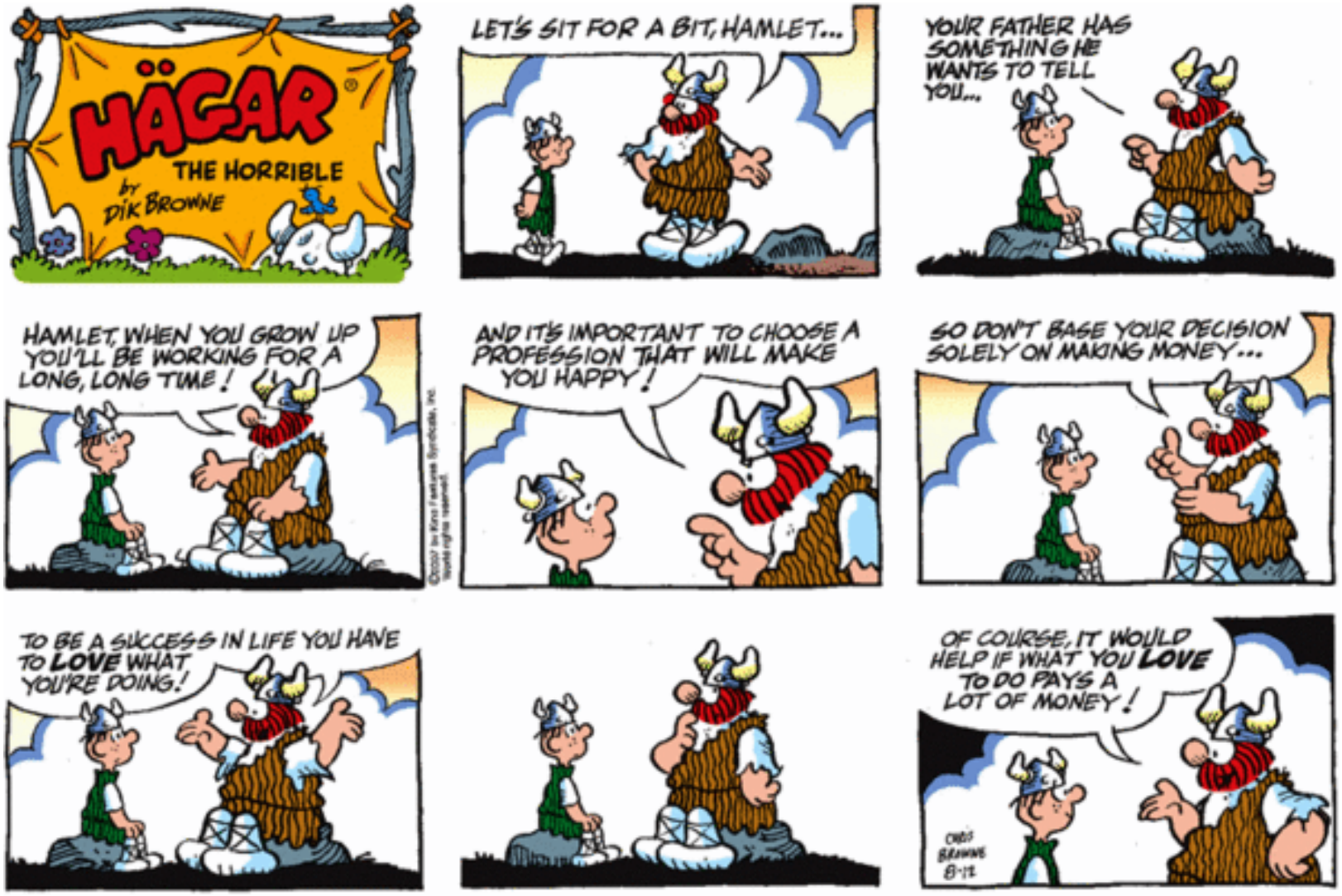
