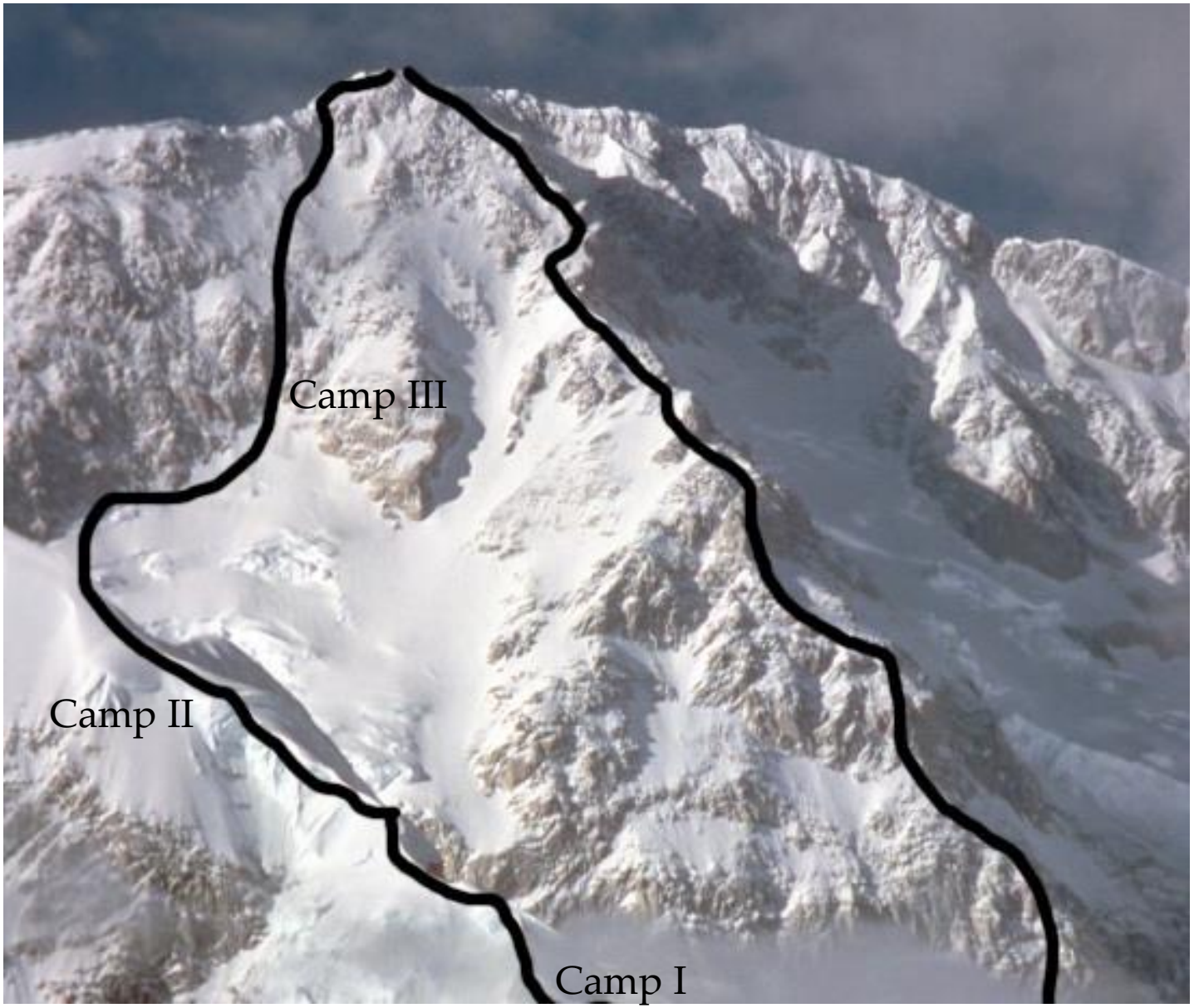
14.2 Work Breakdown Structures



What is the problem?

- Your boss: “How long will this take?”
- You: “Between 1 and 6 months.”
- People are not happy when you respond that way.
  - **You figure out that finishing anytime before six months will meet your promise.**
  - **Your boss figures that with some hard work you can be done in a month!**
- In reality, you don’t have the slightest clue how long it will take, because you don’t know the work to be done.
- Solution: Use divide and conquer
  - **To give a good answer you have to break the work down into activities for which you can get good timing estimates**
  - **From these estimates you compute the estimated project duration**

Activities to obtain good time estimates

- Identify the work that needs to be done
  - **Work breakdown structure (WBS)**
- Identify the dependency between work units
  - **Dependency Graph**
- Estimate the duration of the work to be done
  - **Schedule**

(From last lecture) Let's Build a House

- What are the activities that are needed to build a house?

