Class 13 CS540

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Roadmap- Class 13

- Clarifications from last class
- Log Book volunteer
- Brooks Chapter 15-Epilogue
- Formal methods
- Clean room design
- Software Factories
- Software Archeology
- Outsourcing
- Parnas
- Best Current Practices, OA&M, Life Cycle Software Engineering, Software project Reviews
- Next week: SCRUM, special topics, review

Clarifications

- Apple and the mach kernel

Logbook

- Canary in the coal mine, project indicators

Brooks
No Silver Bullet (1986)

- Accidental vs. essential (abstract conceptual structures). Suggests:
  - Exploit mass market - buy vs. build, recurrent theme
  - Use rapid prototyping for establishing software requirements
  - Grow software organically (incrementally)
  - Identify and develop the great conceptual designers
- Software projects as werewolves - turning from the familiar to the horrible
- There is no silver bullet
  - Unfair to compare software and hardware
  - The essence are inherent difficulties, accidents not inherent. Essence is interlocking concepts of data sets + their relationships + algorithms + invocations of functions

NSB -2

- Hard part of software is specification, design and testing of the conceptual construct not representing and testing its fidelity
- Inherent properties include:
  - Complexity - scaling software is not simply enlarging size of elements, rather increases # of different elements and their interaction
    - Math models will not work because you cannot abstract out the complexity - it is part of the essence
    - Complexity causes:
      - Difficulty communicating among team members
      - Difficulty in enumerating all possible states
      - Unvisualized states resulting in security trap doors
      - Difficulty in providing overview

NSB-3

- Additional Inherent Properties:
  - Conformity - unlike physics with underlying laws, software reflects the arbitrary complexity of human institutions and systems and conformity to the interfaces of other systems
  - Changeability - software is constantly subjected to pressures to change:
    - Successful software is expanded
    - Exists longer than the machine vehicle for which it is written
    - Embedded in a changing cultural matrix of applications, machines, laws, organizations, …
  - Invisibility - hard to visualize in a single space

NSB-4

- Breakthroughs solved many accidental difficulties
  - High level languages
  - Time sharing and now the network

Silver Bullet "Hopefuls"

- OO - has a chance
- ADA and other languages - forces training in modern design techniques
- AI - no common technologies (that has changed a bit)
- Expert Systems - separates application complexity form the program (very underused currently)
- Automatic programming, specification to code, sees little hope
- Graphical programming - screens too small, software hard to visualize, may work for tiny, application specific languages
- Program verification - does not save labor -"much of the essence of the program is debugging the specification"
- Environments and tools - helps to keep track of details, includes integrated project databases
- Workstations - great but no magic, although it does seem magical at times

Promising Approaches to CE

- Buy vs. Build - development of mass market is the most profound trend - also puts simple programming power in the hands of users, (simple programming is becoming a skill - just as people became literate …)
- Requirements Refinement and Rapid Prototyping
- Incremental Development - grow not build, helps morale, instant feedback
- Great Designers, great designs come from great designers

Exciting Products - Brooks

- Great Designers - Yes
- UNIX
- APL
- Pascal
- Modula
- Smalltalk
- Fortran

- Committees - No
- Cobol
- PL/1
- Algol
- MVS/370
- MS-DOS

Great Designers

- Software is a creative process
- Ways to grow great designers (too little practiced these days):
  - Identify top designers early on
  - Career mentor them
  - Plot a career development path with apprenticeships and opportunities
  - Encourage peer interaction with other great designers

NSB Refired

- (review of critiques of NSB)
- Some tidbits:
  - On complexity - if you clean up human organizational structures you do simplify but complexity is also due to data structures and modules
  - Optimistic vs. Pessimistic vs. Realistic - I am a developer therefore I am innately optimistic!
  - Harel claimed conceptual stuff is topological and therefore graphical - Brooks agrees that you can represent software in a collection of representations but disagrees that they will be useful thought and design aids
  - Capers Jones - wrong to focus on productivity, focus on Quality and productivity will follow

Larger Tidbits: OO

- Many OO concepts have a history but OO brings them together:
  - Enforces modularity
  - Emphasizes modularity and hides the details
  - Provides inheritance and a hierarchical structure
  - Strong abstract data typing with the benefit that a particular data type will only be manipulated by appropriate operations
- Why has OO grown so slowly (dated, Java changed things)
  - Parnas, because OO has been tied to complex tools rather than design
  - Brooks, upfront costs are substantial benefit back loading, slow to accrue benefits, 5th project goes real fast (java/web changed this)
  - Requires managerial courage

