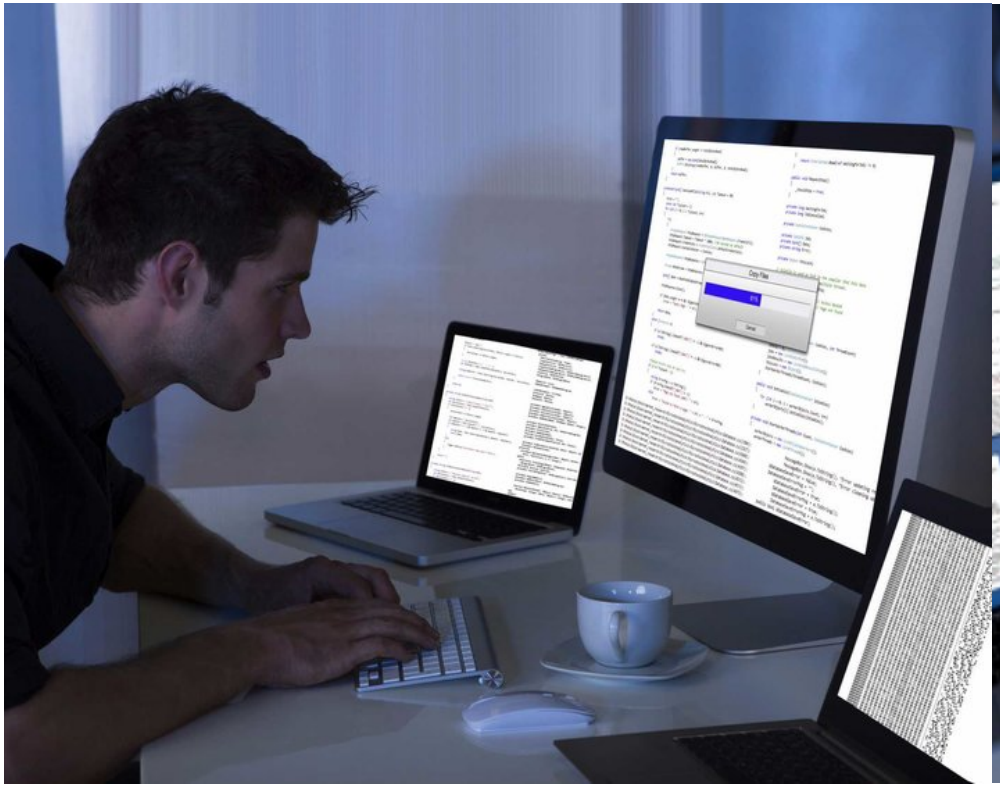
BASE
Biofeedback Augmented Software Engineering

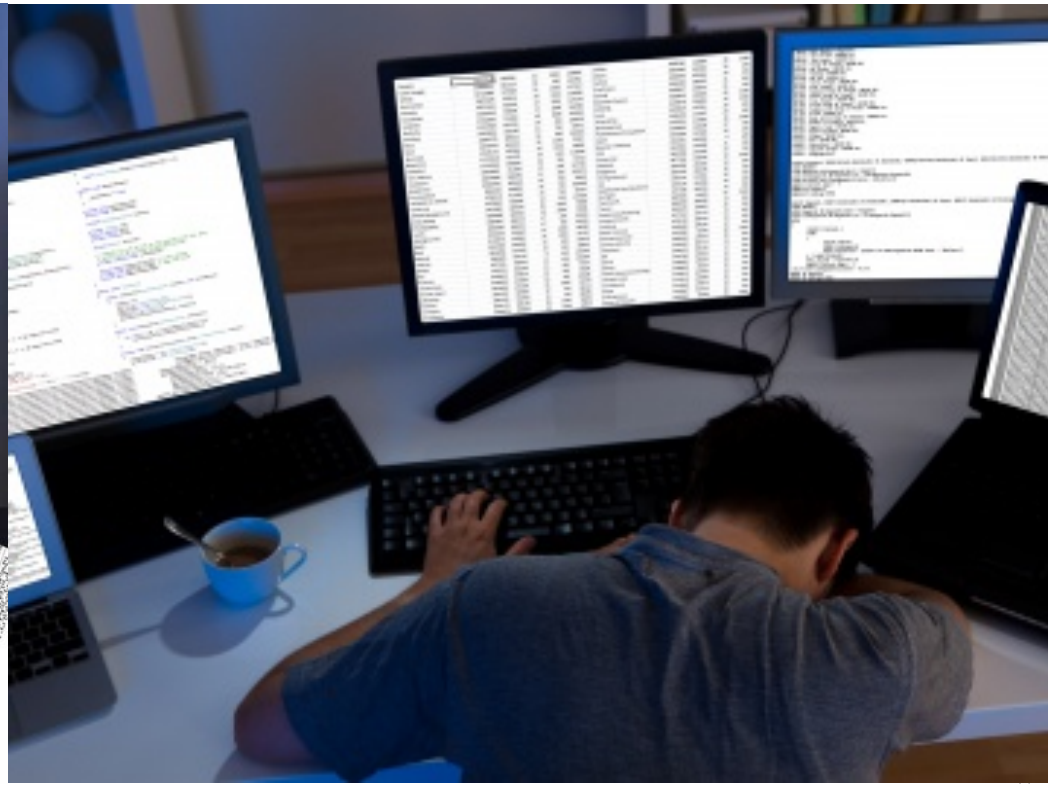
Henrique Madeira
Department of Informatics Engineering
Faculty of Science and Technology
University of Coimbra - Portugal