1) Identify the work to be done: Work Breakdown Structure

- Surveying
- Excavation
- Request Permits
- Buy Material
- Lay foundation
- Build Outside Wall
- Install Exterior Plumbing
- Install Exterior Electrical
- Install Interior Plumbing
- Install Interior Electrical
- Install Wallboard
- Paint Interior
- Install Interior Doors
- Install Floor
- Install Roof
- Install Exterior Doors
- Paint Exterior
- Install Exterior Siding
- Buy Pizza

Finding these activities is a brainstorming activity.
It requires similar activities used during requirements engineering and analysis (use case modeling)

2) *Hierarchically organize the activities*

- Building the house consists of
  - **Prepare the building site**
  - **Building the Exterior**
  - **Building the Interior**

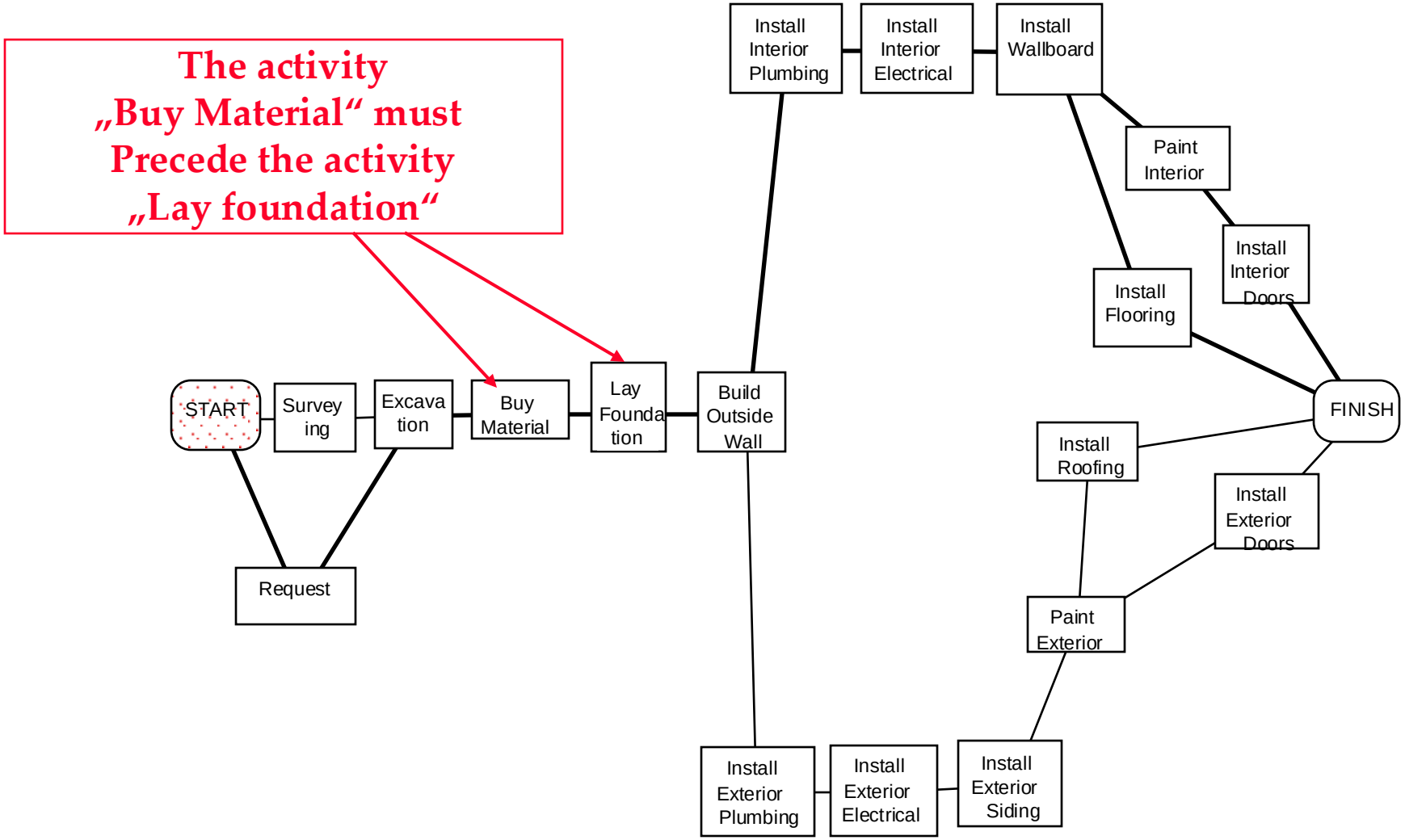
- Preparing the building site consists of
  - **Surveying**
  - **Excavation**
  - **Buying of material**
  - **Laying of the foundation**
  - **Requesting permits**
- …

