Searching for Diverse Software Engineering Solutions

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How make software less brittle / more robust?

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Engineered Systems
often brittle!

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Biological Systems
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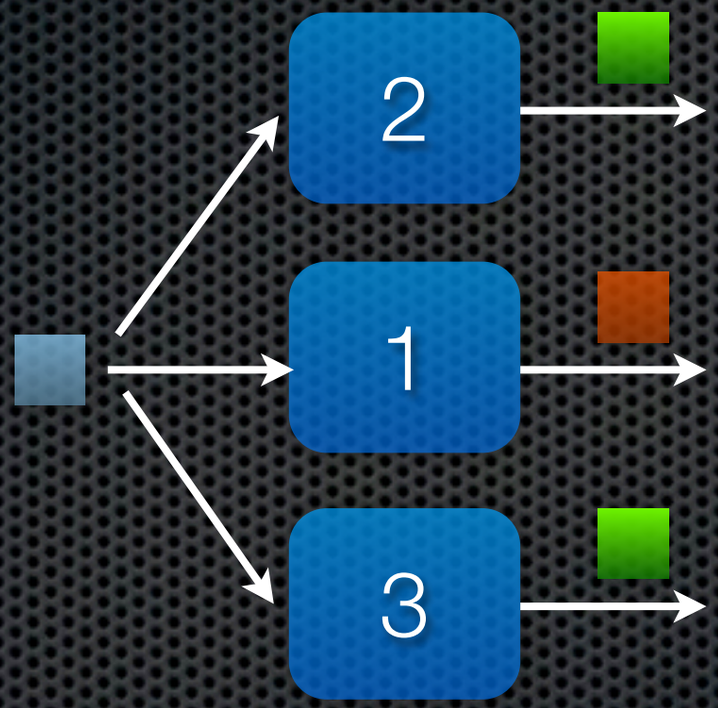

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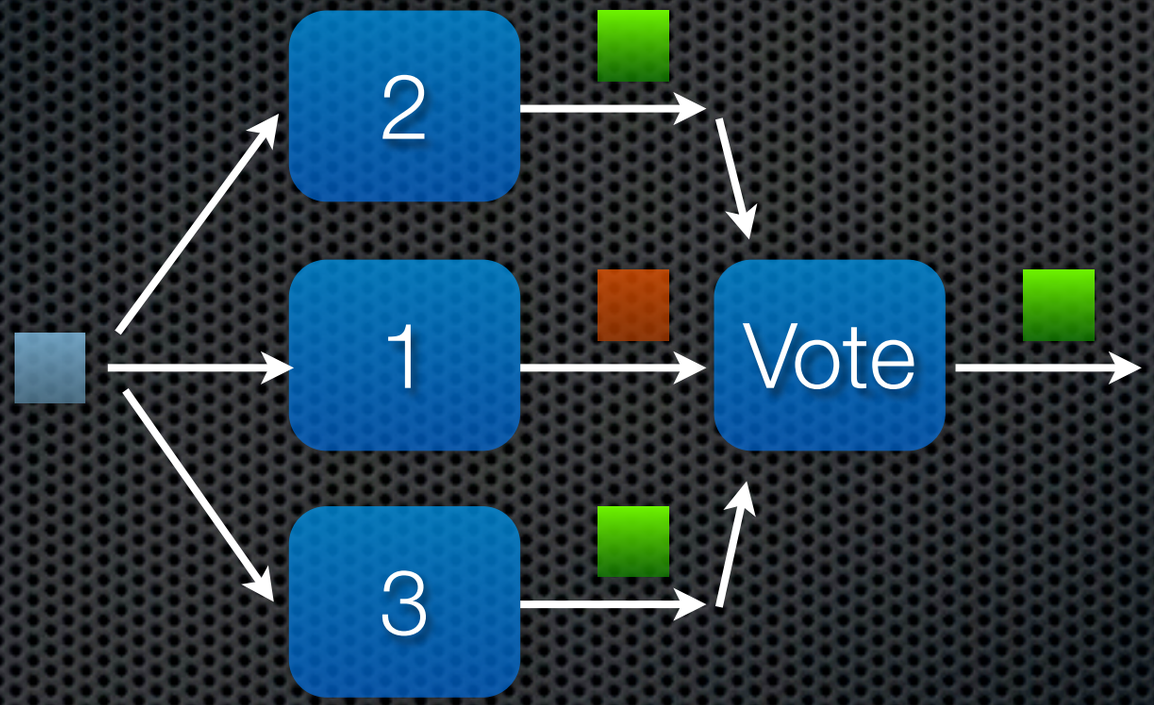

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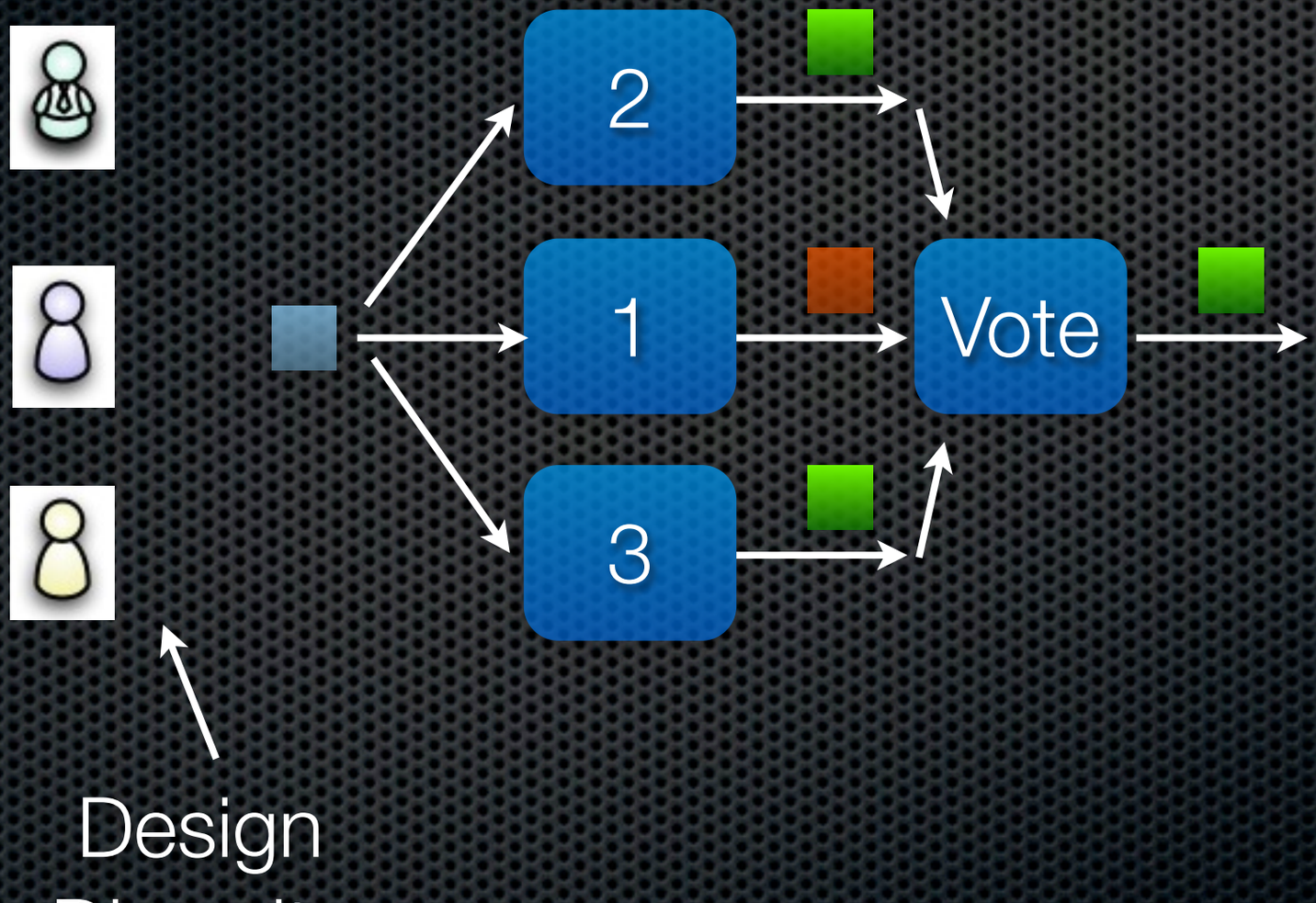

