Software Project Management Part 2: *Work Breakdown Structures*

Introduction into Software Engineering
Lecture 20

Bernd Bruegge
Applied Software Engineering
Technische Universitaet Muenchen

Where are we?

- The lectures on software lifecycle modeling and project management addressed the following questions:
  - Software lifecycle modeling: How do we deal with change?
  - Project planning: How do we plan a project?
  - ⇨ Decomposition of work: What are the tasks?
- Other project management issues:
  - Project organization: Who is doing these tasks?
  - Estimation: How long do these tasks take?
  - Scheduling: How long will it take to finish them?
- Study them in other lectures on project management and organization and experience them in practical courses, eg. a software engineering praktikum.

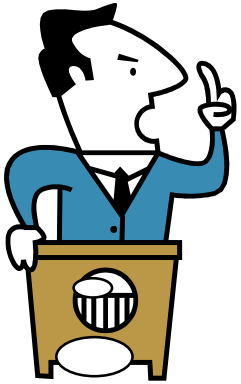
Outline of this Lecture

- Determining Work and Tasks Sizes
- Work Breakdown Structure (WBS)
- Different Approaches for developing a WBS
- Notations for Work Breakdown Structures
- Heuristics and examples
  - Starting with templates
  - How to identify work
  - What do we do with risky tasks?
- Work Breakdown Structures in large projects
  - How detailed should a WBS be?
  - How can you plan the tasks of a long project when things are unknown or changing all the time?

What is the Problem?

Your boss: "How long will this take?"

You: "Between 1 and 6 months."



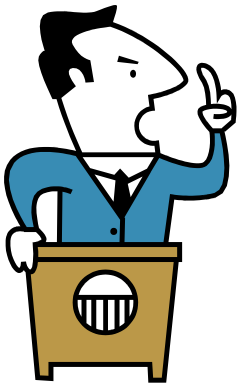
"With hard work, he can do it in 1 month."

"As long as I can do it within 6 months, I keep my promise."

What is the real Problem?

Your boss: "How long will this take?"

You: "Between 1 and 6 months."



"I have not he slightest clue, if this is possible at all."

"Even if it is possible, I don't know, how long it will take."

Solution: Use divide and conquer

- To give a good answer you have to break the work down into activities for which you try to get timing estimates
- Only if with good estimates can you estimate the overall project duration

Activities to obtain Time Estimates

- Identify the tasks that needs to be done
  - Work breakdown structure (WBS)
- Identify dependencies between tasks
  - Dependency Graph
- Estimate the duration for each task to be done
  - Schedule

- These are the topics of the SPMP, Section 5.1, 5.2 and 5.5.

Software Project Management Plan

0. Front Matter
1. Introduction
2. Project Organization
3. Managerial Process
4. Technical Process
5. Work Elements, Schedule, Budget
    - 5.1 Work Breakdown Structure (WBS)
    - 5.2 Dependencies between tasks
    - 5.3 Resource Requirements
    - 5. 4 Budget
    - 5.5 Schedule

Optional Inclusions

Software Project Management Plan

0. Front Matter
1. Introduction
2. Project Organization
3. Managerial Process
4. Technical Process
5. Work Elements, Schedule, Budget
   - ⇨ 5.1 Work Breakdown Structure (WBS)
   - 5.2 Dependencies between tasks
   - 5.3 Resource Requirements
   - 5. 4 Budget
   - 5.5 Schedule

Optional Inclusions

Building a House

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

First Step: Identify the Work to be done

- 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

- **Initially finding these tasks is a brainstorming activity**
- **Similar to activities used during requirements engineering and analysis.**

