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It’s Time For Secure Languages

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October 2017

25 exploited vulnerabilities in 1995

National Vulnerability Database, http://nvd.nist.gov

27287

exploited vulnerabilities in 2013-2016

National Vulnerability Database, http://nvd.nist.gov

3781

exploited vulnerabilities due to **buffer errors** (2013-2016)

National Vulnerability Database, http://nvd.nist.gov

2861

exploited vulnerabilities due to **cross-site scripting** (2013-2016)

National Vulnerability Database, http://nvd.nist.gov

2094

exploited vulnerabilities due to **information leak** (2013-2016)

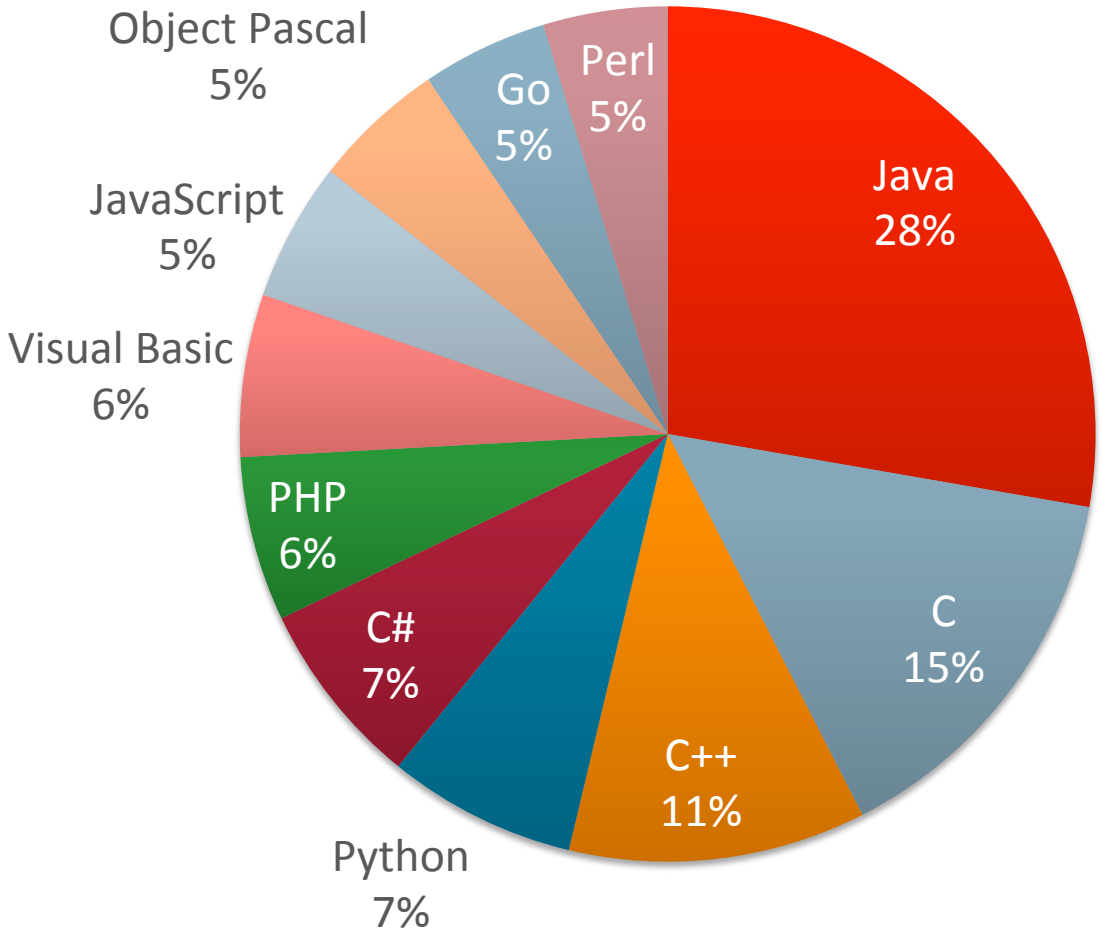
National Vulnerability Database, http://nvd.nist.gov

50%

exploited vulnerabilities in NVD were buffer errors, injections and information leak (2013-2016)

National Vulnerability Database, http://nvd.nist.gov

Top Mainstream Languages



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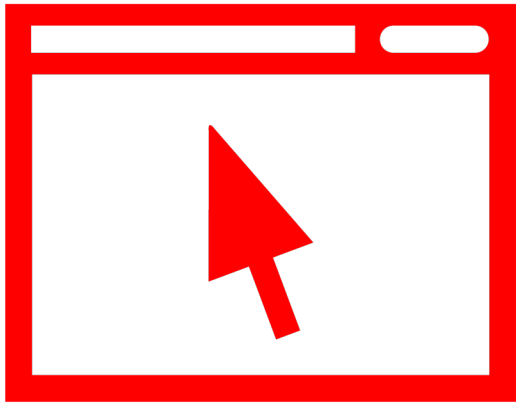
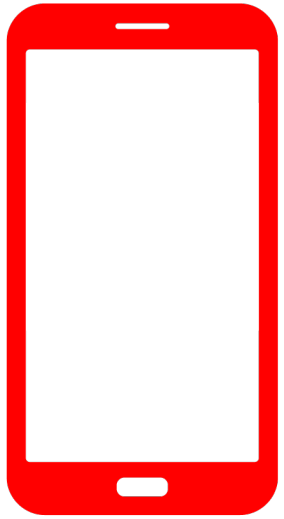
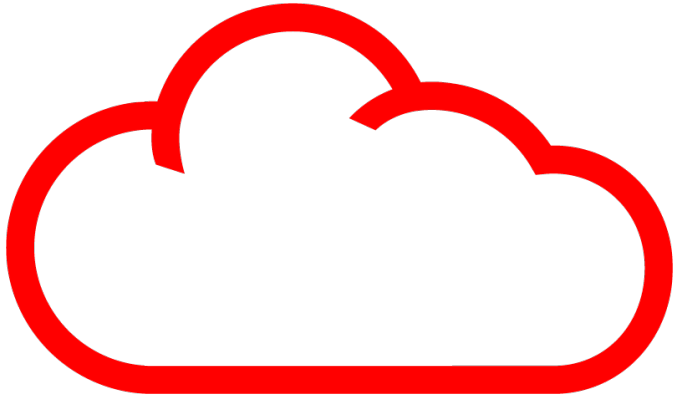