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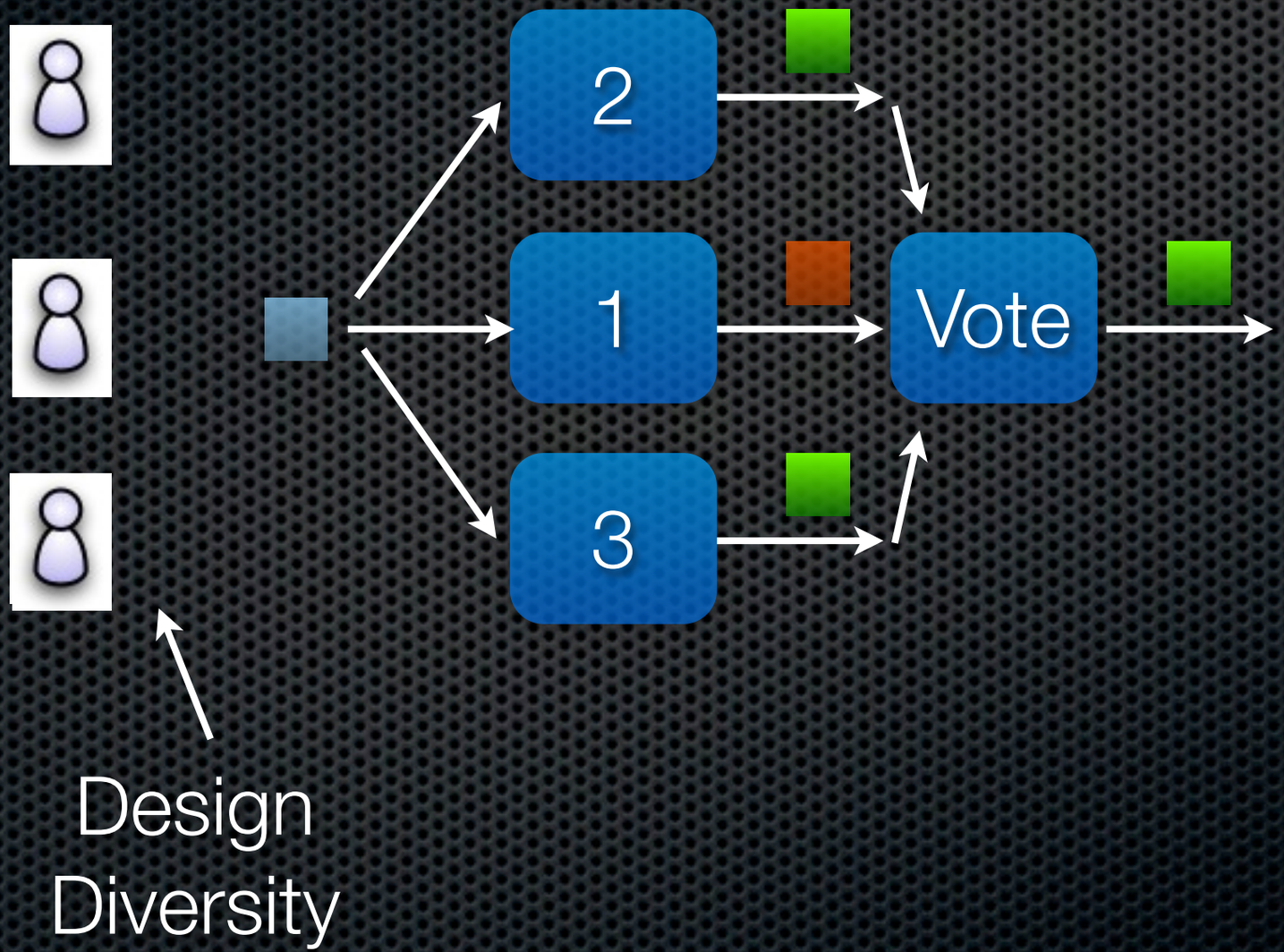

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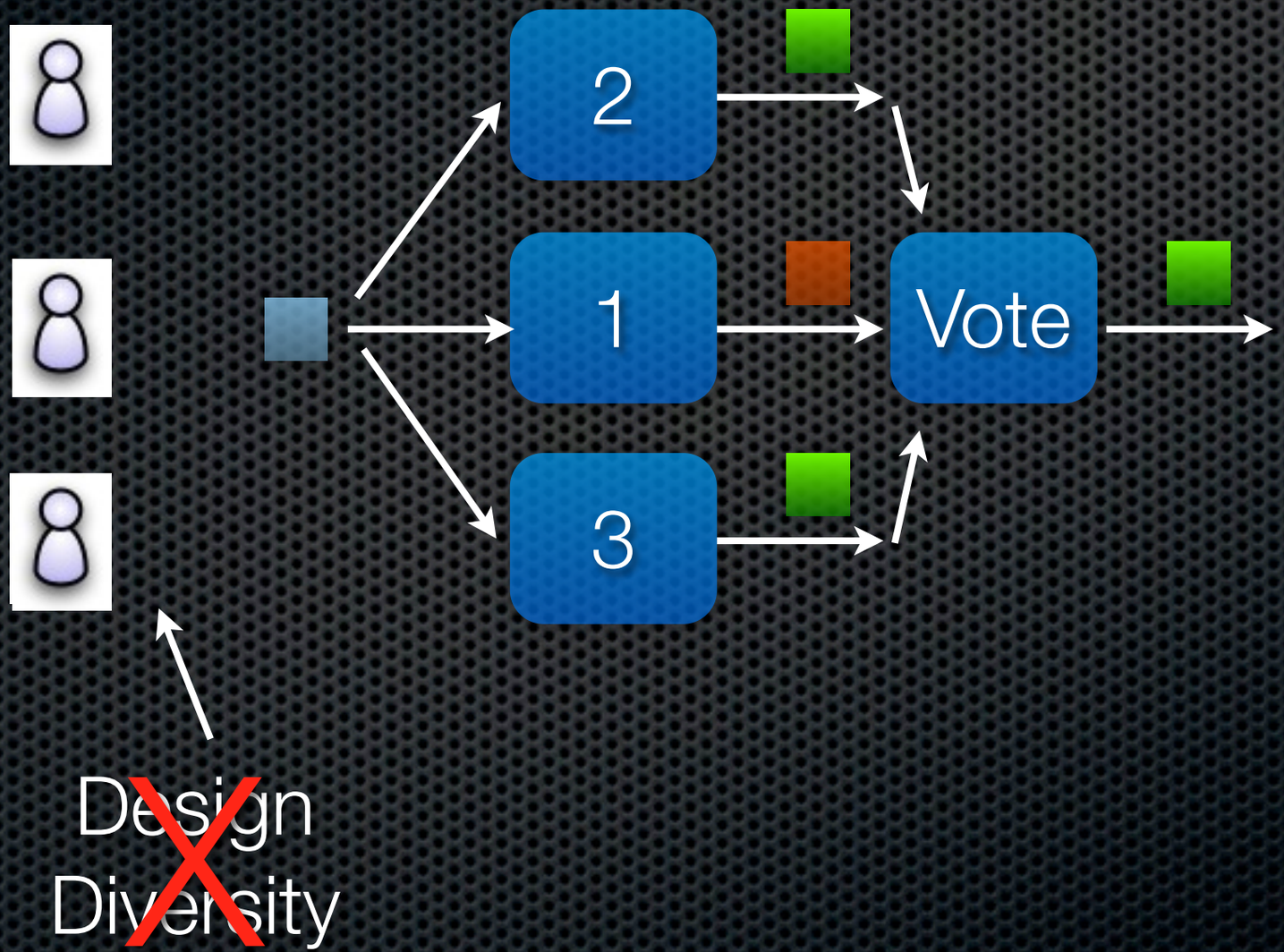

