
4. Requirements of final and quality parameters definitely
5. Resource demand and restrictions definitely
6. Risk factors definitely
7. Assumptions; starting points optional

OUTPUT: feasibility studies, document of project foundation

Planning a project

- **Determination of work breakdown structure (WBS)**
  - broken down into tasks
  - calculation the time requirements of tasks
  - determination the order of tasks
- **Time planning (schedule)**
  - calculation the time parameters of activities (start, finish, spare time)
  - estimation the shortest time possible to complete the project
- **Resource planning**
  - resource inventory
  - determination the resource necessities of activities
  - resource allocation (necessities and capacities, resource leveling)
- **Cost planning**
- **Quality and risk planning**
- **Communication and security planning**

OUTPUT: project plan

WBS: work breakdown structure

WBS is developed by starting with the final objective and **successively** subdividing it into manageable components in terms of **size**, **duration**, and **responsibility** (e.g., systems, subsystems, components, tasks, subtasks, and work packages) which include all steps necessary to achieve the objective.

Levels of WBS:

- project
- main tasks of the project
- tasks of the main tasks (subtasks)
- activities
- ...

Interdependence - relationships among activities

1. Spreading

- activities use same resource(s)
- an error occuring in one of the activities can influence other ones using common resource(s)

2. Sequential

- an activity **depends** on another one
- two types: **simple** and **overlapping**
  - **a)** **simple**: first activity should be finished to start the second one
  - **b)** **overlapping** : it is enough to execute only a part of the first activity to start the second one

3. Reciprocal

- Solution (execution) of a task is iterated among participants until the end of the project.

  e.g.: negotiation between the customer and supplier

Time planning techniques – Gantt-diagram

Advantage:

- schedule is in a clearly arranged form

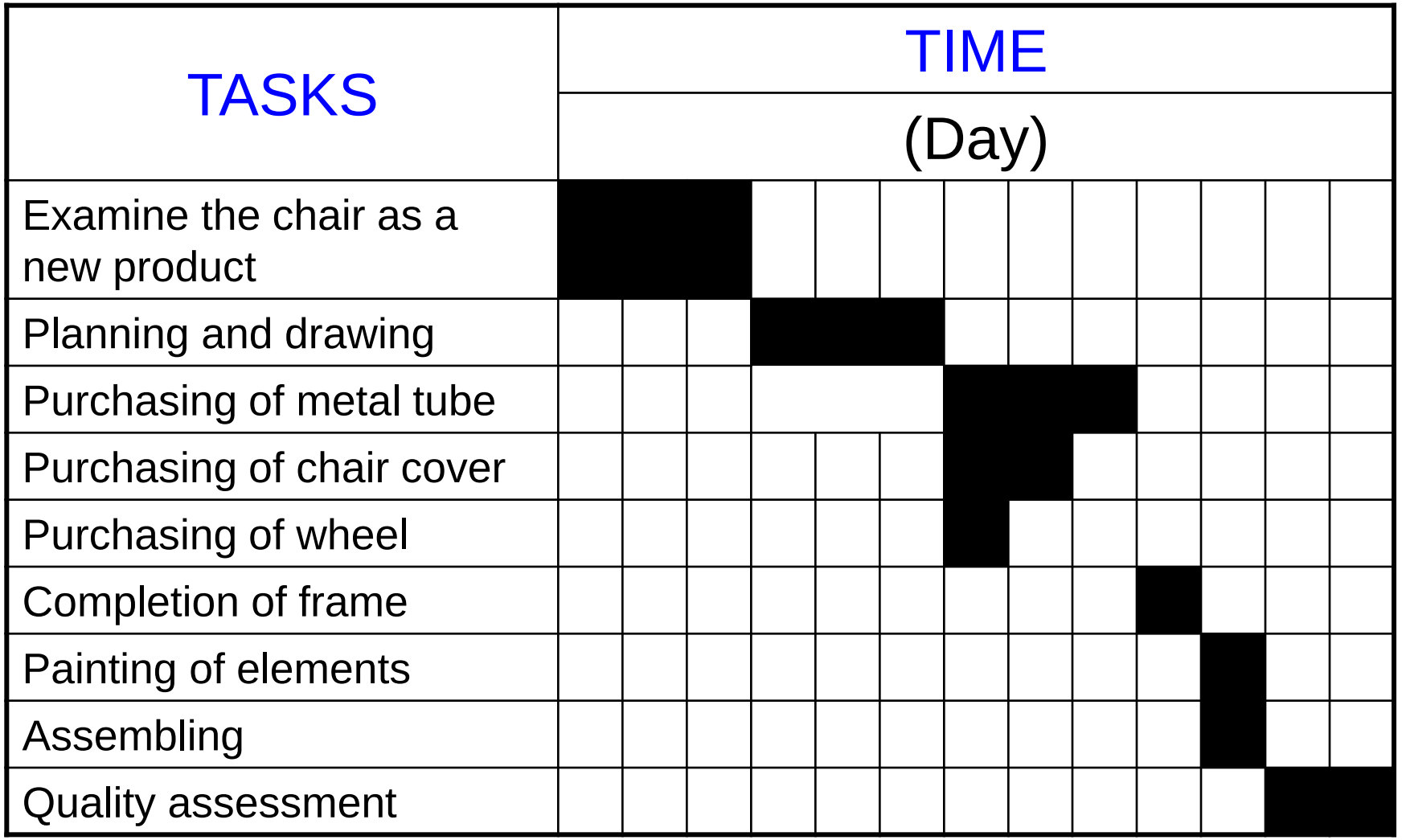
Disadvantages:

- in complex projects of too many activities can be chaotic (not transparent enough)
- relationships can not be clear

Elimination of disadvantages:

- plotting of dependence arrows

Gantt-diagram



Time planning techniques – Network planning

- Essential part is the network diagram in which the **tasks** and **their internal relationships** can be seen.

- Two classical methods:
  - **CPM** (Critical Path Method): the time parameters are fixed (deterministic method)
  - **PERT** (Program Evaluation and Review Technique): the time parameters come from probability distribution (stochastic method)

Steps of CPM 1/2

1. **Identification of tasks**

   (lists of tasks, subtasks and activities)
2. **Determination of predecessor/successor (logical) relationship among tasks**

   (identification of relationships and visualization)
3. **Determination of time parameters of activities**
   - early start time (ES)
   - early finish time (EF)
   - late start time (LS)
   - late finish time (LF)

Steps of CPM 2/2

4. Determination of critical path

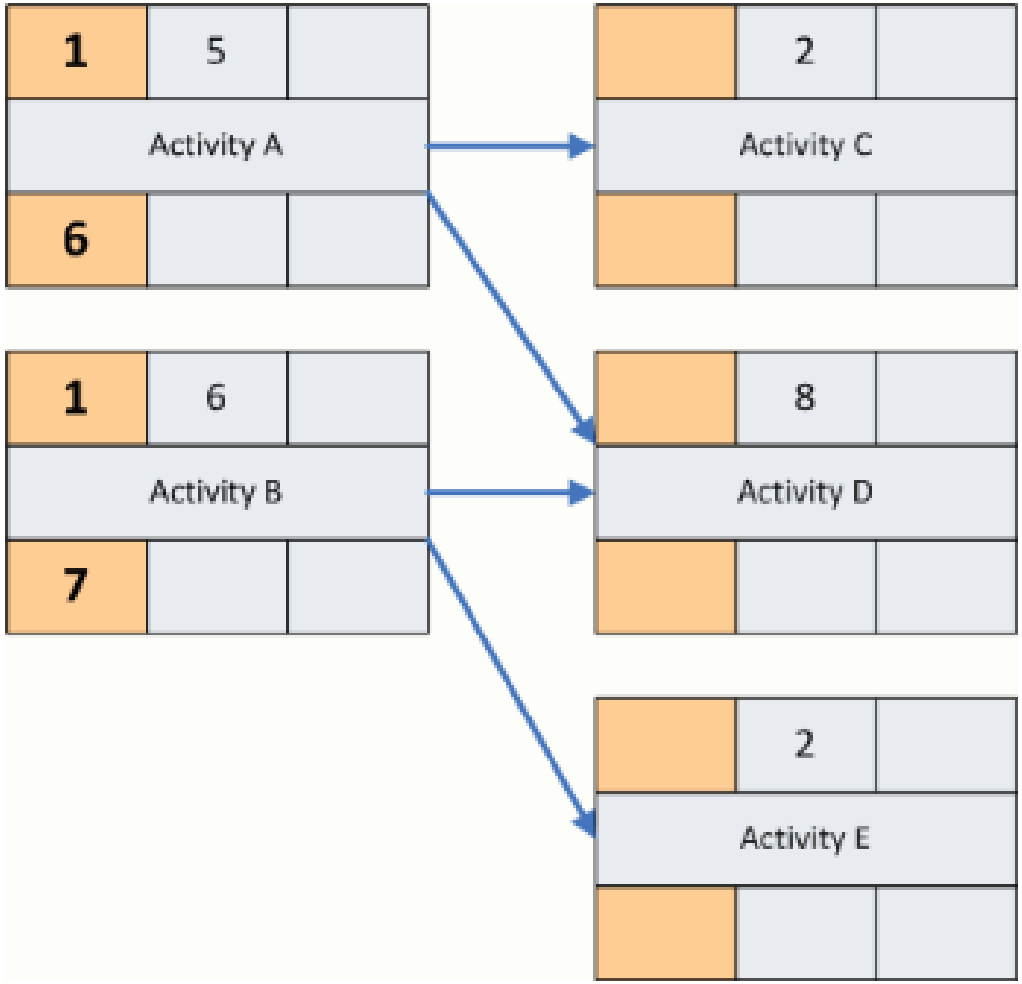
- **critical path:** the longest possible continuous pathway (consisting of critical activities) from the initial event to the terminal one. It determines the total calendar time required for the project.
- **critical activity:** an activity whose total floating time is zero.
- **total floating time (TFT) *(or slack)*:** the amount of time by which a project task can be delayed without causing a delay in any subsequent tasks (free floating time) or the whole project.
- **free floating time:** there is no critical delay