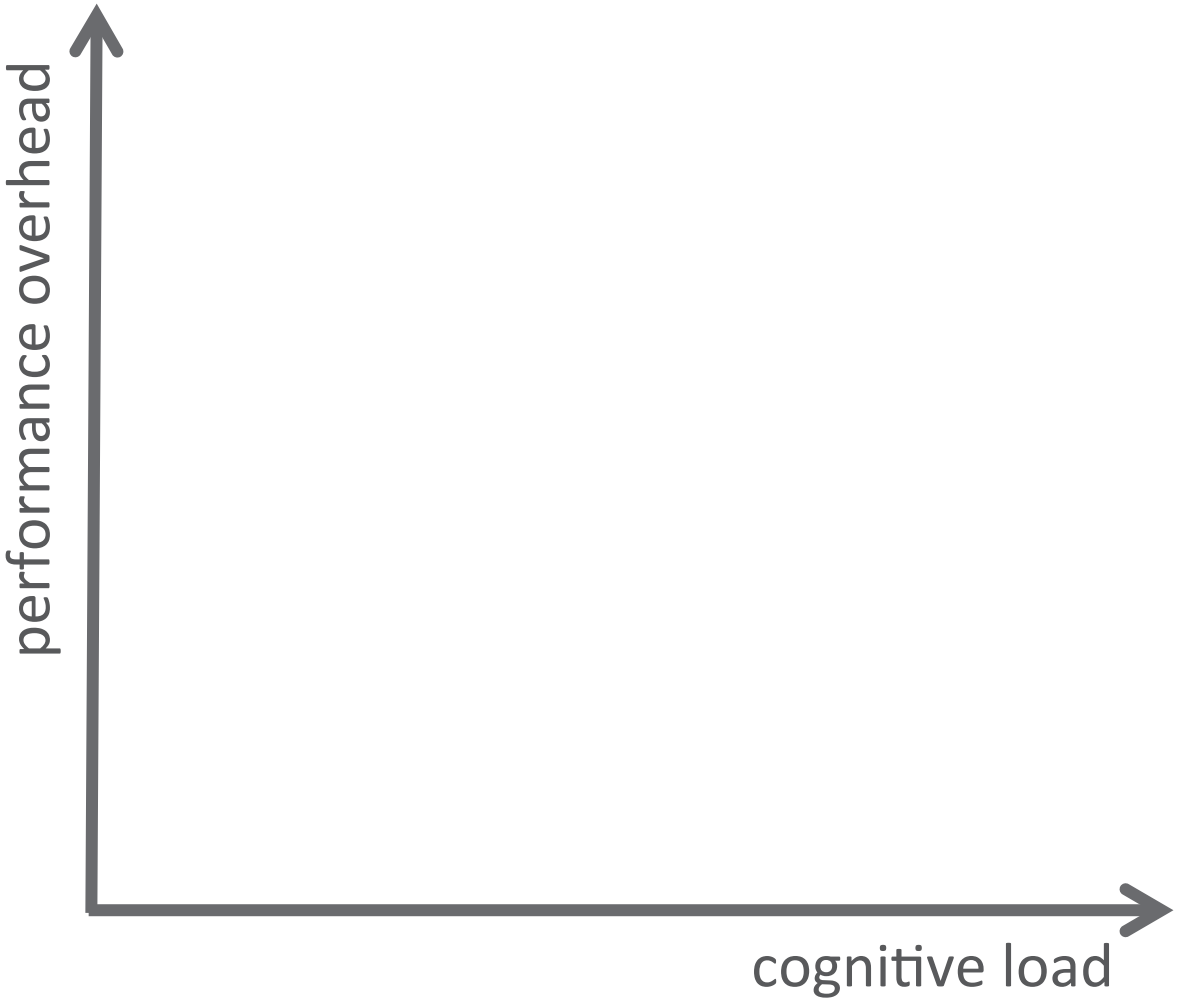


$4M

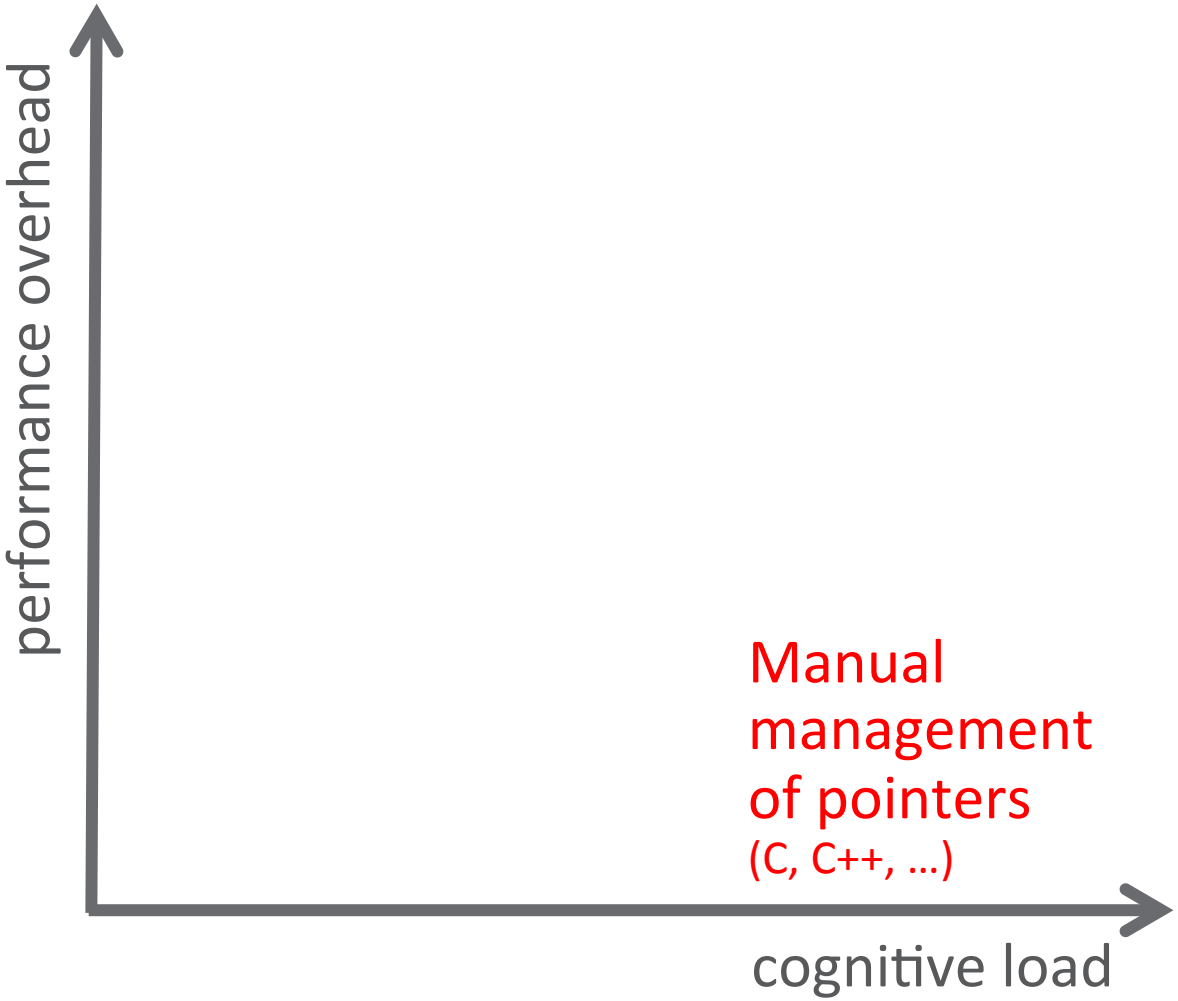
average cost of a data breach

2016 Ponemon Cost of Data Breach Study

Why Is This Happening?



