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Combinatorial Testing

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NIST Combinatorial Testing

- Applying empirical results to reduce the cost of testing.
- Example: 2.5 year study ~ 20% lower test development cost and 20% - 50% better coverage (more on this later)
- Tutorial obtained by > 21,000 people; Tools in > 1,200 organizations
- Joint research with many organizations

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Software Failure Analysis

- NIST studied software failures in a variety of fields
- How many factors involved in software failures?

2 factors

Example medical device failure analysis:

Failure when "altitude adjustment set on 0 meters and total flow volume set at delivery rate of less than 2.2 liters per minute."

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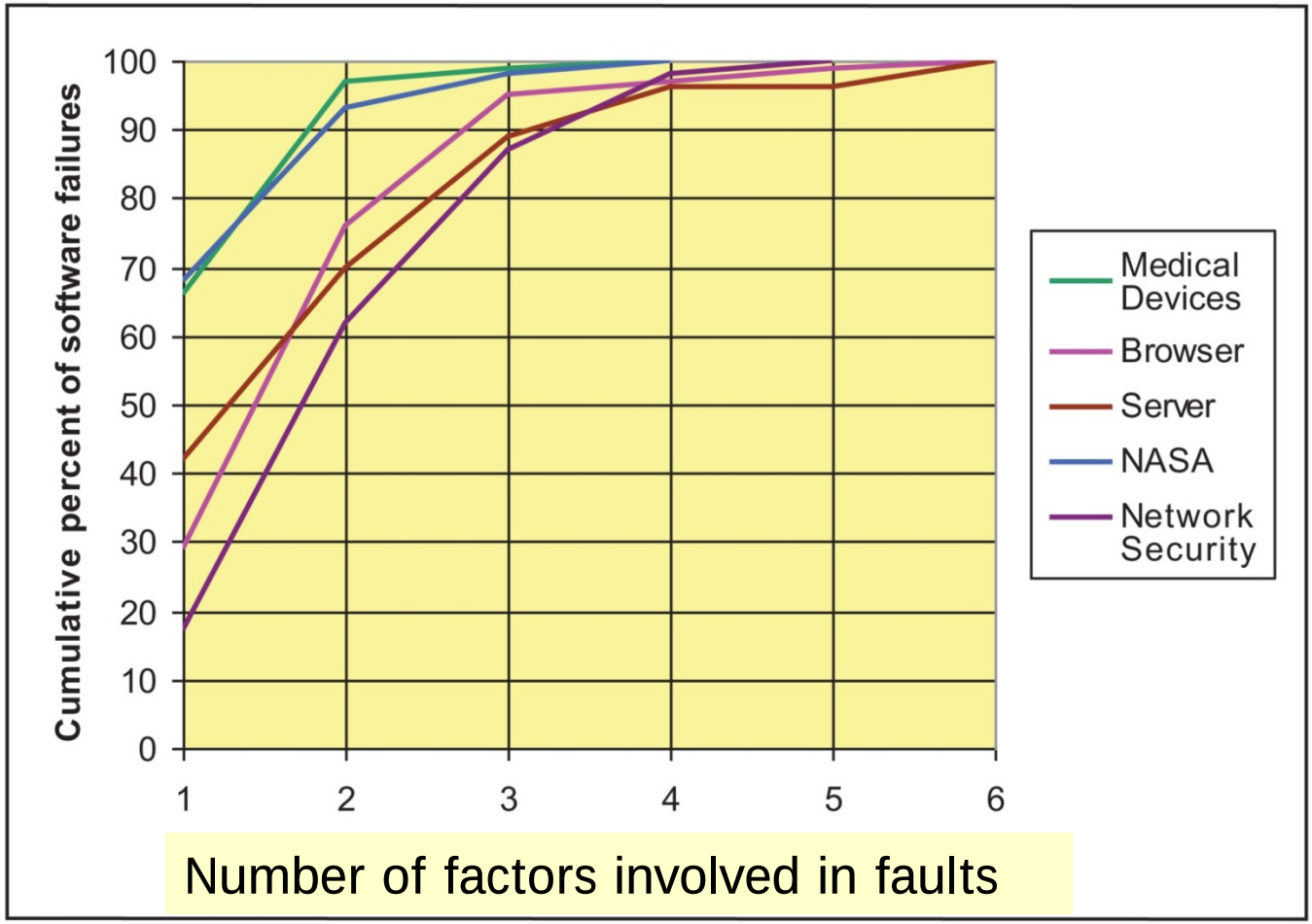

- Number of factors involved in failures is small
- New algorithms make it practical to test these combinations
- We test large number of combinations with very few tests

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How do we use this knowledge?