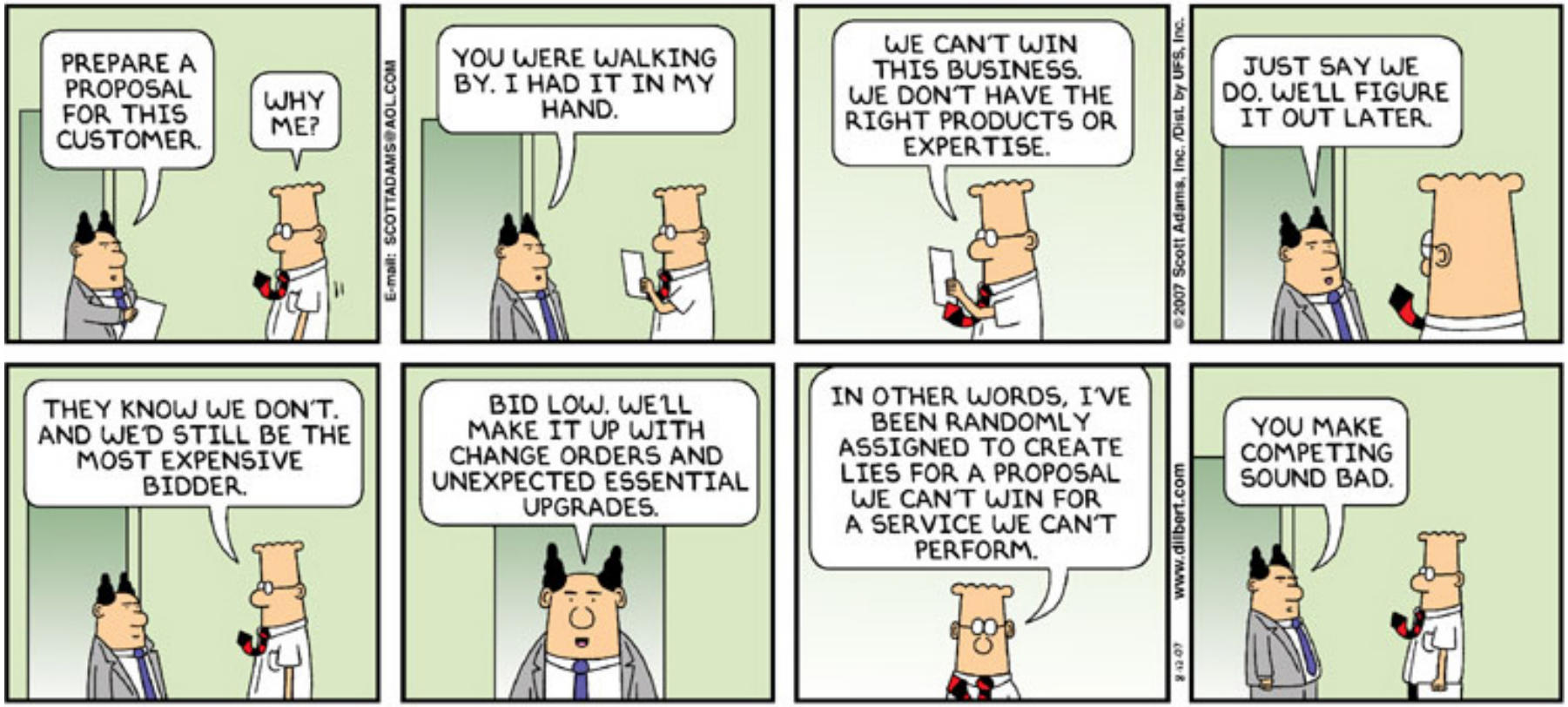
Introduction to Software Engineering