Buffer Errors – The Problem: Unsafe Abstraction



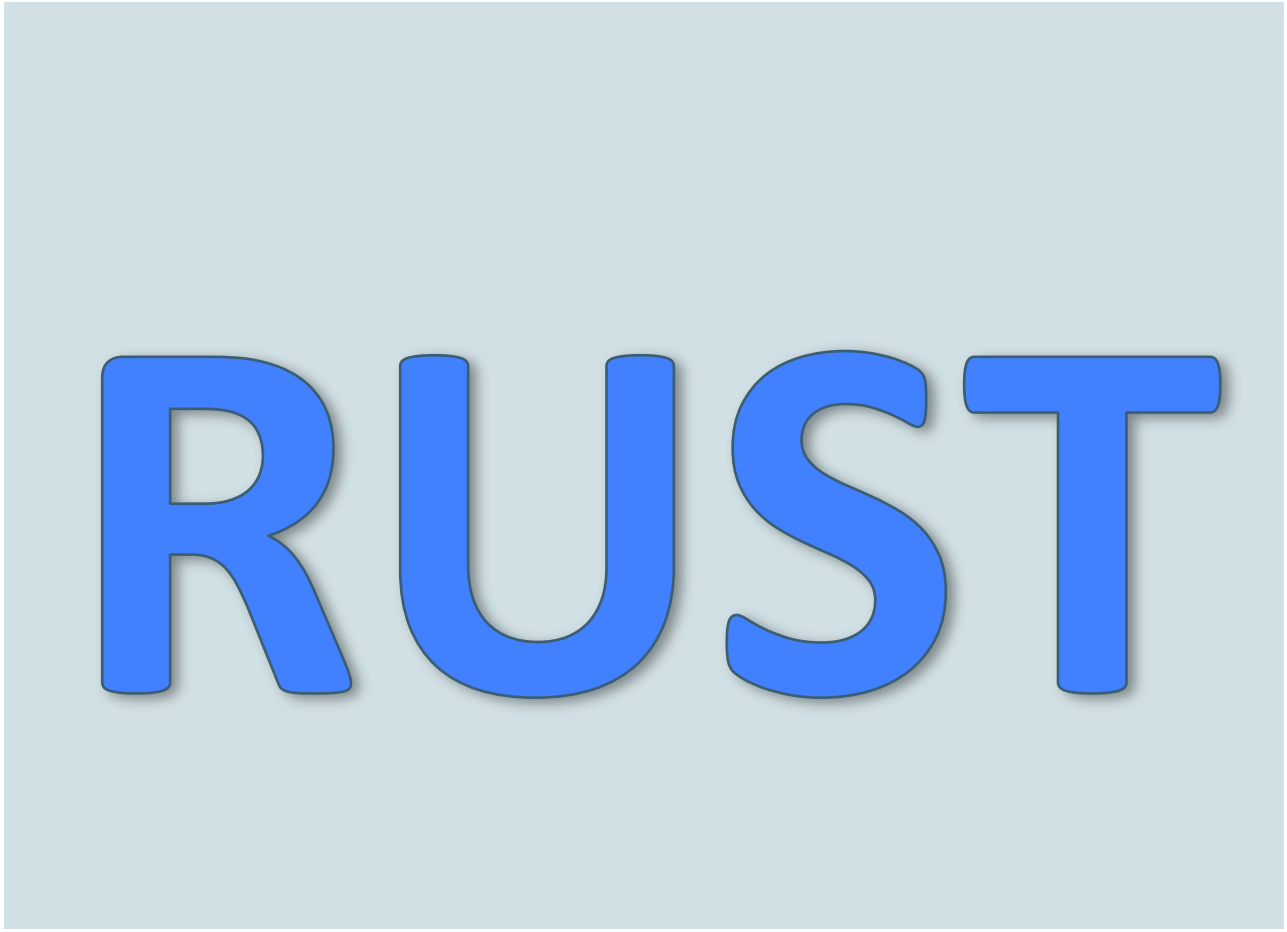
We have designed languages that prevent buffer errors

Avoid Buffer Errors Dynamically

John McCarthy, 1958

- Managed memory
  - Garbage collection
  - First introduced in LISP in 1958
- Now used in
  - OO languages: Smalltalk, Java, C#, JavaScript, Go
  - Functional languages: ML, Haskell, APL
  - Dynamic languages: Ruby, Perl, PHP

