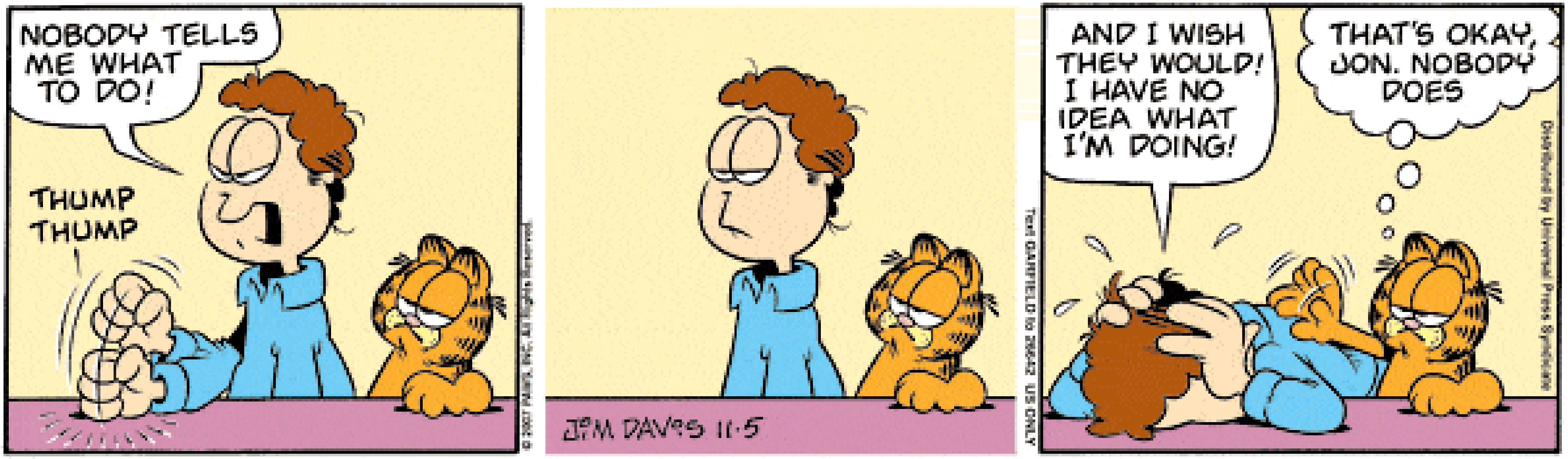
A Common Problem



Review Papers

- Software Fault Study
  - Perry and Steig, "Software Faults in Evolving a Large Real-Time System: A Case Study", ESEC93, Sept. 1993.
- Time Study
  - Bradac, et al., "Prototyping a Process Monitoring Experiment", IEEE TSE, Sept. 1994.
    - Longitudinal study of a single developer, single development
  - Perry, et al., "People, Organizations, and Process Improvement", IEEE Software, July 1994.
    - Self-reporting study of multiple developers/developments
    - Direct observation of a subset of those developers

Experimental Site

- Large-scale, real-time software system
- C Programming language, with some domain specific languages
- UNIX development environment
- Feature is the unit of development
- All changes via Change Management System (CMS)

Software Faults

- Research Context
  - Error studies have usually been done in context of initial and not evolutionary development
  - Interface errors studies of Perry/Evangelist showed the importance of interface problems in evolutionary development.
- Research Questions
  - Were application specific faults the critical problems in a particularly faulty release?
  - What classes of faults were there and when were they found?
  - How hard were they to find and fix?
  - What were their underlying causes?
  - What means could be applied to either prevent or alleviate them?

