The Why of Go

21st Century Programming Languages Track, Qcon SF

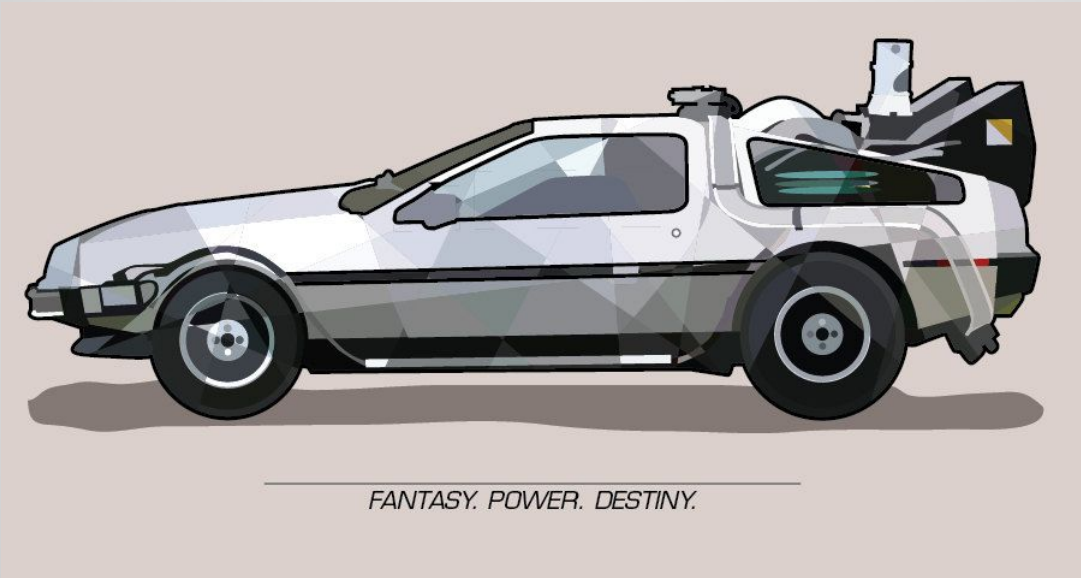
Carmen Andoh

1983

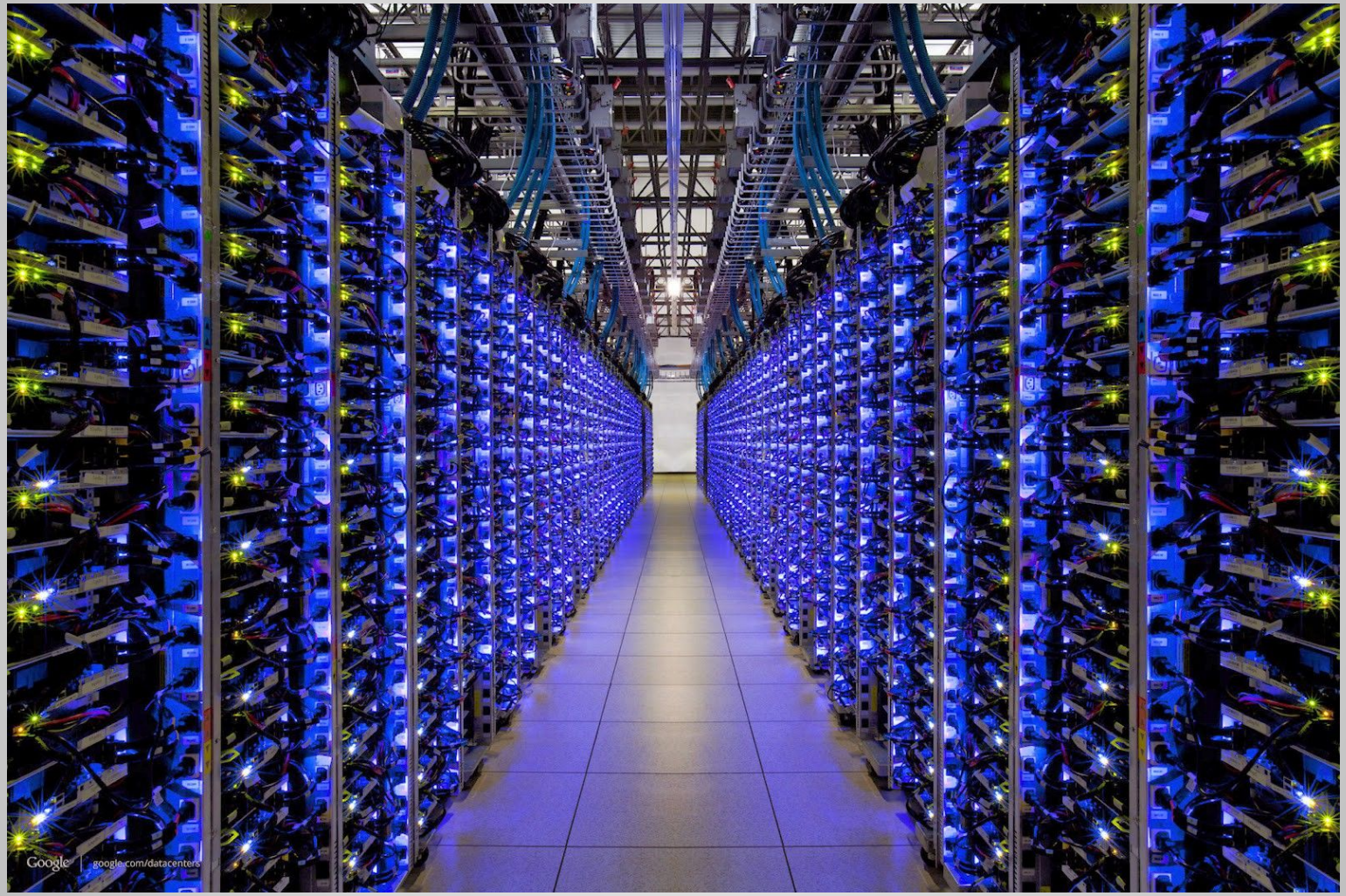
Thank you, fellow time travelers from the Future