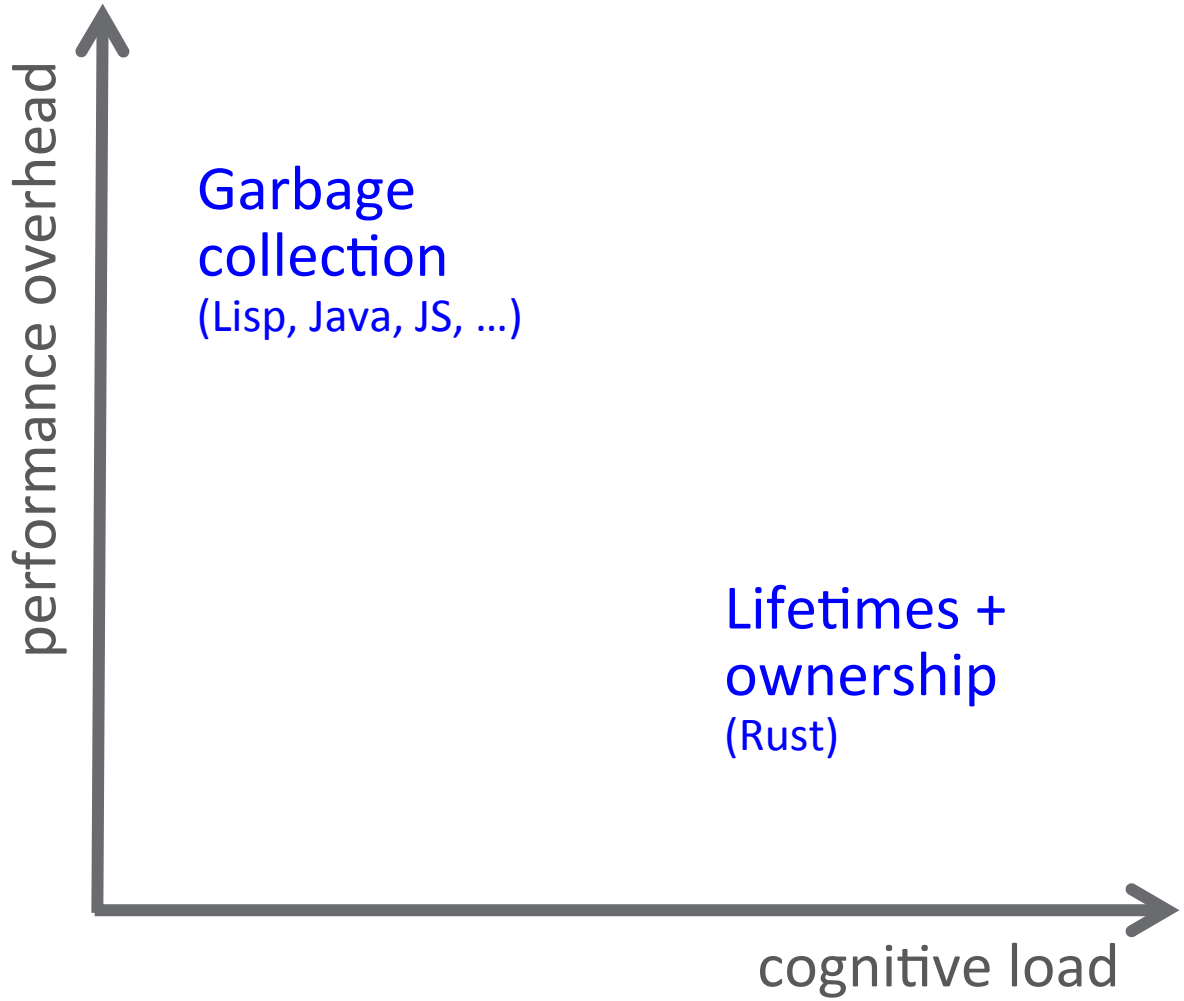
Avoid Buffer Errors Statically



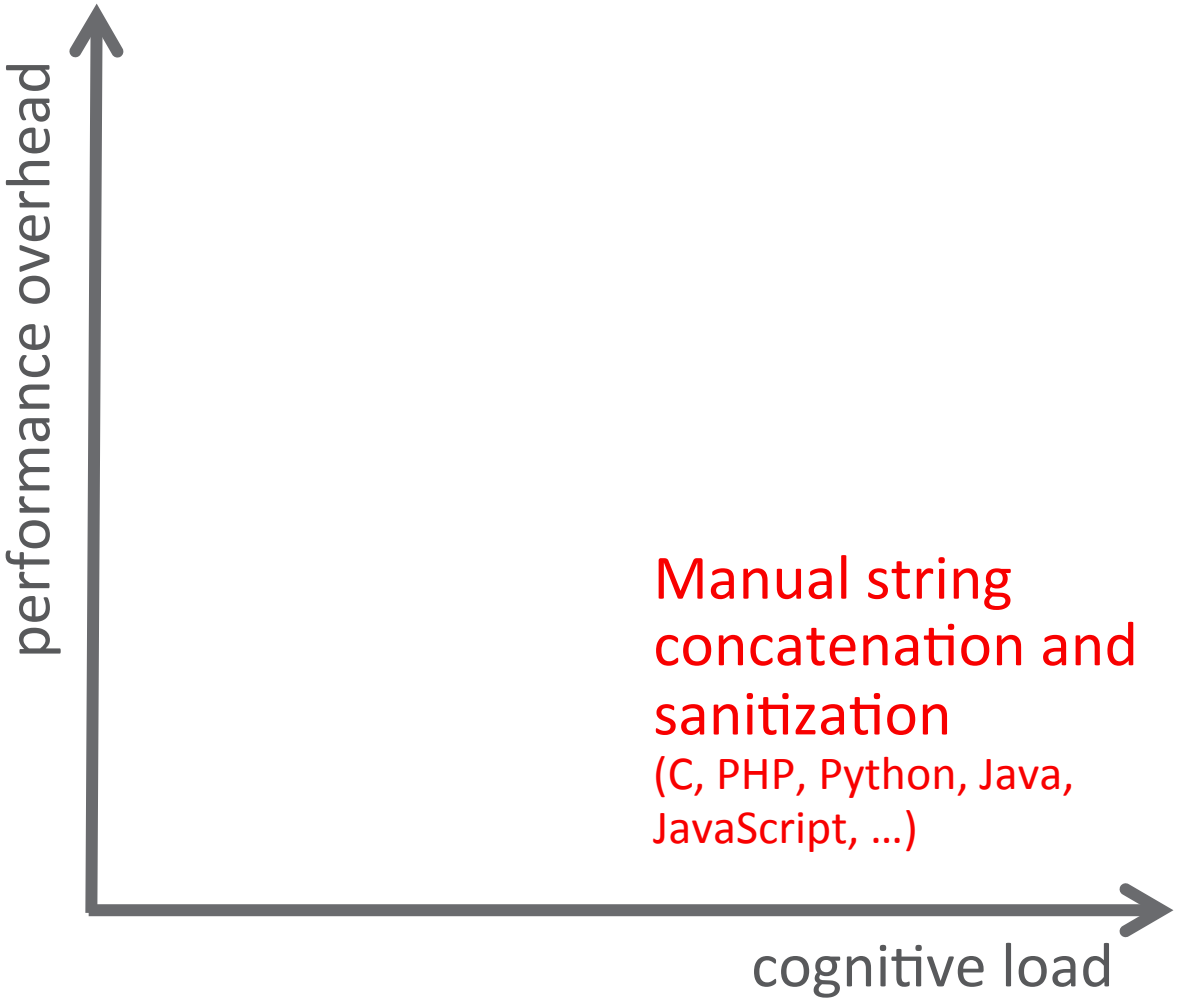
- Guaranteed memory safety
  - Ownership
  - Lifetimes
    shared borrow (`&T`)
    mutable borrow (`&mut T`)