Dewayne E Perry
Office: ACE 5.124 – Hours MW 11-12:00
Phone: +1.512.471.2050
perry @ ece.utexas.edu
www.ece.utexas.edu/~perry/education/SE-Intro/

You Just Made the Wrong Choice ☺



Sometimes ☺



Course Information

- www.ece.utexas.edu/~perry/education/SE-Intro
  - Syllabus –
    - Lists papers to be read in preparation for each lecture
    - Online: at www.ece.utexas.edu/perry/education/
    - All papers are there to be downloaded
  - Class is discussion!
    - Preparation: read the papers
    - Will provide study/thought questions to consider while reading
    - In class excercises
  - Grades: weekly (possibly more) quizzes; 2 exams (no final exam)
    - At the beginning of class for that day's readings
    - NO make-up quizzes – will drop lowest two scores
    - NO make-up exams except under dire circumstances
    - 90%, 80%, 70%, 60%, 50% grade structure
    - Grad students – project with incremental schedule
  - Concepts and principles are the point in this course
    - Details are there to help understand the concepts and principles – will not hold you to remembering all the details
    - See the handout on how to read papers
  - Sample test there to give you an idea for quizzes & exams
  - Standard ECE and UT no cheating policies

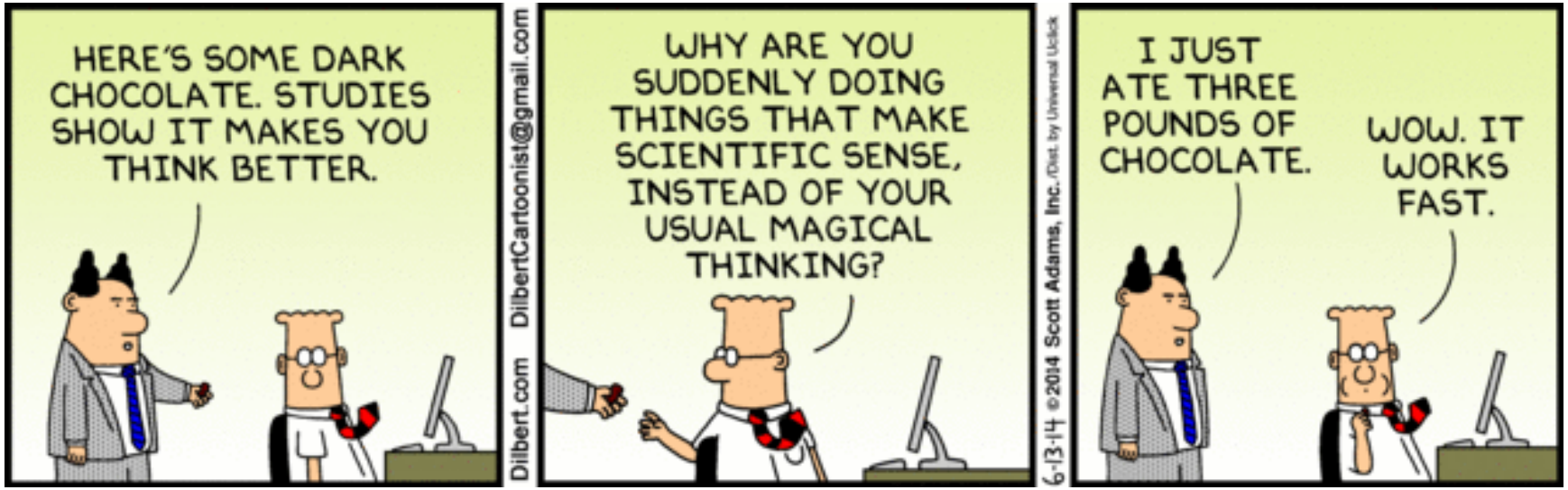
Other Matters

- Class attendance
  - Do not take attendance – BUT will call on you to answer questions
  - BUT weekly (or more) quizzes and two (1st half; 2nd half) exams
  - Generally, no PPT slides – class will be devoted to discussion
- Missing quizzes and exams
  - You are expected to be here for tests
  - IF you are going to miss, get to me first
    - Has to be a significant reason
    - There are phones with answer machines (office: 471-2050)
    - There is email (perry @ ece.utexas.edu)
    - And there is personal contact (I am usually around mornings)
  - The only excuse for not getting to me ahead of time is a death in the family – yours!
  - Interviews for jobs are not sufficient excuses. Your class comes first!!
- You will get out of this as much as you put into it!

