Is There Such a Thing as Software Reliability?

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Defining Reliability

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- The specification is essential – defines *failure*
- Large enough N always means $R(N) = 0$
- How to measure (estimate) R?
- Confidence in measurements?

Life Testing Toasters

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   - If out of 100, one toaster fails first at 379 slices and one lasts longest to 420 slices, then
   - $\hat{R}(1) = \hat{R}(2) = ... = \hat{R}(378) = 1.0$
   - $\hat{R}(379) = 0.99, ..., \hat{R}(419) = 0.01$
   - $\hat{R}(420) = \hat{R}(421) = ... = 0$

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5. An estimate of the *mean runs to failure (MRTF)* is the average $\bar{N}$ of N_i
6. Calculate standard error σ of the N_i
7. Confidence that the actual MRTF is within the interval $[\bar{N} - 2\sigma, \bar{N} + 2\sigma]$ is roughly 95%

Assumptions Required for Life Testing (Toasters)

1. Toaster behavior is continuous
2. Toasters have no systematic cause of failure
3. Each toasting run is independent of the others (Bernuilli trials)
4. Test circumstances duplicate actual toasting

Then the measured MRTF and confidence are accurate predictions

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Interaction between 2 and 4:

- Gap in screen guarding the heating element (2 false)
- Tests use sliced bread but usage is for fat bagels (4 false)
- Bagel protrudes through the gap and burns out heating element long before the predicted MRTF

Can't Wait for Failure?

Five years of breakfast is about 3000 slices

- Time for each toaster to fail is about $\bar{N}$, the MRTF
- 3,000 slices can be toasted in about 5 days
  (@2 min each – overheating violates assumption ❹!)
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What can be predicted from runs that do not fail?

- Confidence C that the failure probability is below $f_{\max}$ based on T runs: $C = 1 - (1 - f_{\max})^T$
- For toasters, 95% confidence in a MRTF of better than 3000 requires $T \approx 9000$
- For $T = 3000$:

confidence	95%	75%	63%	50%
MRTF	1000	2200	3000	4300

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  OK, predict a large enough MRTF from no failures

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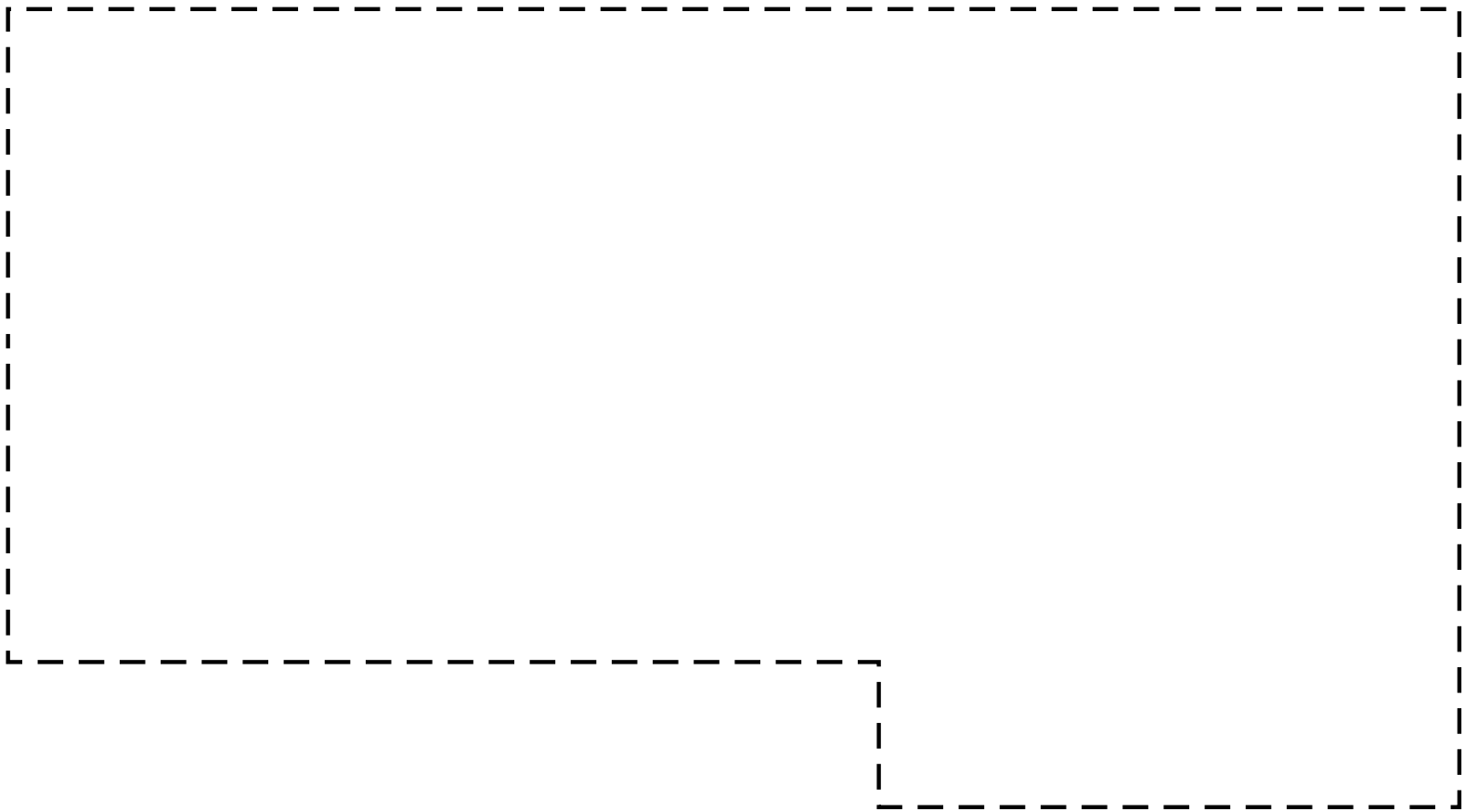
  The minefield analogy