Graydon Hoare et al, 2009

Buffer Errors – Solutions: Safe Abstractions

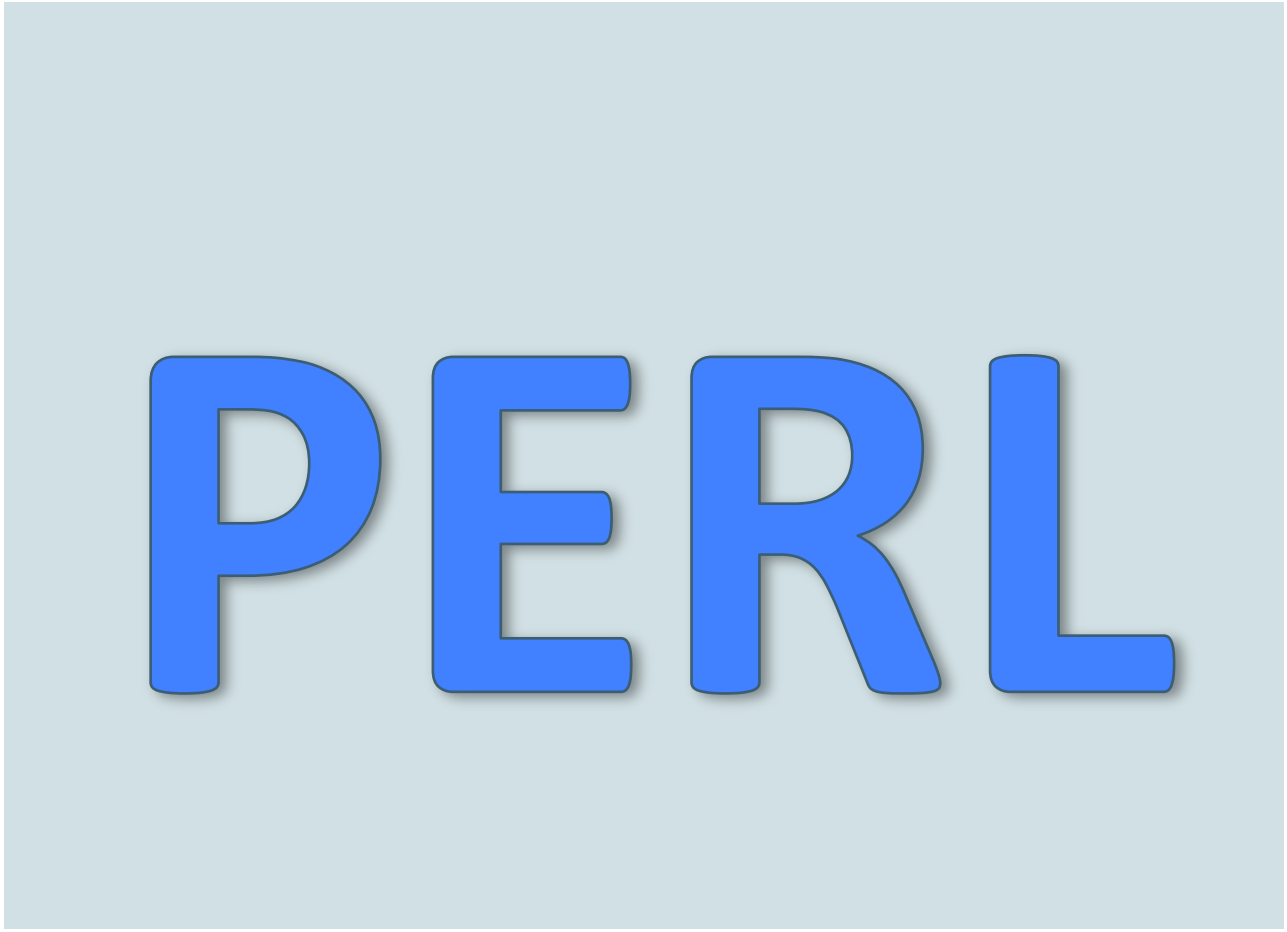


Injections – The Problem: Unsafe Abstraction



We have designed languages that prevent injections

Avoid Injections Dynamically



Larry Wall, 1987

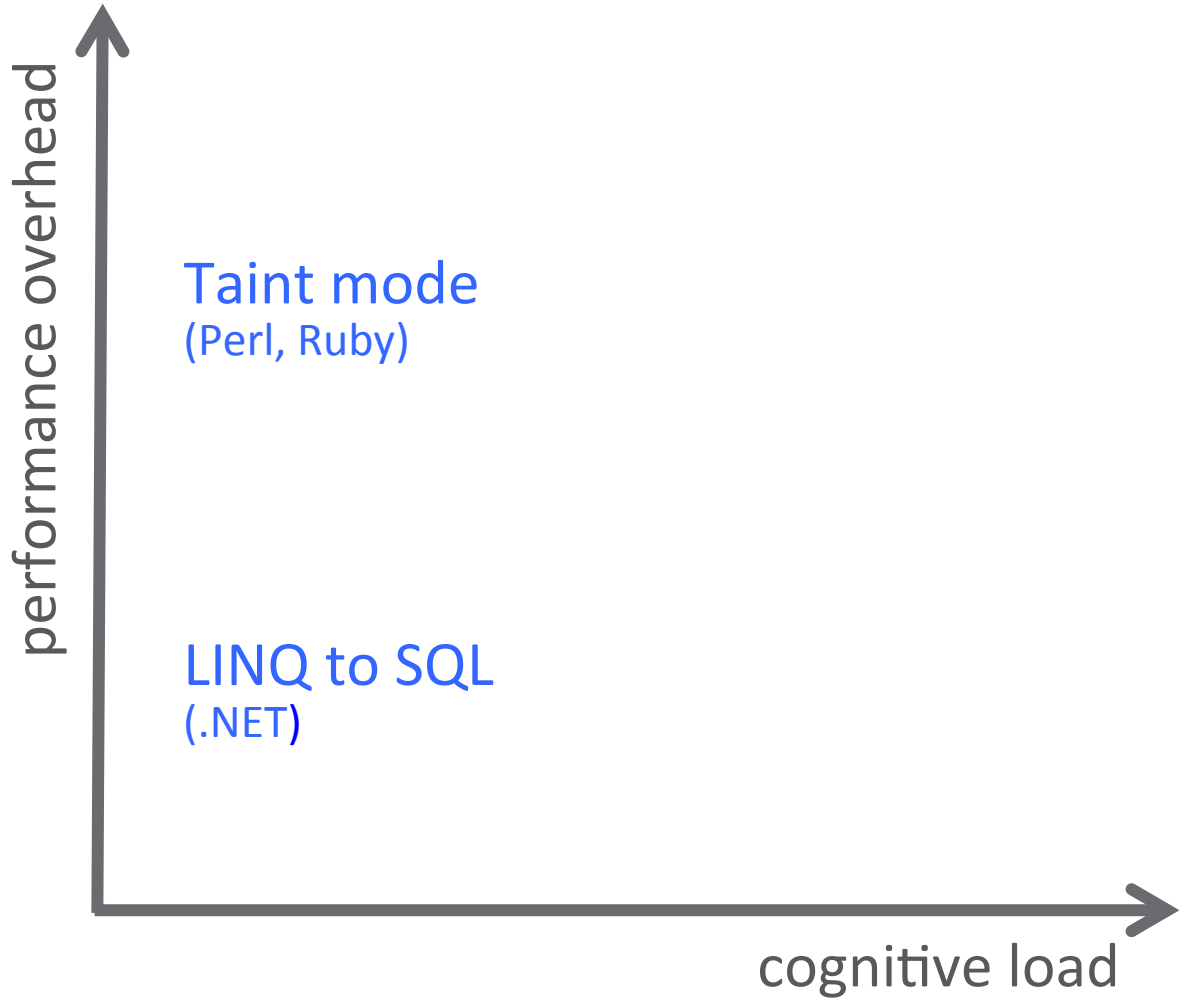
- Taint mode
  - Perl 3, 1989
  - Catches most accidental uses of untrusted string data
  - Automatic checks when program running with different real and effective user or group IDs
  - -T flag to turn it on
  - TBD for Perl 6
- Also used in
  - Ruby