IFIP Working Group 10.4,
Clervaux, Luxembourg,
June 28 – July 1, 2018

University
of Coimbra

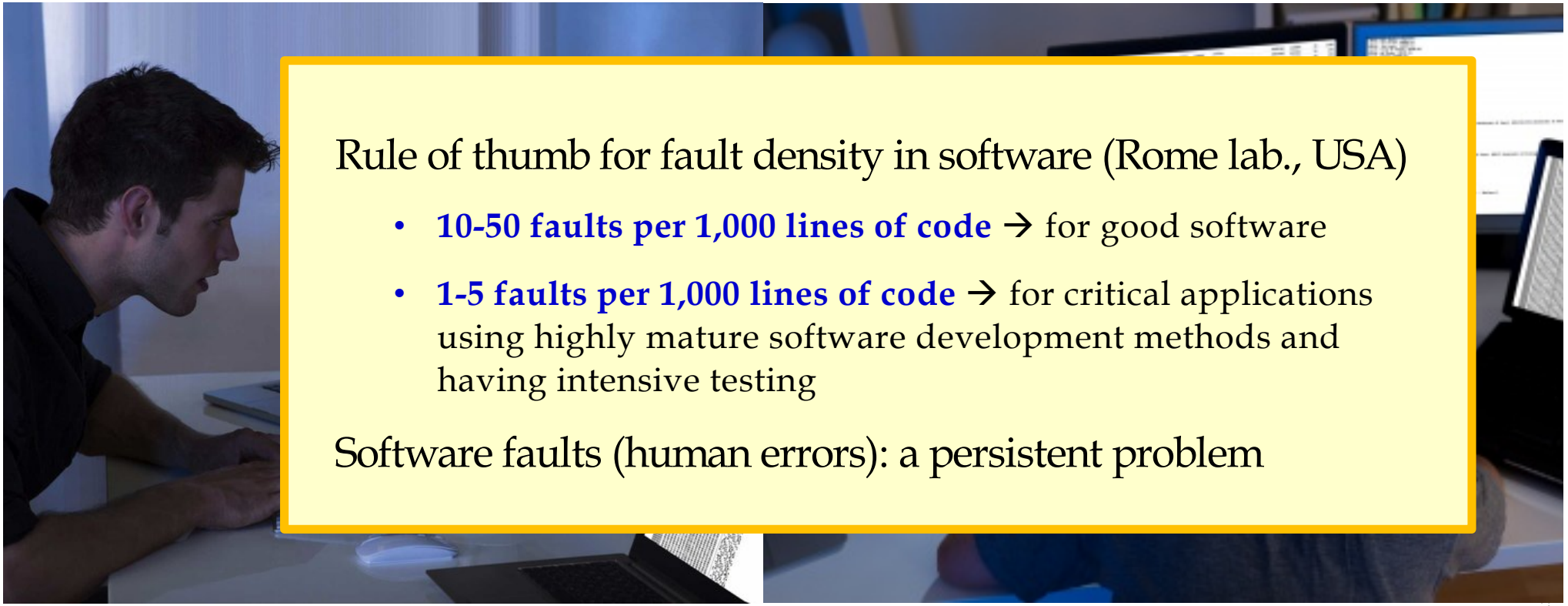
BASE
Biofeedback Augmented Software Engineering





