On the Brittleness of Software and the Infeasibility of Security Metrics

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“If you can not measure it, you can not improve it.”

“When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.”
What About Security?

- I’d really like to know how well software resists attacks.
- Other fields have such numbers.
- Example: a wood frame wall with $2 \times 4$ studs on 16” centers, 3.5” mineral wool batt insulation, and 5/8” Type X gypsum wallboard is rated for 1 hour fire resistance. If has $2 \times 6$ studs on 24” centers with 5.5” insulation, it’s rated for 2 hours.
- What is the software equivalent?
- Reluctant assertion: we not only don’t have such a number, we can’t without a major technology change.
Why Not?

- **Axiom:** All software is buggy
- **Axiom (Murphy):** Anything that can go wrong, will
- **Theorem:** In security software, some of the bugs will be security-critical

In other words, no matter how well-audited security software is, it can contain an unsuspected hole that can be exploited very rapidly. Nor do we have any metric for how much effort a smart enemy may have to expend to find it.
Examples

- The Witty (Black Ice) worm
- Kerberized telnet encryption
- Buffer overflows and more in ssh

Software is brittle — one bug can shatter it!
What About Layered Defenses?

- Suppose we have several layers of defense
- Each layer is easily penetrated, as above
- As soon as a layer is penetrated, it doesn’t hinder attacks on the next layer
- Strength is thus (at best) linear in the number of layers, and the strength of each layer is very, very low
Composition Can Introduce Flaws

- We have no science of security mechanism composition
- Incommensurate layers can result in destructive interference
- Example: Java versus firewall FTP proxies (Martin, Rajagopalan, and Rubin)
- Example: misrouting by switches and overenthusiastic firewalls
Intrusion Detection

- Intrusion Detection Systems are famous for false negatives
- Besides, an attacker can buy a copy of your system and practice attacks at home (Karger and Schell, 1974)
- Even if an IDS can detect it, it can’t react fast enough against an automated attack
What We Need

- We need a way to make software less brittle
- Perhaps self-healing software will do the trick, where a hole can be closed behind the attacker
- Alternatively, we need a science of composition that gives us more than a linear increase in strength
- Until we have at least one of these, we will not have useful security strength metrics