Avoid SQL Injections – LINQ to SQL

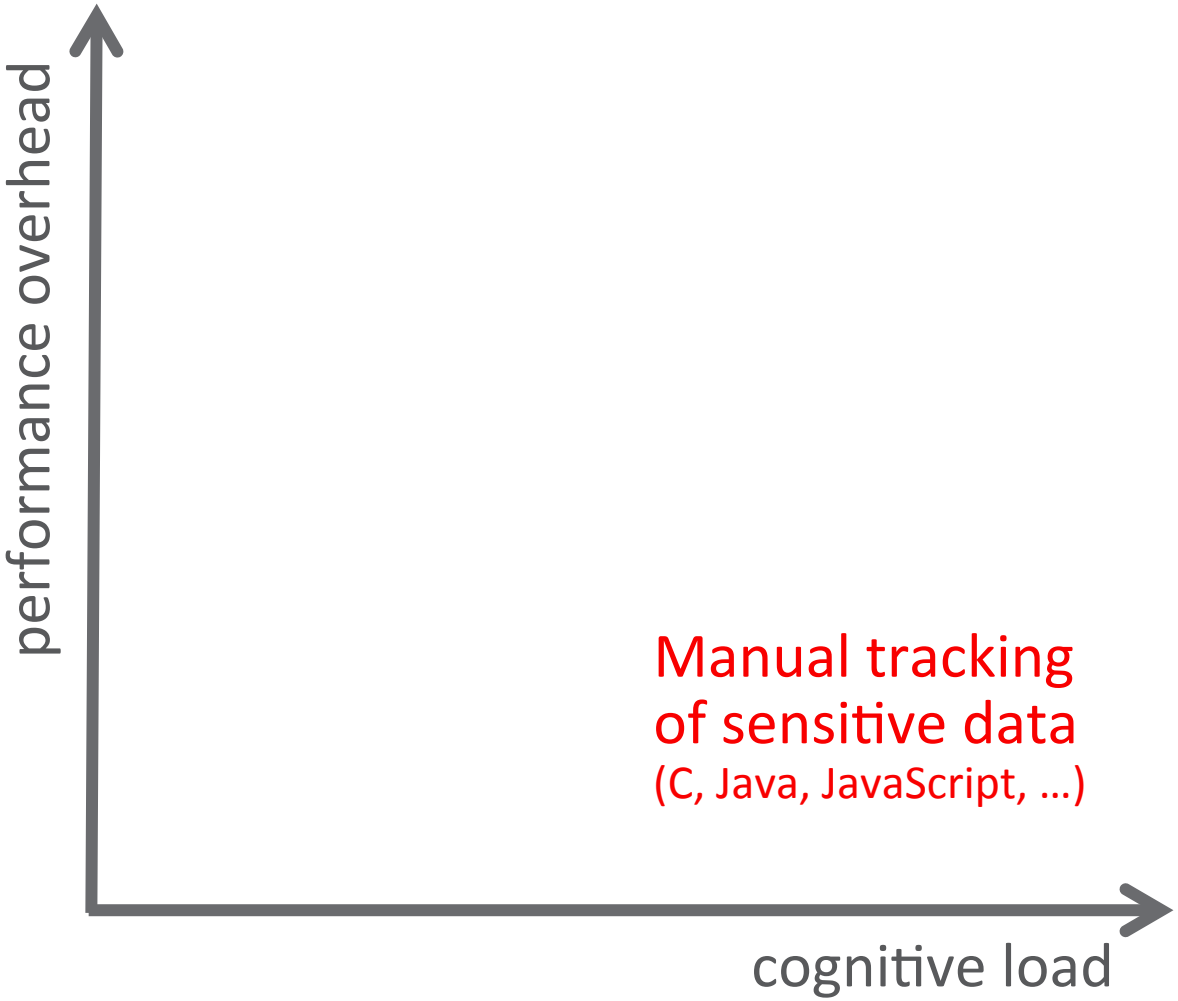
Microsoft, 2007

- .NET's Language INtegrated Query framework
- LINQ to SQL manages relational data as objects without losing the ability to query
  - Statically-typed
  - Not 100% compatible
- Avoids SQL injections by passing all data using SQL parameters
  - Not strings or string concatenation

Injections – Solutions: Safe Abstractions

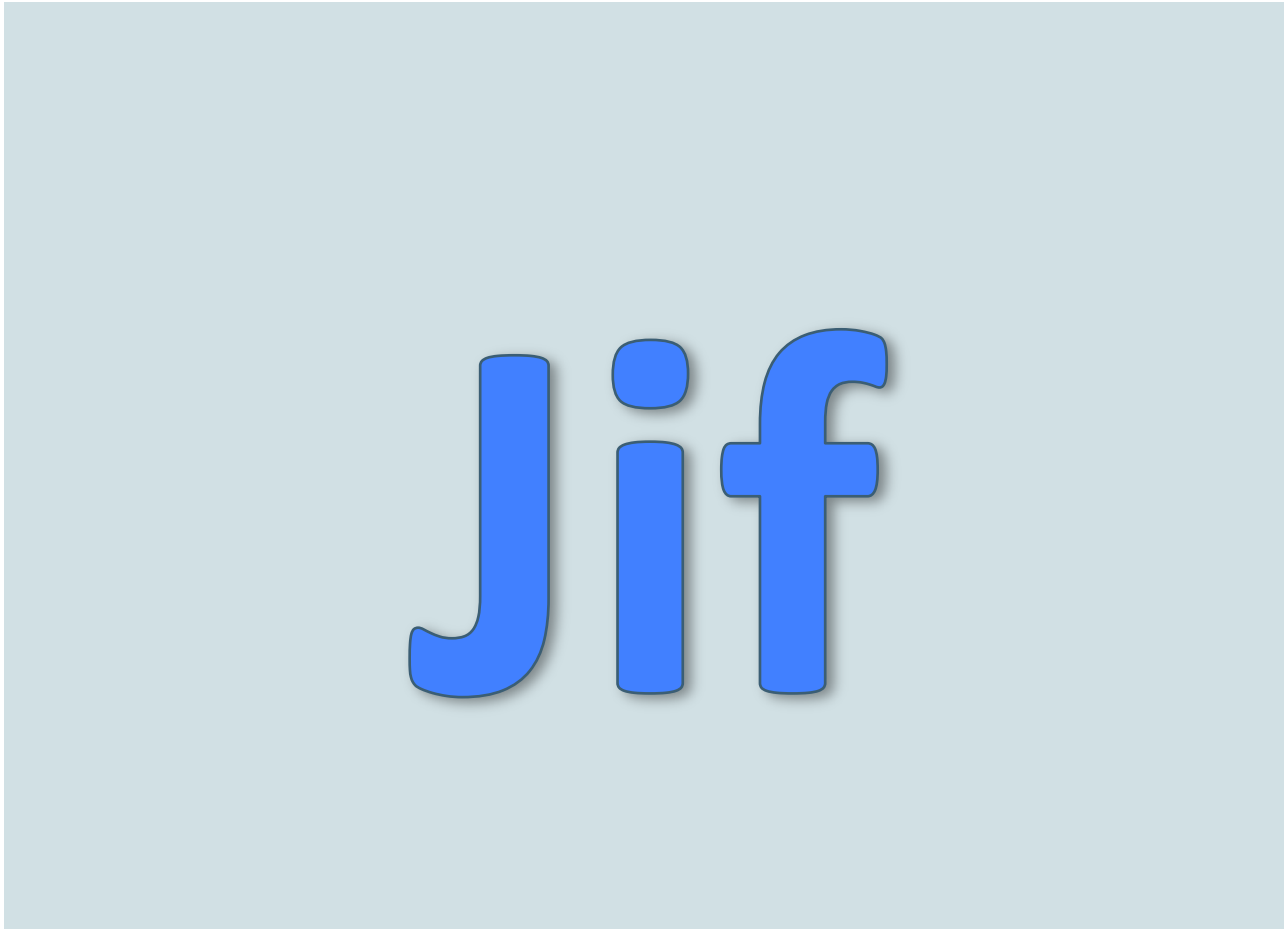


Information Leaks – The Problem: Unsafe Abstraction



We have designed academic abstractions that prevent information leaks, but they haven't made it to mainstream languages

Avoid Information Leaks and Injections Statically



- Extends Java with information flow and access control, enforced at compile time and run time
  - Integrity and confidentiality
  - Can prevent covert information leaks
- Security policies are expressed as label annotations restricting how the information may be used