Finding this organization involves categorization and refinement. Good after brainstorming, not during brainstorming

3) Identify dependencies between tasks

- **The work breakdown structure does not show any dependence among the activities/tasks**
  - Can we excavate before getting the permit?
  - How much time does the whole project need if I know the individual times?
    - What can be done in parallel?
  - Are there any critical actitivites, that can slow down the project significantly?
- **Dependencies like these are shown in the dependency graph**
  - **Nodes are activities**
  - **Lines represent temporal dependencies**

Building a House (Dependency Graph)

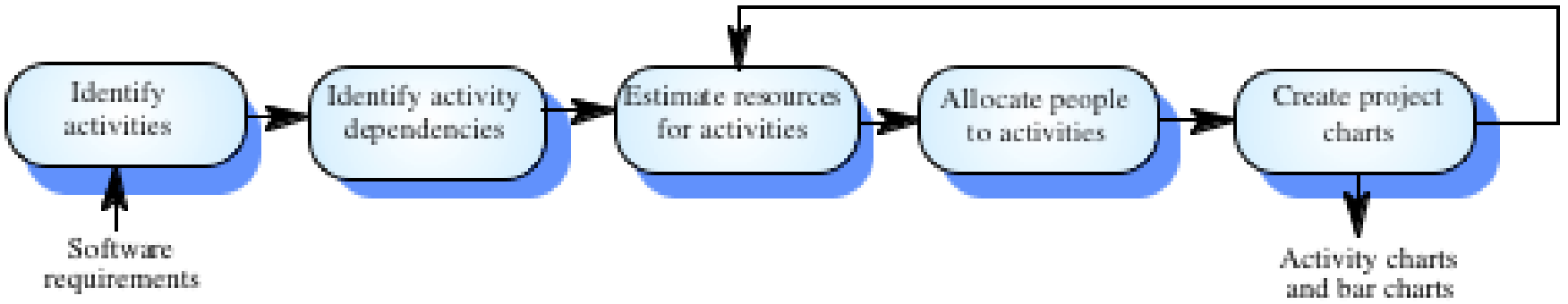


4) Map tasks onto time

- **Estimate starting times and durations for each of the activities in the dependency graph**
- **Compute the longest path through the graph: This is the estimated duration of your project**

How do we get good estimate times?

- **Estimation of starting times and durations is crucial for setting up a plan.**