Larger Tidbits: Reuse

- Programmers reuse their own code (and friends)
- Mathematical software is heavily reused but it is a special case
- DeMarco - big expense to reuse, Yourdon quotes factor of 2 (1.5 to 3).
- Large class libraries, vocabulary is an impediment, simply too many things. Helpful aids:
  - Examples of composed products (not JAVADOC)
  - Learn vocabulary by use
- After all the critiques, no change in his premise - complexity is our business and it does limit us

Chapter 18

- Summarizes all the chapters - good study aid

MMM after 20 Years

- Really addresses how people in teams make things
- Central argument - conceptual integrity and the architect
  - System must be conceptually coherent to the single mind of the user, yet designed by many minds
  - The architect forms and owns the public mental model of the product
  - Separate the architecture, the definition of the product as perceived by the user(s) from its implementation, this boundary is within the design task, user facing vs implementation facing
- Recursion of architects - large projects have a master architect and the master architect partitions the system into subsystems with minimal, easily designed interfaces, each having its own architect
- Having a system architect is the single most important step to achieving conceptual integrity

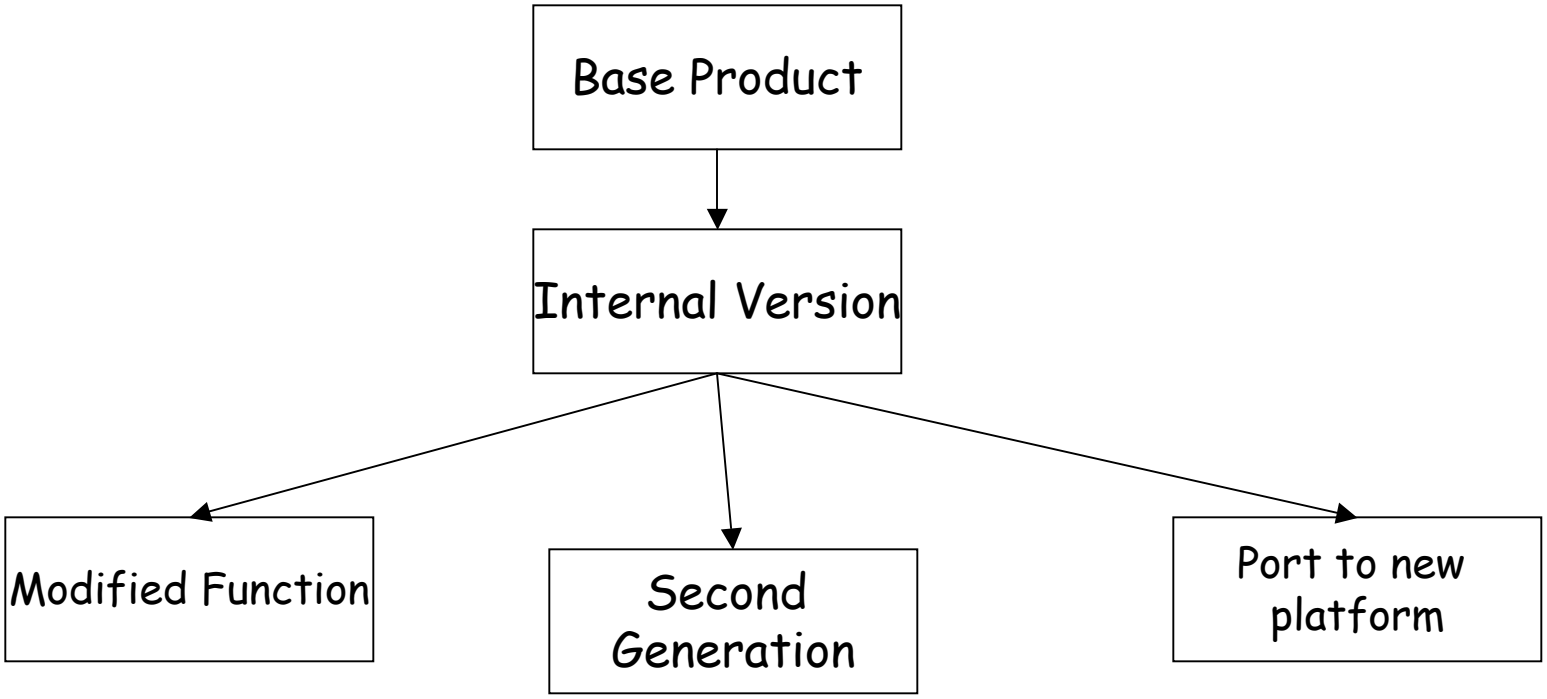
MMM Retro - 2

- Second system effect
  - Mass market particularly susceptible to featuritis over releases, e.g., Microsoft Office
  - Potential cure - frequencies, list explicit guesses for the attributes of the prospective users
- WIMP (Windows, Icons, Menus, Pointing) interface
  - Dragging and dropping, overlaying windows, trash can, folders, … follows from the office metaphor
  - Suggests two mice (not!) and marvels at keyboard chording .. The apple command key
  - Apple and Microsoft have made it standard for apps (with coercion)
  - Promotes speech (too slow, too linear)

MMM Retro -3

- Felt he was too tainted with Waterfall model
- "The basic fallacy of the waterfall model is that it assumes projects go through the process only once" (but it did define the stages)
- Fallacies of the waterfall model: places testing at the end and assumes one builds the whole system at once
- Again promotes incremental model
  - Permits early user testing
  - Permits build to budget strategy, albeit with some functional shortfall - but what is there works
- Parnas families concept - designing software project as a family of related products - near the root less likely to change

Parnas Family Concept



MMM - Retro 3

- Microsoft recommends build every night - (we do)
- Rapid Prototyping technique - Wizard of Oz
- Parnas was right about information hiding
  - Programmers are most effective if shielded from the innards of modules not their own (all in moderation)
  - More robust in a design for change (but …)
- How Mythical is the Man Month - hardly any projects succeed in 3/4ths of calculated time regardless of how many people are deployed

MMM-Retro 4

- How true is Brooks's Law : adding manpower to a late software project makes it later - most looked for remedies
  - Add manpower as early as possible
  - Focus on strategies for incorporating new folks