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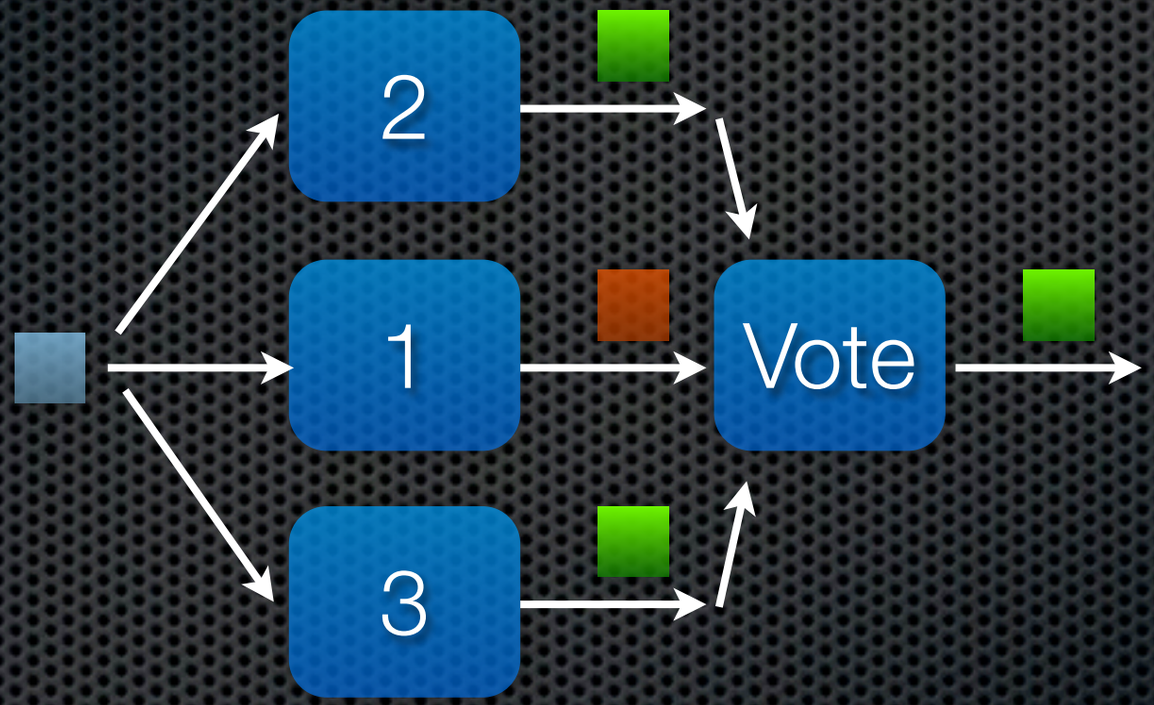

Design Diversity

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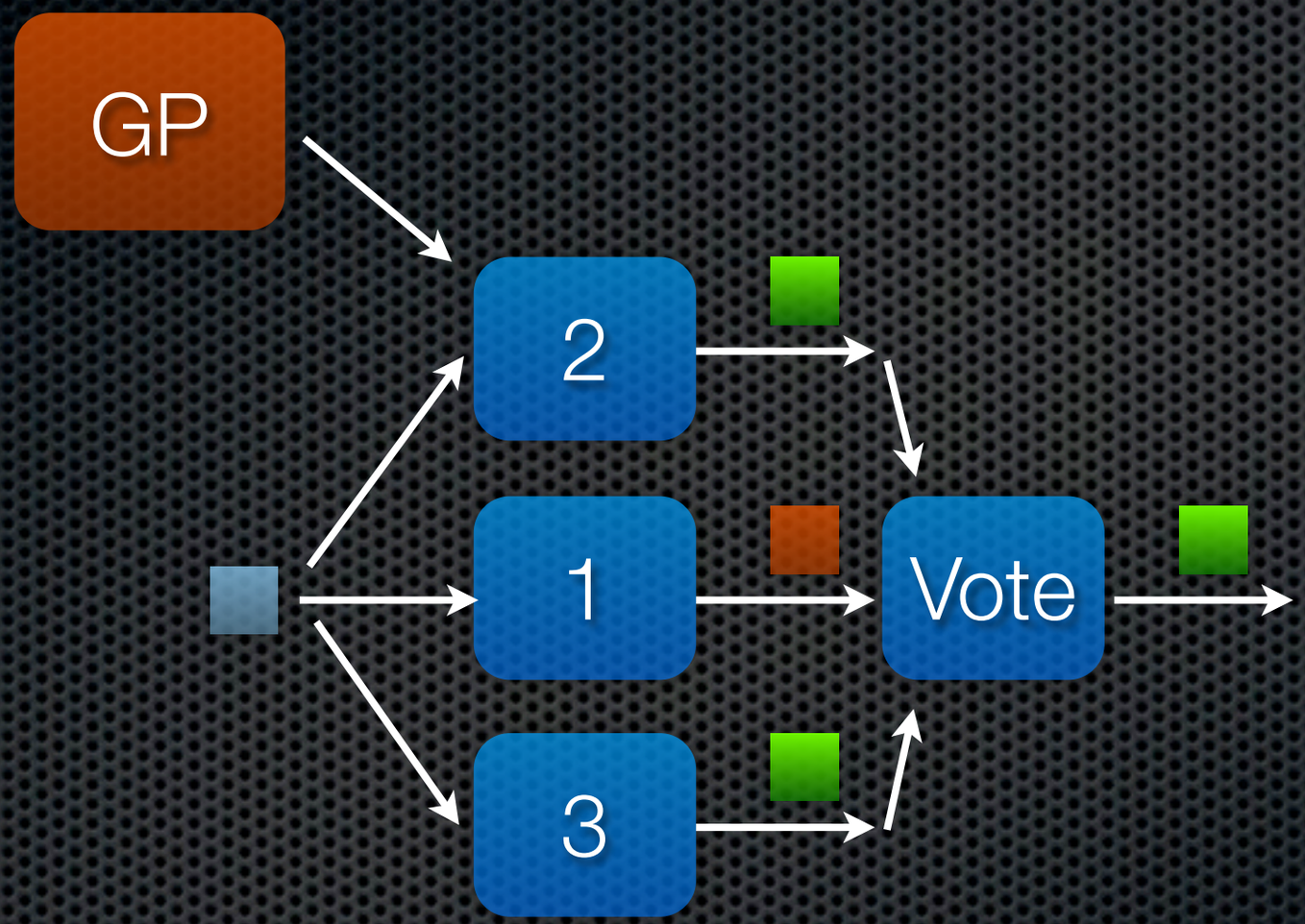

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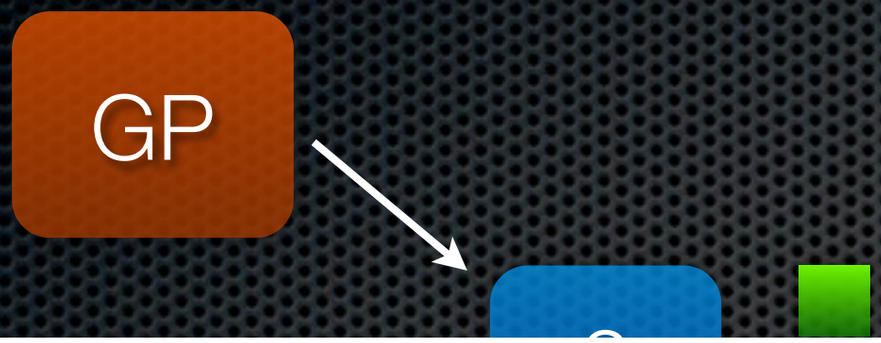

Generating diverse software versions with genetic programming: an experimental study

R. Feldt

Indexing terms: Design diversity, Fault tolerance, Genetic programming

Abstract: Software fault-tolerance schemes often employ multiple software versions developed to meet the same specification. If the versions fail independently of each other, they can be combined to give high levels of reliability. Although design diversity is a means to develop these versions, it has been questioned because it increases development costs and because

common-mode failures, i.e. several versions failing for the same input, and limit the diversity that can be achieved. Experimental research has shown that there are systems for which the independence assumption is not valid [2]. The strength of using design diversity has thus been questioned.