To Help You Do Well

- Improve comprehension
  - WSJ: report on studies for improving comprehension
  - Look at ART –
    - Go visit the Blanton Museum
    - Take an art class
  - Stimulates the part of the brain related to comprehension
- Improve retention
  - WSJ: report on study for improving retention
  - Writing longhand notes versus typing (eg on you laptop)
    - Writing longhand exercises that part of the brain associated with retention
    - Typing does not.
- If all else fails, eat dark chocolate
  - See proof on next slide

Proof of Dark Chocolate



Reading Assignments

- Classic and seminal papers
  - The underlying concepts and principles are critical!
  - You will be thankful when you go to interview for a software position – your interviewers will like what you can say about engineering software systems
- I am going to be a CE/EE – why is SE relevant?
  - Software is invading every aspect of our lives
  - For CE (and even EE) you will build software systems
  - The concepts and principles are just as relevant for CE/EE
    - All engineering is about design, measurement and evaluation etc
- Building software systems is Fun!
  - One of the most creative and intellectually challenging fields today
  - The papers provide examples and lessons

The Joys and Sorrows

- Joys
  - Sheer joy of making things
  - Delight in working in a hackable medium
    - Thought stuff
    - Limits: imagination, logic and complexity
  - Fashioning complex puzzle-like objects
  - Creativity – grand concepts
  - Always learning new things
  - Making things useful for/to other people
- Sorrows
  - Other people often set the objectives and boundaries
  - Has to work perfectly
    - Finding bugs is hard work
    - Debugging has linear convergence, or worse
    - Make progress by finding our silly and not so silly mistakes
  - What we build may be obsolete before completed

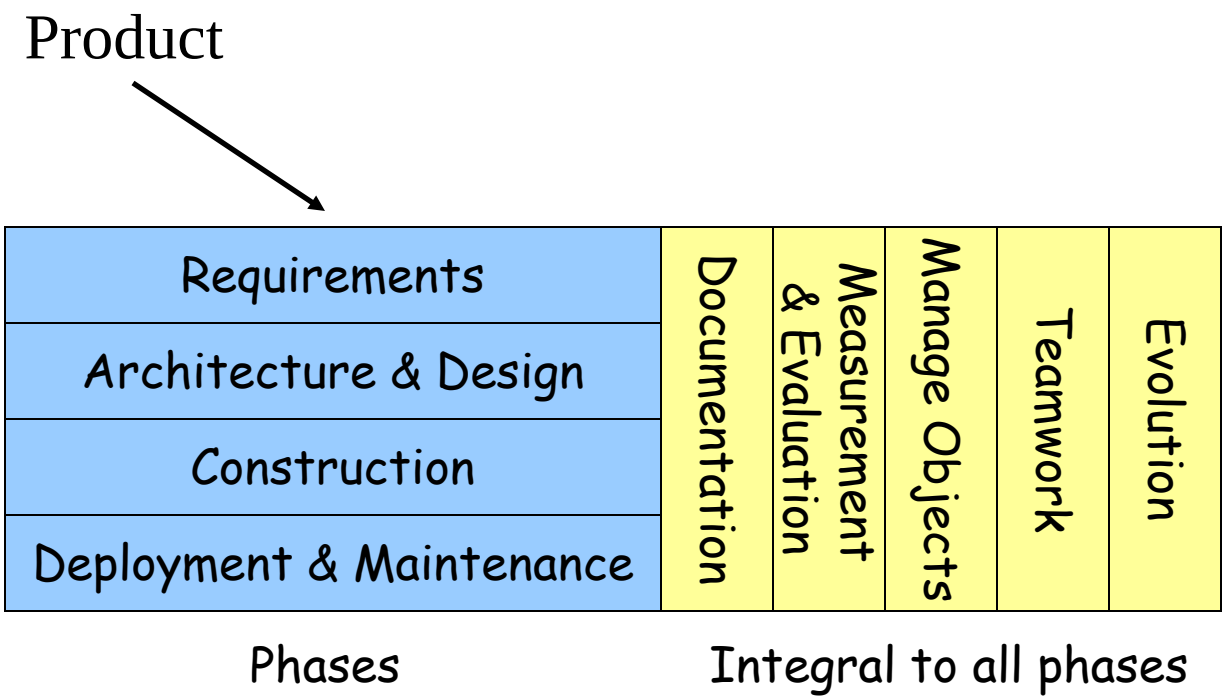
The Gospel according to BC ☺

- We are here to learn about software engineering
- We have a book and papers for basic understanding
- There are libraries, internet sites, colleagues, and me to supplement your basic knowledge