  - Brooks: none have addressed the added communication links
- People are (almost) everything
  - Quality of people and their organization and management are the major factors, *COCOMO* model quality of people is strongest factor
  - Managers must enhance creativity
  - Delegating power down

MMM-Retro 5

- Biggest surprise over 20 years - millions of computers
  - Creativity enhancer
  - Predicts rise in virtual environment systems
- Shrink wrap software
  - Focus on 5 (now 4) operating systems: MVS, DEC VMS, UNIX, Windows, MAC
  - Development stars in small companies

Buy and Build - Shrinkwrap Software

- My UNIX experience
- Metaprogramming, e.g., HyperCard - web and HTML replaced this sort of thing
- Shrink wrapped products need to make products easy to incorporate in larger systems - has happened in strange ways: databases as meeting place, shells stitch things together
- 4 levels of users for shrinkwrap:
  - As is user
  - Metaprogrammer - templates of functions
  - External function writer - adds functions to applications
  - Metaprogrammer using several applications in a larger system

Software Engineering Concerns

- Remain the same
- How to design and build a set of programs into a system
- How to design and build a program or a system into a robust, tested, documented and supported product
- How to maintain intellectual control over complexity in large doses

Formal Methods

- Formality = degree of mathematical rigor during analysis and design
  - Mathematically based techniques for describing system properties
  - Strive for consistency, completeness and lack of ambiguity - the usual suspects
  - Issues with less formal approaches: contradictions - statements at variance with each other, usually separated by substantial text in the requirements, ambiguities, vagueness, incompleteness, mixed levels of abstraction
- Mathematics provides a high level of validation

Formal Method Concepts

- Data invariant is a set of conditions that are true throughout the execution of the system that contains a collection of data
  - Example: constraint on table size in a symbol table = maxids and all items are unique names
- State - stored data that the system accesses and alters
- Operator - an action that reads or writes data to a State, e.g. adding and removing names to a symbol table. Operator is associated with two conditions:
  - Precondition - defines circumstances in which a particular operation is valid
  - Postcondition - defines what happens when an operator has completed its action defined by its affect on state
- Brainstorming techniques are useful to develop a data invariant for a complex function, e.g., bounds, restrictions and limitations

Set Preliminaries

- Set - collection of objects and elements, all elements are unique and order is immaterial
- Cardinality - number of items in a set
- Sets are defined by enumerating elements or using a constructive set specification
  - $\{n:\mathbb{N} \mid n < 3 \cdot n\}$
    - $n:\mathbb{N}$ is signature, specifies range of values considered
    - $n < 3$ is predicate defines how set is constructed
    - n is term provides general form of the item of the set, when n is obvious it can be omitted
  - {0, 1, 2}

