Software Development Project Management
Software Development Process?

1) Announce availability.
2) Order the T-shirts for the Development team.
3) Write the code.
4) Write the manual.
5) Hire a Product Manager.
6) Spec the software (Writing the specs after the code helps to ensure that the software meets the specifications).
7) Ship.
8) Test (the customers are a big help here).
9) Identify bugs as potential enhancements.
10) Announce the upgrade program.
Cynical Views or Reality?
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- Projects progress quickly until they are 90% complete. Then they remain at 90% complete forever.
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- If project content is allowed to change freely, the rate of change will exceed the rate of progress.

- Project teams detest progress reporting because it manifests their lack of progress.
Software Project Elements

- All *technical* and *managerial* activities required to deliver the deliverables to the client.

- A software project has a specific duration, consumes resources and produces *work products*.

- Management categories to complete a software project:
  - Tasks, Activities, Functions
Software Project Management Plan (SPMP)

- The controlling document for a software project.
- Specifies the technical and managerial approaches to develop the software product.
- Companion document to SRS: Changes in either may imply changes in the other document.
- SPMP may be part of project agreement.
Project Agreement

- Document written for a client that defines:
  - scope, duration, cost and deliverables for the project.
  - exact items, quantities, delivery dates, delivery location.
- Can be a contract, a statement of work (SOW), a business plan, or a project charter.
- Client: Individual or organization that specifies the requirements and accepts the project deliverables.
- Deliverables:
  - Software
  - Documents
  - Demonstrations of function
  - Demonstration of nonfunctional requirements
  - Demonstrations of subsystems
**Terms**

- **Work product**: Something that needs to be done or get created in the project:
  - Applies to activities as well as tangible products
Phases in the Unified Process

- Inception: Vision, requirements
- Elaboration: Design
- Construction: Coding, testing
- Transition: Delivery, testing
Work-Products by Phase

- Inception phase
  - Business case/justification
  - Problem statement
  - Requirements Specification
  - Use cases
  - Risk analyses
  - Priorities
  - Acceptance plan
Work-Products by Phase

- Design phase
  - System architecture
  - Various diagrams (class, sequence, ...)
  - Documentation plan
  - Identify third-party components
  - Configuration management plan
  - Testing plan
  - Maintenance plan
Work-Products by Phase

- **Construction phase**
  - Product source code
  - Test code
  - Documentation
    - Internal
    - User
Work-Products by Phase

- Transition phase
  - The software
  - Installation instructions
  - User manual
  - Customer support
Additional Work-Products

- Management “products”
  - Design and development processes
  - Resource plan
  - Schedule, milestones
  - Release plan
  - Quality assurance plan
  - Risk management plan
Work-product Traceability Diagram

- Shows impacts of one work product on another
Project Management Terms
(not universal)

- **Tasks**: Small units of work
- **Activities**: Major work units
- **Milestones**: When activities are completed
- **Functions**: Pervasive, on-going management functions
Tasks: Small units of work

- **Smallest** unit of management accountability
  - Atomic unit of planning and tracking
  - Finite duration, need resources, produce tangible result (documents, code)

- Specification of a task: Work package
  - Name, description of work to be done
  - **Preconditions** for starting, **duration**, required **resources**
  - Work product to be produced, acceptance criteria for it
  - Risk involved

- Completion criteria
  - Includes the acceptance criteria for the work products (deliverables) produced by the task.
Activities: Major Units of Work

- Culminates in major project milestone:
  - Internal checkpoint should not be externally visible
  - Scheduled event used to measure progress
- Milestone often produces baseline:
  - Formally reviewed work product
  - Under change control (change requires formal procedures)

- Activities may be grouped into larger activities:
  - Establishes hierarchical structure for project (phase, step, ...)
  - Allows separation of concerns
  - Precedence relations often exist among activities (PERT Chart)
Examples of Activities

- **Major Activities:**
  - Planning
  - Requirements Elicitation
  - Requirements Analysis
  - System Design
  - Object Design
  - Implementation
  - System Testing
  - Delivery