Software Faults - Experimental Design

- Two phase study
  - Investigate the entire set of faults
  - Investigate the largest subset (design and implementation)
- Data capture from owners of faults when closed
  - Members of development part of team to design the survey
  - Development volunteers to review/pre-test the instruments
- Management imposed limitations:
  - Strictly voluntary participation
  - Complete anonymity of responses
  - Completely non-intrusive

Software Faults

- Phase 1 Results
  - Response rate of 68%
  - 34% development
    - requirements (5%), design (11%) and coding (18%)
  - 25% testing
    - testing(6%) and environment (19%) problems
  - 30% overhead
    - duplicates (14%) and no problems (16%)
  - 11% other
- Phase 1 Summary
  - Requirements, design and coding faults were found throughout all testing phases
  - Majority of faults were found in system test and late in the testing process
  - The evolution of large, complex software systems involves a large overhead

Software Faults - Analyses

- Test for pair-wise independence
  - Chi-Square test:
    - if observed is the pairwise product, then the variables are independent
    - if observed is not the pairwise product, then they are not behaviorally independent
  - Example - using find and fix data (assume 1000 responses)

fix (e+m, d+vd)		784	216
find (e+m, d+vd)	909	e:713 o:725	e:196 o:184
	91	e:71 o:59	e:20 o:32

  - None of the relationships were independent
    - means of prevention and ease of finding had least significant dependence
    - root causes and means of prevention had most significant dependence

Software Faults - Analyses

- On the basis of the Chi-Square test, we concluded the following were correlated:
  - costs and faults
  - costs and underlying causes
  - costs and means of prevention
  - underlying causes and means of prevention
  - interface and implementation faults

Software Faults - Results

- Response rate of 68%
- The variables were not independent of each other
- Lack of information tended to dominate the underlying causes
- Knowledge intensive activities tended to dominate the means of prevention
- Informal means of prevention were preferred over formal means
- Interface faults were harder to fix than implementation faults

Software Faults - Evaluation

- Better empirical studies
  - Answers an important question
    - Yes: What are the significant development problems
  - Establishes principles
    - Yes: Knowledge issues are fundamental problems
  - Enables generating and refining hypotheses
    - Exposes a number of interesting problems
  - Cost effective
    - Inexpensive design/implementation
    - Expensive analysis (people intensive)
  - Repeatable
    - useful design; expect similar correlations, not same results

Software Faults - Evaluation

- Credible interpretations –
  - Strengths in construct, internal and external validity
    - CV: Important variables
    - IV: Instrument created by developers themselves
    - IV: Random trial with developers
    - IV: Data from people who owned the fault solutions
    - EV: Release similar to other releases
    - EV: Commonly used language and environment
    - EV: Response rate of 68%
  - Limits/Weaknesses in construct, internal and external validity
    - CV: Find, Fix interpretation not identical
    - CV: Fault categories poorly structured (too many faults, etc)
    - IV: No post survey validation - only pre-survey
    - IV: Up to a year lapse between problem resolution and survey
    - IV: Analysis weakened by find/fix problem
    - IV: Interface/Implementation division not clean
    - IV: Effect of 32% not returned
    - EV: Single case study, single system
    - EV: Single domain

Software Faults - Evaluation

- Credible interpretations - continued
  - Test hypotheses
    - Yes - refuted the hypothesis that application specific faults were the critical faults
  - Adequate precision
    - Over two thirds results - significant set of responses
    - Three place precision is justified by the response volume
    - dependence/independence analysis
    - correlations of fault factors
    - comparison of interface and implementation faults
  - Available to public
    - Lack of absolute numbers
    - Basic data is not provided in paper, only summaries of analysis

Software Faults - Summary

- Useful case study - answers important questions
- Done within limitations of management constraints
- Significant effect on internal development process
- Important for research implications
- Weaknesses in the survey instrument
- Questions about generalizability

Time Studies

- Research Context
  - Single programmer studies usually in context of simple problems
  - Few studies of programmers in the context of team
  - Few studies of programmers in the context of teams in large-scale software development
- Research Question (Hypothesis)
  - How does a developer spend his or her time in the context of a team development as part of a large system development?
  - What effects do inter-team/personal dependencies have?
  - How much time is spent in communication?
  - How much time is spent in the relevant processes? Where?
  - How much time is lost for various reasons?