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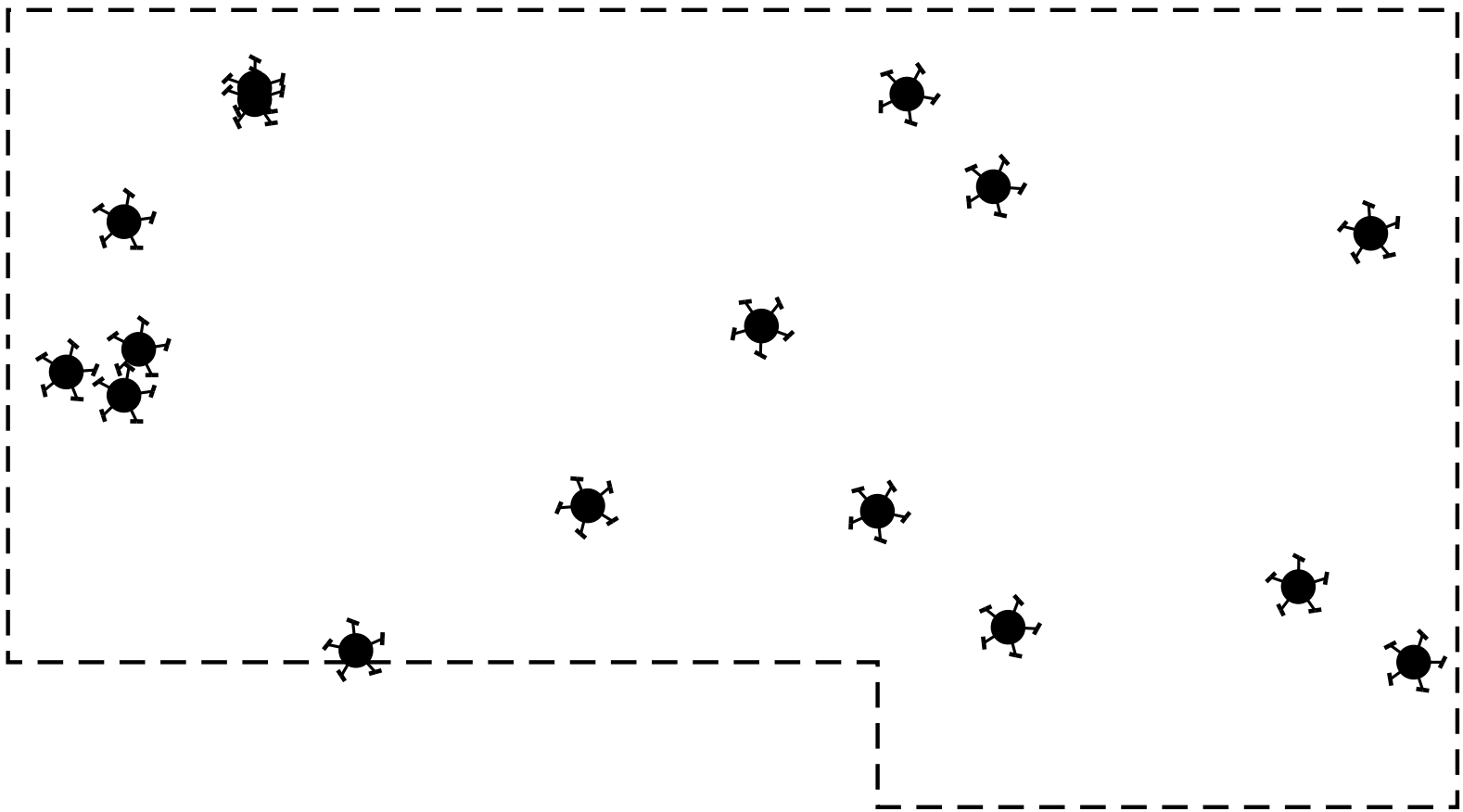