Overview of Course

- Overview of Software Engineering
- Life-Cycle Phases – ½ semesster
  - Requirements
  - Architecture & design
  - Construction
  - Deployment & Maintenance
- Integral Activities – ¼ semester
  - Documentation
  - Measurement & evaluation
  - Management of objects
  - Teamwork
  - Evolution
- Process Life-Cycle & Integral activities – ¼ semester
- Project Management – week before 2nd exam

SE Life-Cycle



Software Engineering (SE)

- Software Engineering is about building, maintaining and evolving software systems
  - Fundamentally, SE is a set of problem solving skills, methods, techniques and technology applied in a variety of domains to create & evolve useful software systems that solve practical problems
  - Programming is just one of these basic problem solving skills
- Brooks: "Software entities are more complex for their size than perhaps any other human construct"
- Wulf & Shaw: "Large programs, even not so large programs, are among the most complex creations of the human mind"
- Why?
  - Need more memory? Add more memory cards – replicate
  - In SE, add new distinct components, generally little replication.
- Basic Job of a Software Engineer
  - Discover, create, build and evolve
    - abstractions, behaviors and representations
  - Effectively evaluate and decide among alternative solutions

SE and Other Engineering Disciplines

- Two major components in engineering systems
  - Design
  - Manufacture
- Engineering is applied to both design and manufacture
  - Significant part of an engineering discipline is the manufacturing process
    - Have mathematics, for example, for optimization of processes
    - Engineer manufacturing and fabrication equipment
- SE: engineering is applied to both as well, BUT
  - Manufacture is
    - Trivial (by comparison – sometimes complex and time-consuming)
    - Mundane
    - Automated
  - Much larger emphasis on engineering applied to DESIGN
    - Building a software product is a DESIGN process
    - General design approaches/principles applied to diverse domains

Essential Characteristics of Software Systems

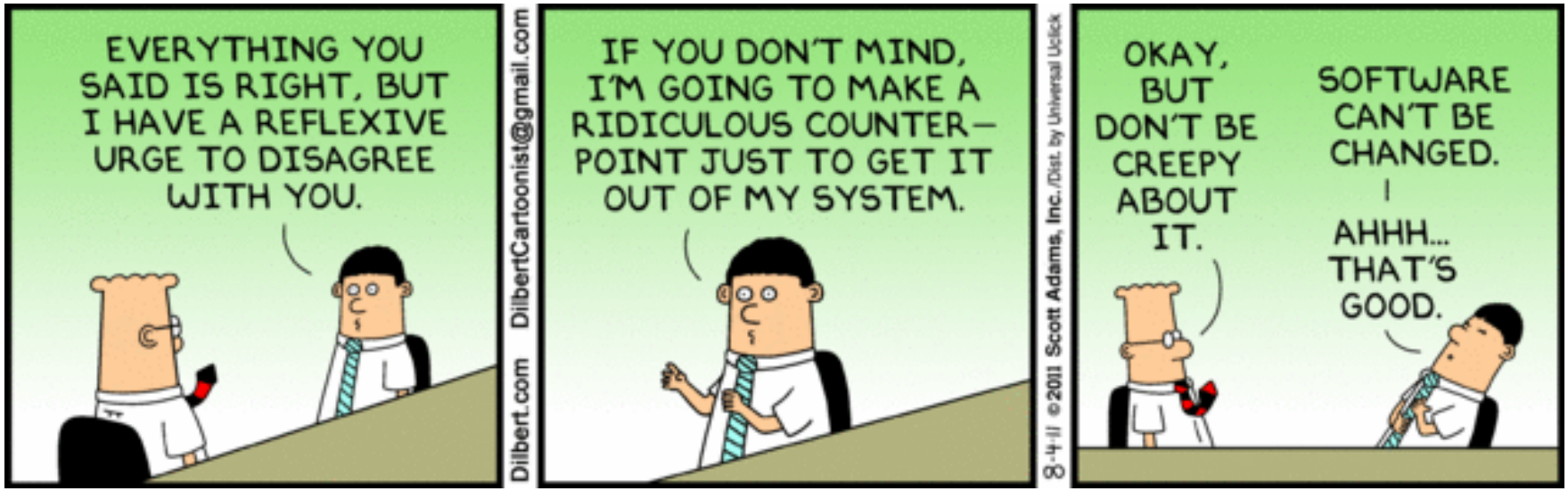
- Main Message of Brooks' *No Silver Bullet* paper:
  - . . . no single development, in either technology or management technique, that by itself promises even an order of magnitude improvement in productivity, reliability or simplicity !
- Brooks distinguishes between
  - Essential characteristics
  - Accidental characteristics
- Basic fact (and first important lesson):