Second Step: Hierarchically organize the Tasks

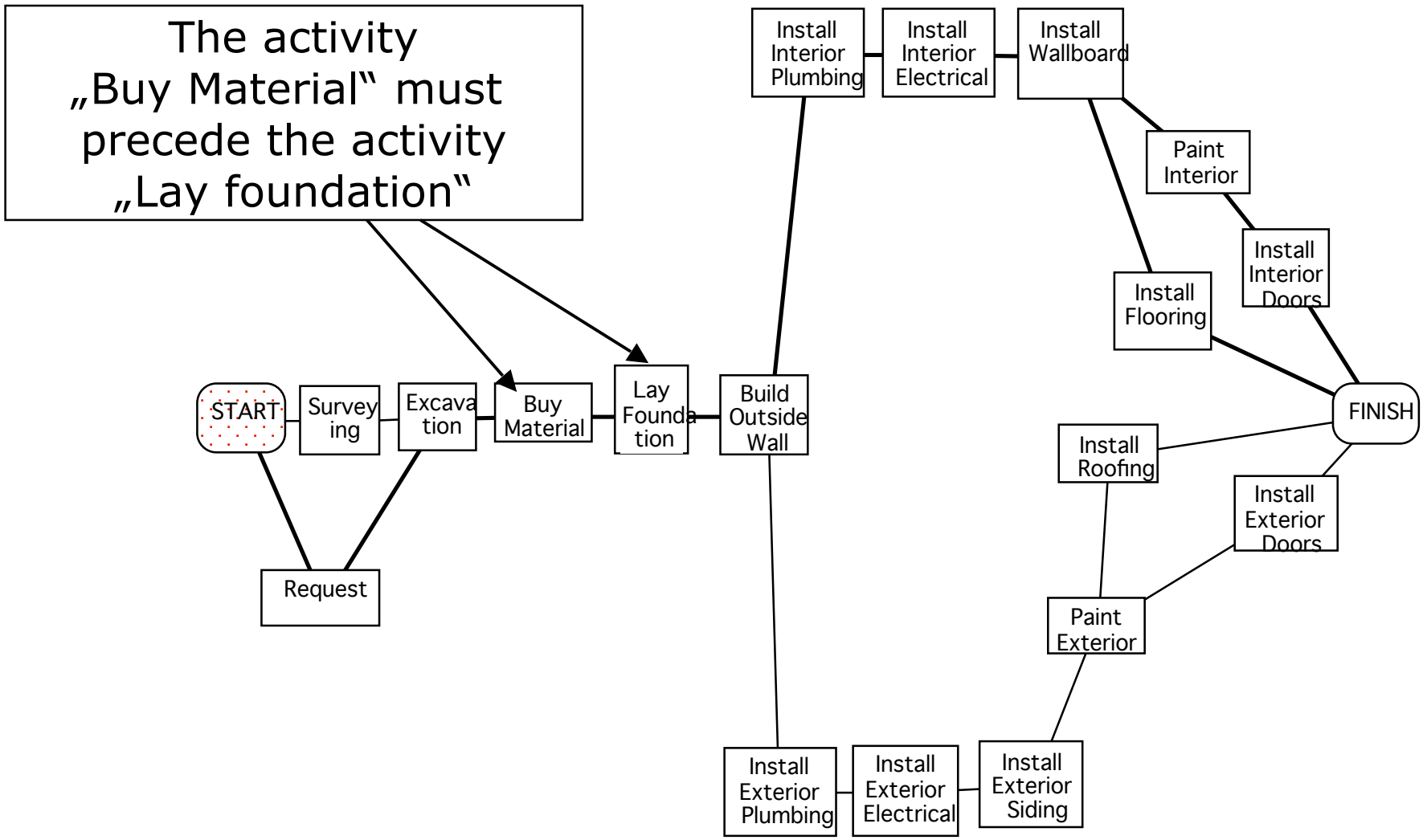
- Building the house consists of
  - Prepare the building site
  - Building the Exterior
  - Building the Interior
- Preparing the building site consists of
  - Surveying
  - Excavation
  - Buying of material
  - Laying of the foundation
  - Requesting permits

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

Third Step: 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)