Ex: 34 switches = 2^{34} = 1.7 x 10^{10} possible inputs

= 17 billion tests for all combinations – impossible

So how much testing do we need?

How much testing can we afford?

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- Recall key finding that a small number of factors are involved in failures
- How well can we compress combinations into a small number of tests?

- For 3-way interactions, need only **33** tests
- For 4-way interactions, need only **85** tests
- 5-way interactions, **213** tests
- 6-way interactions, **522** tests

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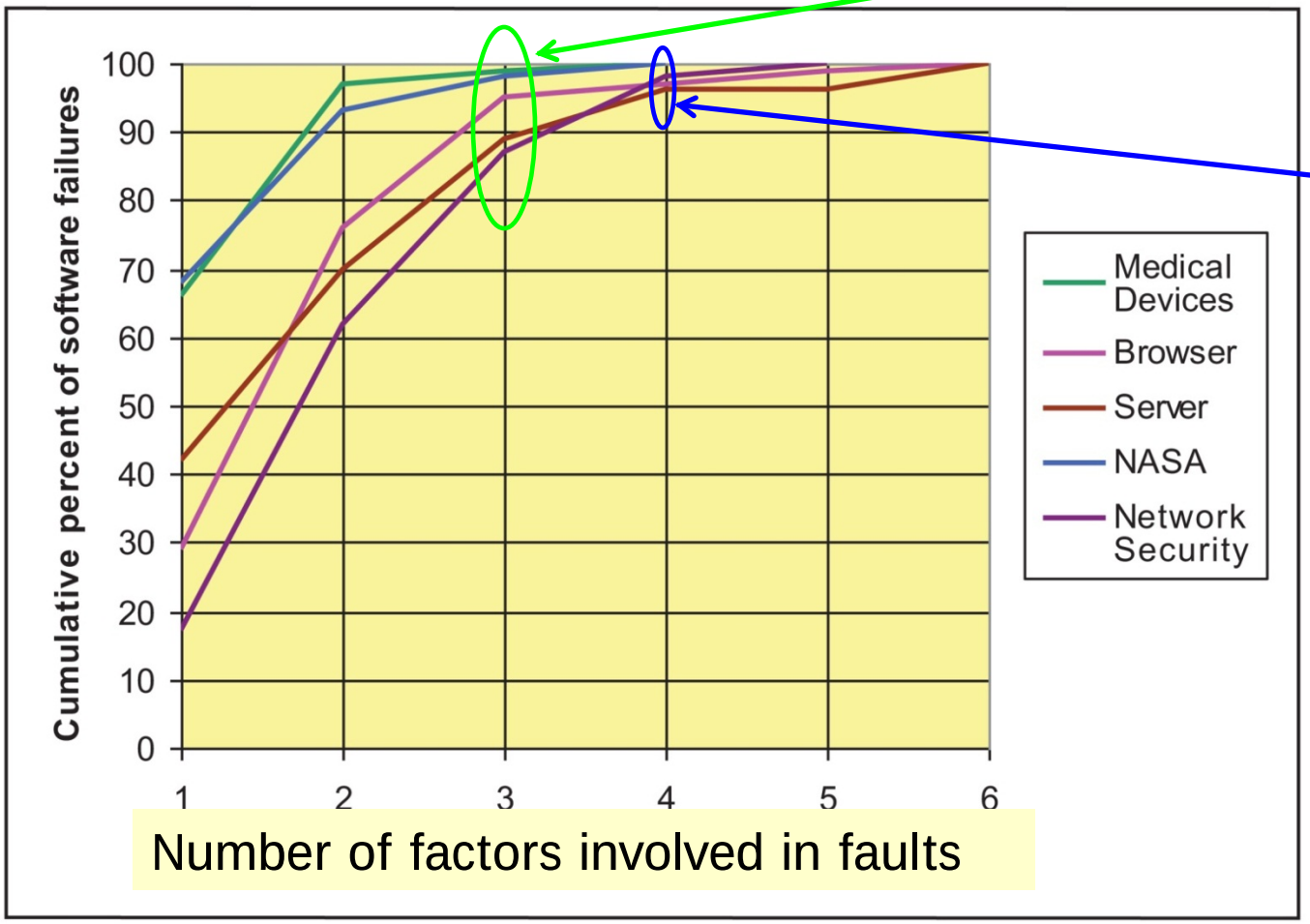

33 tests for this range of fault detection

85 tests for this range of fault detection

That's way better than 17 billion!