Time Studies - Phase 1

- Specific null hypothesis:
  - A person is 100% effective (ie, race time = lapse time) in the context of teams in large scale software development
- Experimental Design
  - Longitudinal study
  - Retrospective reconstruction of 32 month development from project notebooks and personal diaries.
  - Categorized time spent in the specific process activity:
    - working, documentation, rework, reworking documentation
  - Categorized how time was spent when not in process:
    - waiting on lab, expert, review, hardware, software, documentation, other

Time Studies - Phase 1 Results

- Race time / lapse time = .4
- Blocking significant
  - long significant periods early in the process
  - short periods in the middle - least blocking here
  - short periods, large amounts of blocking late in the process
- Process phenomenology
  - waterfallish early
  - iterative later
- Provides an important basis for iteration to delve deeper into the question of how developers spend their time.

Time Studies - Phase 2

- Research Context
  - Refines phase 1
  - Vertical slice of multiple developers and developments
- Research Questions (in addition to initial questions)
  - How significant was the Phase 1 study and where does its significance lie?
  - How representative was the subject used in longitudinal study?
  - Is blocking as significant a factor as in the initial study?
- Experimental Design
  - Self-reporting instrument - finer resolution
  - Activity and state of work for each process step in half/hours

Time Studies - Phase 2 Results

- Confirmed race time / lapse time = .4
- Longitudinal study congruent with self-reporting study
- Blocked = context switching
- Clarifies our understanding of how developers spend their time
- Raises questions about variance of self-reporting

Time Studies - Phase 3

- Research Context
  - Self-reporting follow-on
  - A more detailed look at what developers do with their time
- Research Questions (Hypothesis)
  - How valid was self-reporting
    - What are the variances in self-reporting?
    - How close is the correspondence between perception and reality
  - What is there that happens at a finer time resolution than 1/2 hour?
- Experimental Design
  - Series of arranged full-day observations
  - Comparison of the observations with the self-reports

Time Studies - Phase 3 Results

- Delineates reliability of self-reporting
  - Self consistent but not uniform
  - 20% variance between observed and report
- Clarifies further our understanding of the how developers spend their time
  - Significant amount of unplanned interruptions
  - 75 minutes average per day in informal communication
  - importance of oral communication, avoidance of written
- Importance of informal communications in development processes

Time Studies - Summary

- Race time / elapse time = .4
- Blocking / context switching significant
- Developers consistent, but not uniform, in self-reporting
- Significant number of, and time spent in, informal interactions

Time Studies - Evaluation

- Better empirical studies
  - Answers an important question
    - Yes: how developers spend their time
  - Establishes principles
    - Yes: race/lapse time, informal interactions
  - Enables generating and refining hypotheses
    - Exposes a number of interesting problems
  - Cost effective
    - Varying costs - dependent on resolution desired
    - Effective for the results desired
  - Repeatable
    - useful design; expect similar correlations, not same results

Time Studies - Evaluation

- Credible Interpretations
  - Strengths in construct, internal and external validity
    - CV: Complete data source over complete development
    - CV: Well-defined retrospective, self-reporting and observational structures
    - CV: Established process vs state in process
    - IV: Congruency of results
    - IV: Established self-report consistency and range of variance
    - IV: Varying degrees of resolution
    - EV: People in team context in large-scale software development
    - EV: Entire life-cycle
    - EV: Common language and development environment

Time Studies - Evaluation

- Credible Interpretations – continued
  - Limits/Weaknesses
    - CV: Blocked, context switching ambiguity
    - IV: Loss of details due to time passed
    - IV: Inaccuracy of self-reporting
    - IV: Observations effects
    - EV: Representativeness of application domain
    - EV: Cultural representativeness
  - Test hypotheses
    - Yes - refuted the hypothesis
  - Removal of alternative explanations
    - Exposed where critical problems were
  - Adequate precision
    - Differing degrees of resolution as needed
  - Available to public
    - Data in various useful forms or presentation

Time Studies- Evaluation Summary

- Useful set of case studies - answers important questions
- Confirmed project managers fudge factor: 2.5
- Important Principles:
  - race vs elapse times
  - Blocking and context switching
  - Significant number of, and time spent in, short, unplanned interactions
- Large amount of informal interaction critical to the project! That has implications in formalizing processes
- Triangulation provides well rounded view of time in different granularities
- Reasonably strong validity – some minor weaknesses