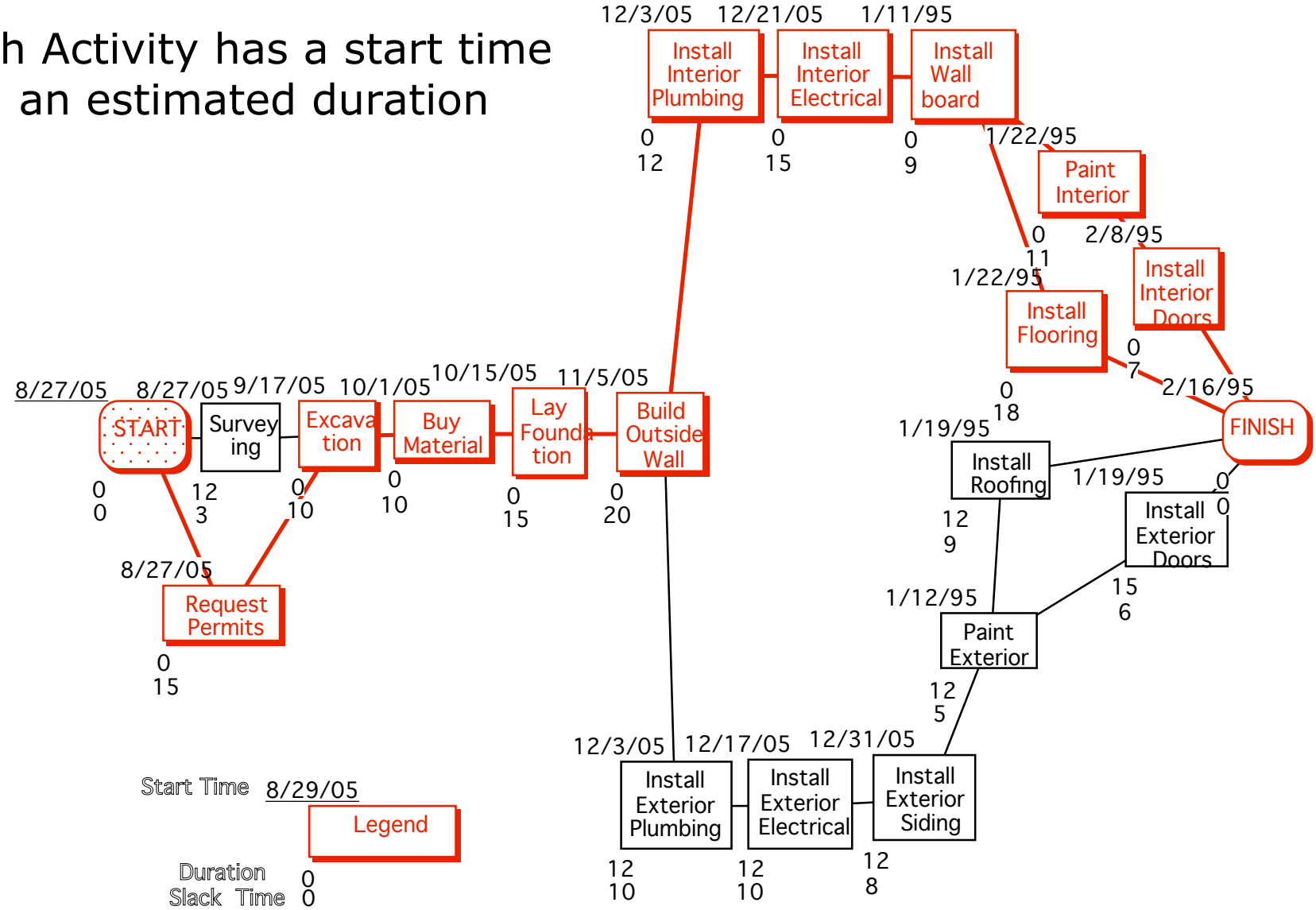


Fourth step: Map tasks onto time

- 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

Building a House (Schedule, PERT Chart)