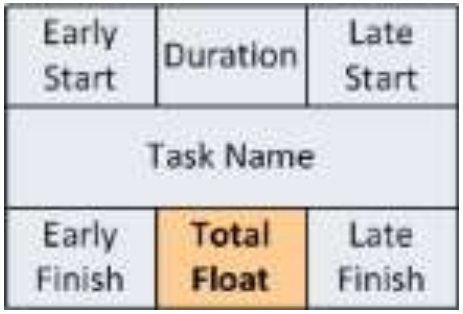
Determination of critical path

Steps:

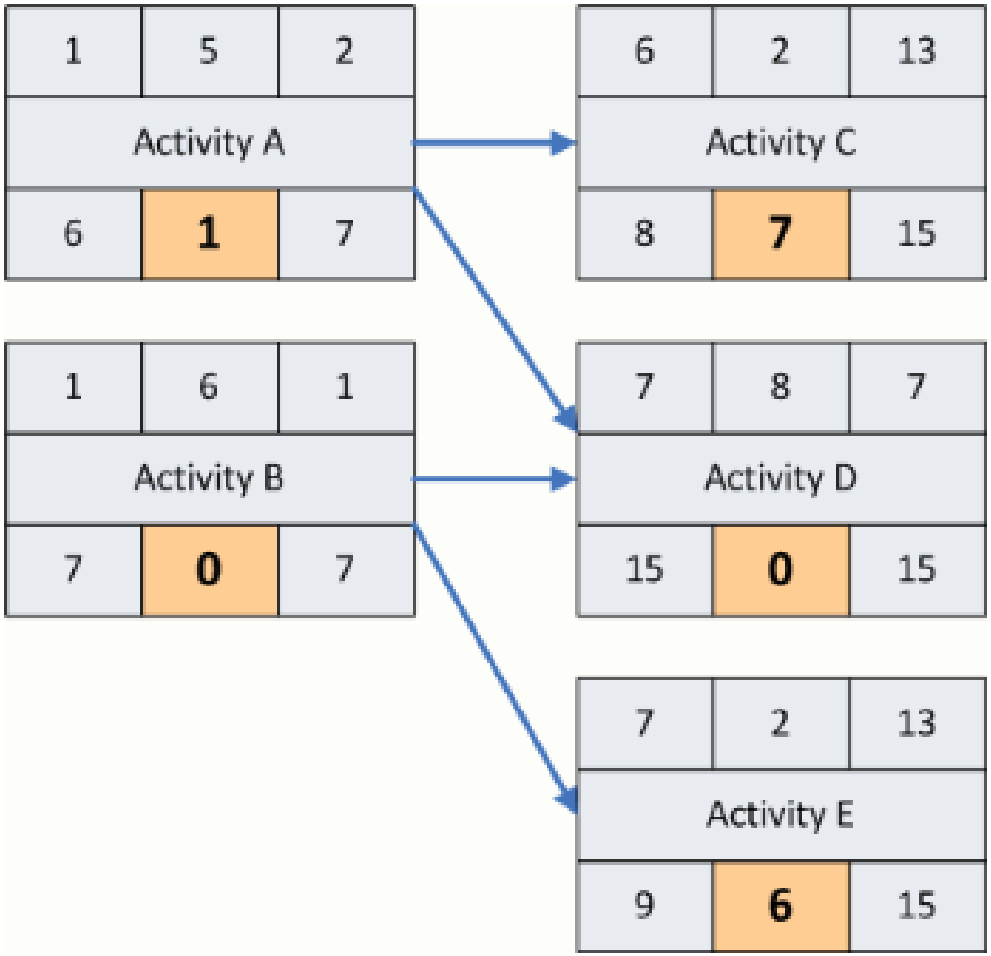
1. Determination of ES, EF, LS, LF values of activities
2. Calculation of total floating time of each activity TFT = LS – ES; TFT = LF – EF
3. Joining the critical activities we can get the critical path