- *Dave Cheney*
- *Alan Donovan*
- *Steve Francia*
- *Jérôme Pettazoni*

Back to 1983 … (from 1985, but whetev, 80s rule)




The 80s
ARE COOL
IN 2017


Google | google.com/datacenters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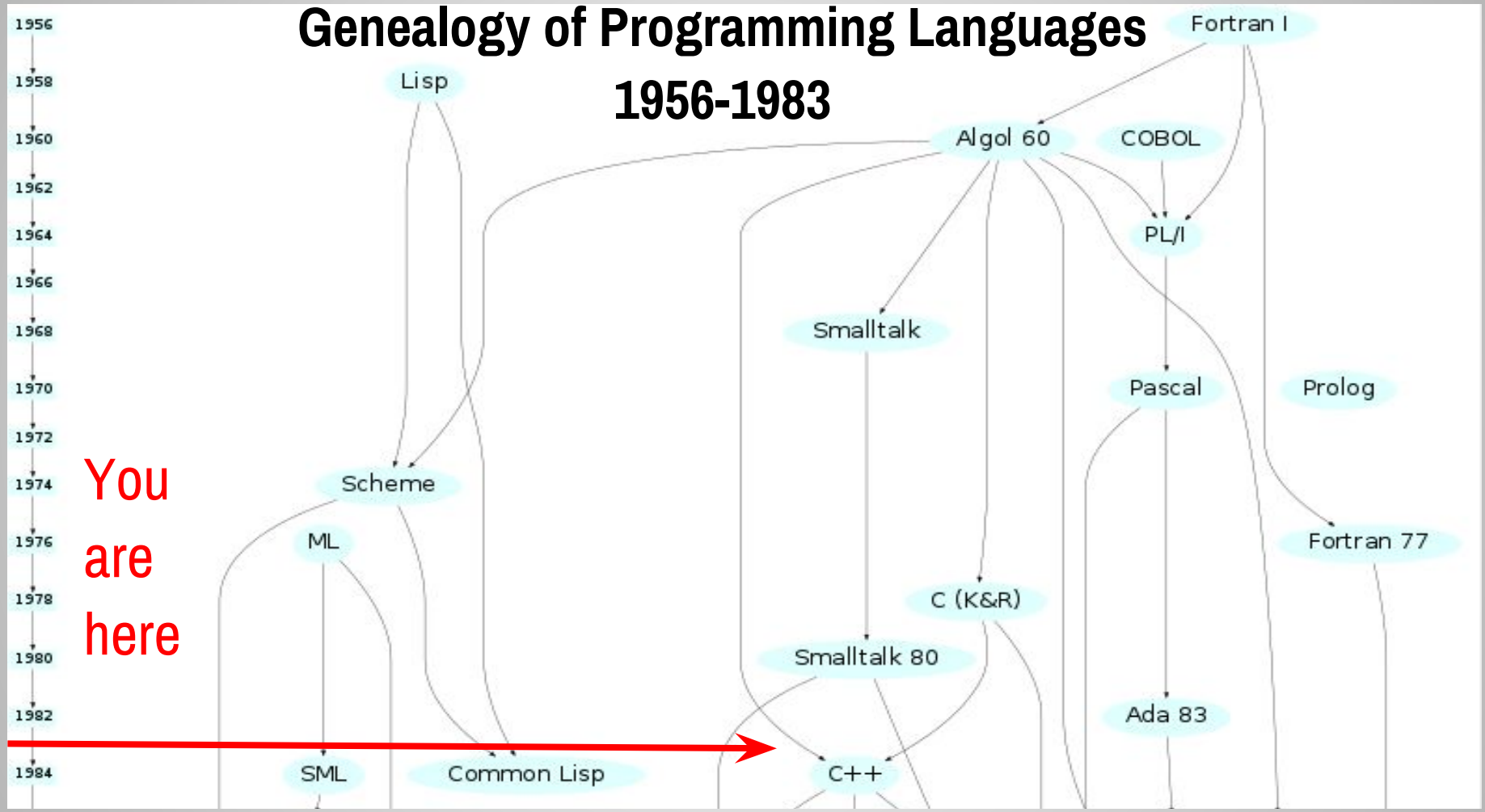
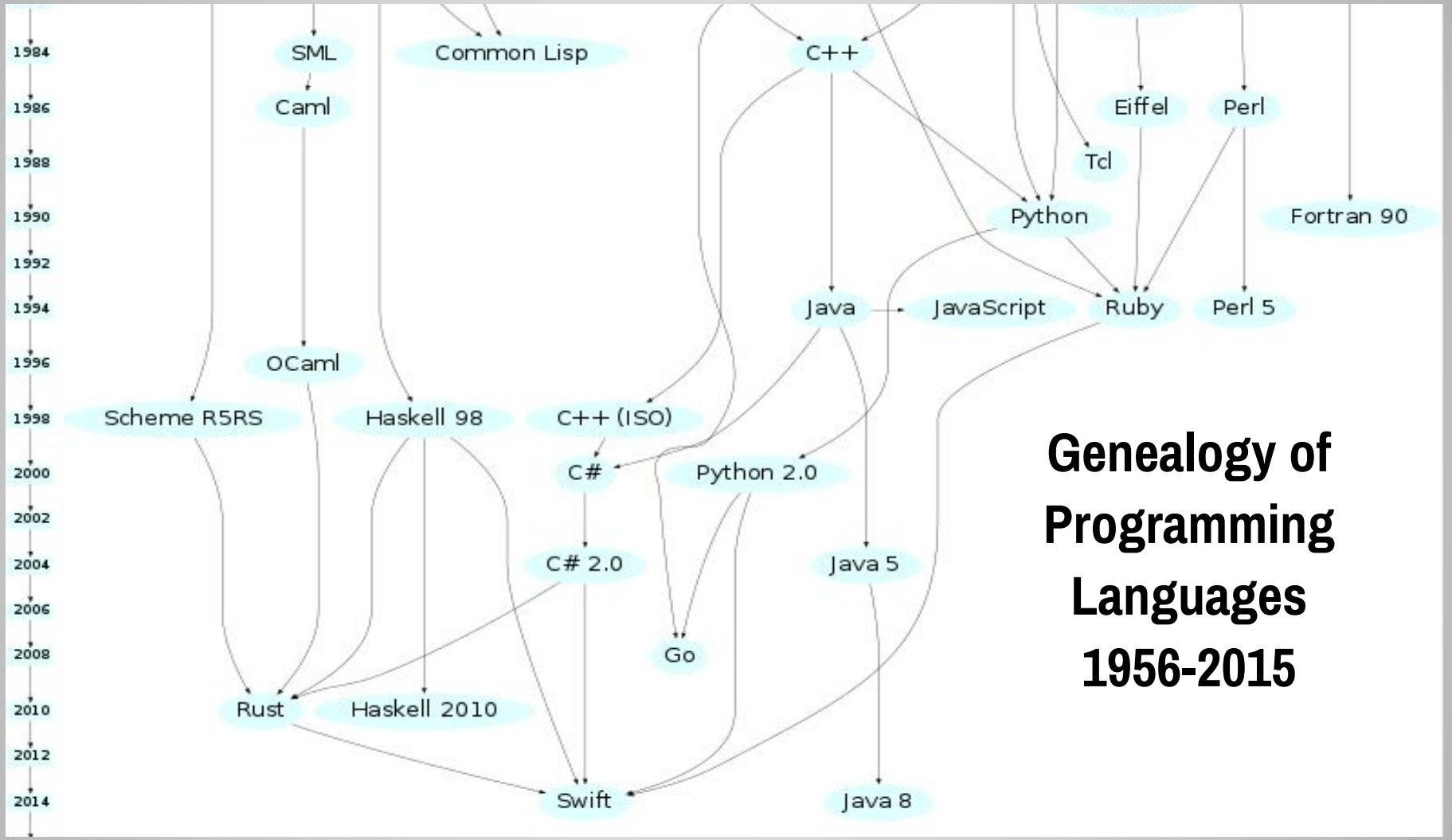
Genealogy of Programming Languages 1956-1983