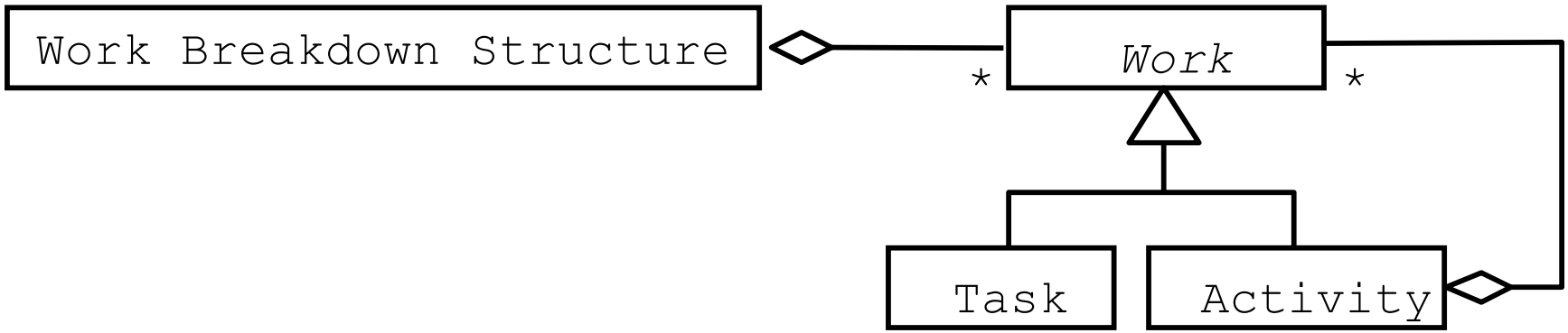
Each Activity has a start time and an estimated duration



How do we get good Time Estimates?

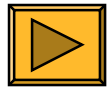
- Estimation of starting times and durations is crucial for setting up a plan
- Estimation is still like black magic
- Methods and heuristics on how to do it and how to establish a software project schedule , eg:
  - Traditional methods:
    - Project Management and Organization (Module IN2082)
  - Agile Techniques like Scrum:
    - Agile Project Management Seminar (WS 2007-8)
- Practice, practice, practice:
  - Real Project
  - Software Engineering Praktikum WS 2007-8

Work Breakdown Structure



Work Breakdown Structure: The aggregation of all the work to be performed in a project. Often called WBS

Approaches to Develop Work Breakdown Structures



- Result-oriented approach
  - Structure the work based on the work products
- Activity-oriented approach
  - Structure the work based on development activities and project functions
- Geographical area approach
  - Structure the work based on geographical location
- Organizational approach
  - Structure the work based on organizational structure

When to use what Approach

- The teams are distributed over the continent:
  - Geographical area approach
- The teams consist of experienced developers:
  - Result-oriented approach
- The project has mostly beginners or an inexperienced project manager:
  - Activity-oriented approach
- The project is a continuation of a previously successful project, no changes
  - Organizational approach

Whatever approach you choose, stick with it to prevent possible overlap in categories.

Should you mix the WBS Approaches?

- Consider a WBS for the activity „Prepare report“
- Activity-oriented approach:
  - Write draft report (Joe)
  - Review draft report (Ann)
  - Write final report (Joe)
- Result-oriented approach:
  - Chapter 1 (Joe)
  - Chapter 2 (Ann)
- Mixed approach:
  - Chapter 1 (Joe)
  - Chapter 2 (Ann)
  - Review draft report (Ann)
  - Write final report (Joe)

Why is this bad?

Who do check with on the the task?
“Write the final version of Chapter 2”
Ann or Joe?

“Write the final version of Chapter 2”
can be included Ann’s task:
“Chapter 2” or in Joe’s task
“Write final report”.

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
- Bottom up approach ("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.