In [3], the term random diversity was proposed to denote the above scenario: generation of diversity is left to chance and arises from differences in the back-

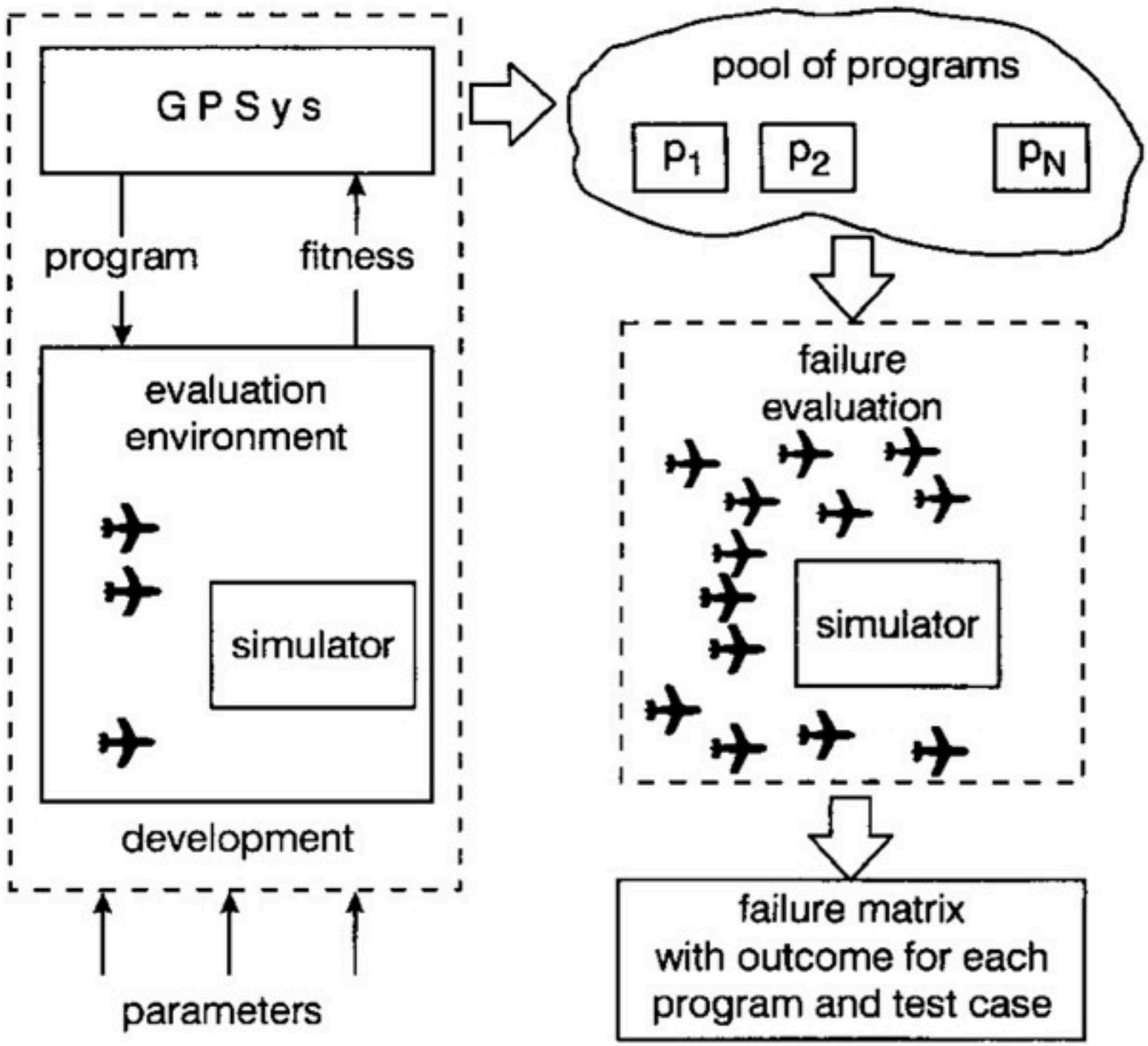

Fig. 1 *Experiment environment for developing and evaluating aircraft arrestment controllers*

15 US Air Force - 99: Military Specification: Aircraft Arresting System BAK-12A/E32A; Portable, Rotary Friction, MIL-A-38202C, Notice 1, US Department of Defense, 1986

Table 2: Description of parameters varied in experiment and their levels

Factors	Levels	Type	Description	Anticipated effect/Motivation
A	−1	PSP	no effect.	for comparison of values during braking
	1		the statement If, and operators LE, And and Not can be used in programs	
B	−1	PSP	no effect.	for oscillatory and/or damping behaviour
	1		the functions Sinus and Exp can be used in the programs	
C	−1	PSP	the average velocity, average retardation and index to current checkpoint can be used in programs	for structural diversity; average velocity and retardation are pre-calculated before they can be used in programs
	1		the angular velocity, current time since start of braking, previous angular velocity and time of previous checkpoint can be used in programs	
D	−1	PSP	programs cannot use any subroutines	For greater program complexity without need for one long program
	1		two subroutines (automatically defined functions) can be used in program; they are evolved in same manner as rest of program	
E	−1	EP	maximum penalty on retardation failure criterion is 1000.0	force programs to find solutions that solve retardation criterion with higher priority than other criteria
	1		maximum penalty on retardation failure criterion is 2000.0.	
F	−1	EP	linear penalties are not used	without linear penalties, fitness only expresses 'amount' of failure; performance on non-failure aspects is not measured
	1		linear penalties are used, and maximum penalty of 30.0 is assigned to each failure criterion	
G	−1	EP	25 test cases uniformly spread over range of possible values for mass and velocity are used to evaluate fitness during evolution	uniform spreading of test cases 'samples' all parts of possible input cases; random spreading can give both easier and more difficult test cases
	1		25 test cases chosen randomly for each run of the GP system are used to evaluate fitness during evolution	
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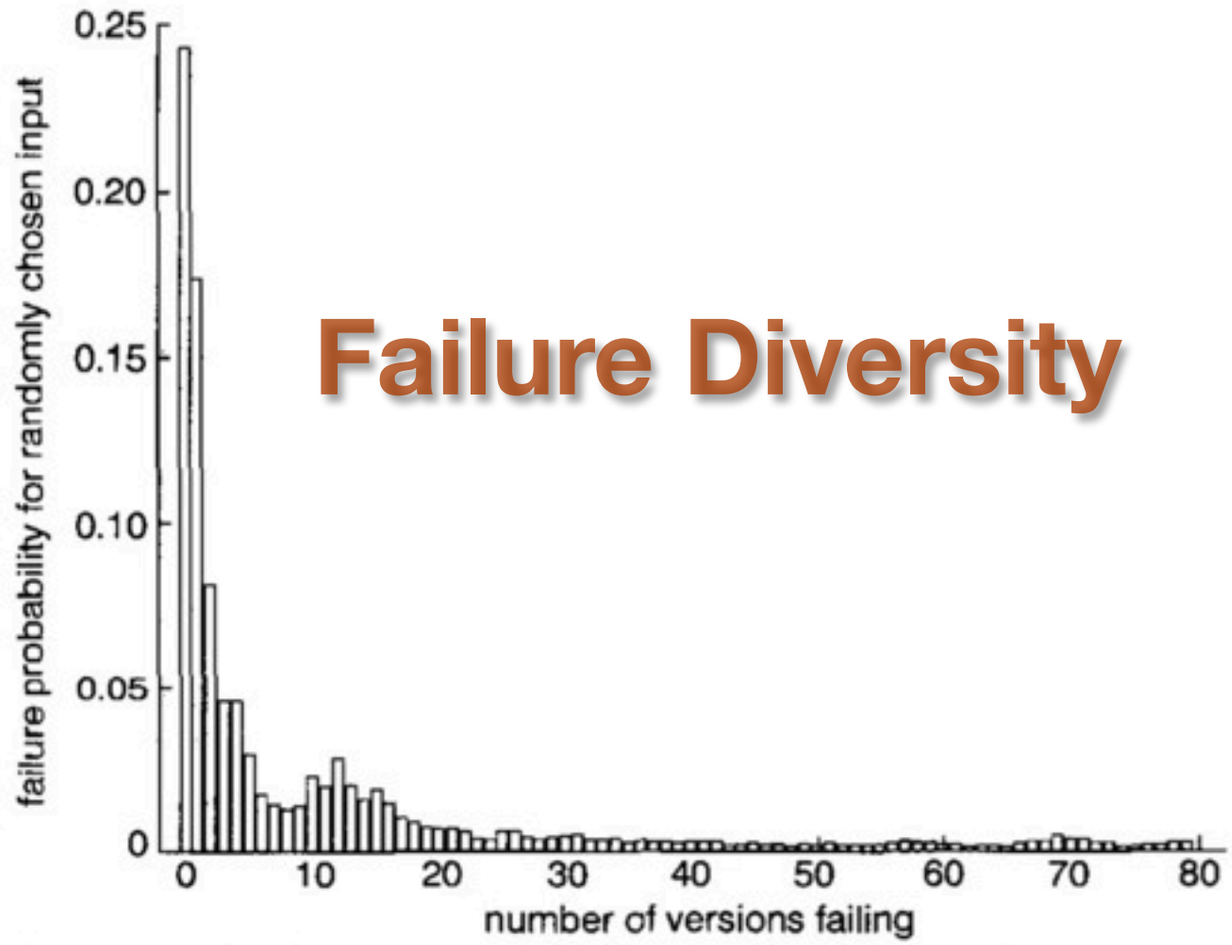