  Building software systems is just plain hard
- Essence of software systems
  - A construct of interlocking constructs: data sets, relations between/among data, algorithms and invocations
  - Abstract

Essential Characteristics of Software Systems

- Essential characteristics
  - Complexity
  - Conformity
  - Changeability
  - Invisible
  - Implicit
  - Evolution
- Accidental Characteristics
  - Inadequate modes/means of expressions
  - Inadequate abstractions
  - Inadequate support
  - Resource limitations

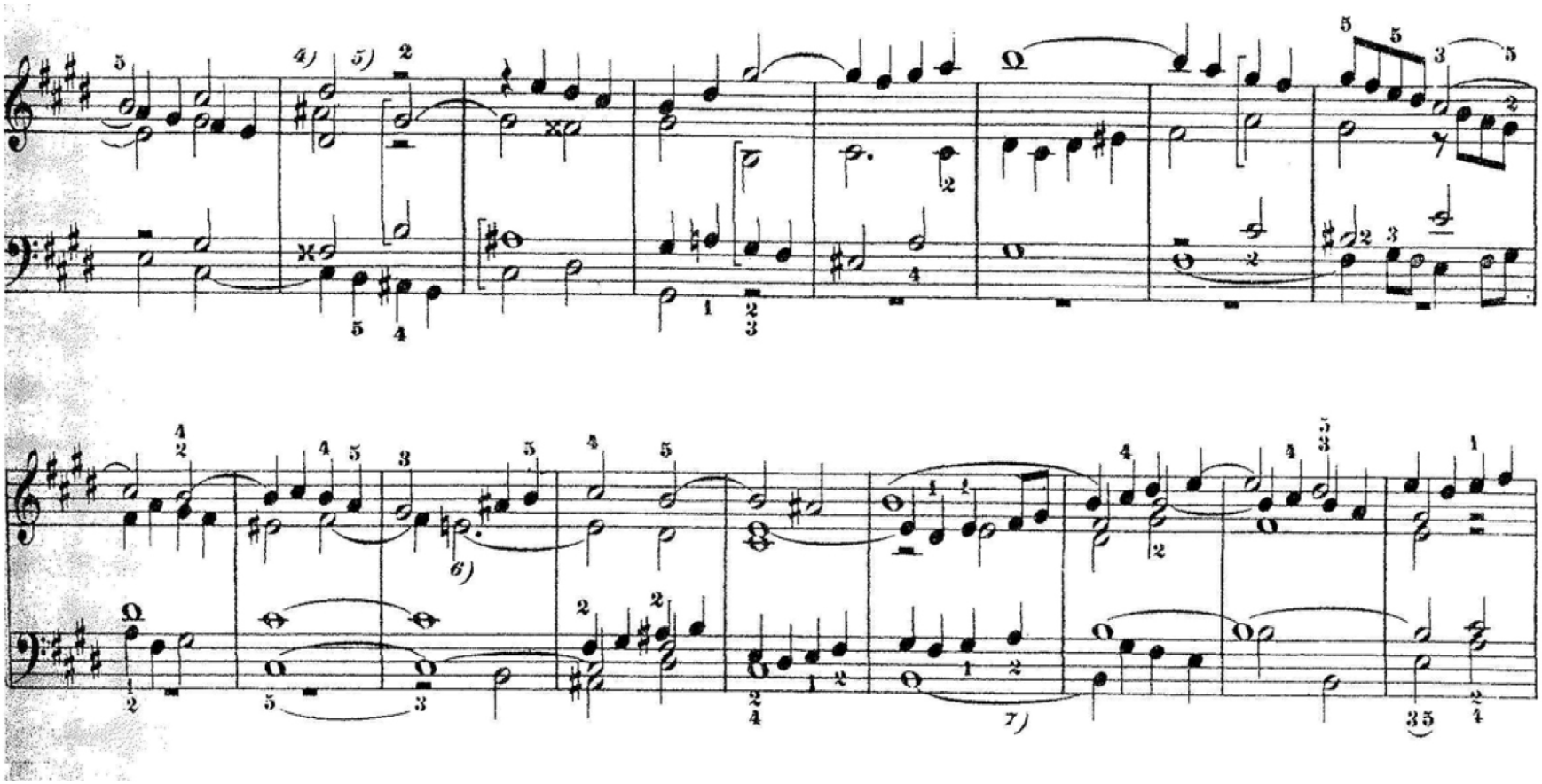
Dilbert & Brooks



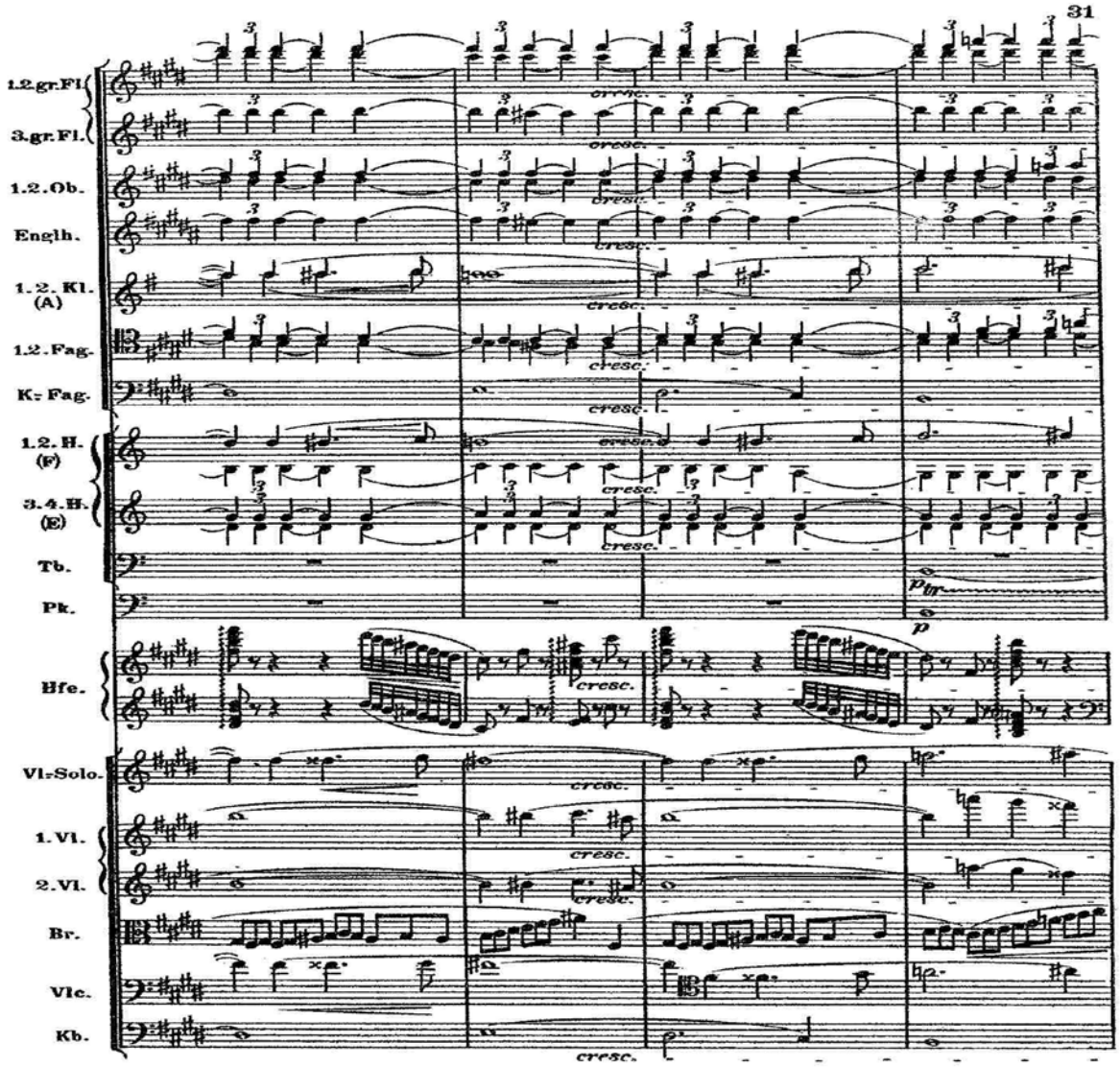
Essential Characteristics of Software Systems