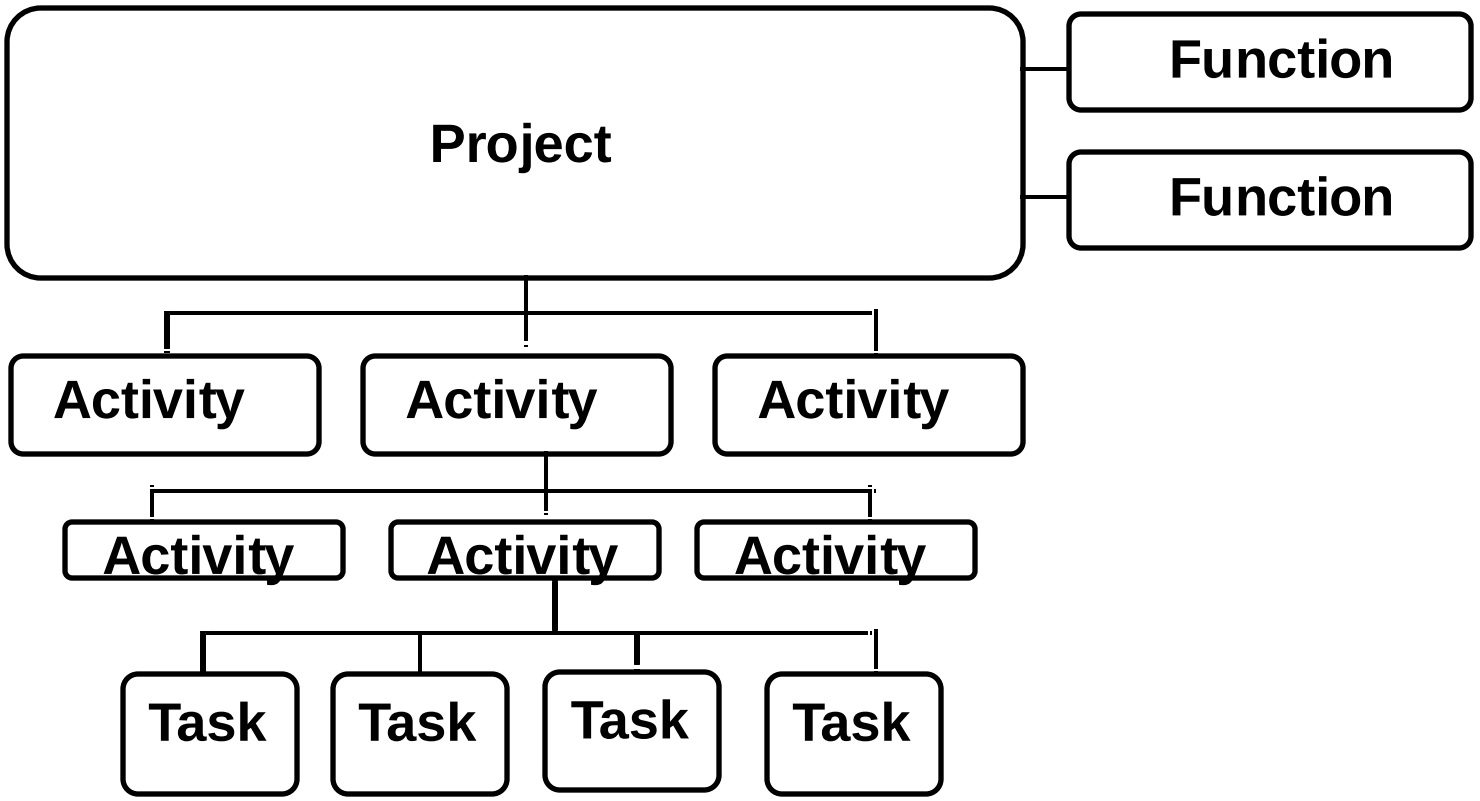
- **We will discuss methods and heuristics on how to do it and how to establish a project schedule.**
  - **However, first let us learn a few more technical terms**

Recall SPMP Definitions

- Project:
  - **A Project has a duration and consists of functions, activities and tasks**
- Work Package:
  - **A description of the work to be accomplished in an activity or task**
- Work Product:
  - **Any tangible item that results from a project function, activity or task.**
- Project Baseline:
  - **A work product that has been formally reviewed and agreed upon.**
  - **A project baselines can only be changed through a formal change procedure**
- Project Deliverable:
  - **A work product to be delivered to the customer**

Project: Functions, Activities and Tasks

A Project has a duration and consists of functions, activities and tasks



Developing Work Breakdown Structures

- There are several different approaches to develop and display a work breakdown structure. Each is effective under different circumstances
- Approaches to break activities into detail by
  - **Product component approach**
    - Examples: Design documents, manuals, the running system
  - **Functional approach**
    - Analysis, design, implementation, integration, testing, delivery, reviews
  - **Geographical area**
    - Examples: TUM team, CMU team, off-shore team, ...
  - **Organizational approach**
    - Research, product development, marketing, sales

When to use what approach

- Distributed teams:
  - **Geographical area approach**
- Experienced teams:
  - **Product component approach**
- Project has mostly beginners or project manager is inexperienced:
  - **Functional approach**
- Project is a continuation of previously successful projects, no change in requirements, no new technology
  - **Organizational approach**

- When you choose an approach, stick with it to prevent possible overlap in categories

How do you develop a good WBS?

- **Top down approach**:
  - **Start at the highest, top level activities and systematically develop increasing levels of detail for all activities.**
- **Brainstorming:**
  - **Generate all activities you can think of that will have to be done and then group them into categories.**

- Which one you use depends on
  - **how familiar you and your team are with the project,**
  - **whether similar projects have successfully been performed in the past, and**
  - **how many new methods and technologies will be used.**