Fig.2 *Probability of failure of n versions for randomly chosen input*

# test cases	# failing programs
0	0
22	79
24	78

Structural Diversity

Size Statistic	Value
Max	459
Average	100.2
Min	17

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34% of all 3VP voters (worst case) improved, best was -20%

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Ideal group = High ability & Diverse

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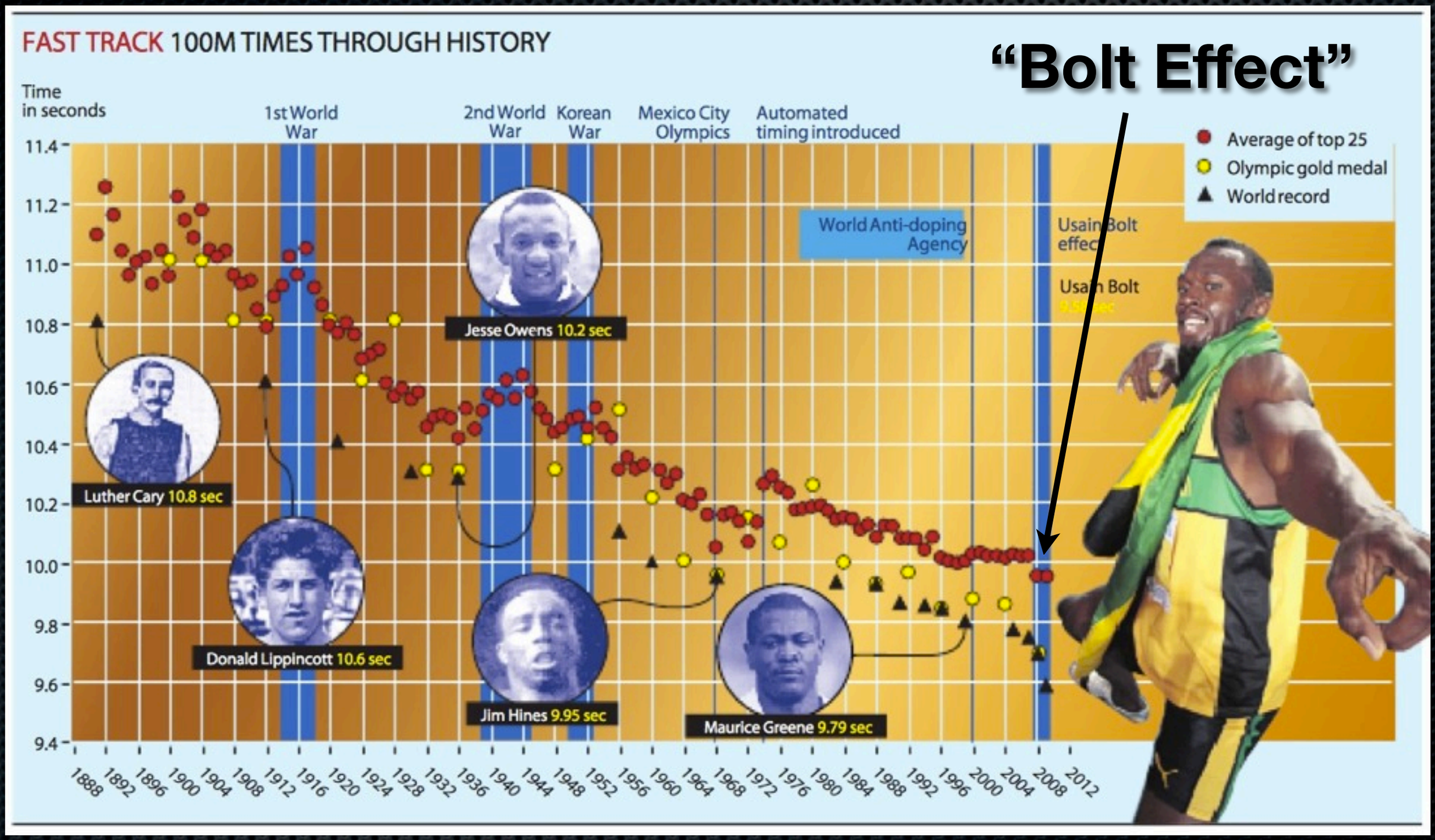
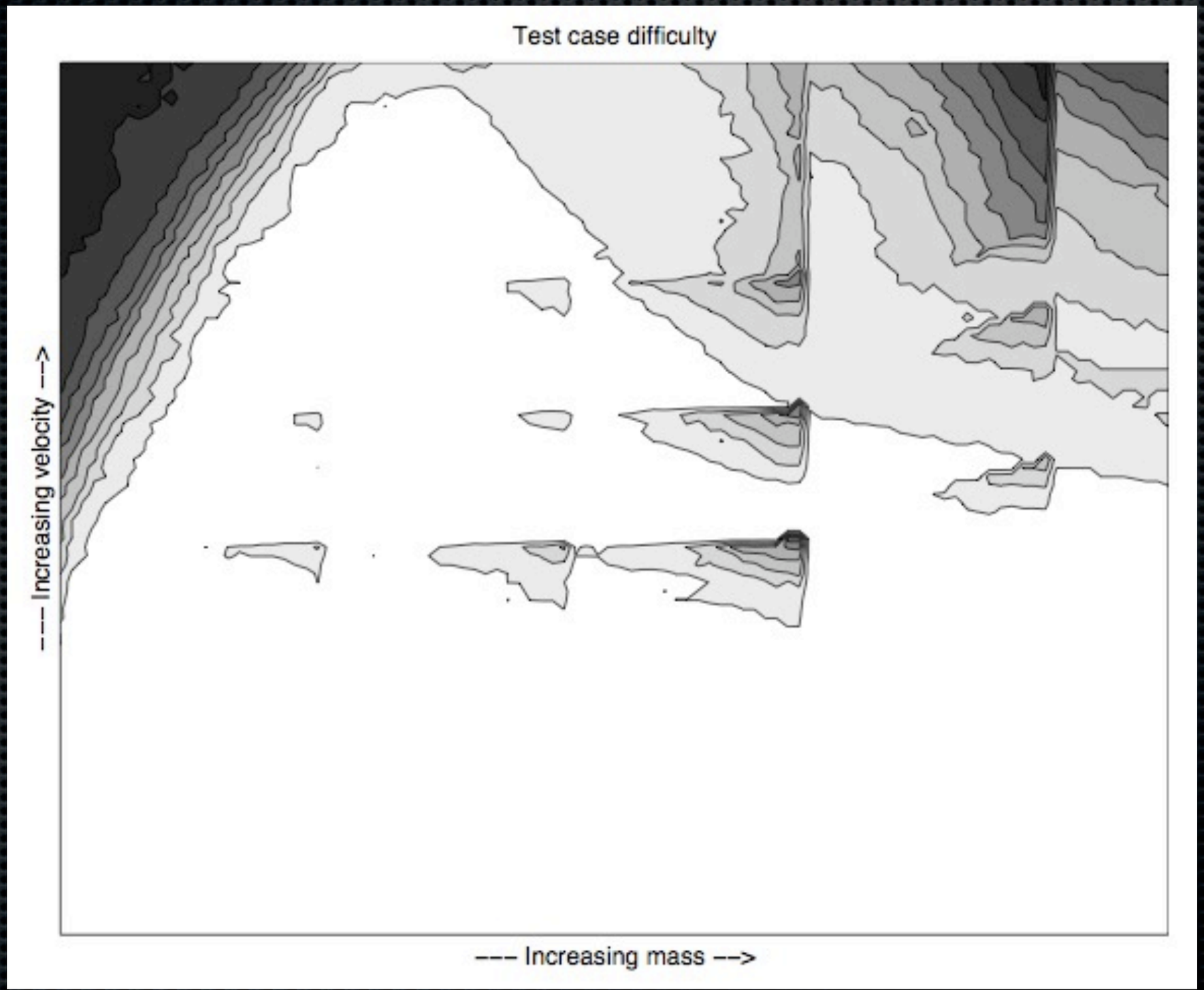
BUT, disregards Communication and Learning

But Diversity is not a simple concept...