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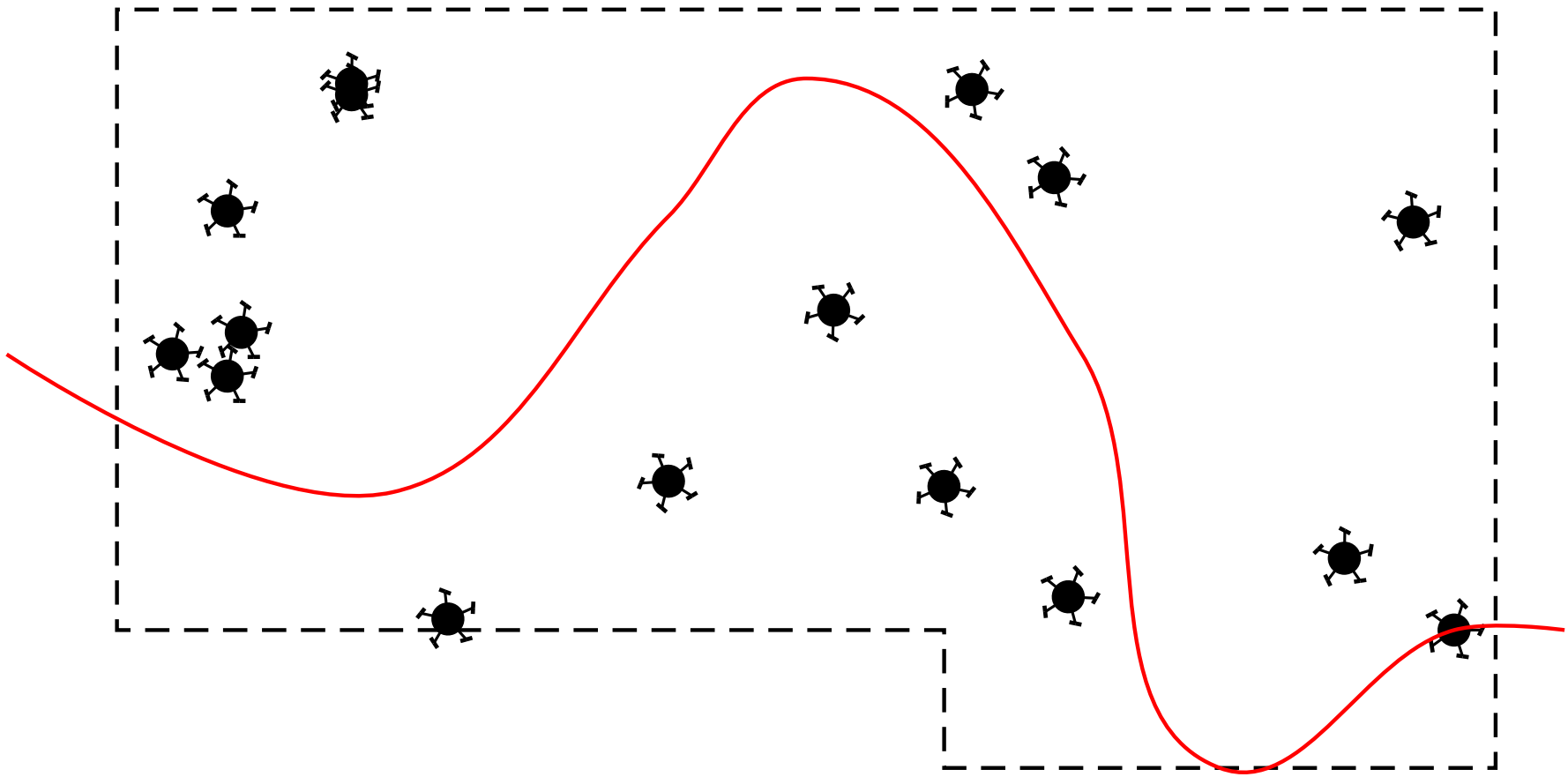