The Top Down WBS approach

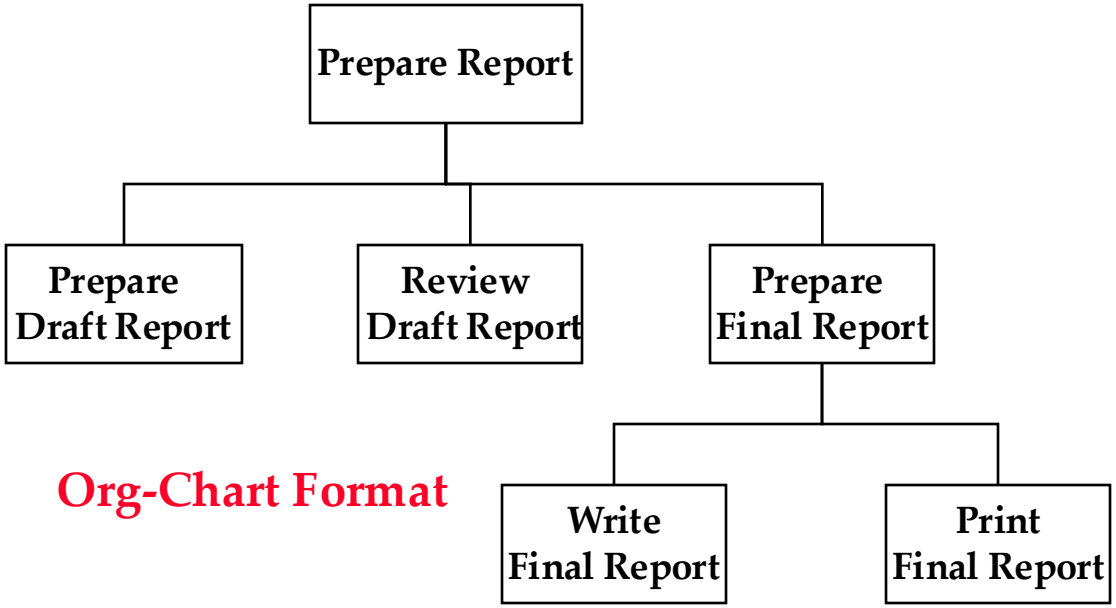
- Specify all activities required for the entire project to be finished
- Determine all task required to complete each activity
- If necessary specify subactivities required to complete each task
- Continue in this way until you have adequately detailed your project.
- **Approach is good if**
  - **You are or your team is familiar with the problem.**
  - **You have successfully managed a similar project in the past**
  - **You are not introducing new methodologies, methods or tools**

The Brainstorming WBS approach

- On a single list, write any activities you think will have to be performed for your project.
- Brainstorming means you
  - **Don't worry about overlap or level of detail**
  - **Don't discuss activity wordings or other details**
  - **Don't make any judgements**
  - **Write everything down**
- Then study the list and group activities into a few major categories with common characteristics.
- If appropriate group activities under a smaller number of tasks
- Consider each category you have created and use the ***top-down WBS approach*** to determine any additional activities you may have overlooked.

Displaying Work Breakdown Structures

- Three different formats are usually used
- Organization-chart format:
  - **Effectively portrays an overview of your project and the hierarchical relationships of different activities and tasks.**
- Outline format
  - **Subactivities and tasks are indented**
- Bubble format
  - **The bubble in the center represents your project**
  - **Lines from the center bubble lead to activities**
  - **Lines from activities lead to tasks**