[The Indepedent, March 23 2012]

Analysis of Failures of GP programs



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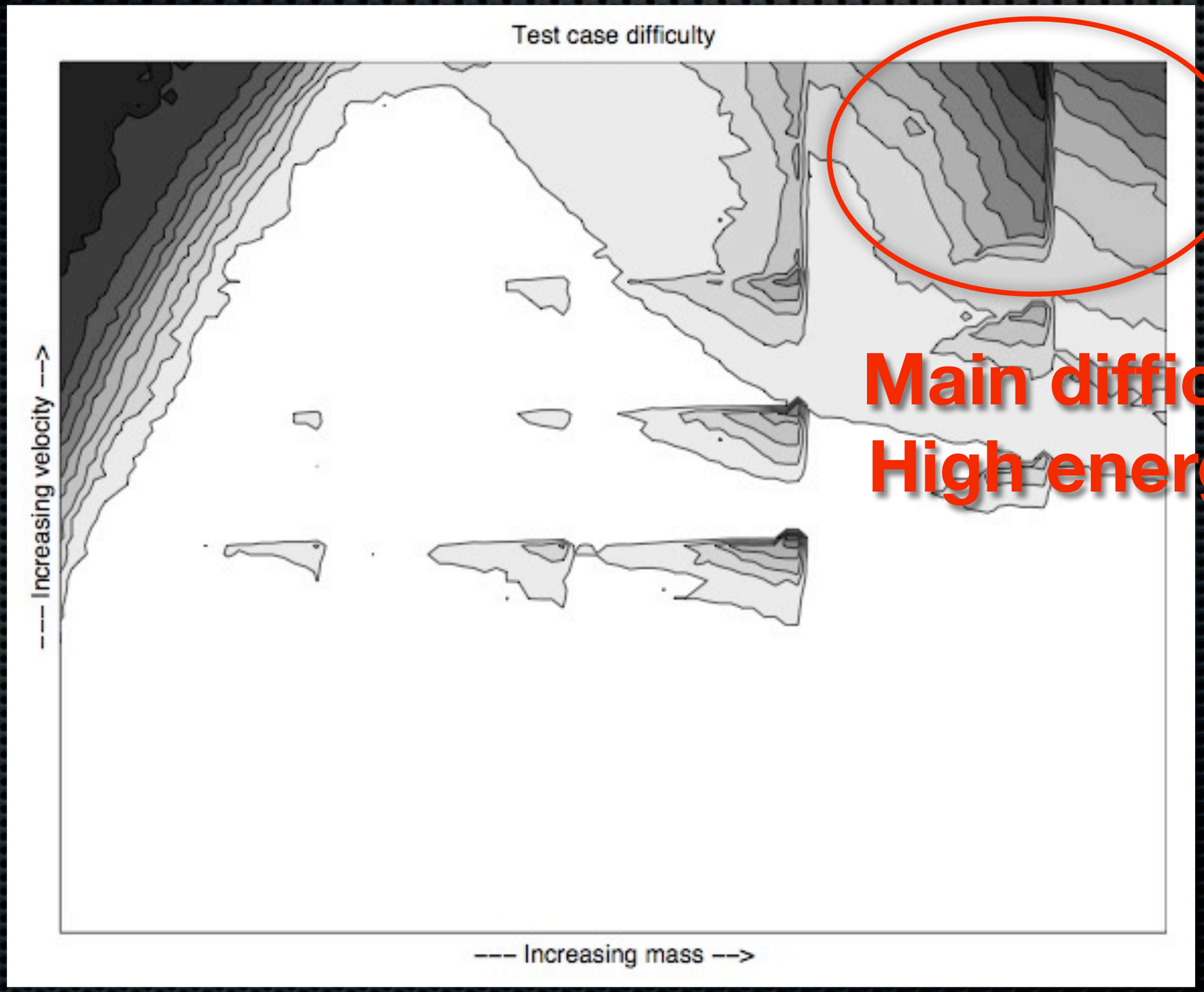

Main difficulty: High energies!

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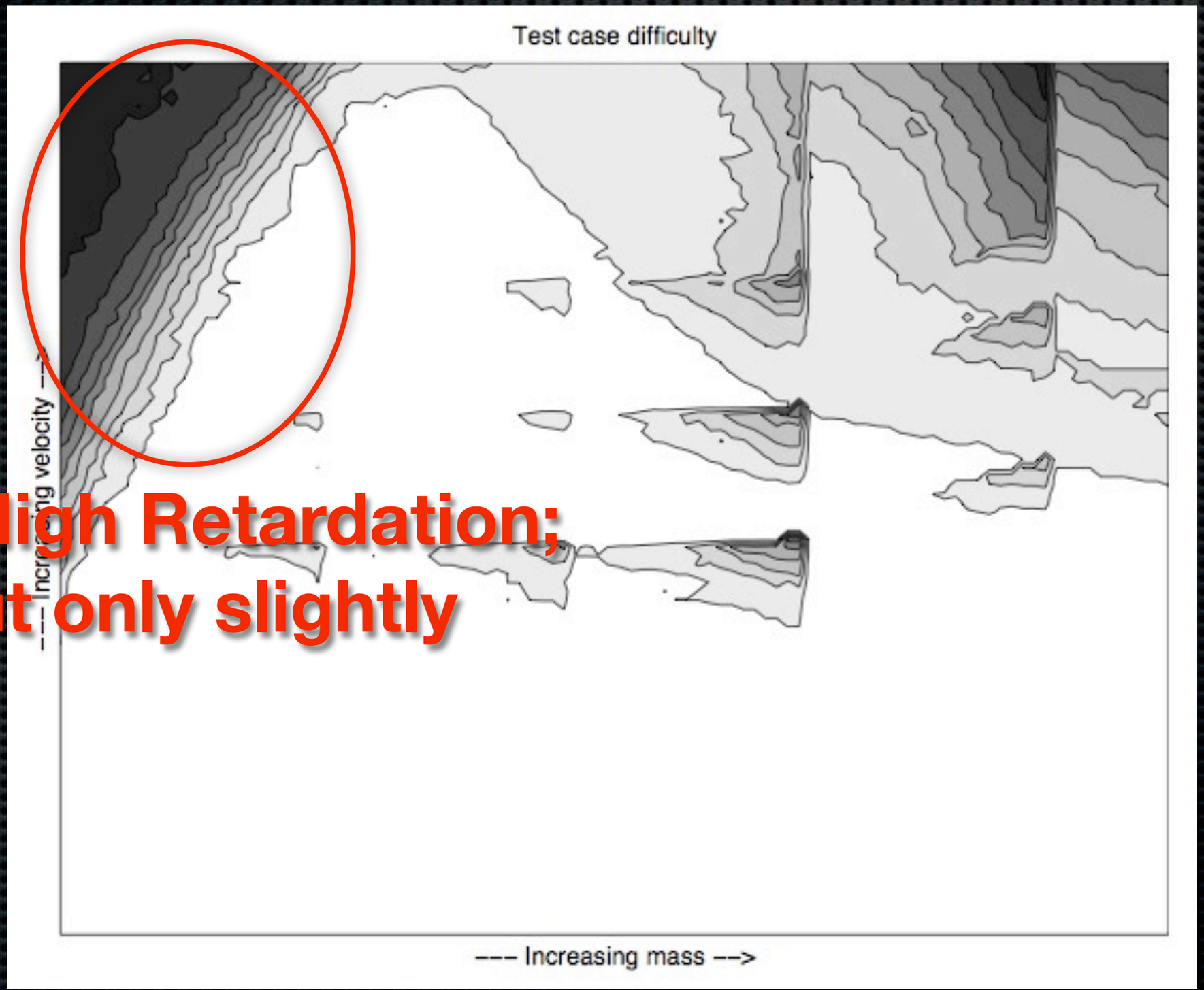