Hen

BASE
Biofeedback Augmented Software Engineering



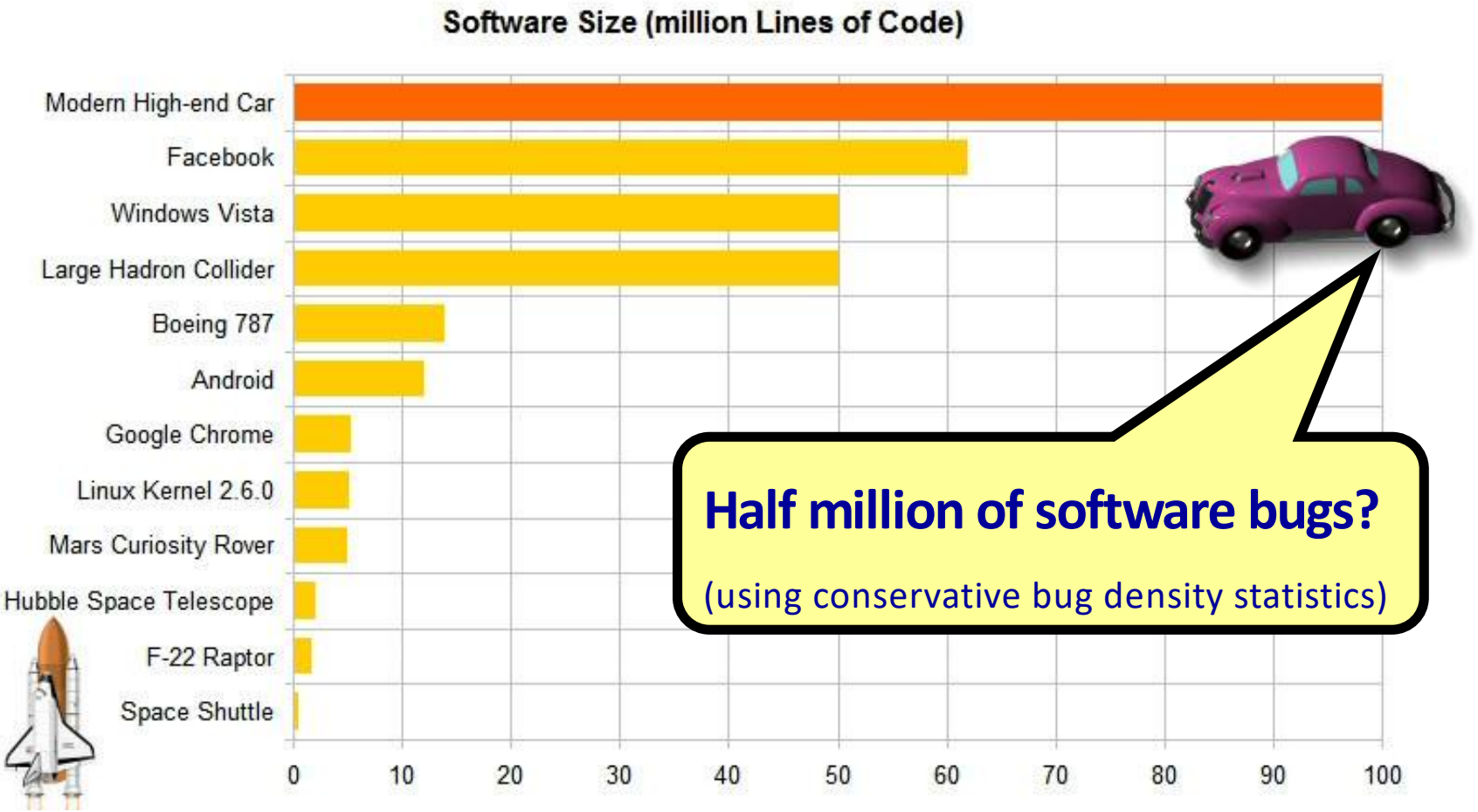
Rule of thumb for fault density in software (Rome lab., USA)

- **10-50 faults per 1,000 lines of code** → for good software
- **1-5 faults per 1,000 lines of code** → for critical applications using highly mature software development methods and having intensive testing