Org-Chart Format

Prepare Report

1.0 Prepare draft report

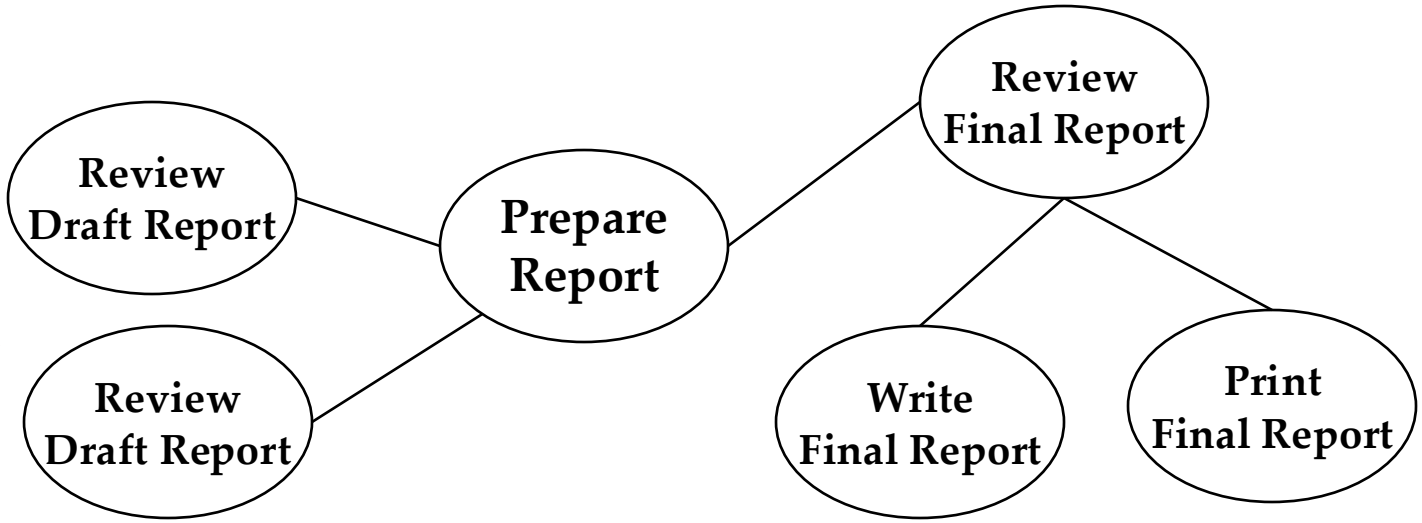
2.0 Review draft report

3.0 Prepare final report

3.1 Write final report

3.2 Print final report

Outline Format



Bubble Format

Best format for displaying WBS?

- **Org-chart format:**
  - Often good for a "bird view" of the project (executive summaries,...)
  - Less effective for displaying large numbers of activities
- **Outline format:**
  - Easier to read and understand if WBS contains many activities
- **Bubble format:**
  - Effective for supporting the brainstorming process
  - Not so good for displaying work breakdown structures to audiences who are not familiar with the project.
  - Use bubble format to develop the WBS, then turn it into Org-Chart or outline format.
- **In large projects:**
  - Use a combination of org-chart and outline formats:
    - **Display activities in org-chart format,**
    - **Display subactivities and tasks in outline format.**

Heuristics for developing high quality WBS

- Involve the people who will be doing the work in the development of the WBS
  - **In particular involve the developers**
- Review and include information from work breakdown structures that were developed for similar projects
  - **Use a project template if possible**
- Use more than one WBS approach just to identify all the activities
  - **Do project component and functional approach simultaneously**
  - **This allows you often to identify overlooked activities**
- Make assumptions regarding uncertain activities
  - **Identify risky activities**
  - **These are often the activities that whose times are hard to estimate**
- Keep your current work breakdown structure current
  Update your WBS regularly

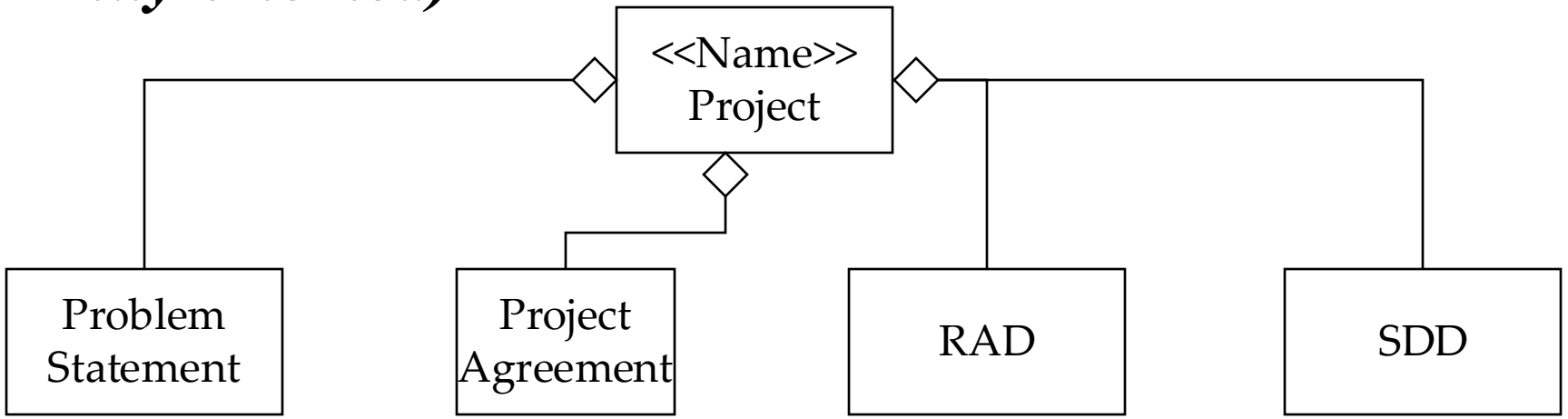
Heuristic: Use Templates

- Try to derive the SPMP from a template, either an existing one or one that you start developing with this project.
  - **A template reflects the cumulative experience gained from doing numerous projects of a particular type.**
  - **Using templates can save you time and improve your accuracy**
- When developing templates, develop them for frequently performed tasks (reviews, meetings, …). "Checklists"
  - **Develop and modify your WBS templates from previous projects that worked, not from plans that looked good.**
  - **Use templates as starting points, not as ending points**
  - **Continually update your templates to reflect the experience gained from performing different projects.**