Too High Retardation; but only slightly

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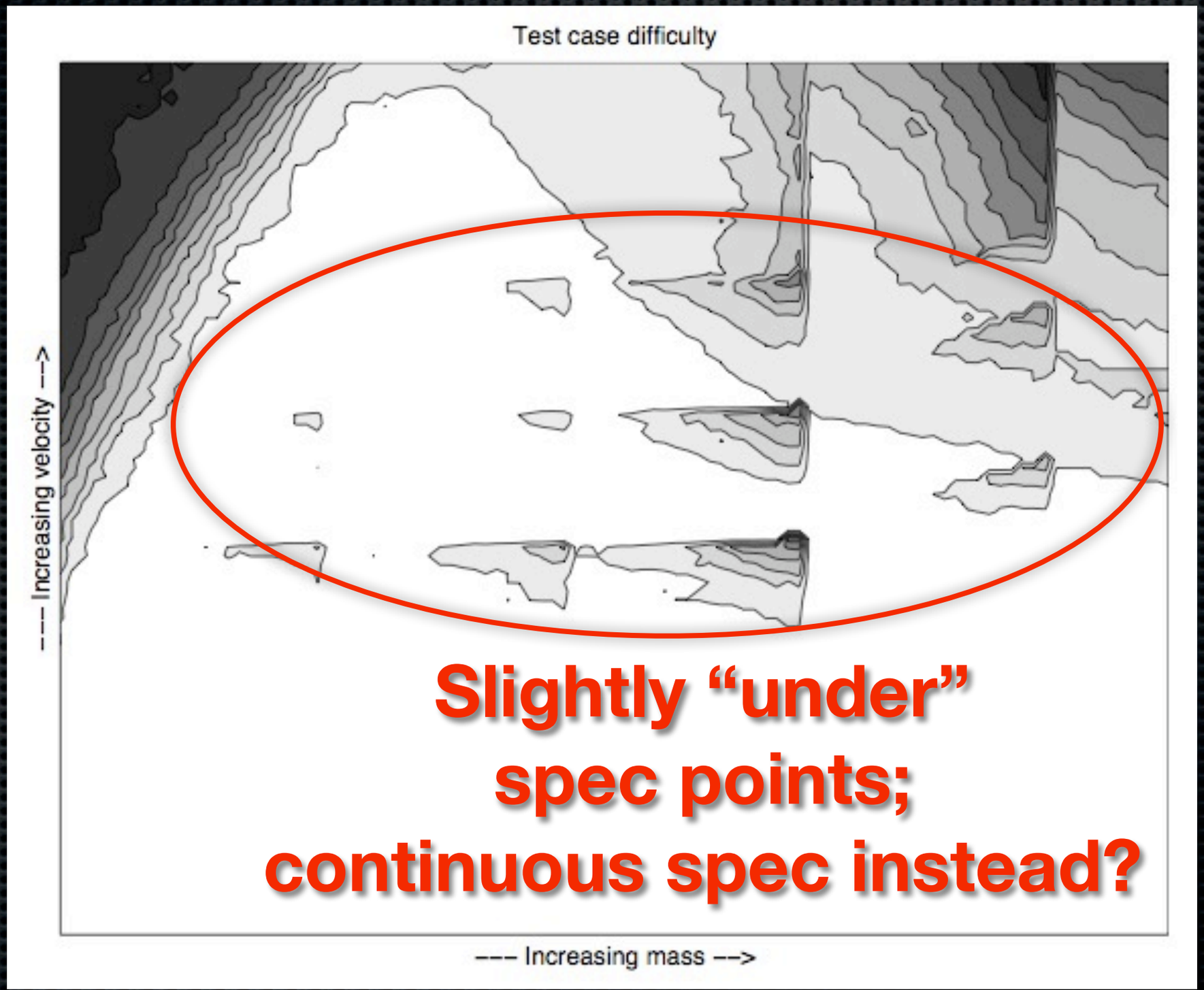

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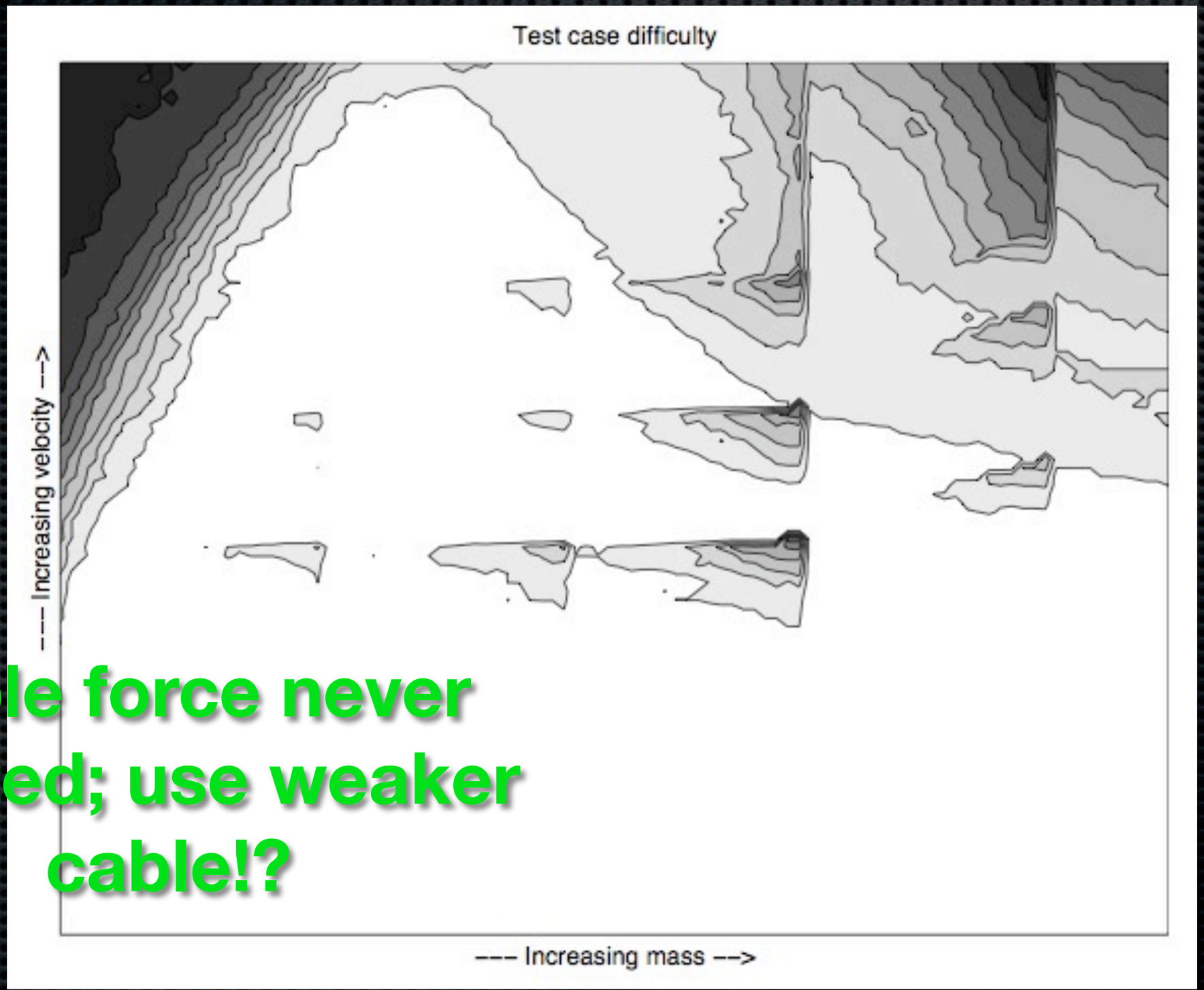

Cable force never violated; use weaker cable!?