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OCaml
Scheme R5RS
Haskell 98
C++ (ISO)
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Haskell 2010
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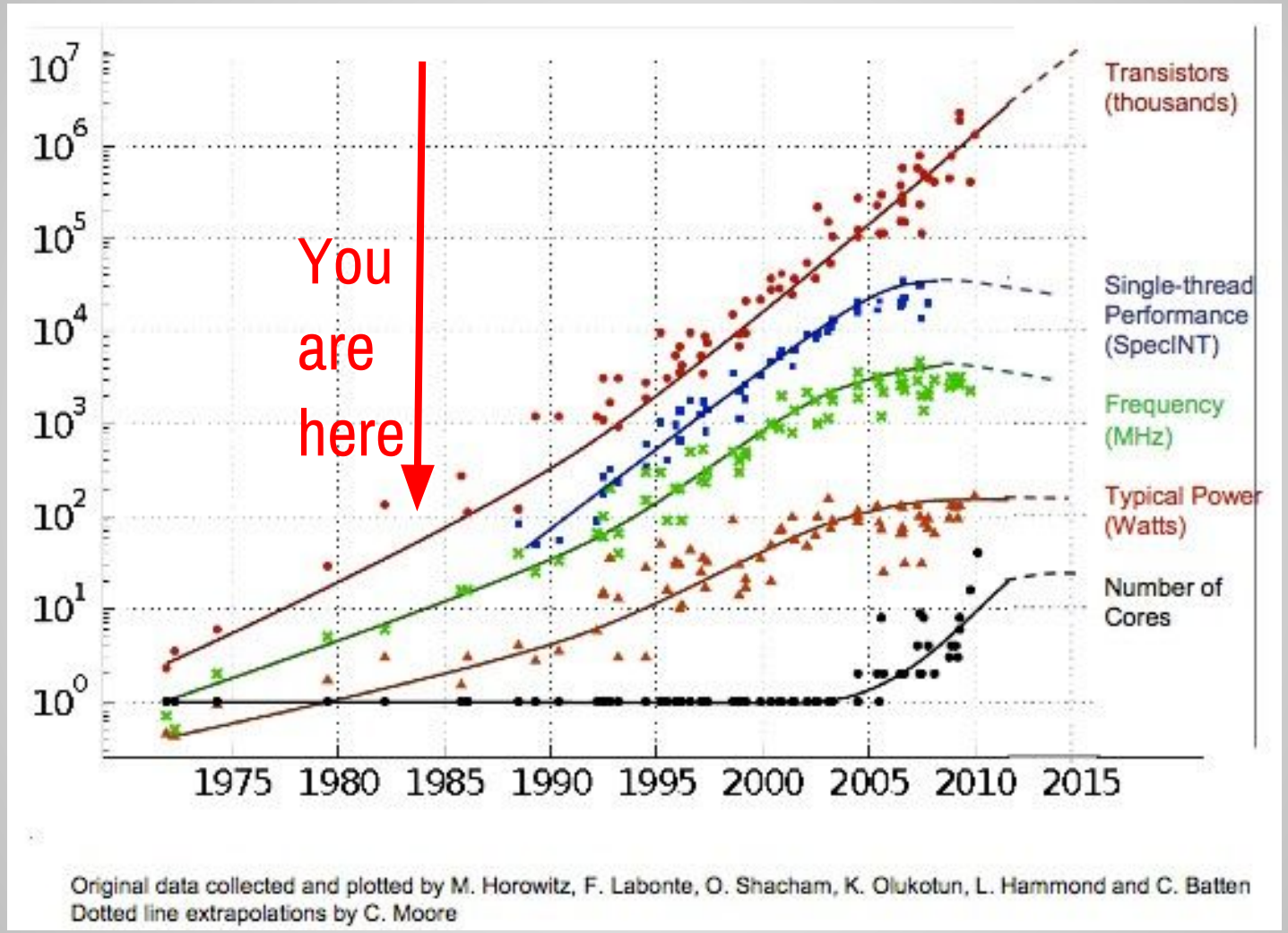
Java 8
Genealogy of Programming Languages 1956-2015


You are here
Transistors (thousands)
Single-thread Performance (SpecINT)
Frequency (MHz)
Typical Power (Watts)
Number of Cores
10^7
10^6
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10^4
10^3
10^2
10^1
10^0
1975 1980 1985 1990 1995 2000 2005 2010 2015
Original data collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond and C. Batten
Dotted line extrapolations by C. Moore

Unix®

Operating System

Programming Techniques

S. L. Graham, R. L. Rivest Editors

Communicating Sequential Processes

C.A.R. Hoare
The Queen's University
Belfast, Northern Ireland

This paper suggests that input and output are basic primitives of programming and that parallel composition of communicating sequential processes is a fundamental program structuring method. When combined with a development of Dijkstra's guarded command, these concepts are surprisingly versatile. Their use is illustrated by sample solutions of a variety of familiar programming exercises.