Determination of critical path: EXAMPLE





Determination of critical path: EXAMPLE (Solution)



Early Start	Duration	Late Start
Task Name		
Early Finish	**Total Float**	Late Finish

Shortening of critical path 1/2

- **More (human) resources for critical activities:**
  - more own human resource (more people),
  - lease-work,
  - overtime,
  - more tools (eg.: IT) to replace human resource.

Shortening of critical path 2/2

- **Move resources** from non-critical activities to critical ones.
- **Change the project network** introducing:
  - parallel activities,
  - overlapping the activities on the critical path.
- Focus on **earliest** and **longest** activities.

PERT

- Similar to CPM
- If the duration of the activities cannot be determined because of random (uncertain) factors.
- Two requirements for the use:
  - **duration** of the activities should be *independent random variables*
  - **expected values** and **standard deviations** of *independent random variables* should be well estimated

PERT

Estimations:

1. **optimistic time** (t_o): the minimum possible time required to accomplish a task, assuming everything proceeds better than is normally expected
2. **most likely time** (t_m): the best estimate of the time required to accomplish a task, assuming everything proceeds normally.
3. **pessimistic time** (t_p): the maximum possible time required to accomplish a task, assuming everything goes wrong (but excluding major catastrophes).

Calculation:

$$t_e = \frac{t_o + 4t_m + t_p}{6} \quad \text{and} \quad \mathrm{v} = \left(\frac{t_p - t_o}{6} \right)^2$$

t_e = expected time; the best estimate of the time required to accomplish a task

v = variance of time

Cost management

Methods and tools to accomplish the project in the predetermined cost plan.

Elements:

1. Resource planning
2. Cost estimation
3. Budget calculation
4. Cost verification

Resource planning

- Determination of **resources** (human, tool, equipment, material) and their **quantity** and **quality** for the project.
- Required:
  - WBS – resource usage
  - A priori information – experience
  - Intent declaration – aim of the project
  - List of resources – real demand
  - Policy in organization – human resources and tools
  - When are the resources available?

Planning the load of resources

- The resource allocation is a distribution involving eg. **manpower**. In resource loading each employee is assigned to a task in a percentage of a project (x% of the whole).
- The **total load of resource** is the summary of resources in all parallel activities.