- **Activities during requirements analysis:**
  - Refine scenarios
  - Define Use Case model
  - Define object model
  - Define dynamic model
  - Design User Interface
Project “Functions”

- Examples:
  - Project management
  - Configuration Management
  - Documentation
  - Quality Control (Verification and validation)
  - Training

- Project Functions in the IEEE 1058 standard are called *Integral processes* in the IEEE 1074 standard.
Organizational Diagrams

- **Work breakdown structure (WBS):** Shows hierarchy of work products

- **PERT chart:** Shows the order in which activities must be done (a partial order)

- **Gantt Chart or Schedule:** Shows scheduling of work products as a function of time
Creating Work Packages

- **Work Breakdown Structure (WBS)**
  - Break up project into *activities* (phases, steps) and *tasks*.
  - *The work breakdown structure does not show the interdependence of the tasks*
Build communications software

System planning (1.0)
- Review specification (1.1)
- Review budget (1.2)
- Review schedule (1.3)
- Develop plan (1.4)

System design (2.0)
- Top-level design (2.1)
- Prototyping (2.2)
- User interface (2.3)
- Detailed design (2.4)

Coding (3.0)  Testing (4.0)  Delivery (5.0)

Source: Pleeger, ch. 3
WBS Tradeoffs

- Work breakdown structure influences cost and schedule
- Determination of work breakdown structure may be incremental and iterative
PERT Chart

- "Program Evaluation and Review Technique"
- U.S. Navy, 1957
PERT chart
(Similar to UML Activity Diagram)
To Build a PERT chart

- List all the tasks.
- For each task:
  - List the tasks that must (immediately) precede that task
  - Remove implied dependencies (called the "transitive reduction" of the graph)
Tasks in Building a House:
What are likely required orders?

- Install roofing
- Install interior electrical
- Buy materials
- Excavate
- Build outside wall
- Install interior plumbing
- Install exterior siding
- Paint interior
- Install flooring
- Lay foundation
- Obtain permits
- Install exterior electrical
- Install exterior doors and fixtures
- Paint exterior
- Survey land
- Install interior doors and fixtures
- Install wallboard
- Install exterior plumbing
## Task durations and dependencies

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration (days)</th>
<th>Dependencies</th>
</tr>
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<tbody>
<tr>
<td>T1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>15</td>
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</tr>
<tr>
<td>T3</td>
<td>15</td>
<td>T1</td>
</tr>
<tr>
<td>T4</td>
<td>10</td>
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<td>T5</td>
<td>10</td>
<td>T2, T4</td>
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<td>T6</td>
<td>5</td>
<td>T1, T2</td>
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<td>T7</td>
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<td>T1</td>
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<tr>
<td>T8</td>
<td>25</td>
<td>T4</td>
</tr>
<tr>
<td>T9</td>
<td>15</td>
<td>T3, T6</td>
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<tr>
<td>T10</td>
<td>15</td>
<td>T5, T7</td>
</tr>
<tr>
<td>T11</td>
<td>7</td>
<td>T9</td>
</tr>
<tr>
<td>T12</td>
<td>10</td>
<td>T11</td>
</tr>
</tbody>
</table>

Source: Ian Sommerville, Software Engineering, 5th Ed.
Task network with Milestones (ovals)

source: Ian Sommerville, Software Engineering, 5th Ed.
As we saw, PERT enforces certain precedence constraints.

Other kinds of constraints:

- **Staff assignment** (task -> person) and loading constrains number of activities that can go on concurrently.
- **Resource availability** further constrains time at which various activities can happen.

The **Gantt chart** (or schedule) shows a particular scheduling of the tasks, subject to all of the constraints.
source: Ian Sommerville, Software Engineering, 5th Ed.
Real-life Gantt Chart
(source: http://www.kidasa.com/information/examples/aerospace/aerospace2.html)
Henry L. Gantt (1861-1919)
(http://accel-team.com/scientific/scientific_04.html)

- well-known pioneer in the early days of scientific management
- remembered for his humanizing influence on management, emphasizing the conditions that have favorable psychological effects on the worker
- “The Gantt chart for which he will be remembered, is a visual display chart used for scheduling, which is based on time, rather than quantity, volume or weight.”
A “critical path” on a PERT chart is one in which the sum of durations of the tasks on the path equals the shortest overall project-completion time.