Key Words and Phrases: programming, programming languages, programming primitives, program structures, parallel programming, concurrency, input, output, guarded commands, nondeterminacy, coroutines, procedures, multiple entries, multiple exits, classes, data representations, recursion, conditional critical regions, monitors, iterative arrays

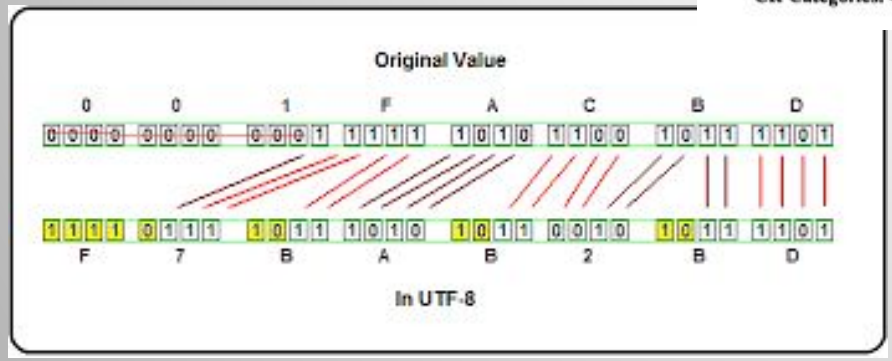
CR Categories: 4.20, 4.22, 4.32

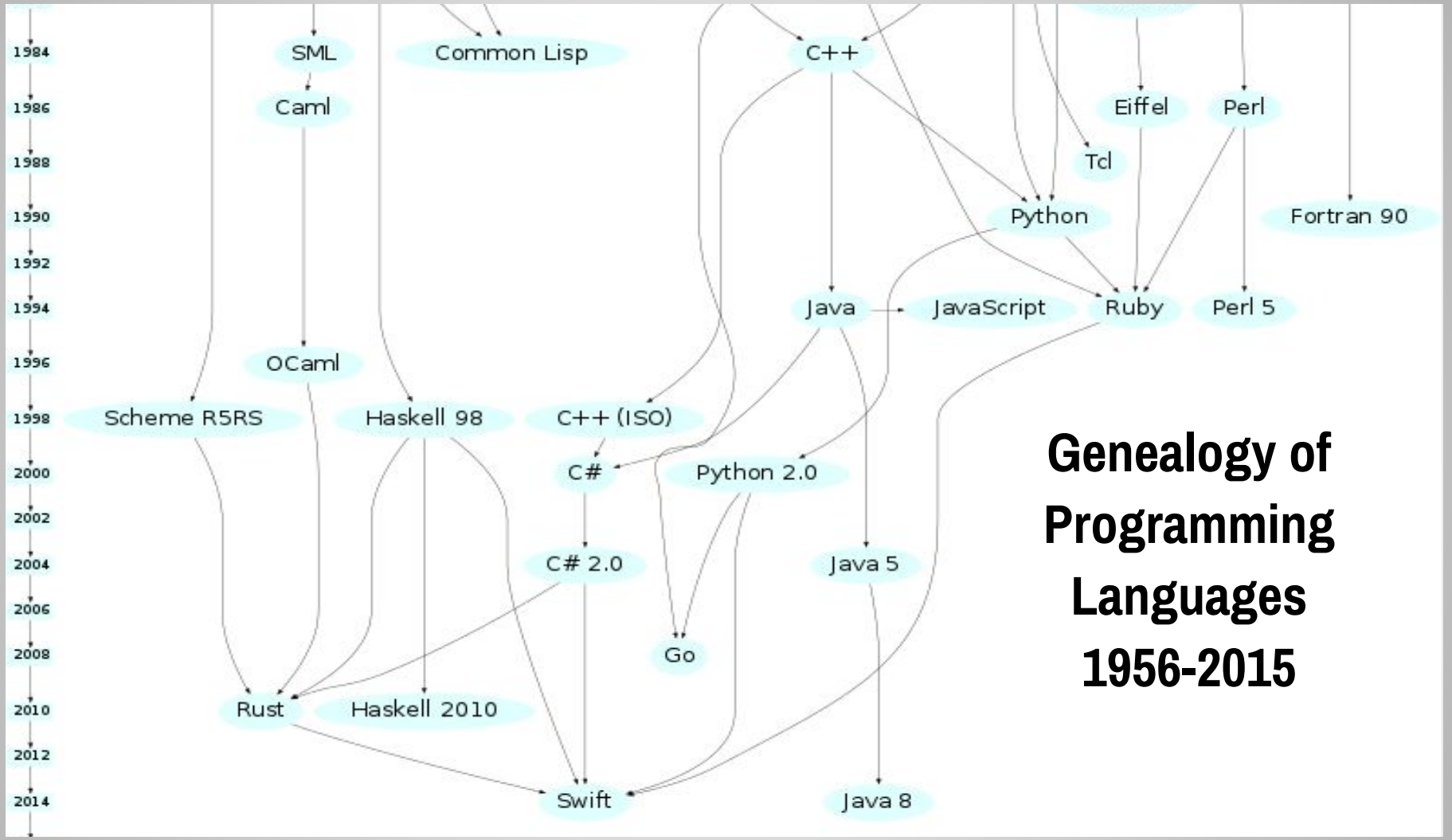
SECOND EDITION

THE C ANSI C PROGRAMMING LANGUAGE

BRIAN W. KERNIGHAN
DENNIS M. RITCHIE

PRENTICE HALL SOFTWARE SERIES

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C++
Eiffel
Perl
Tcl
Python
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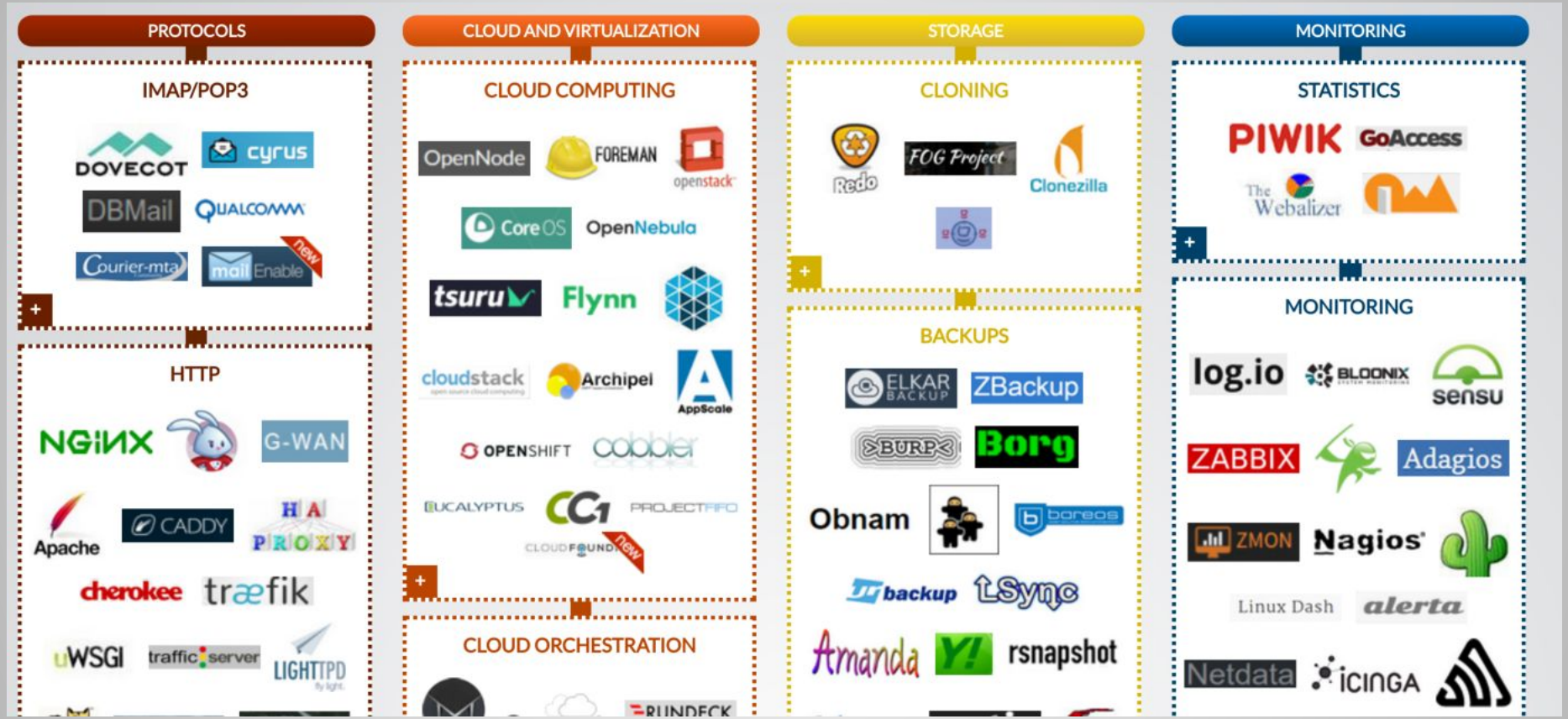
Java
JavaScript
Ruby
Perl 5
OCaml
Scheme R5RS
Haskell 98
C++ (ISO)
C#
Python 2.0
C# 2.0
Java 5
Go
Rust
Haskell 2010
Swift
Java 8
Genealogy of Programming Languages 1956-2015

"What's that?" snapped the King.
And he looked down the stack.
And he saw at the bottom, a turtle named Mack.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CLOUD COMPUTING
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StackStorm
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ZBackup
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Obnam
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BackupPC
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duplicity
kvmBackup
SNEBU
REAR
SafeKeep
Attic
HashBackup
Déjà Dup
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rdiff-backup
bup
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GoAccess
The Webalizer
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ZMON
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RIEMANN
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EasyDCP
webmin
ISPCONFIG
tipboard
nethserver
POWERDNSGUI
VESTA
CALAMARI
WebVirtMgr
Kimchi
ViMbAdmin
CWP
Froxlor
Easy-WI
Virtualmin
postfixadmin
OpenVZ Web Panel
iF.SVNAdmin
WebSVN
KeyHelp
SPACEWALE
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NetBeans
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IUS
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PROTOCOLS
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MDaemon
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G-WAN
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lighttpd
Hiawatha
Resin
SMTP
Postfix
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Haraka
Mailtrain
Sendmail
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VBox.Adm
ZoneMTA
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BIND
Unbound
Dnsmasq
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tinydns
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LDAP
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Mosh
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CLOUD AND VIRTUALIZATION
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ZBackup
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OpenLDAP
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Cassandra
Hypertable
FlockDB
Neo4j
RethinkDB
MariaDB
MySQL
PostgreSQL
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ngrep
BOOKS
O'REILLY

GNU

GNU’s Not Unix Project

Started in 1983

Vague but exciting ...