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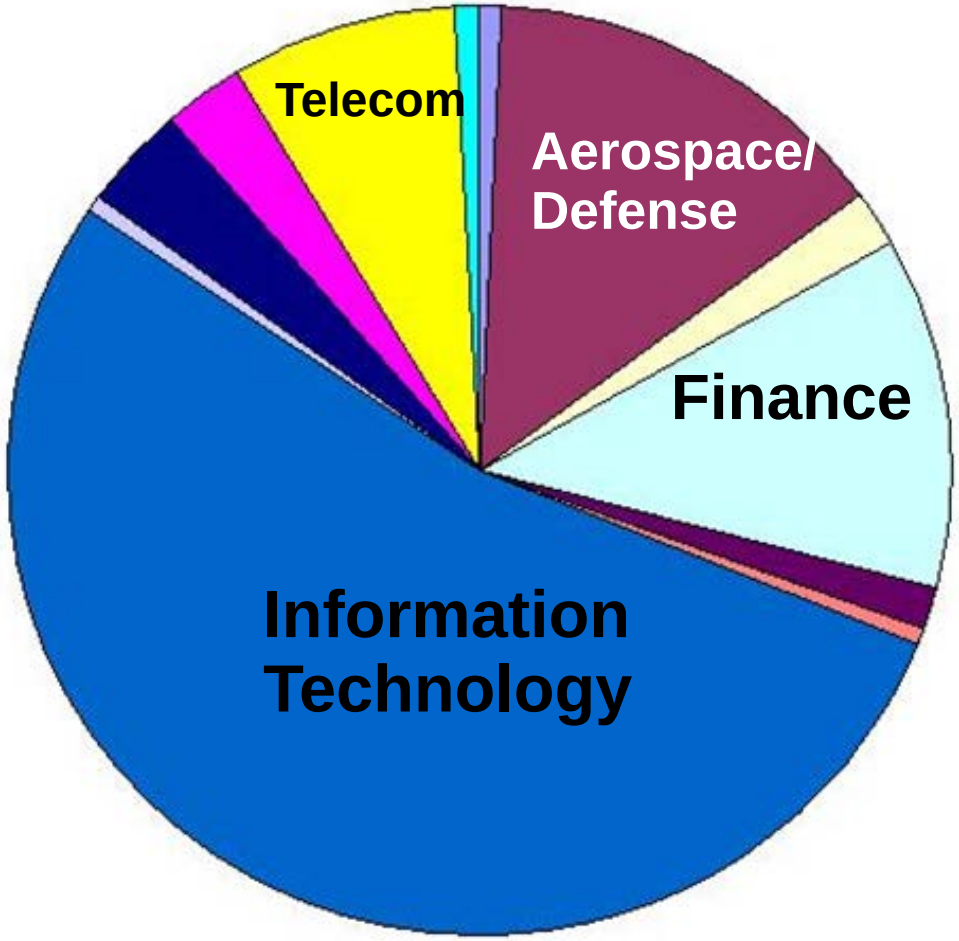
Technology Applications

- Greatest use in IT – hardware and software; networks, cloud, transaction processing
- Strong adoption for aerospace and financial systems
- Good for detecting inputs that cause failures, or configurations that lead to problems

ACTS Users - industries

software with
- *high complexity*
- *high risk*



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Commercial Applications

- Software testing
- Large system hardware/software eval
- Integrated circuit testing
- Product lines and highly configurable software
- Modeling and simulation
- Example: 2.5 year evaluation in one of the world's largest defense firms, across multiple business areas: Better fault detection/analysis effectiveness & 20% lower test development cost

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Collaboration Opportunities

- Software is freely distributed in binary; plan to make it open source
- Products built from NIST software
- Many companies use it in consulting and contract testing
- See **csrc.nist.gov/acts**

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Summary

- Analyzed failure causes in real-world systems: few variables interacting (none > 6 seen)
- Developed advanced algorithms to efficiently compress tests based on this finding
- Demonstrated effectiveness in large, complex real-world systems: better testing, test development cost reduction about 20% (testing is typically half of total s/w cost)

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