Software faults (human errors): a persistent problem

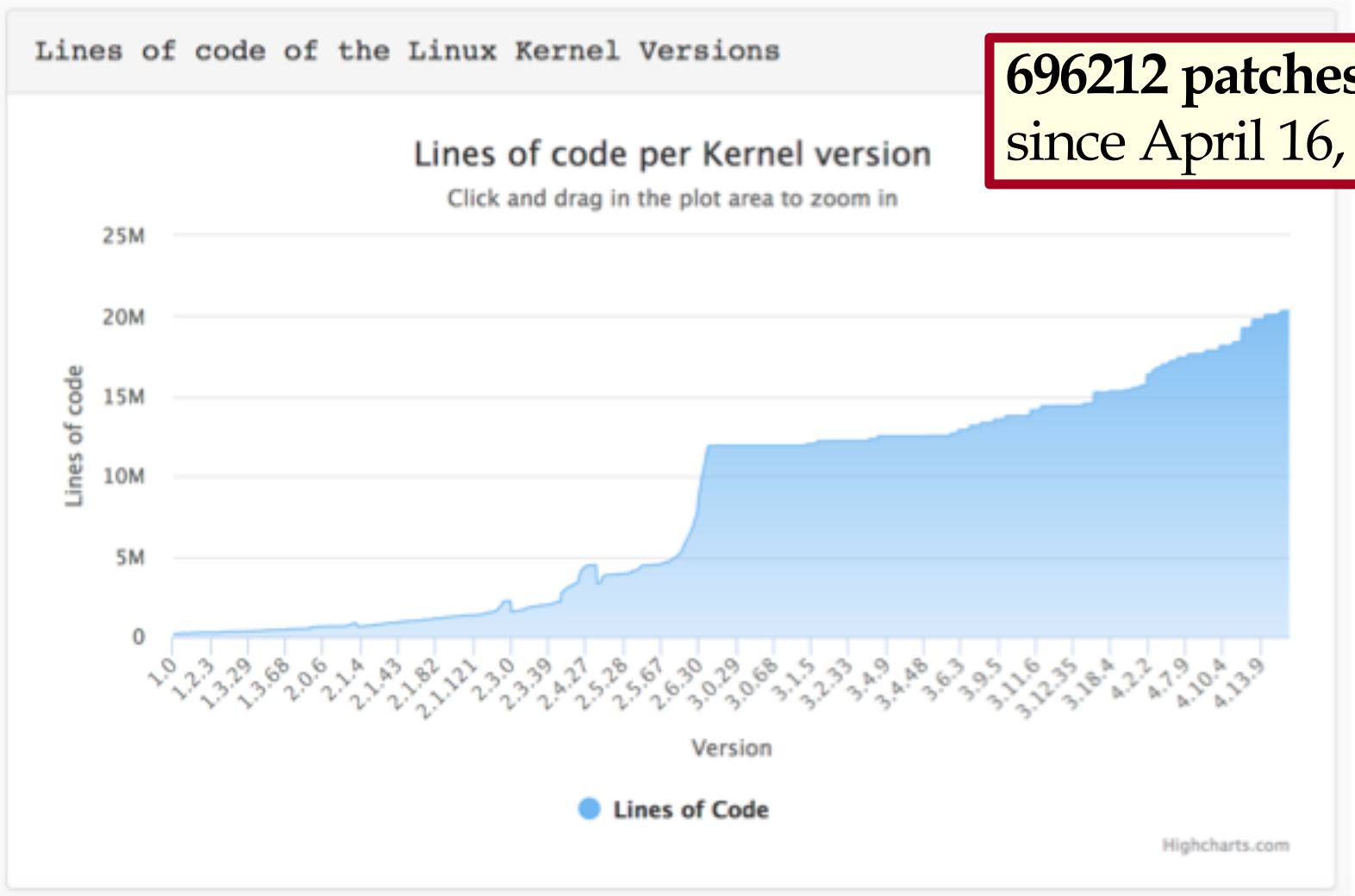
Hen

Size of software: examples



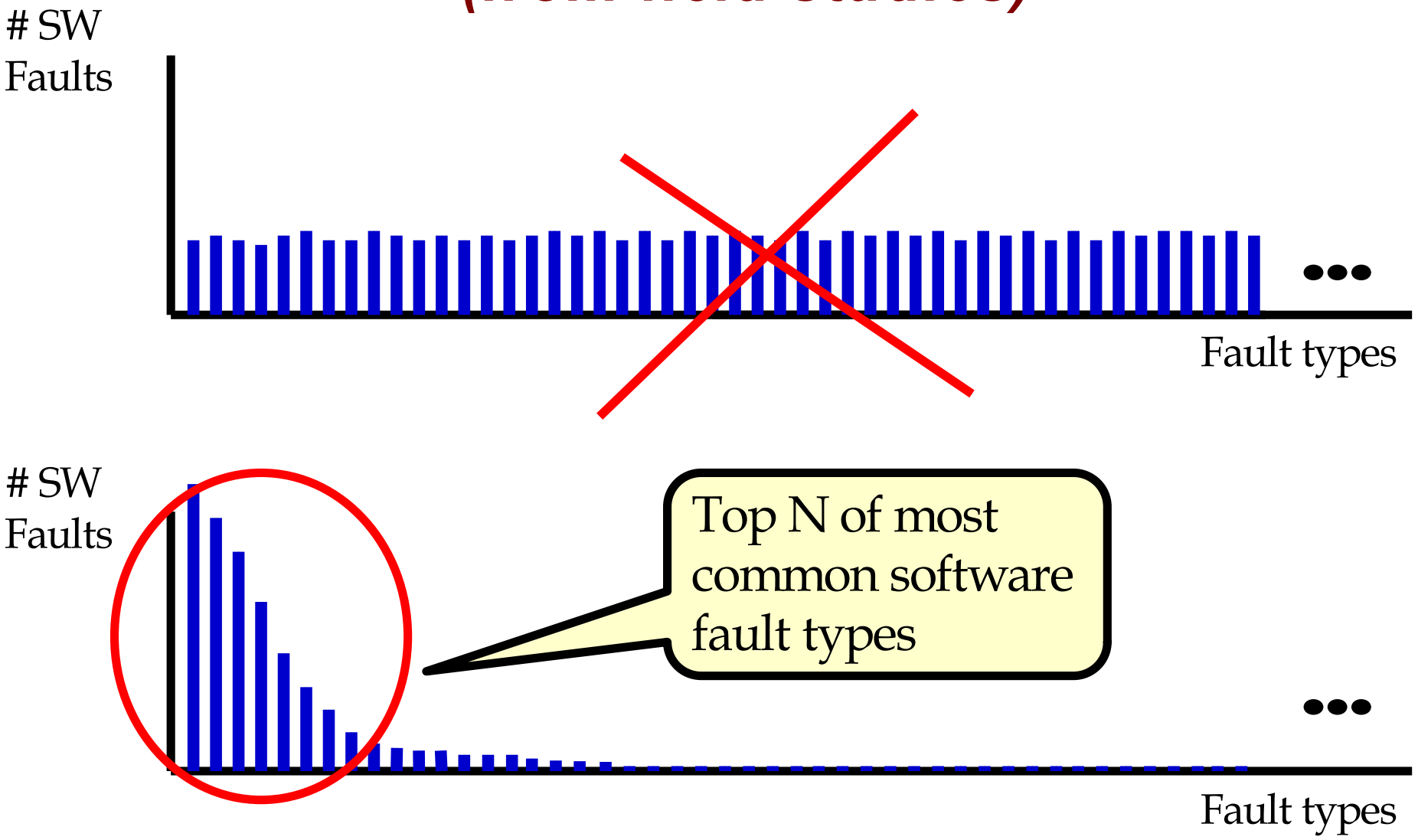
From Rich Rogers, https://twitter.com/richrogersiot/status/958112741218111489