Andrew Myers, 2002+

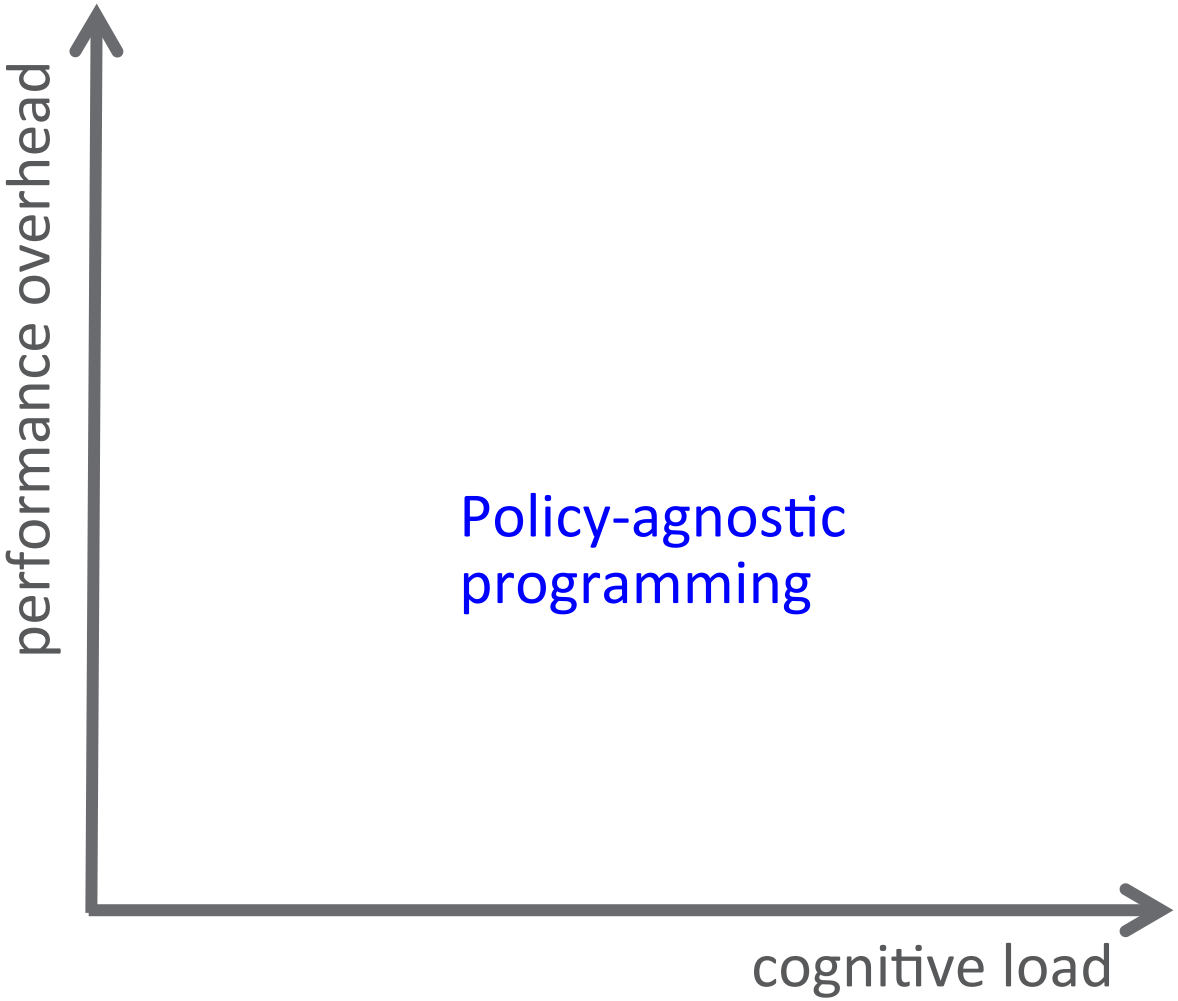
Avoid Information Leaks Dynamically

Policy-Agnostic Programming

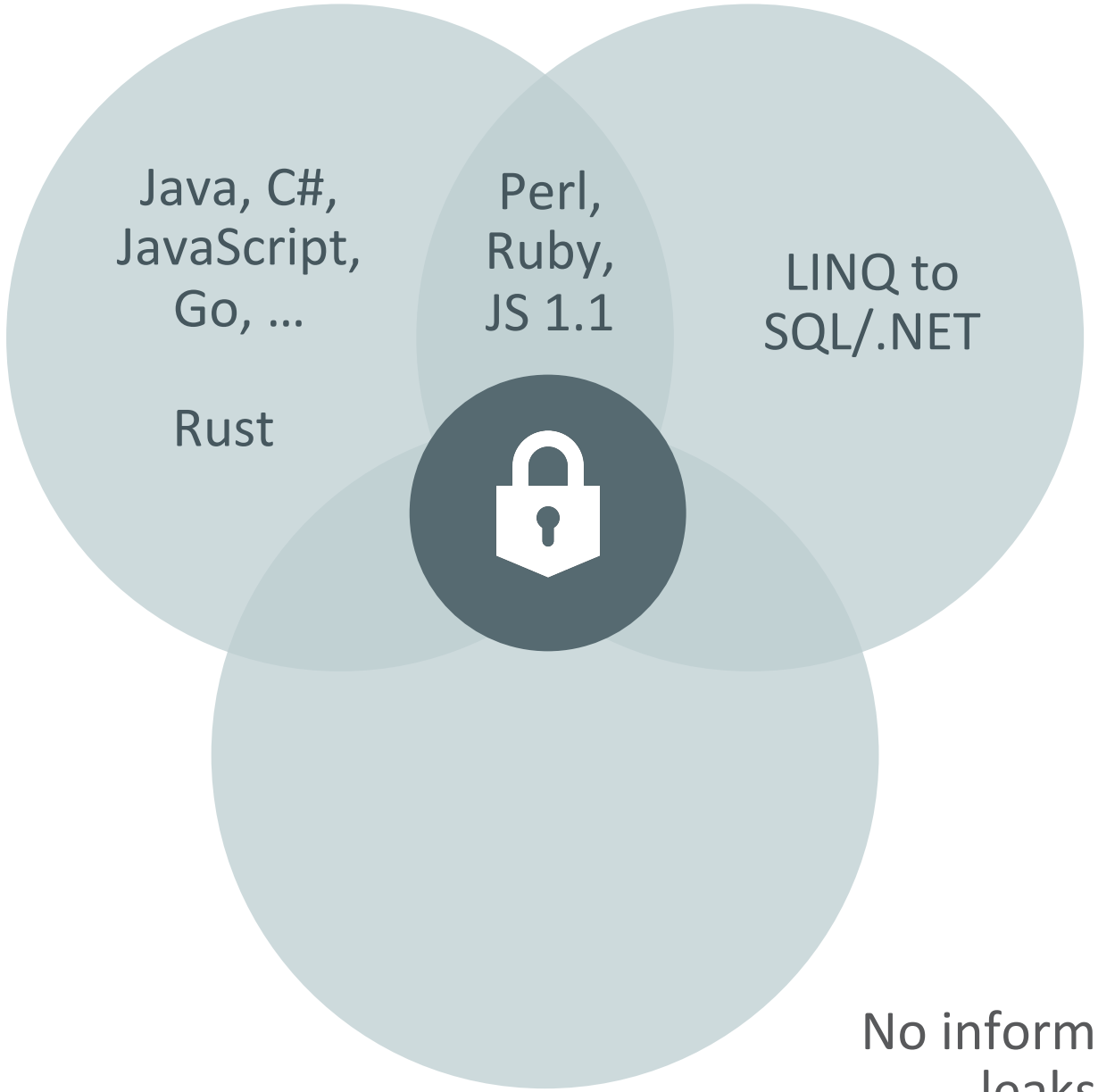
Jean Yang, 2013+

- Faceted values: a policy guarding both, the security-sensitive and non-sensitive values
  - The runtime keeps track of policies associated with conditionals
  - Faceted database saves faceted
- Sample web applications yield reasonable (< 2x) overheads