Heuristic: Develop always more than one WBS

- Consider to create more several different hierarchies with different categories for your work breakdown structure.
  - **Having two or more different perspectives helps you identify activities you may overlook.**
- Good starting point are the following hierarchies:
  - **Entity-oriented decomposition**
  - **Activity-oriented decomposition**
- Example: You are running your first object-oriented project.
  - **Develop a WBS based on the project documents**
  - **Develop a WBS based on the software process activities**

WBS Based on Project Documents (Entity-oriented)



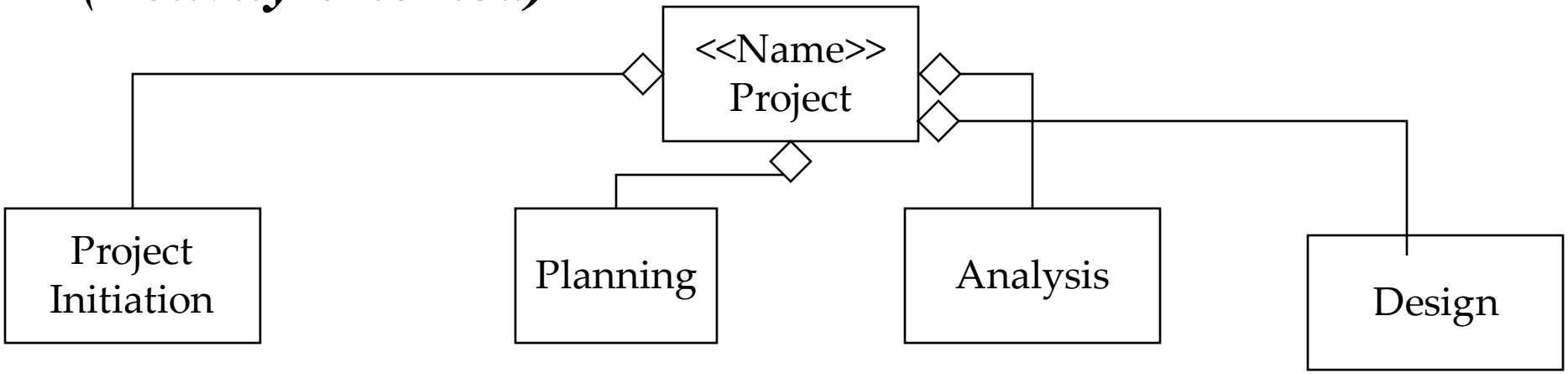
- Write Introduction
- Write Requirements
- Write Constraints
- ...

- Write Requirements
- Write Constraints
- Write Acceptance Criteria
- Promise delivery date

- Write Introduction
- Describe Functional Model
- Describe Object Model
- Describe Dynamic Model
...

- Write Design Goals
- Write Hardware Software mapping
-Write boundary conditions
- Write Data Management
- Write Open Issues
...

WBS Based on Software Process (Activity-oriented)



- Establish guidelines
- Formulate requirements with client
- Establish scenarios
- Write project agreement

- Determine WBS
- Determine dependencies between tasks
- Write SPMP
- Assign teams to subsystems
- Establish project calendar

- Brainstorm on application domain objects
- Develop class diagram
- Partition objects into boundary, entity and control objects
- Develop use cases

- Develop Models
- Write code
- Present problems to coach
- Give status reports
- Write RAD
- Write SDD
- Write ODD

Heuristic: Identifying Risky activities

- When you identify activities for a work breakdown structure, you can also identify the risks in your project.
- Risks are usually associated with "unknown information".
- Unknown information comes in two flavors
  - **A known unknown:** Information that you don't have but someone else does.
    - Find out who has the information and determine what the information is. (Interviews, Phone calls, tasks analysis)
  - **An unknown unknown:** Information that you don't have because it does not yet exist.
    - Develop **contingency plans** for each of these risks.
    - These contingency plans need be followed when you find out the information does not exist.
- Write these risks down in SPMP section Risk Management