Linux kernel size: another example



696212 patches
since April 16, 2006

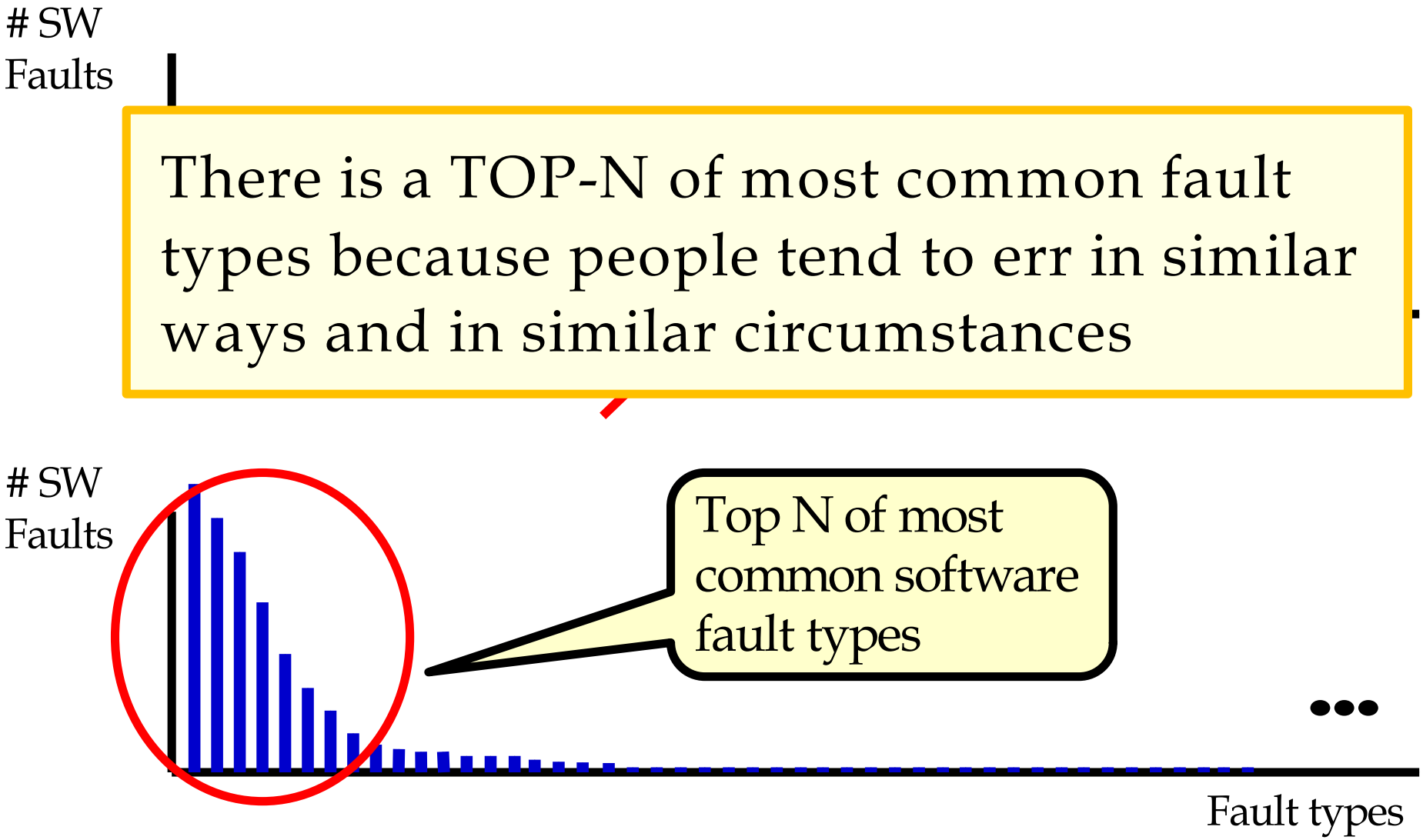
Fault models for software faults
(from field studies)



