RECOVERY-ORIENTED COMPUTING

Recovery Oriented Computing (ROC)

Dave Patterson and a cast of 1000s:

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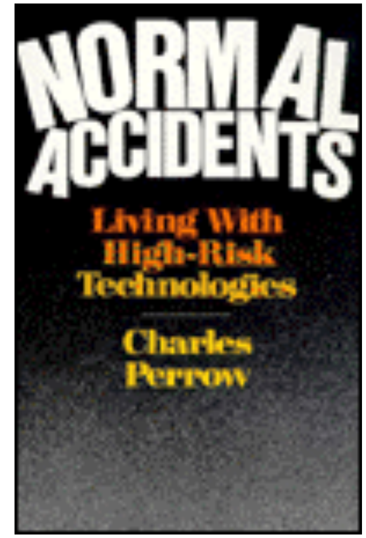
Outline

- **The past:** where we have been
- **The present:** new realities and challenges
- **A future:** Recovery-Oriented Computing (ROC)
- **ROC techniques and principles**

The past: research goals and assumptions of last 20 years

- **Goal #1: Improve performance**
- **Goal #2: Improve performance**
- **Goal #3: Improve cost-performance**
- **Simplifying Assumptions**
  - Humans are perfect (they don't make mistakes during installation, wiring, upgrade, maintenance or repair)
  - Software will eventually be bug free (Hire better programmers!)
  - Hardware MTBF is already very large (~100 years between failures), and will continue to increase
  - Maintenance costs irrelevant vs. Purchase price (maintenance a function of price, so cheaper helps)

Learning from other fields: disasters



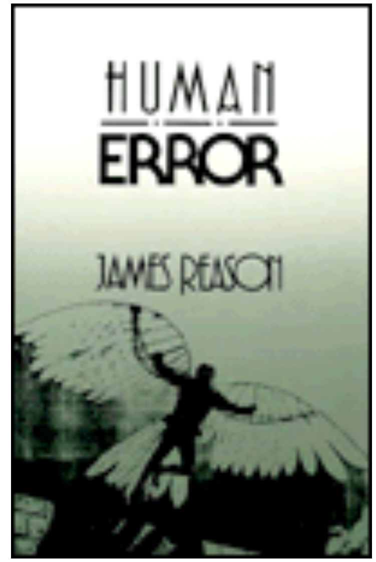
Common threads in accidents ~3 Mile Island

1. More multiple failures than you believe possible, because latent errors accumulate
2. Operators cannot fully understand system because errors in implementation, measurement system, warning systems. Also complex, hard to predict interactions
3. Tendency to blame operators afterwards (60-80%), but they must operate with missing, wrong information
4. The systems are never all working fully properly: bad warning lights, sensors out, things in repair
5. Emergency Systems are often flawed. At 3 Mile Island, 2 valves in wrong position; parts of a redundant system used only in an emergency. Facility running under normal operation masks errors in error handling

Source: Charles Perrow, *Normal Accidents: Living with High Risk Technologies*, Perseus Books, 1990

Learning from other fields: human error

- **Two kinds of human error**
  - 1) **slips/lapses:** errors in execution
  - 2) **mistakes:** errors in planning
  - – errors can be **active** (operator error) or **latent** (design error, management error)
- **Human errors are inevitable**
  - – "humans are furious pattern-matchers"
    - » sometimes the match is wrong
  - – cognitive strain leads brain to think up least-effort solutions first, even if wrong
- **Humans can self-detect errors**
  - – about 75% of errors are immediately detected

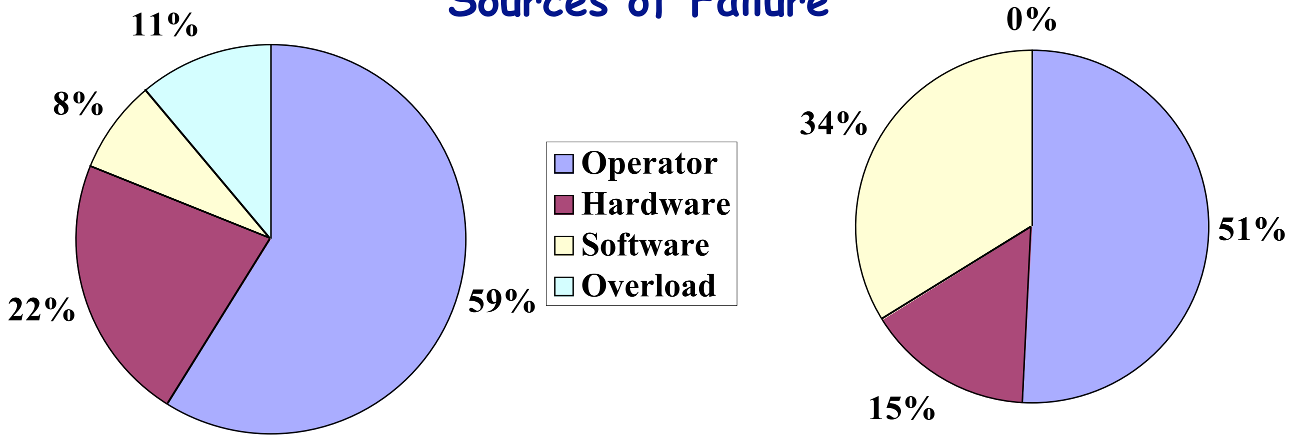


Source: J. Reason, Human Error, Cambridge, 1990.