Steps of resource planning

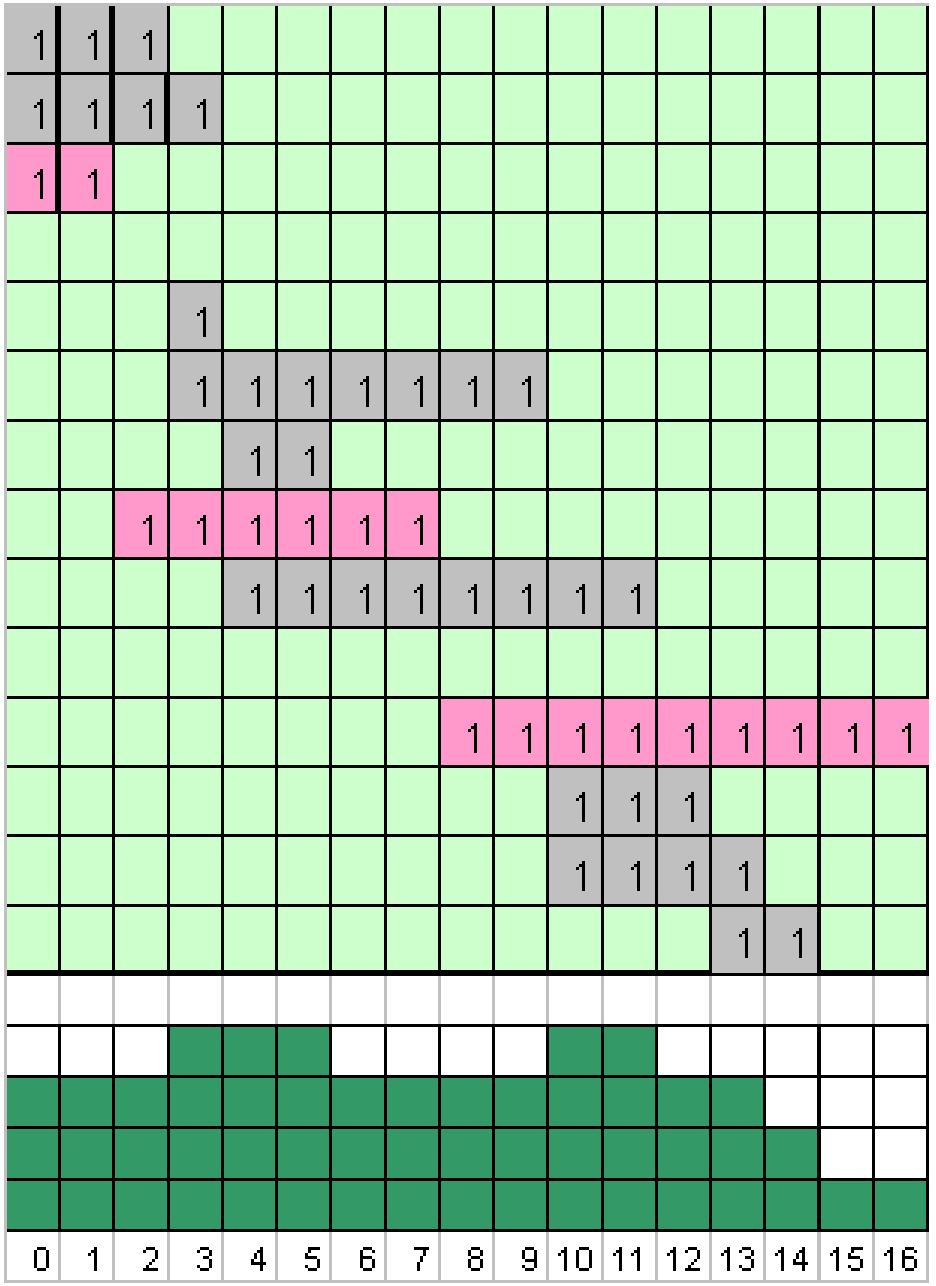
- **For each activity:**
  - gathering the resources into **resource inventory.**
  - determining the **resource needs** (norms)
- **For each resource:**
  - investigation of the **cumulative resource demands** as a function of time
  - use of **resource leveling** if required
    - exploitation of free float
    - modification of norms
    - more delay (modification of original time schedule)

Resource allocation

- How to manage the resources of the project?
- What is the resource need in function of time during the project?
- What should be done when the demand exceeds our capacities?
- „Time is money”. Why?
  - more salaries
  - indemnity (extra fee, penalty)
  - worse deals
  - consequences of damages

Resource allocation

- Each activity starts at earliest time in the Gantt diagram.
- The dark green diagram shows the *cumulative demands* of the concerned resource as a function of time.
- **Resource leveling** in case of limited capacity



Expected software (IT) functionalities to support projectmanagement

- **All calculation** from the basic data
- Flexible **activity modeling**
- **Results** visualized **in several aspects**
- Software **recalculates** output online after any modification
- **Calendar, work schedule** for resources
- Automatic or manual **resource leveling**
- **Comparison** between plan and reality (for controlling purpose)
- Relationship to **other projects** (for multiproject management purpose)

Risk analysis

Assessment of

- probabilities of problems (risks, dangers) and
- effects of problems to the project.

Assessment starts with problem recognition, identification and classification.

Action plan:

- how to prevent from risks,
- what to do if something wrong happens (BRP, BCP)

Scopes of project controlling

- Scope of the project
- (Time) Schedule
- Resource usage
- Costs
- Risks

Steps of project controlling

- **Monitoring**: collecting information from actual project status.
- **Comparison** of actual state with the original plan.
- **Difference analysis**: the aim is to reveal and explore the effects and causes of the difference.
- **Determination of interventions**: the aim is to decrease the difference.
- **Revision of plan**: the original plan should be revised if necessary.

Closing of project

- Looking at the final project data.
- The project team should **verify** whether terminating criteria and indicators of success factors are achieved.
- The **aim** of projectmanagement is to develop and improve the enterprise or organization via **successful projects** serving **satisfied clients**.