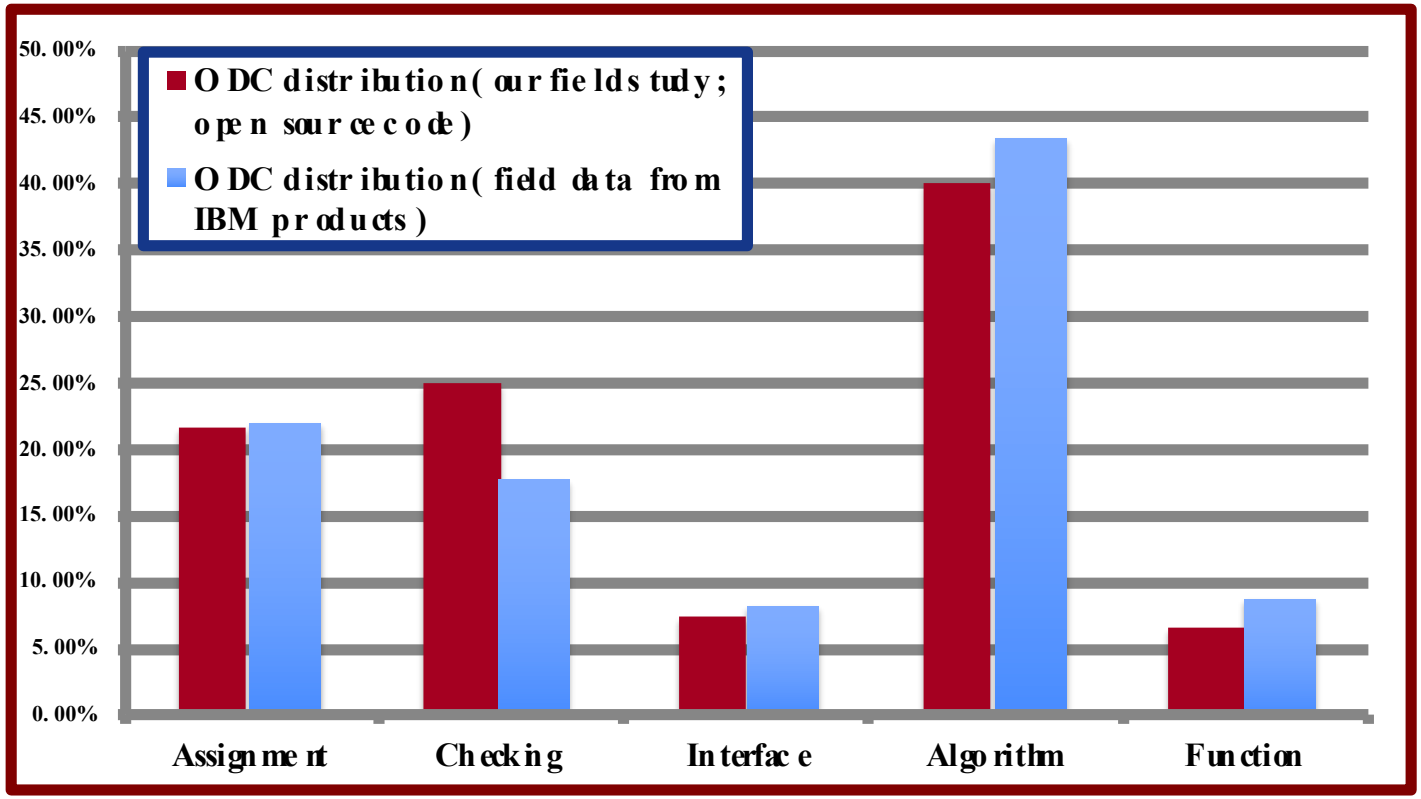
The "Top-N" software faults (example)

Fault types	Perc. Observed in field study	ODC classes
Missing "If (*cond*) { statement(s) }"	9.96 %	Algorithm
Missing function call	8.64 %	Algorithm
Missing "AND EXPR" in expression used as branch condition	7.89 %	Checking
Missing "if (*cond*)" surrounding statement(s)	4.32 %	Checking
Missing small and localized part of the algorithm	3.19 %	Algorithm
Missing variable assignment using an expression	3.00 %	Assignment
Wrong logical expression used as branch condition	3.00 %	Checking
Wrong value assigned to a value	2.44 %	Assignment
Missing variable initialization	2.25 %	Assignment
Missing variable assignment using a value	2.25 %	Assignment
Wrong arithmetic expression used in parameter of function call	2.25 %	Interface
Wrong variable used in parameter of function call	1.50 %	Interface
Total faults coverage	**50.69 %**	

Fault models for software faults



People fail in similar ways and in similar circumstance



Different environments, different cultures, different development processes, different systems and applications, different programming languages, etc., etc…

→ but apparently similar error patterns; **people is the only common element**

Field data studies on SW faults and SW fault models representativeness

For more details:

- **"Definition of Software Fault Emulation Operators: a Field Data Study"**, J. Durães and H. Madeira, IEEE/IFIP International Conference on Dependable Systems and Networks, Dependable Computing and Communications, DSN-DCC 2003, San Francisco, CA, USA, June 22-25, 2003.

- **“Emulation of Software Faults: A Field Data Study and a Practical Approach”**, J. Durães and H. Madeira, IEEE Transactions on Software Engineering, Vol. 32, No. 11, November 2006.

- **"On Fault Representativeness of Software Fault Injection"**, R. Natella, D. Cotroneo, J. Duraes, H. Madeira, IEEE Transactions on Software Engineering, December 2013

A new research direction

BASE - **Biofeedback Augmented Software Engineering**

Interdisciplinary research using neuroscience and software reliability engineering– 3 major steps

1. Identify the brain network underlying human errors in software development activities
2. Define predictive relationships between the brain patterns associated to bug making/discovery and autonomic physiologic manifestations that can be captured by wearable or low intrusive sensors
3. Build a prototype of Biofeedback Augmented Software Engineering framework and validate the approach

A new research direction

BASE - **Biofeedback Augmented Software Engineering**

Interdisciplinary research using neuroscience and software reliability engineering– 3 major steps

SW reliability people (us)

Artificial intelligence people

Biomedical Engineers

Neuroscientists

Engineering framework and validate the approach

Brain network underlying human errors in SW development activities

Step 1 uses "heavy artillery"

- fMRI – Functional Magnetic Resonance Imaging
- EEG – Electroencephalography
- fNIRS – Functional Near-Infrared Spectroscopy

Brain network underlying human errors in SW development activities

SpringerLink

Brain Imaging and Behavior

pp 1–15 | Cite as

The role of the insula in intuitive expert bug detection in computer code: an fMRI study

Authors | Authors and affiliations

Joao Castelhano, Isabel C. Duarte, Carlos Ferreira, Joao Duraes, Henrique Madeira, Miguel Castelo-Branco