The critical path is shaded on the preceding diagram.

PERT is also called CPM (Critical Path Method)
What is the Critical Path in Building your House, given the number of days required as shown?

- Install roofing (4)
- Install interior electrical (2)
- Buy materials (5)
- Excavate (7)
- Build outside wall (5)
- Install interior plumbing (4)
- Install exterior siding (3)
- Paint interior (2)
- Install flooring (2)
- Lay foundation (2)

- Obtain permits (24)
- Install exterior electrical (3)
- Install exterior doors and fixtures (2)
- Paint exterior (1)
- Survey land (1)
- Install interior doors and fixtures (2)
- Install wallboard (2)
- Install exterior plumbing (1)
Exercise

- List as many ways you can for shortening the critical path in a set of tasks.
Staff Loading & Resources

- Staff loading and resource constraints are two aspects of scheduling not represented directly on PERT charts.

- Generally they have the effect of providing added sequencing, and therefore lengthening overall project time.
Staff Loading & Resources

- Staff loading refers to:
  - Some tasks can be assigned only to certain staff members, based on specialized skills.
  - A given staff member can only do so much at a time.
  - Staff members differ in their productivity on a given task.
source: Ian Sommerville, Software Engineering, 5th Ed.
Staff Loading & Resource Constraints

- Resource constraints refers to certain resources being needed for certain tasks, but being limited in the number of tasks they can support concurrently.

- Resources include:
  - Machines, workstations, storage units
  - Rooms, offices
How Do Constraints Differ from Precedence Relationships?
How Do Constraints Differ from Precedence Relationships?

- Precedence relationships specify a particular sequencing between two tasks.
How Do Constraints Differ from Precedence Relationships?

- Precedence relationships specify a particular sequencing between two tasks.

- Constraints don’t specify a particular sequence, but only that two tasks can’t be done simultaneously.
Tools

- Microsoft Project
  - Handles WBS
  - Handles PERT to Gantt
  - Does not handle resources
  - Sort of handles staff loading, except that a single staff member can be overloaded.
Tracking How Well are We Doing
Earned-Value Tracking Method/Chart

- One way to track how close to “done” the project is:
  - As key parts of a product are completed, the product “earns value”.
  
- Express earned value in % of total value or $ (= % x budgeted amount for task)
  
- Some variations allow partial credit, others don’t.
Earned Value vs. Time

earned value

100% target: project complete

time

100 200 300
Earned Value vs. Time

Task completed

Project complete

100%
Use of Earned Value Diagram
Use of Earned Value Diagram

- Based on project Gantt chart, create a profile plan of earned value
Use of Earned Value Diagram

- Based on project Gantt chart, create a profile plan of earned value
- Track actual earned value against plan
Use of Earned Value Diagram

- Based on project Gantt chart, create a profile plan of earned value
- Track actual earned value against plan
- Use discrepancies to make projections about delivery dates, cost, etc.
Project Ahead of Schedule