Top Down WBS Development

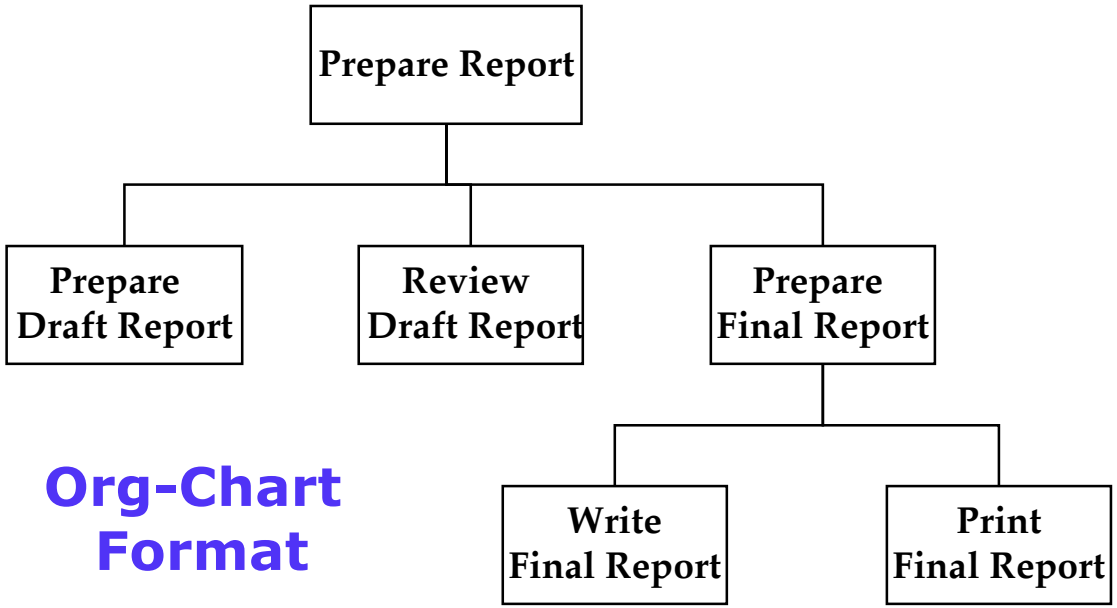
- Specify all activities for the entire project to be finished
- Determine all tasks to complete each activity
- If necessary, specify sub-activities required to complete each task
- Continue in this way until you have adequately detailed your project
- **Approach is good if**
  - You (or your team)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

Brainstorming WBS Development

- 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
- On a single list, write any activities you think will have to be performed
- Then study the list and group activities into a few major categories with common characteristics
- Try to group activities into higher level activities
- Consider each category you have created
  - Use *top-down WBS development* 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
  - Hierarchical relationships of participants, different activities and tasks
- Outline format
  - Subactivities and tasks are indented
- Bubble format
  - The bubble in the center represents the project
  - Lines from the center bubble lead to activities
  - Lines from activities lead to tasks.



Org-Chart Format

Prepare Report

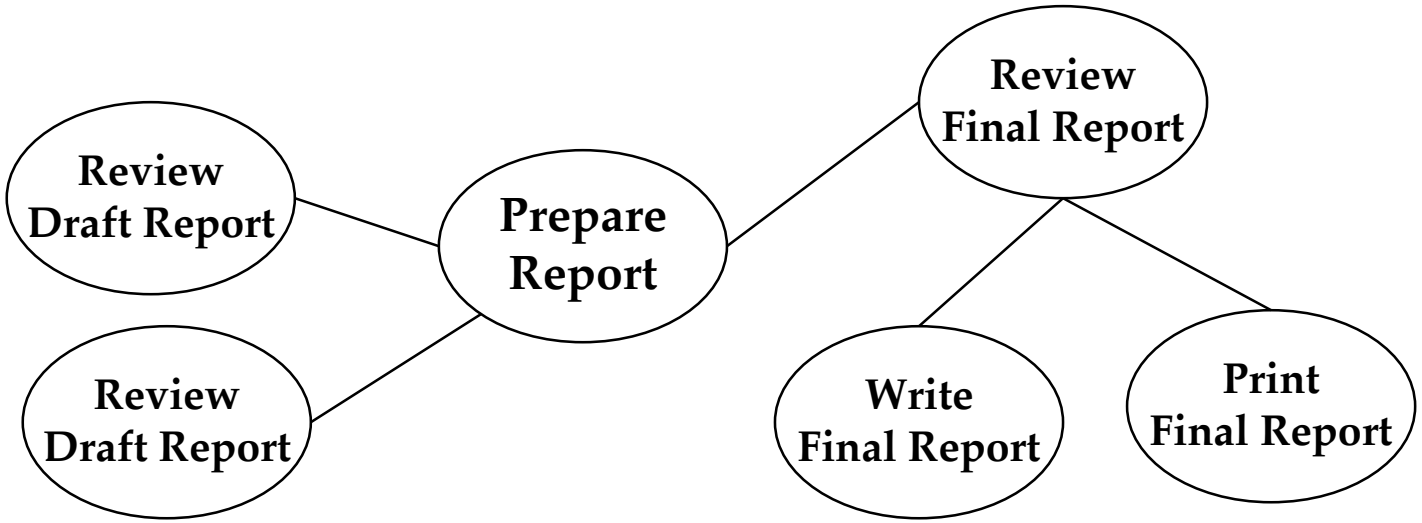
1.0 Prepare draft report

2.0 Review draft report

3.0 Prepare final report

- 3.1 Write final report
- 3.2 Print final report

Outline Format



Bubble Format

What is the best display format for WBS?