CERN DD/OC

Tim Berners-Lee, CERN/DD

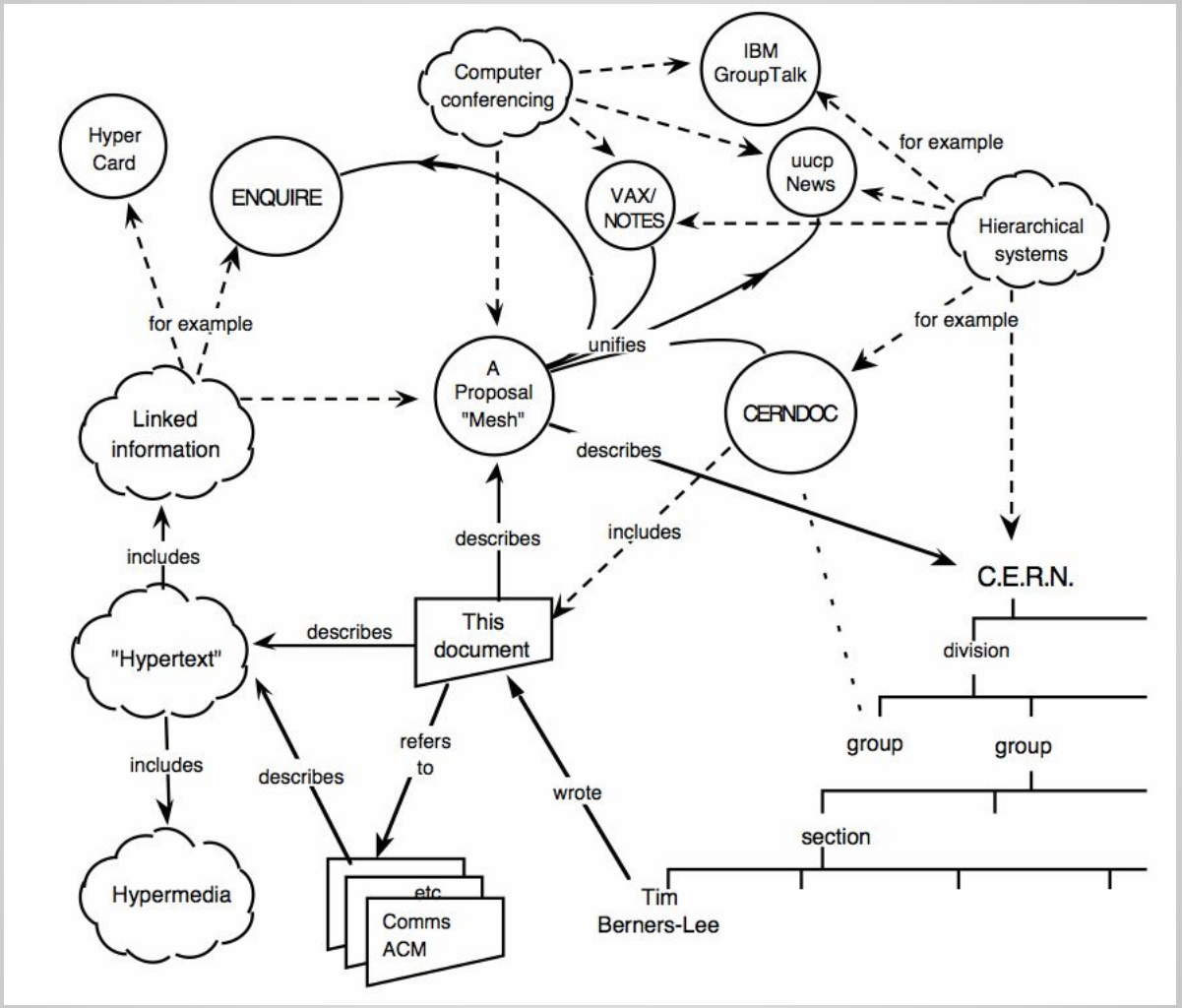
Information Management: A Proposal

March 1989

Information Management: A Proposal

Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a


Computer conferencing
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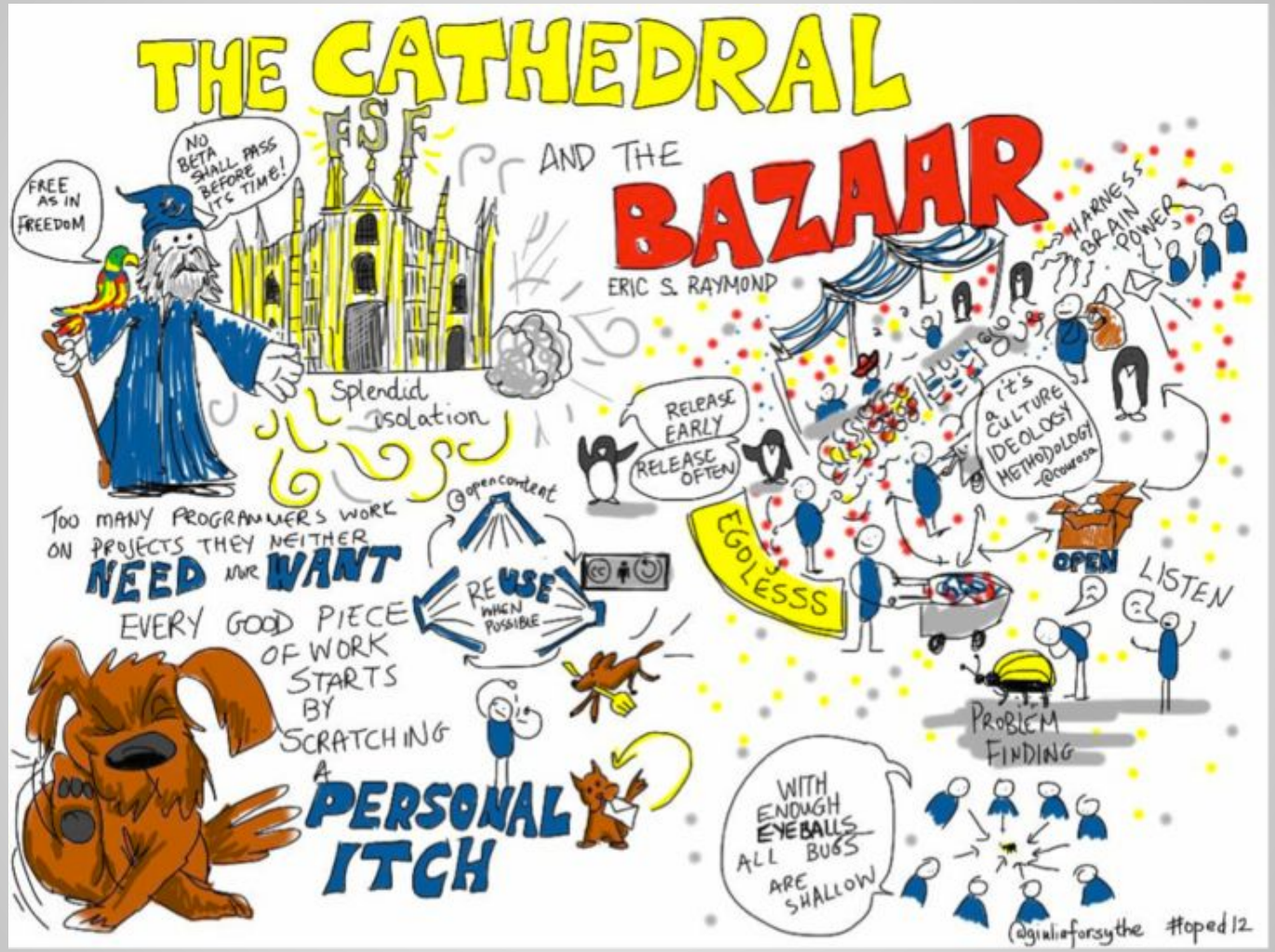
Tim Berners-Lee