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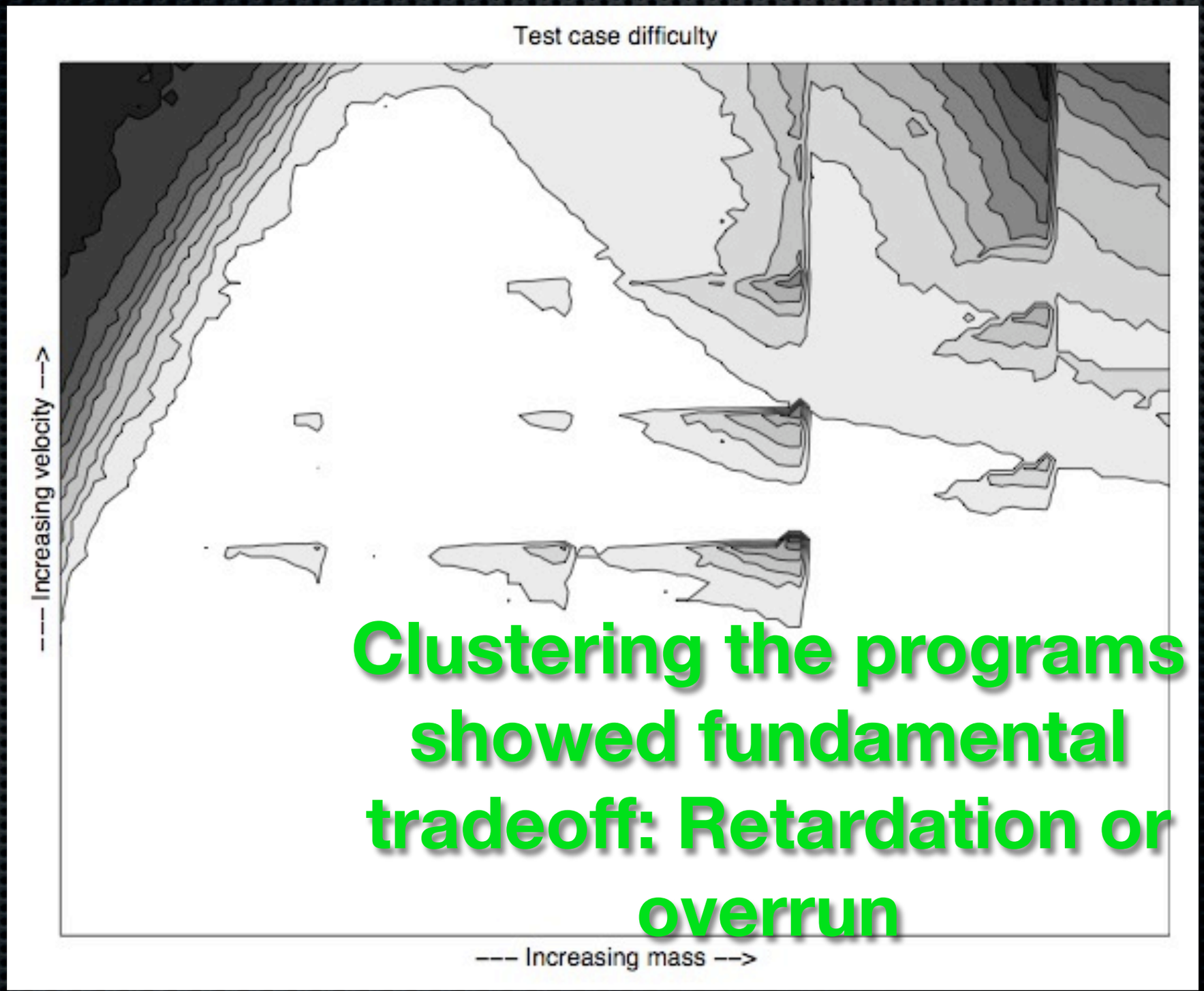

Clustering the programs showed fundamental tradeoff: Retardation or overrun

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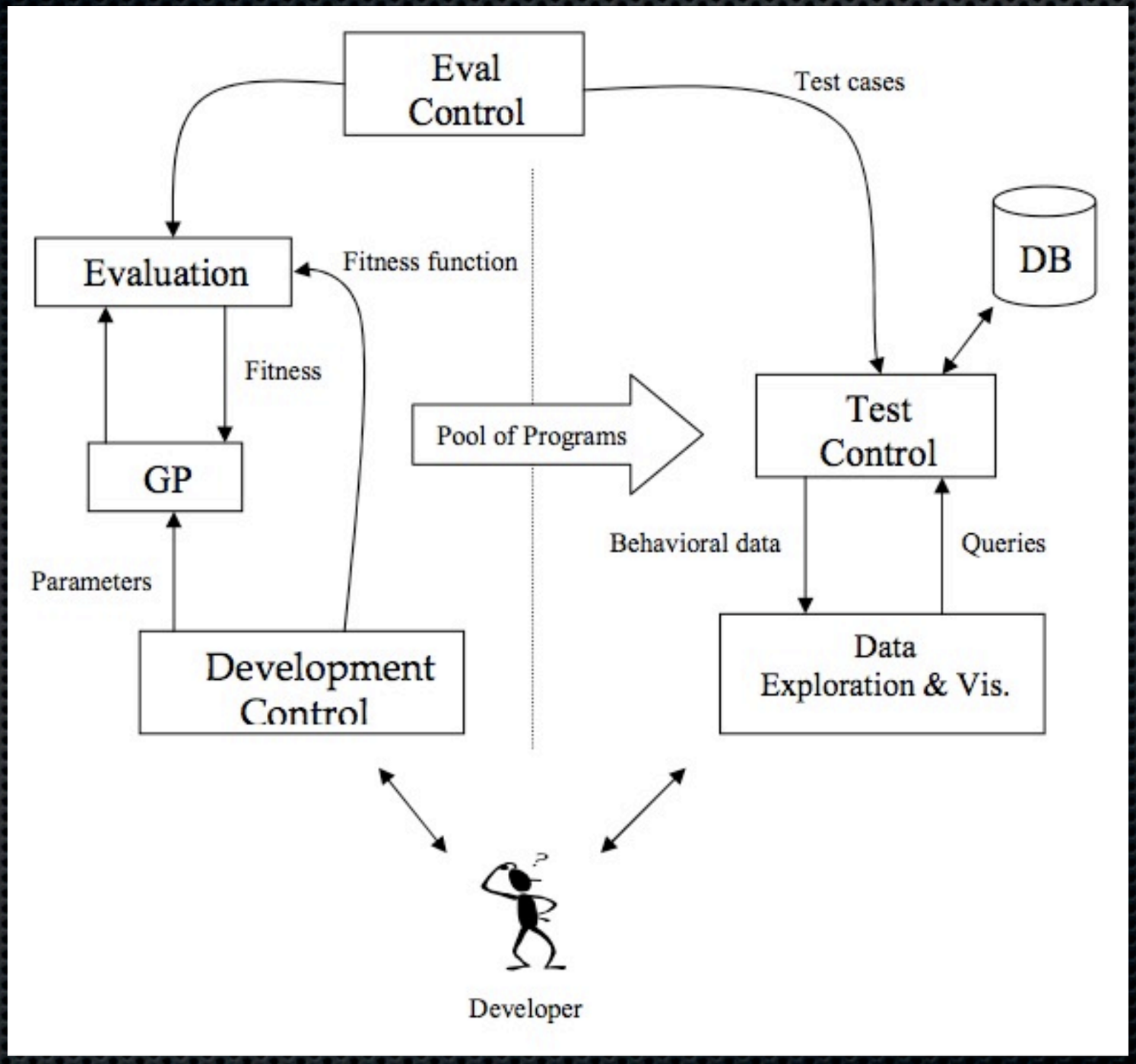
- Fundamental assumption: SB AutoProgramming fail in similar ways to human programmers

Generalization: Search-Based SW Prg Exploration



Questions?

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