More Set Prelims

$\in$ $x \in X$ denotes membership in a set

$12 \in \{6, 1, 2, 12, 22\}$

$x \notin X$ x is not a member of X

$\emptyset$ is empty set

$\emptyset \cup A = A$ and $\emptyset \cap A = \emptyset$

union, cup

intersection, cap

contained in relationships

Union combines both sets with duplicates eliminated

Intersection provides list of common elements

Yet More Set Prelims

- \ is set difference operation removes elements of 2nd from 1st
- X is cross product, each of the elements of the 1st combined with each of the elements of the 2nd
- Powerset is collection of subsets of set
- Logical operators
- Universal quantification
- Sequence, elements are ordered, 1st element is domain, 2nd element is range
- Sequence operators: concatenation, head, tail, front, last

Example: Block Handling

- Blocks of storage held on a file storage device
- State is collection of free blocks, collection of used blocks and queue of returned blocks
- Data Invariants:
  - No block will be marked as used and unused
  - All sets of blocks held in the queue will be subsets of the collection of currently used blocks
  - No elements of the queue will contain the same block numbers
  - Collection of used and unused blocks is the collection of blocks that make up files
  - The collection of {used, unused} blocks have no duplicate block number
- Operations: adds a collection of blocks to the end of queue, checks whether queue of block is empty

Block Handling - 2

- Blocks = set of all block #s
- AllBlocks is the set of blocks between 1 and MaxBlocks
- 2 sets, Used & Free
- Invariants:
  - Used ∩ Free = ∅ ∧ Used ∪ Free = AllBlocks ∧ …
- Operation, remove a block from head of queue
  - # BlockQueue > 0 : precondition
  - Postcondition: head must be removed and placed in Free and queue adjusted to show removal
  - Used' = Used \ head BlockQueue ∧ Free' = Free ∪ head BlockQueue ∧ BlockQueue' = tail BlockQueue

Formal Specification Language

- Three components:
  - Syntax defining specific notation of specification
  - Semantics to help define a universe of objects used to describe the system
  - Set of relations that define the rules indicating which objects properly satisfy the specification
- Syntax is usually derived from formal set theory
- Semantics abstraction usually are things such as states, state transitions, …

10 Commandments of Formal Methods

- Choose the appropriate notation - that is good match for application
- Formalize but not overformalize - not necessary for every (most) aspects of the system
- Estimate costs - formal methods have high startup, training costs
- Know a formal guru - for consultation
- Keep your standard development methods
- Document sufficiently including natural language commentary

10 Commandments (cont'd)

- Maintain quality standards - FM do not supplant quality efforts
- Do not be dogmatic - you will still get bugs
- Test, test and test again - does not replace testing
- Reuse

Cleanrooms

- Cleanroom techniques - build correctness into software as it is being developed
- Instead of analysis, design, code, test and debug
- Write code increments correctly the first time and verify correctness before testing - Do it right the first time
- Verification is through mathematical techniques
- Testing certifies software reliability

Steps in Cleanroom Design

- Analysis and design uses a box structure notation
  - Box encapsulates some aspect of the system (or entire system) at a level of abstraction
  - Correctness verification is done once the box structure design is completed
  - This is done in place of unit testing
- Testing is done by defining set of usage scenarios and probability of use for each scenario, then defining random tests that conform to the probabilities
- Error records from testing are analyzed to compute reliability
- Heavily incremental approach

Software Factories

- Applying factory techniques to software development emphasizing process, measurement and reuse (Toshiba's view)
- Software Workbench - integrated environment that supports all workers in factory - includes programming, debugging, configuration, test, requirements, documentation. Project management, quality assurance and reuse
- Uses waterfall model
- Project is divided into unit workloads with daily and weekly status, tracking actual vs expected, provides feedback and identifies issues
- Heavy Quality emphasis
- Reuse is the single most critical issue in improving quality and productivity
- Quality circles - voluntary groups of works that focus on improving quality, process, …

Software Archeology

- Trying to understand what was in the minds of software developers using only artifacts left behind
- Hampered by the fact that the artifacts were not created to communicate to the future
- Only part of what was originally created has been preserved
- Relics from different eras (versions) are intermingled
- Dynamic and static techniques
- Support for refactoring
- Browse the workshop!