- Organization-chart format:
  - Often good for a "bird view" (executive summaries,...)
  - Less effective for displaying large numbers of activities
- Outline format:
  - Easier to understand, if WBS contains many activities
- Bubble format:
  - Effective for supporting brainstorming
  - Not so good for displaying work breakdown structures to audiences who are not familiar with the project.
- Mixed approach
  - In large projects

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
- Include information from WBS structures developed for similar projects
  - Use a project template if possible
- Use more than one approach to develop a WBS
  - Do project activity-oriented and result-oriented approach simultaneously
    - This allows you often to identify overlooked activities
- Make assumptions regarding uncertain activities
  - Identify risky activities
    - These are often the activities whose times are hard to estimate.

How Detailed should the WBS be?

- Activities in software projects are often unclear:
  - Vague requirements and/or changing requirements
  - Dependency on technology enablers that are promised
  - Simultaneous development of hardware and software ("concurrent engineering")
- Heuristic:
  - A WBS, especially for an innovative software project, should not address details beyond 3 months.
- How should we describe a WBS for a longer project?

Project planning

Introduce phases

- *Phase 1* (1-3 months):
  - Plan your WBS in detail
  - List all activities that take one week or less to complete
- *Phase 2, Phase 3, … (1-3-months)*:
  - Plan the WBS for these phases in less and less detail
  - List activities that will take between one and two months
- At the end of each phase, revise the activities and plan them on the weekly level for the next 3 months

Phases in Projects

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

Project-Initiation Phase: To-Do List

- Activities
  - Meet with client, develop visionary scenario
  - Develop initial top level design (software architecture):
    - System as a set of subsystems
  - Establish staffing plan (flat staffing, ramping up)
  - Identify human resources
    - Hire team members
  - Assign each team to a subsystem
  - Establish additional cross-functional teams
  - Write problem statement (with client and other stake holders; if possible, involve project participants early)
  - Write initial SPMP with WBS, but without schedule, without budget

Initial Planning Phase: To-Do List

- Activities
  - Do scouting on technology enablers that might influence the design or nonfunctional requirements
  - Revise requirements and initial top level 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 the "project agreement" (companion document to the SPMP)
- Duration: About 2 weeks time.
- When: After project kickoff, often called "planning phase", 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)

Where are we?

- SPMP IEEE Std 1058
- 0. Front Matter
- 1. Introduction
- ✓ 2. Project Organization
- 3. Managerial Process
- 4. Technical Process
- 5. Work Elements, Schedule, Budget
  - ✓ 5.1 Work Breakdown Structure (WBS)
  - 5.2 Dependencies between tasks
  - 5.3 Resource Requirements
  - 5. 4 Budget
  - 5.5 Schedule
- Optional Inclusions

Additional Readings

- [IEEE Std 1058] Standard for Software Project Management Plans
- Stanley E Portny, Project Management for Dummies, Hungry Minds, 2001, ISBN 0-7645-5283-X

Summary

- Different approaches to develop a WBS
  - Product Approach
  - Functional Approach
  - Geographical Approach
  - Organizational Approach
- Top down and bottom up WBS development
- Heuristics for developing good WBS
- WBS for Large Projects

Additional and Backup Slides

Heuristic: Use Templates

- Try to derive the SPMP from a template
  - 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)
- Develop "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 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.

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
  - An "unknown unknown": Information that you don't have because it does not yet exist
- Describe these risks in SPMP 3.3 Risk Management.

