Manufacturing Quality

18-849b Dependable Embedded Systems

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Overview: Manufacturing Quality

- **Introduction**
- **Key concepts**
  - The Manufacturing Paradigm
  - Manufacturing from an embedded systems perspective
  - Manufacturing software
  - Quality
- **Relationship to other topics**
  - Robustness
  - Reliability
  - Business model
- **Area of Exploration**
  - Can high quality manufacturing lead to high quality software?

Why should we care about Manufacturing?

- Affects cost, reliability, and robustness
- Maybe we can learn from its methods

The Manufacturing Paradigm

- **Interchangeable parts**
- **Mass Production**
- **Total Quality Management**
- **Six-sigma Quality**

The Manufacturing Paradigm

- **Interchangeable parts**
  - Traditional approach
    - each machine is made from scratch, with a unique set of parts
  - New idea, circa 1900
    - make machines from common parts
      - » eased construction and replacement
      - » a machine could be made using one construction method
      - » led way for Henry Ford and Mass production
- **Mass Production**
  - Henry Ford created a factory to mass produce Model-T's in 1913
  - Bring the foundation to the parts
  - Labor is interchangeable and specialize
  - This method works for food too (McDonalds), how about software?

The Manufacturing Paradigm

- **Quality Engineering**

- **STDM, VOC, CAD/CIM, ISO 9001, and UATAQ**
  - (Using Acronyms To Achieve Quality)
- **TQM (Total Quality Management)**
  - Quality issues exist in every part of a corporation, so apply quality everywhere
- **Measuring Quality: defined from the end user's perspective**
- **Design to Manufacture**
  - From CAD directly to the manufacturing floor.

The Manufacturing Paradigm

- **Six-Sigma Quality (Motorola Inside™)**
  - The mean value of an operating parameter may vary as much as 1.5σ.
  - 6σ quality means a product will work when its operating parameters are within 6σ of the norm.
  - Achieving Six-Sigma requires both quality in design both and manufacturing
  - Process driven method

Embedded Systems Considerations

- **Cost**
- **Design For Assembly**
  - Minimize resources needed to assemble (motion, locality)
- **Design in high tolerance for variation**

Manufacturing Software

- **Bringing the factory to the software industry**
- **Software Factories in Japan**
- **Cleanroom Software Engineering**

Manufacturing Software

- **Can factory methods be moved to the software house**
  - Design to manufacture? (Automatic program generation)
  - Reusable/interchangeable parts?
  - Total Quality assurance

Manufacturing Software

- **Software Factories**
  - Japanese combining western software engineering methods with their own manufacturing quality techniques.
  - Features
    - All phases of software creation done in a unified environment
    - Reusable components (trying to automate this)
    - Assembly line organization (design separated from test)
    - Quality checks: specified number of faults allowed per each phase
    - Group peer reviews
  - Research Areas
    - Design to Manufacture: code generation from a specification
    - computer assisted programming
  - Results
    - claim from Toshiba Fuchu Software Factory: for real-time control system 0.3-0.1 faults per KLOC

Manufacturing Software

- **Cleanroom Software Engineering**
  - Separation of design and test (factory line organization)
    - Designers are not allowed to compile code, but all code is subject to intense peer review.
  - Formal specification as much as project allows
  - Statistical testing to certify quality done from user's perspective
  - Incremental additions always done at the user level
  - Different groups adapt different pieces as needed

  - Results
    - IBM: COBOL/SF added 52,000 lines of code to 40,000 base, 179 errors (norm 1500 - 3000), 740 LOC/LM (norm 150)
    - NASA: training was 4% of project hours, 69% higher productivity, 45% reduction in error rate

Conclusions & Future Work

- **What should an Embedded systems engineer worry about?**
  - Manufacturing quality control
  - Manufacturing costs

- **What can we take from the factory?**
  - Separation of design and test
  - Get it right in the design phase
  - Design to manufacture won't happen for a long time

Paper: Cleanroom Software Engineering

- **How useful is the Cleanroom method?**

- **Are their any other areas of manufacturing that can be applied to software engineering?**