Outsourcing

- Should you outsource?
- Outsourcing strategies
- Outsourcing tactics/plan
- Cultural issues in outsourcing (and in general distributed development)

Outsourcing Definition

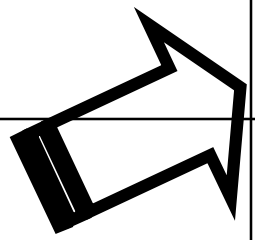
- Contracting of various information system functions such as managing of data centers, operations, hardware support, software maintenance, network and even application development to outside service providers.

Should you outsource?

- "no one really likes outsourcing, even well run initiatives" (http://www.cio.com)
- Outsourcing in combination with offshoring can get more value and reduce staff
- It can be leveraged to improve process discipline
- But root causes will still remain - e.g., lousy diagnostics will not make a help desk any better
- Privacy, security and reliability concerns must be addressed

Outsourcing Strategy
(Kishore, et.al. 2003)

	Low Strategic Importance	**High Strategic Importance**
High Control by Service Provider	Reliance	Alliance
Low Control by Service Provider	Support	Alignment



Outsourcing Plan

- Do a vendor assessment before contract is signed
  - Process, Technology, Operations audit (Reliance, Alliance)
  - Does vendor have privacy policy limiting data sharing
  - **Does the vendor subcontract?**
  - If live feed, proof that there are access controls, identity management and authentication in place
- Audit of privacy and security practices
- Senior executives must consent to sign a compliance pledge for privacy, security, process, …
- Complete due diligence
- Outsourcing should not be treated as a simple IT contract but as relationship management

Cultural Differences

- Exist in both collocation and virtual collocation
- Culture is acquired, it helps people read world signals, artifacts gestures. It molds the way people think and are motivated.
- Many kinds of culture - national, regional, organizational, avocational and generational
- Affects how projects are formed and managed

Dimensions of Culture

- Hofstede (IBM employees)
  - Revering hierarchy
  - Individualism vs. Collectivism
  - Task (Japan, Germany, US) vs. Relationship (France, Russia, Netherlands) focused
  - Risk avoidance (Japan, Russia vs US, India)
  - Longterm orientation
- Hall
  - Space
  - Material goods
  - Friendship (transitory or lasting)
  - Time
  - Agreement
- Low context (US) vs. High context cultures

Issues

- Team composition:
  - Short term teams difficult in high context cultures
  - Attribution of team mates - recognize skills (misattribution of dress in videos)
  - Motivation- money vs time off
- Teamwork
  - "microstructure of conversations" eye contact, tone of voice (soft, respect; loud, control)
  - Planning: buy in vs. authoritarion
  - Decision making: past, present, time/cost/quality
  - Argumentation styles: democracy versus authority
  - Use of time: abrupt meetings vs. slow chatty
  - Virtual collocation (high context need video, IM is an advantage(slowness issue))
  - Brainstorm - anonymity
  - Time of day: (Israel, Sunday-Thursday, French 35 hr week, Holidays)

Steps in Collocation

- Awareness of cultural factors
- Awareness of specific cultural values
- Adjust to suit others, understanding is not enough
- Establish a management communication covenant detailing how the team will be managed and how the team will communicates - just as important as agreeing on development rules and conventions!

UE - Undesired Events

- Basis for exception handling
- Always aspects of a program's execution environment that do not behave as we wish - if you will, defensive programming
  - Arises from the "normal" behavior of the real world
- Goal is to anticipate what can go wrong and make (the possibility for) accommodations in advance that do not mess with the structure
- Basis for variants of throw and catch

More on UEs

- Differentiate from errors that should be corrected
- UEs demand an evolutionary approach - they evolve as experience with system increases
- Responses to UEs include:
  - Self diagnosis
  - Saving of partial results
  - Printing of diagnostic Information
  - Retrying
  - Use of alternate resources
  - Job cessation only occurs as a last resort
- Traps keep code for UE separate from code for modules, lexical separation of normal use, from detection and correction procedures

Classes of UEs to detect

- Limitations on values of parameters
- Capacity limits
- Requests for undefined information
- Restrictions on order of operations
- Detections of action which are likely to be unintentional
  - "open" when opened, but this could be overloaded by convention
- Errors of mechanism - failure of modules is more difficult than failure by applicability condition

More on UEs

- Assign priorities to these traps usually more than one is active
- Try to consolidate UE routines, not one for one
- Eliminate some of the redundant checks as data is passed around for efficiency.
- Incidents, UEs that were expected and where recovery attempts were successful versus crashes

And the Rest

- Best Practices
- Life cycle software engineering - refactoring
- OA&M
- Project reviews

Thought Problems

- What is the most significant development in the software world since you became a software student/professional?

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