Risk Management Examples

- Risk: Members in key roles leave the project.
  - ***Contingency Plan?***
  - **Roles are assigned to somebody else. Functionality of the system is renegotiated with the client.**
- Risk: The project is falling behind schedule.
  - ***Contingency Plan?***
  - **Extra project meetings are scheduled.**
- Risk: Team 1 cannot provide functions needed by team 2.
  - ***Contingency Plan?***
  - **The liaisons of both teams get together to solve this problem**
- Risk: The XXXX computer will not be available.
  - ***Contingency Plan?***
  - **We will use an YYYYY instead.**

Risk Management Examples ctd

- Risk: The selection of the DBMS takes too much time
  - **Contingency Plan?**
  - **The Database team uses a bridge pattern and provides a test stub to be used by the other teams for data access while the selection process goes on.**
- Risk: The customer is not available for discussing and reviewing the user interface during development.
  - **Contingency Plan?**
  - **Make the design decisions that we feel are appropriate**
- Risk: No suitable wireless library can be found.
  - **Contingency Plan?**
  - **The wireless team develops its own library**

Choose a single WBS format

- Writing the WBS in different formats is good, because it allows you to identify activities that you may have overlooked
- However, after you identify these activities add them to either WBS
- Choose a *single* WBS format to be used in the SPMP and for your project:
  - **Nothing confuses people fast than trying to use two different work breakdown structures to describe the same project.**

How Detailed should the WBS be?

- Sometimes the activities are not clear at all, especially in software projects:
  - **Unclear requirements and/or changing requirements**
  - **Dependency on technology enablers that appear or are promised to appear after project kickoff**
  - **Simultaneous development of hardware and software ("concurrent engineering")**
- A project plan, especially for an innovative software project, should not address details beyond 3 months.
  - **Even for the first 3 months project activities might not all be detailable, for example when the requirements are unclear or change or introduction of technology enablers is expected.**
- How should we describe a WBS for a longer project?

Doing a WBS for Long-Term Projects

- When developing a work breakdown structure for a long-term project (longer than 3 months), introduce at least two phases
- *Phase 1* (3 months): Plan your WBS in detail
  - **Here list all activities that take two weeks or less to complete**
- ***Phase 2, Phase 3, …*** *(n-months)* Plan the WBS for these phases in less and less detail
  - **Here list activities that you estimate will take between one and two months**
- At the end of phase 1, revise the phase 2 activities to the two week level for the next 3 months.
  - **Modify any future activities as necessary based on the results of your first three months work.**
- Continue to revise the SPMP this way throughout the project. (SPMP as an "evolving" document)

Phases and large Projects

- Project-Initiation Phase
- Steady State Phase
  - **Initial Planning phase**
- Project-Termination Phase

Project-Initiation Phase

- Fred Brooks, The mythical months
- Activities
  - **Meet with client, develop the scenarios (as-is, visionary) for problem statement**
  - **Develop an initial top level design: System as a set of subsystems.**
  - **Establish staffing plan (flat staffing, ramping up)**
  - **Identify human resources: existing employees, new employees.**
  - **Hire team members**
  - **Assign a subsystem to each team. Establish two additional cross-functional teams: Architecture&Documentation.**
  - **Write problem statement (with client and other stake holders, involve project members early)**
  - **Write initial SPMP with WBS, without schedule, without budget.**
  - **Get project plan approved**
  - **Kick project off with 2 documents: Problem statement and SPMP**
- Duration: About 4 weeks
- When?
  - **Before project kickoff**

Initial Planning Phase

- Usually after project kickoff, often called "planning phase"
- Activities
  - **Do innovation management on technology enablers that might influence the design or nonfunctional requirements**
  - **Revise requirements and initial design if necessary**
  - **Revise team structure, reassign team members if necessary**
  - **Revise WBS and dependencies**
  - **Establish cost and scheduling information**
  - **Agree with client on requirements, duration and cost of the project (write this in a "project agreement", a companion document to the SPMP)**
- Duration: About 2 weeks time.
- When?
  - **Parallel to "requirements elicitation phase"**

Project-Termination Phase

- Do a project-review: “What went right, what went wrong”
  - **also often called “project post-mortem review”**
- Based on input from the post-mortem session
  - **Revise your software process, identify in particular any new activities that happened in the project**
  - **Revise your project kickoff activities**
  - **Revise the SPMP template (to be reused for your next project)**

Summary

- **Work Breakdown Structure (WBS):** Set of activities to do ("use cases")
- **Dependency Graph:** Identification of dependency relationships between activities identified in the WBS
- **Schedule:** Dependency graph decorated with time estimates for each activity
- **PERT:** One of the first techniques proposed to analyse complex dependency graphs and schedules
- **Gantt Chart:** Notation used to visualize schedule