earned value

100%

actual earned value

planned earned value profile

100 200 300

time
Project Behind Schedule

earned value

planned earned value profile

actual earned value

slippage

time

100 200 300
### Earned Value Calculation Example

<table>
<thead>
<tr>
<th>Task</th>
<th>Budget</th>
<th>Percent Complete</th>
<th>Earned Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 1-1</td>
<td>$333.00</td>
<td>100.0%</td>
<td>$333.00</td>
</tr>
<tr>
<td>Task 1-2</td>
<td>$444.00</td>
<td>100.0%</td>
<td>$444.00</td>
</tr>
<tr>
<td>Task 1-3</td>
<td>$555.00</td>
<td>100.0%</td>
<td>$555.00</td>
</tr>
<tr>
<td>Task 1-4</td>
<td>$55.00</td>
<td>100.0%</td>
<td>$55.00</td>
</tr>
<tr>
<td>Task 2</td>
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<td></td>
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<tr>
<td>Task 2-1</td>
<td>$434.00</td>
<td>100.0%</td>
<td>$434.00</td>
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<tr>
<td>Task 2-2</td>
<td>$333.00</td>
<td>85.0%</td>
<td>$216.45</td>
</tr>
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<td>Task 2-3</td>
<td>$111.00</td>
<td>100.0%</td>
<td>$111.00</td>
</tr>
<tr>
<td>Task 2-4</td>
<td>$333.00</td>
<td>50.0%</td>
<td>$166.50</td>
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<tr>
<td>Task 3</td>
<td></td>
<td></td>
<td></td>
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<td>Task 3-1</td>
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<td>Task 3-3</td>
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<td>37.0%</td>
<td>$246.42</td>
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</table>

### Notes
- Earned Value with sub-tasks in $ (\% \times \text{budget})
### Example Gantt Chart with Earned Value Overlay


#### Contract Review

**Earned Value Report**

<table>
<thead>
<tr>
<th>Task</th>
<th>2001</th>
<th>BCWS</th>
<th>ACWP</th>
<th>BCWP</th>
<th>PRCNT CMPLT</th>
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<tr>
<td></td>
<td>November</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 1</td>
<td>10/14</td>
<td>4000.00</td>
<td>$950.00</td>
<td>$725.00</td>
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<tr>
<td>Task 1-A</td>
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<td>3500.00</td>
<td>$300.00</td>
<td>$200.00</td>
<td>$216.67</td>
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<tr>
<td>Task 1-B</td>
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<td>3000.00</td>
<td>$400.00</td>
<td>$350.00</td>
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<td>Task 1-C</td>
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<td>$250.00</td>
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<td>$225.00</td>
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<td>$350.00</td>
<td>$200.00</td>
<td>$190.91</td>
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<td>1000.00</td>
<td>$1775.00</td>
<td>$150.00</td>
<td>$713.32</td>
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<tr>
<td>Task 3-A</td>
<td>12/17</td>
<td>500.00</td>
<td>$550.00</td>
<td>$150.00</td>
<td>$310.26</td>
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<td>Task 3-B</td>
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<td>$800.00</td>
<td>$0.00</td>
<td>$320.00</td>
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<tr>
<td>Task 3-C</td>
<td>12/17</td>
<td>0.00</td>
<td>$425.00</td>
<td>$0.00</td>
<td>$90.15</td>
</tr>
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</table>

- **Earned Value**
- **Budget**
- **Spending**

- ▲ Program Review
- 🔤 Status
- ▬ Summary

Contracts review: 11-30-01

Sign Off: ______________
Implication of Slippage

- Slippage in earned value may imply slippage in delivery date,
  especially if the slipped task is on the critical path.
Slip Chart

announced delivery date

days into project
Slip Chart

slip = delivery date minus previously announced delivery date

new announcement
slip = 50 days

100 200 300 days into project
300
200
100

announced delivery date
Slip Chart

announced delivery date

slip = 25 days
Slip Chart

smaller slips are better

slip = 25 days

announced delivery date

days into project
Slip Chart

announced delivery date

actual delivery

line of announced = elapsed

overall slippage

elapsed
Word for Windows 1.0 Slip

\[
\frac{1880}{365} = 515\% \text{ net slip}
\]

Slip vs. Lead

- slip = delivery date
  minus
  previously announced delivery date

- lead = previously announced delivery date
  minus
  date on which new delivery announced
Example of Lead

- lead = previously announced delivery date minus date on which new delivery announced

Example:

- Original delivery date = day 200
- On day 100 announce new delivery date: day 300: moderate lead
Example of Lead

- lead = previously announced delivery date minus date on which new delivery announced

- Original delivery date = day 200

- On day 195 announce new delivery date: day 300: very small lead

- Small leads are bad (but small slips are good)
Slip-Lead Chart
(plots slips vs. leads)
Slip-Lead Chart
(plots slips vs. leads)

- **unhealthy region** (large slips, small leads)
- **healthy region** (large leads, small slips)

Announcements