- Complexity
  - Basic issues
    - No two parts alike - ie, all parts distinct
    - Scale up by addition, not replication
    - Very large number of states – hard to conceive, understand
  - 2 kinds of complexity
    - Intricacy
      - ✓Particularly true of algorithms
      - ✓Like a Bach 4 voice fugue
        - Horizontal and vertical relationships
        - Hard to change one note without severe repercussions
    - Wealth of detail
      - ✓Nothing very deep, just masses of details
      - ✓Like a Strauss tone poem, or Mahler symphony
        - Massive number of notes on a page – provide texture
        - Missing one would hardly be noticed
      - ✓Makes very hard to comprehend the entire system (eg, 10M lines)

Complexity: Intricacy (Bach)



Complexity: Wealth of Detail (Strauss)



Essential Characteristics of Software Systems

- Conformity
  - There are complex objects in physics
    - BUT they have uniformity
  - Not so in software systems – eg, interfaces
    - Often arbitrary complexity
- Changeability
  - Thought stuff → infinitely malleable
  - Hence, *soft*
- Invisible
  - Not inherently embedded in space
  - No inherent geometric representation
  - Multi-dimensional relationships

Essential Characteristics of Software Systems

- Implicit
  - Explicit part
    - Code – a desiccated relic of a long intellectual process
  - Very large design space
    - Narrow to code thru large number of design decisions
    - Various architectural, design and implementation decisions
    - Numerous and various trade-offs
  - Syntax represents gross and obvious dependencies
  - BUT, not the logical or semantic dependencies
- Evolution
  - Not a matter of "getting it right the first time"
    - Though sometimes that needs to be done
  - Changes in the world forces evolution
    - Context
    - Use
    - Technology

Accidental Characteristics of Software Systems

- Inadequate modes/means of expression
  - Languages are important:
    - Wittgenstein: "the limits of my language are the limits of my world"
    - Johnson: "language is the dress of thought"
  - High Level Languages
    - Frees us from accidental complexity
    - Provides useful abstractions that can be automatically checked
  - Eg, Ada
    - Modularity, abstraction, concurrency
    - BUT, still just an incremental improvement
  - Eg, OO
    - Abstract data types + hierarchical types with inheritance
    - Reduces syntactic stuff with no information content
    - BUT, type underbrush is not 9/10ths of the work we do

Accidental Characteristics of Software Systems

- Inadequate abstractions
  - AI heuristics
    - rules of thumbs
    - But much doesn't apply
  - Graphical programming – not convincing
    - An exception: Kramer & Magee's state simplification work
      - ✓Helps to find faults and reduces accidental complexity
  - Automatic programming: higher level language + generator
    - Need well understood domain
    - Relatively few parameters
    - Known methods for alternatives
    - Explicit rules for selecting solution techniques
  - Program verification: verify instead of test
    - No magic – hard work
    - Programming hard, Specifications harder, proofs harder yet
      - ✓Very hard to debug the specifications
      - ✓Virtually all published proofs of programs have bugs

Accidental Characteristics of Software Systems

- Inadequate support
  - Programming environments
    - Libraries, structures, standard formats
  - Eg, language oriented editors
    - Never did make it
    - Useful: integrated data base for impact details
- Resource limitations
  - Time-sharing systems
    - Immediacy, availability, continuity
  - Workstations
    - Think time still dominant
  - Cloud – just servers on steroids
    - Expands availability
    - But still possible connection problems

Brooks' Recommendations

- Buy not build
  - Will see later there are "flaws in the ointment"
- Requirements, refinement, prototypes
- Incremental development
  - Grow, don't build, software systems
- Use great designers
  - Good design practices → good designs
    - Can be taught
  - Great designs → need great designers
    - Creative (the difference between Salieri and Mozart)
    - Achieve *conceptual integrity*
      - ✓ The right mix of simplicity and functionality