THE CATHEDRAL
AND THE
BAZAAR
ERIC S. RAYMOND
FSF
FREE AS IN FREEDOM
NO BETA SHALL PASS BEFORE IT'S TIME!
Splendid isolation
HARNESS BRAIN POWER
RELEASE EARLY
RELEASE OFTEN
"IT'S A CULTURE IDEOLOGY METHODOLOGY" @cowrosa
EGOLESSS
OPEN
LISTEN
PROBLEM FINDING
TOO MANY PROGRAMMERS WORK ON PROJECTS THEY NEITHER NEED NOR WANT
@opencontent
RE USE WHEN POSSIBLE
EVERY GOOD PIECE OF WORK STARTS BY SCRATCHING A PERSONAL ITCH
WITH ENOUGH EYEBALLS ALL BUGS ARE SHALLOW
@gialiaforsythe #oped12

Bell Labs: A Hive of Invention

A selection of its most important innovations in the decades leading up to the breakup of its parent company, AT&T, in 1984, and how they helped lead to some of the latest technologies.

1940s

) First long-distance computing Remote eration of a computer, Bell Labs in New York, by a teletypewriter in New Hampshire.

46 First commercial obile phone service most, three subscrib- s per city could make lls at one time; each er's phone apparatus weighed almost 80 pounds.

1947 Cellular elephone technology l Labs paper was the propose a network of interlocking cell sites g users as they move, g their calls from one te to another without opping the connection.

1950s

1947 The transistor A landmark invention. Replaced vacuum tubes and mechanical relays; transformed electronics.

1948 Information theory Calculates maximum capacity for any communications system and shows how to send digital messages essentially error-free. Enabled data compression and cryptography.

1951 Direct-distance dialing No operator necessary for long-distance calls.

1954 Solar cells First use of the sun's energy to create a practical level of electricity.

1956 First transatlantic telephone cable Designed and implemented by Bell Labs; could carry up to 36 simultaneous calls.

1957 Digitized music First demonstrations of digitized and computer-synthesized music.

1958 The laser "Light Amplification by Stimulated Emission of Radiation" was described in a Bell Labs paper. It is crucial for communications, surgical and DVD technologies.

The Murray Hill, N.J., buildings opened in 1941.

1960s

1962 Digital transmission, switching First digital transmission of multiple voice signals.

1960-62 First communications satellites Echo is first to reflect a voice signal from coast to coast; Telstar I shows an orbiting relay can amplify and resend multiple phone and TV transmissions.

1962 Paging system Bellboy pager is introduced at the Seattle World's Fair.

1963 Touch-tone telephone Enables voice mail and call centers.

1965 Evidence of the Big Bang Discovery of cosmic background radiation from beyond the Milky Way.

1969 Charge-coupled device A solid-state chip that transforms patterns of light into information. Vital to digital cameras, high-definition television, medical endoscopes and video conferencing.

Bell Labs opened in Holmdel, N.J., in 1962. It was vacated in 2007.

1970s and '80s

1969-72 UNIX operating system and C programming language Makes large-scale networking of varied computing systems, and the Internet, practical.

1976 Fiber-optic network The first test of Bell Labs' experimental lightwave communication system begins in Atlanta. Information is carried by pulses of light.