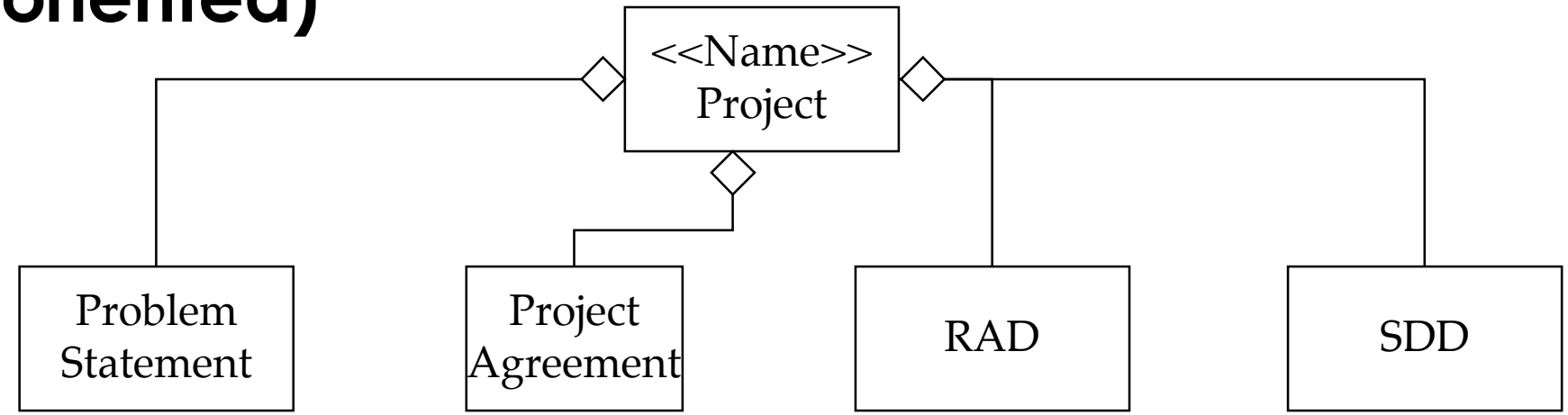
Risk Management Examples

- 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?*
  - A: We drop the functionality
  - B: The liaisons of both teams get together to solve this problem
- Risk: The planned PDA platform will not be available in time
  - *Contingency Plan?*
  - We will use an PC for development.

Risk Management Examples ctd

- Risk: The selection of the database system 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 team develops its own library.

WBS Based on Project Documents (Entity-oriented)



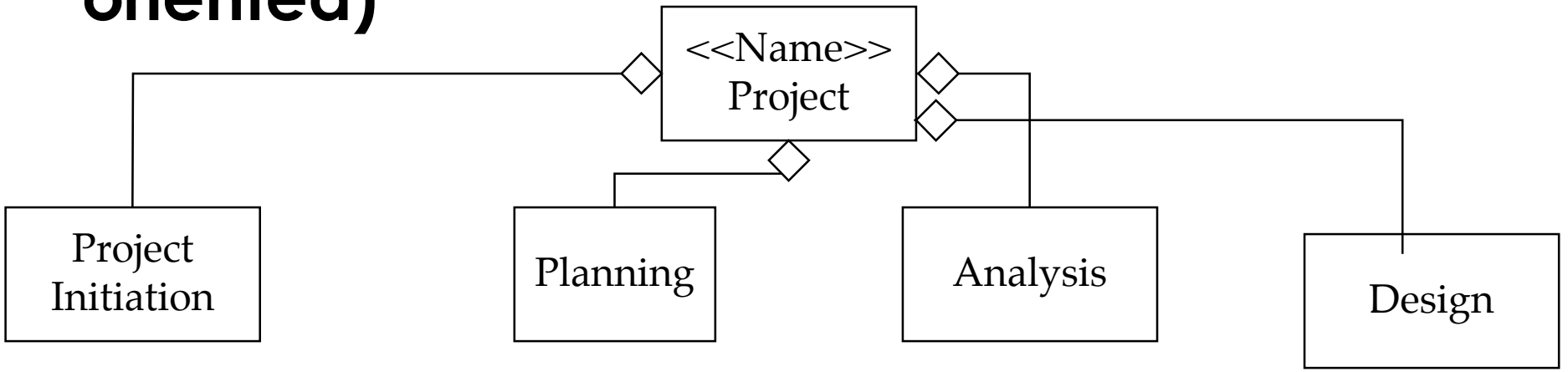
- Write Introduction
- Write Requirements
- Write Constraints
- ...

- 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
- Giove status reports
- Write RAD
- Write SDD
- Write ODD

Question: Which activities mentioned in the WBS based on Project documents is left out in the WBS based on Software Process?