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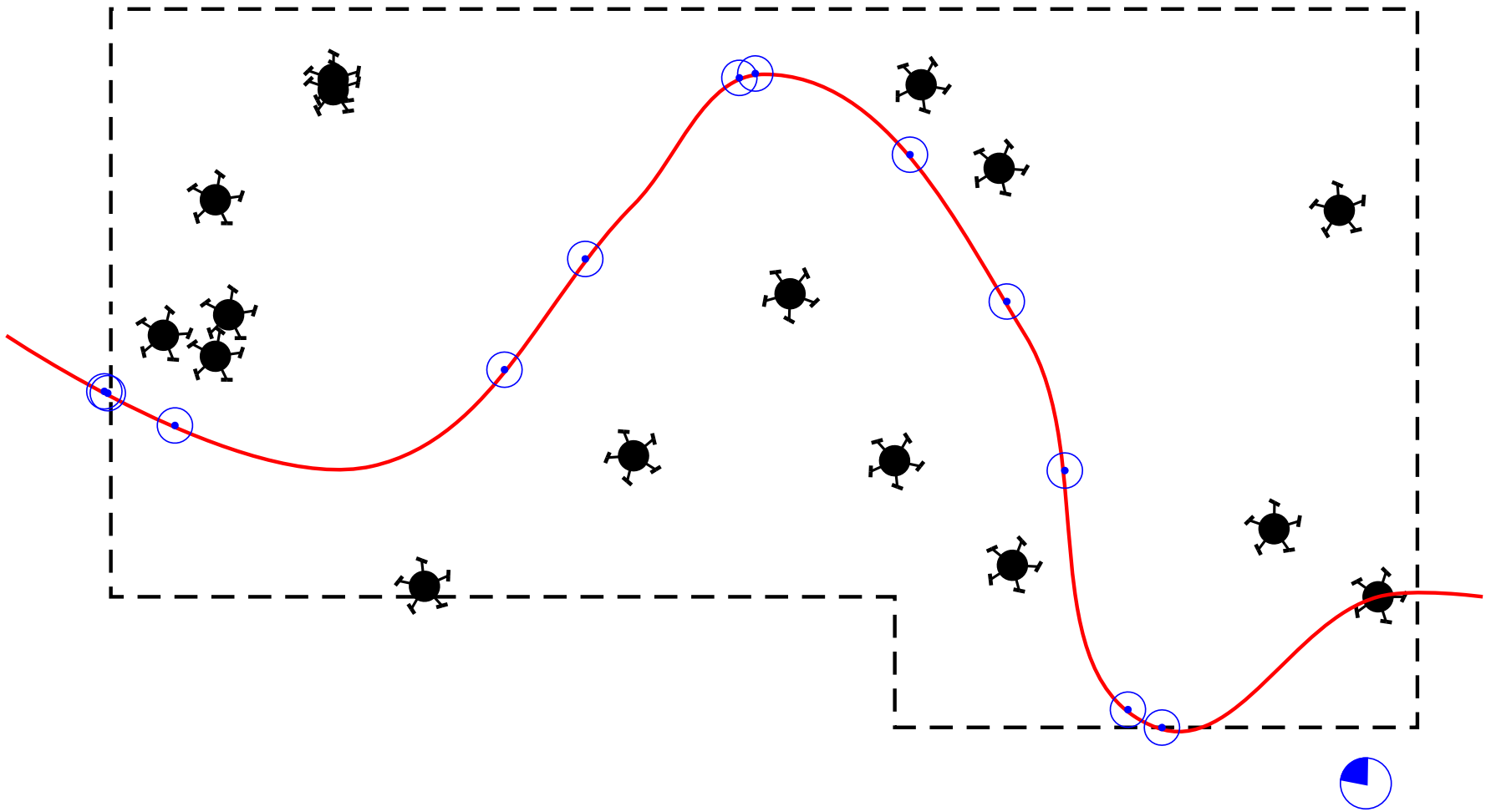

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  12 rocks thrown with no explosion

  $\Rightarrow$ *70% confidence that 10 steps are safe*

Mindfield	*Software*
field	input space
mines	failure inputs
path	usage profile
rocks thrown	tests executed
explosions	failures
steps on the path	runs

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- Assumptions of life testing are false
  1. ~~Toaster~~ Software behavior is dis continuous
  2. ~~Toasters have no~~ Software bugs are systematic cause s of failure
  3. ~~Each toasting run is~~ Hard to make software runs independent of the others (Bernuilli trials)
  4. Test circumstances duplicate actual ~~toasting~~ usage

Hard to make software

Conclusions

HELP WANTED

SOFTWARE RESEARCHER
The successful applicant will have degrees in mathematical probability and in software engineering plus a minimum of five years experience in software test. This position requires creativity and the ability to reject accepted ideas about reliability and reinvent the subject. Salary commeasurate with results.

Theory is lacking

Experiments needed

- How important is continuity?
- Is MRTF well defined for software?
- Study minefield simulations?