Human error

- **Human operator error is the leading cause of dependability problems in many domains**

Sources of Failure



Public Switched Telephone Network — Average of 3 Internet Sites

- **Operator error cannot be eliminated**
  - humans inevitably make mistakes: "to err is human"
  - *automation irony* tells us we can't eliminate the human

Source: D. Patterson et al. Recovery Oriented Computing (ROC): Motivation, Definition, Techniques, and Case Studies, UC Berkeley Technical Report UCB//CSD-02-1175, March 2002.

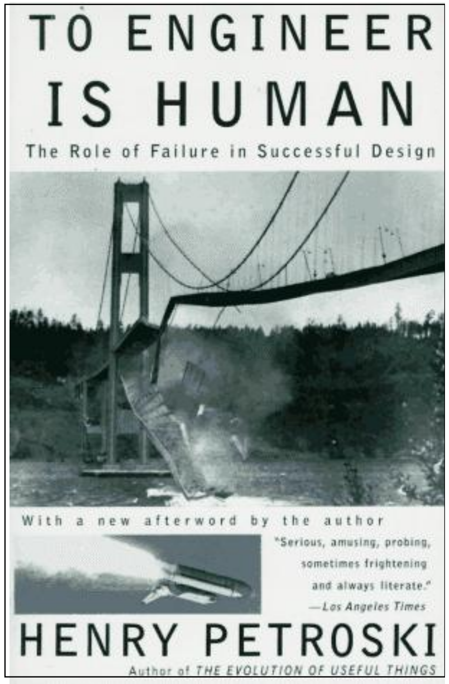
The ironies of automation

- **Automation doesn't remove human influence**
  - shifts the burden from operator to designer
    - » designers are human too, and make mistakes
    - » unless designer is perfect, human operator still needed
- **Automation can make operator's job harder**
  - reduces operator's understanding of the system
    - » automation increases complexity, decreases visibility
    - » no opportunity to learn without day-to-day interaction
  - uninformed operator still has to solve exceptional scenarios missed by (imperfect) designers
    - » exceptional situations are already the most error-prone
- **Need tools to help, not replace, operator**

Source: J. Reason, <u>Human Error</u>, Cambridge University Press, 1990.

Learning from others: Bridges

- 1800s: 1/4 iron truss railroad bridges failed!
- Safety is now part of Civil Engineering DNA
- Techniques invented since 1800s:
  - Learn from failures vs. successes
  - Redundancy to survive some failures
  - Margin of safety 3X-6X vs. calculated load
  - (CS&E version of safety margin?)
- What will people of future think of our computers?



Where we are today

- **MAD TV, "Antiques Roadshow, 3005 AD"**

  VALTREX:

  "Ah ha. You paid 7 million Rubex too much. My suggestion: beam it directly into the disposal cube.

  These pieces of crap crashed and froze so frequently that people became violent!

  Hargh!"

"Worthless Piece of Crap: 0 Rubex"

Recovery-Oriented Computing Philosophy

"If a problem has no solution, it may not be a problem, but a fact, not to be solved, but to be coped with over time"

— Shimon Peres ("Peres's Law")

- **People/HW/SW failures are facts, not problems**
- **Recovery/repair is how we cope with them**
- **Improving recovery/repair improves availability**
  - UnAvailability = $\frac{MTTR}{MTTF}$ *(assuming MTTR much less than MTTF)*
  - 1/10th MTTR just as valuable as 10X MTBF
- **ROC also helps with maintenance/TCO**
  - since major Sys Admin job is recovery after failure
- **Since TCO is 5-10X HW/SW $, if necessary spend disk/DRAM/CPU resources for recovery**

ROC Summary

- **21st Century Research challenge is Synergy with Humanity, Dependability, Security/Privacy**
- **2002: Peres's Law greater than Moore's Law?**
  - Must cope with fact that people, SW, HW fail
  - Industry may soon compete on recovery time v. SPEC
- **Recovery Oriented Computing is one path for operator synergy, dependability for servers**
  - Failure data collection + Benchmarks to evaluate
  - Partitioning, Redundandy, Diagnosis, Partial Restart, Input/Fault Insertion, Undo, Margin of Safety
- **Significantly reducing MTTR (people/SW/HW) => better Dependability & Cost of Ownership**

Interested in ROCing?

- **More research opportunities than 2 university projects can cover. Many could help with:**
  - Failure data collection, analysis, and publication
  - Create/Run Recovery benchmarks: compare (by vendor) databases, files systems, routers, …
  - Invent, evaluate techniques to reduce MTTR and TCO in computation, storage, and network systems
  - (Lots of low hanging fruit)

"If it's important,
how can you say it's impossible if you don't try?"
Jean Monnet, a founder of European Union

http://ROC.cs.berkeley.edu