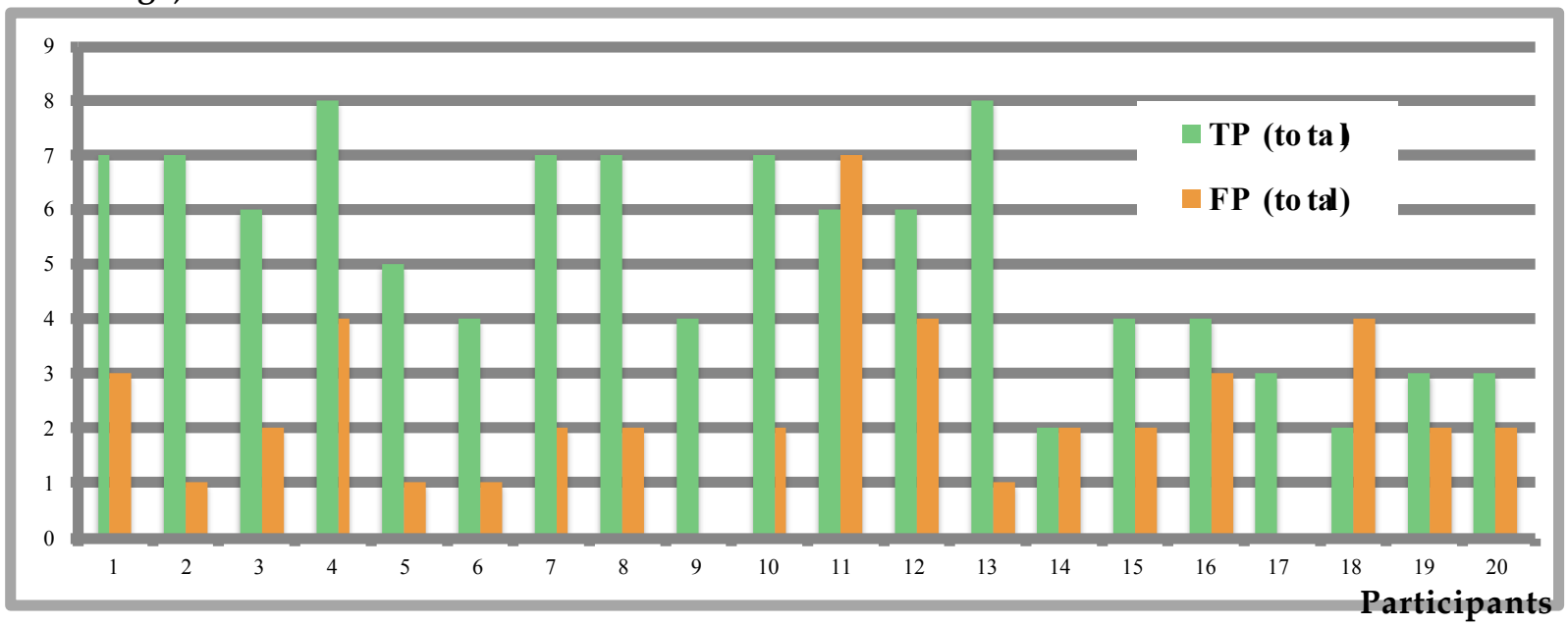
Open Access | Original Research

First Online: 09 May 2018

6 Shares

888 Downloads

Code inspection results: True positives and false positives

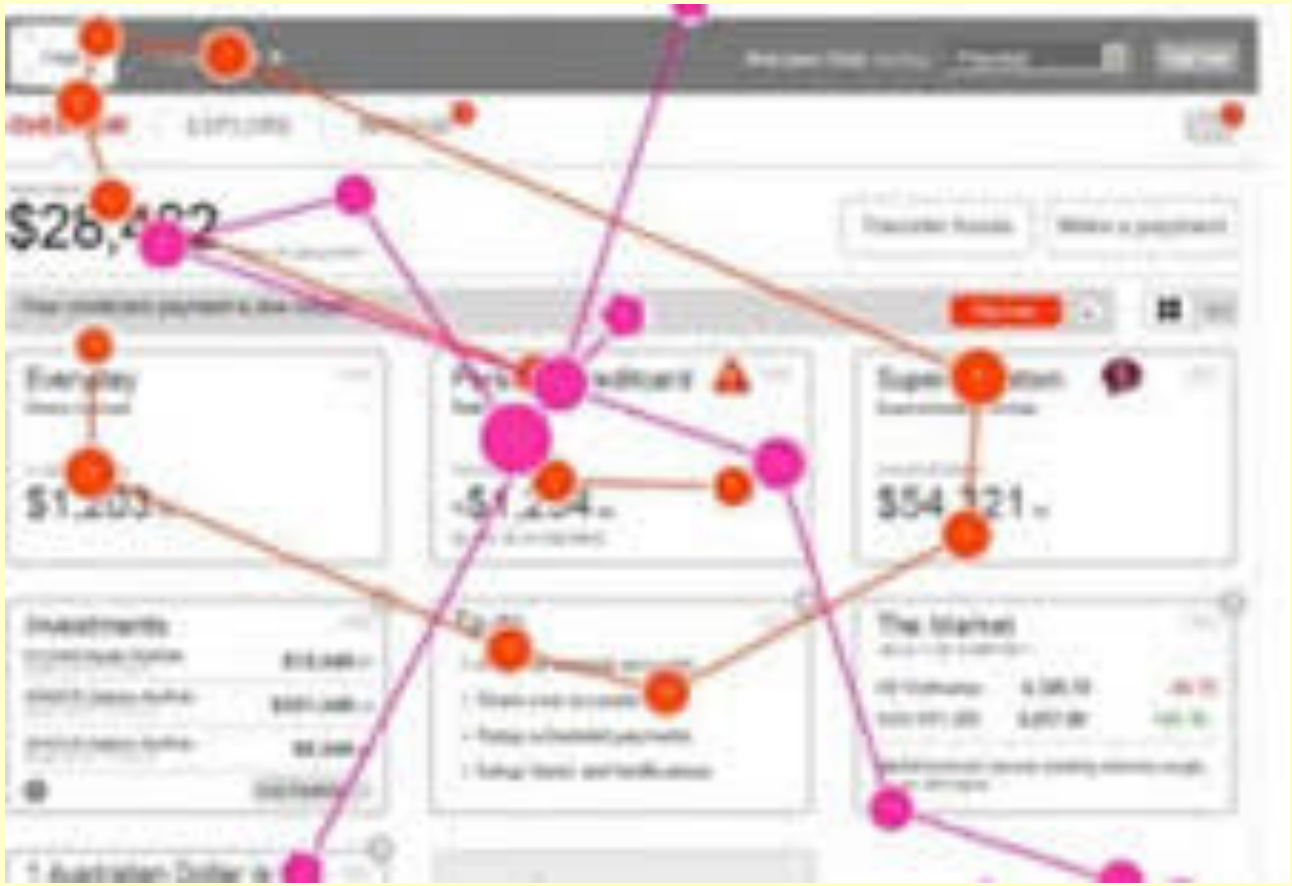


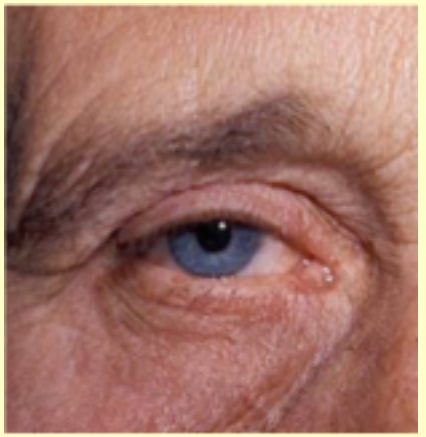
True Positive (TP) – Bugs correctly identified (i.e., correspond to bugs inserted in the programs)
False Positive (FP) – Bugs incorrectly identified (i.e., do not correspond to bugs inserted)

Accurate autonomic physiologic manifestations

Step 2 uses wearable and low intrusive devices

Accurate autonomic physiologic manifestations





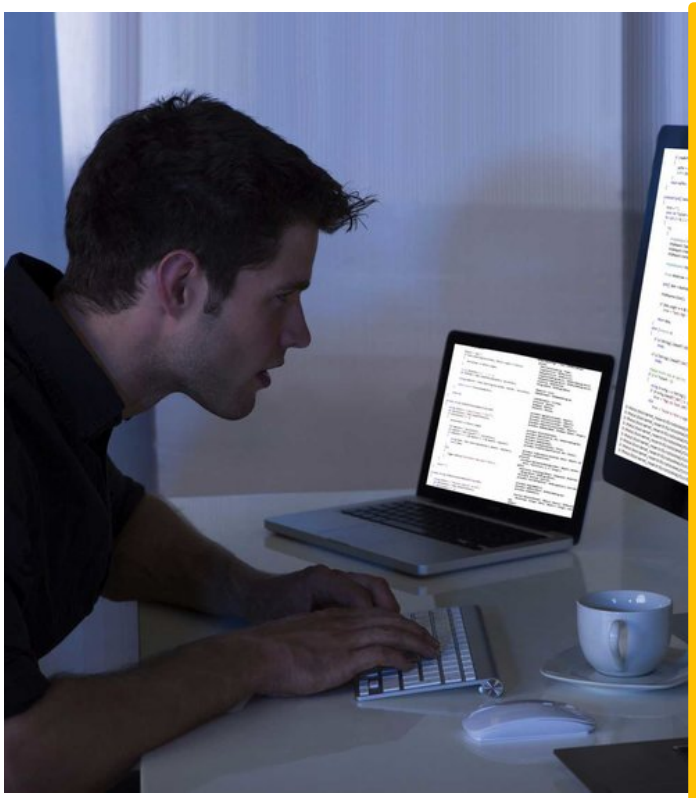
Accurate autonomic physiologic manifestations

Step 2 uses wearable and low intrusive devices

Accurate autonomic physiologic manifestations

Features of the prototype Biofeedback Augmented Software Engineering

Step 3 - Prototype of BASE to validate key features



- **Online warning of the programmer** (during code development) by highlighting the lines of code that may have bugs and need a second look from the programmer (**a kind of alter-pair**).
- **Guidance for optimized testing effort** (after programming) by taking into account the individual information gathered from each programmer that has participated in the code development.
- **Improved models of bug density estimation and SW risk analysis,** through the use of additional information on programmer's emotional and cognitive states, in conjunction to code complexity metrics and test coverage
- (there are more)

Summary

- BASE project (low budget so far) is starting in July 2018
  - We are hiring 2 PhD students and 1 postdoc
  - Call for these positions opens in July
- Preliminary results are encouraging
- We are digging for a more serious budget…

  these interdisciplinary studies are very expensive