Information Leaks – Solutions: Safe Abstractions



Mainstream Languages



Abstractions

ONE LANGUAGE TO RULE THEM ALL

ONE
LANGUAGE
TO
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ALL

27287

exploited vulnerabilities in 2013-2016

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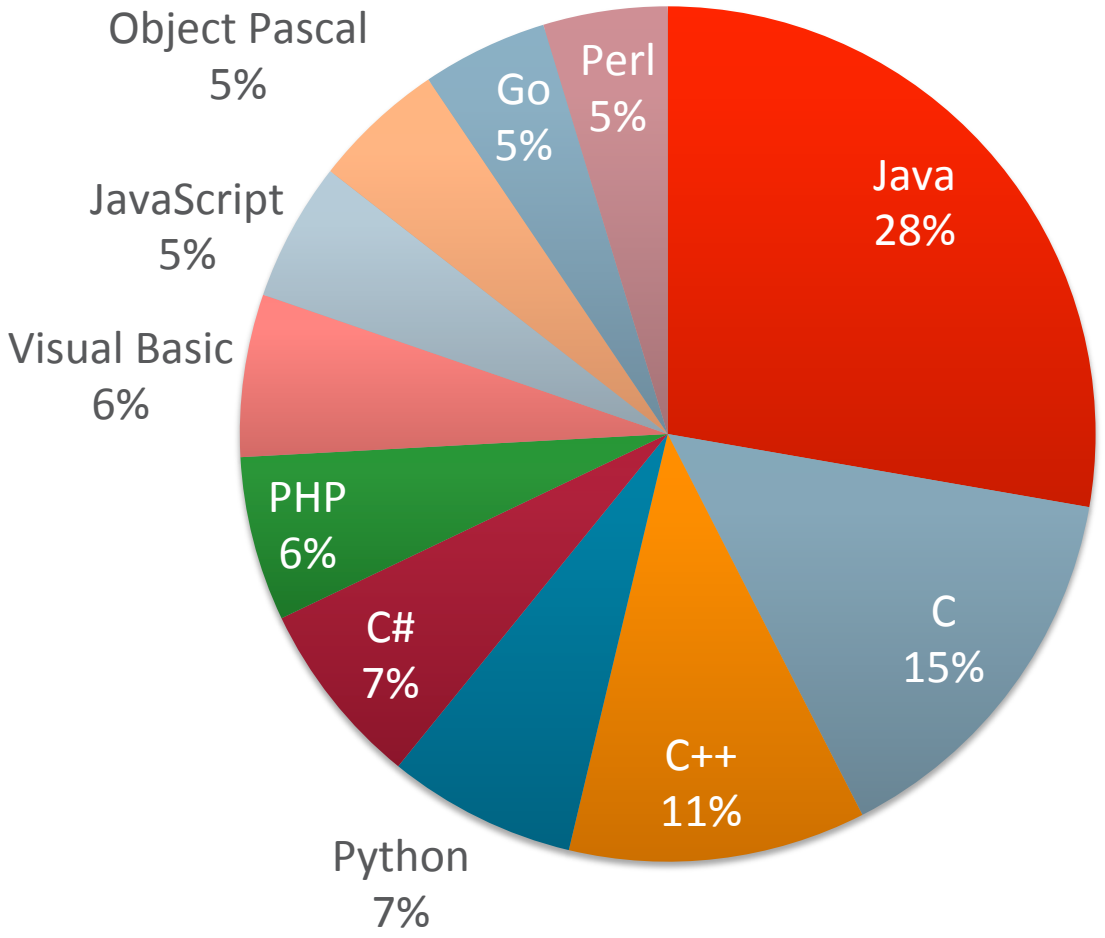
Top Mainstream Languages



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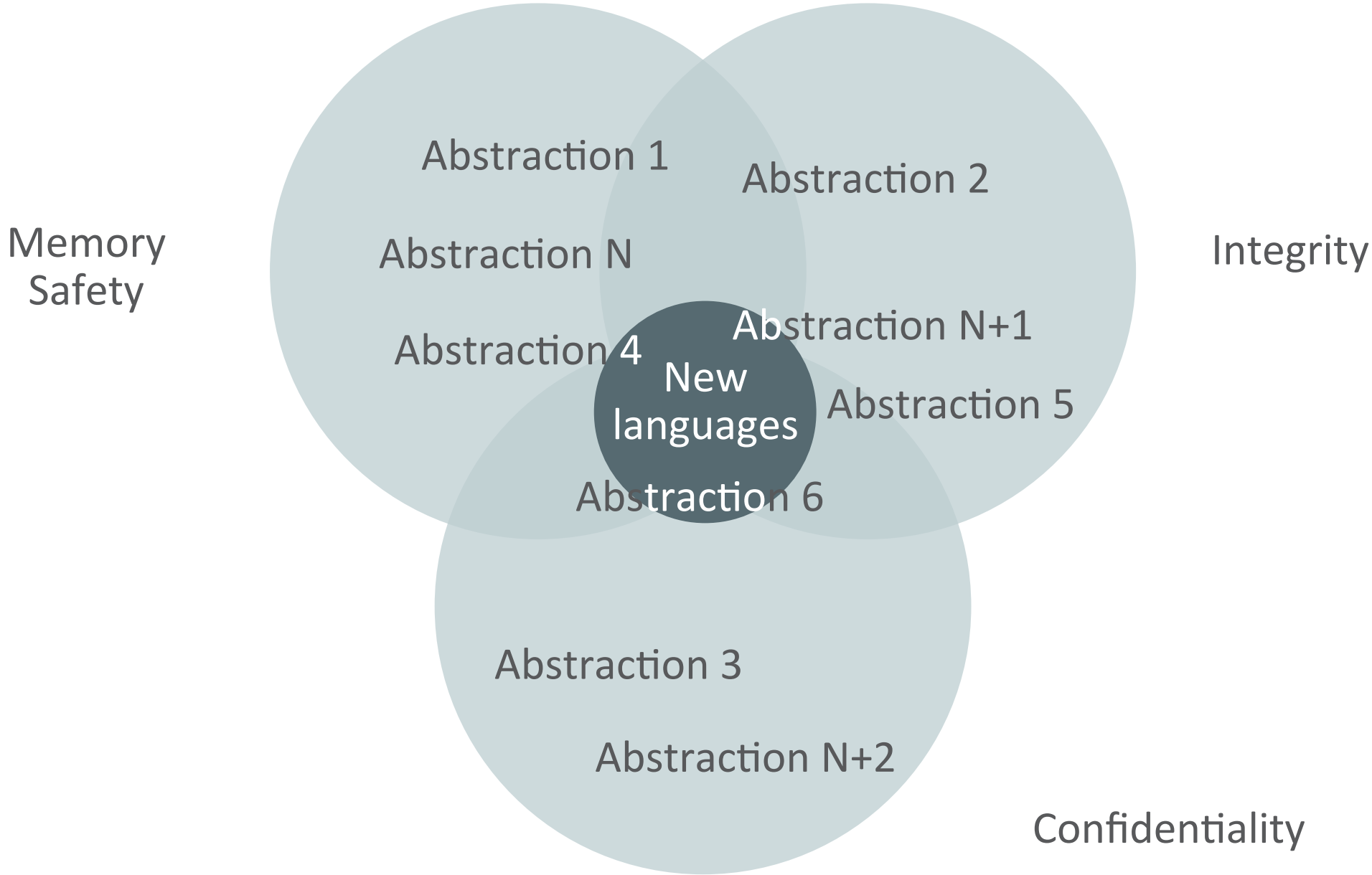
It’s time to include security in our **language design**

Challenge – To design languages that free developers from input (i.e., buffer errors, injections) and output (i.e., leaks) vulnerabilities

Challenge – To develop abstractions that minimise the cognitive load of tracking tainted data and leaked data across a system



Challenge – To provide **security guarantees** in the languages we design

18.5

million software developers worldwide (11M professional, 7.5M hobbyist)

http://www.idc.com, 2014 Worldwide Software Developer and ICT-Skilled Worker Estimations

Security is not just for expert developers


KEEP
CALM
AND
CARRY ON
PROGRAMMING

It’s time for secure languages

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http://labs.oracle.com/locations/australia

@criscifuentes

Integrated Cloud

Applications & Platform Services

Why Didn't You Mention My Favourite Mainstream Language?

Python

PHP

JavaScript

Go, …

- Provide memory safety dynamically
- Do not provide solutions for injections or information leaks


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