1978 First commercial cellular network Installed by Bell Labs in Chicago.

1979 Digital signal processor An essential component of cellphones, modems, PCs and video game systems.

1980 Digital cellular phone Better sound quality, greater channel capacity, lower cost.

1982 Fractional quantum hall effect Discovery of a new state of subatomic matter that wins the Nobel Prize.

LEFT AND CENTER PHOTOS COURTESY OF ALCATEL-LUCENT USA INC. AND THE AT&T ARCHIVES AN

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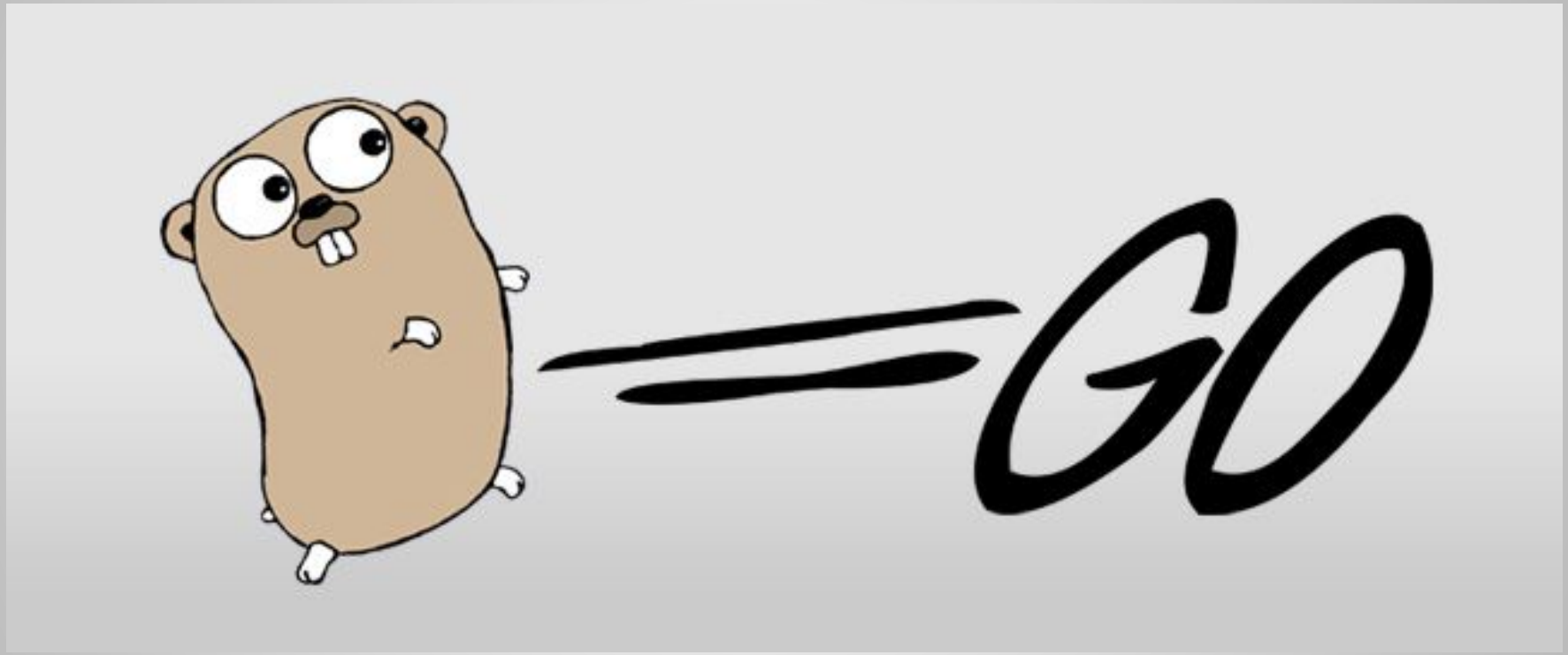
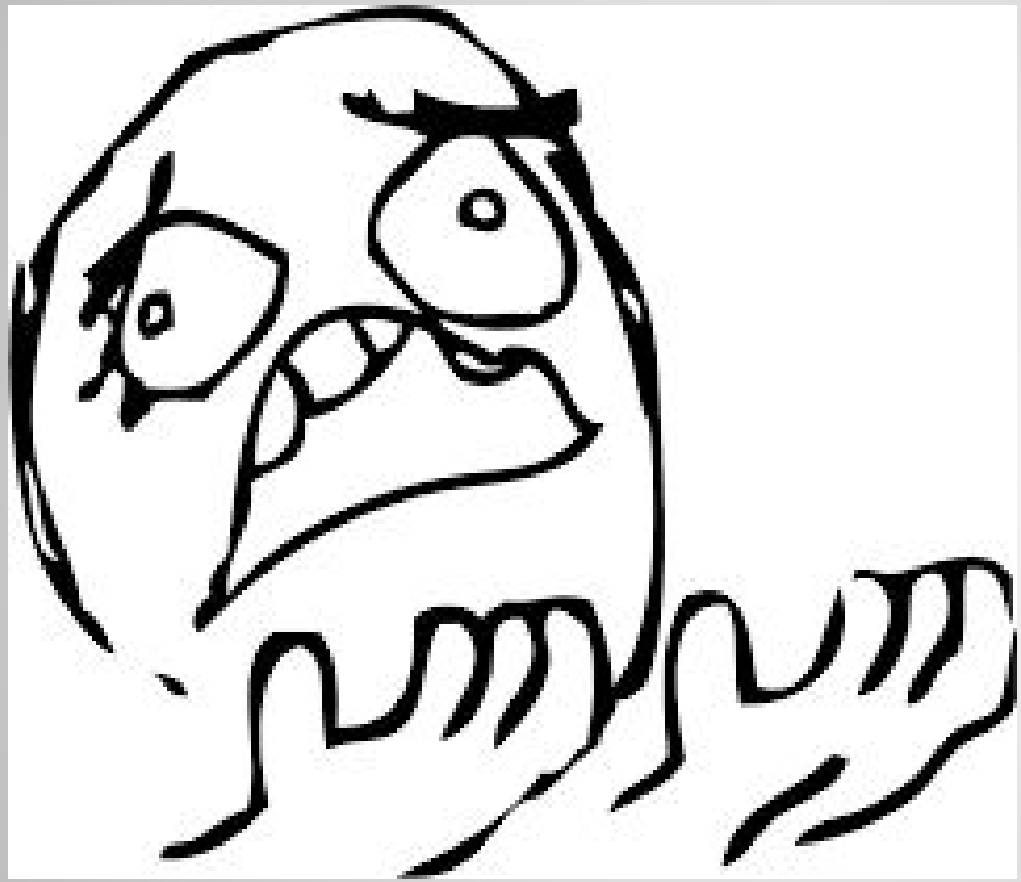

GO


Golang
IS COOL
IN 2017

- too simple / lack of syntactic sugar
- no generics
- bad dependency management
- stuck in 70/80's
- error handling

- no unused imports
- too opinionated
- too verbose
- no ternary operator
- no macros or templates

https://github.com/ksimka/go-is-not-good




WHERE WE'RE GOING, WE DON'T NEED ROADS

“Go programming language was conceived as an answer to some of the problems we were seeing developing software infrastructure at Google. The computing landscape today is almost unrelated to the environment in which the languages being used, mostly C++, Java, and Python, had been created. The problems introduced by **multicore processors**, **networked systems**, **massive computation clusters**, and the **web programming model** were being worked around rather than addressed head-on.

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Moreover, the scale has changed: today's server programs comprise tens of millions of lines of code, are worked on by hundreds or even thousands of programmers, and are updated literally every day. To make matters worse, build time have stretched to many minutes, even hours, even languages,on large compilation clusters,"

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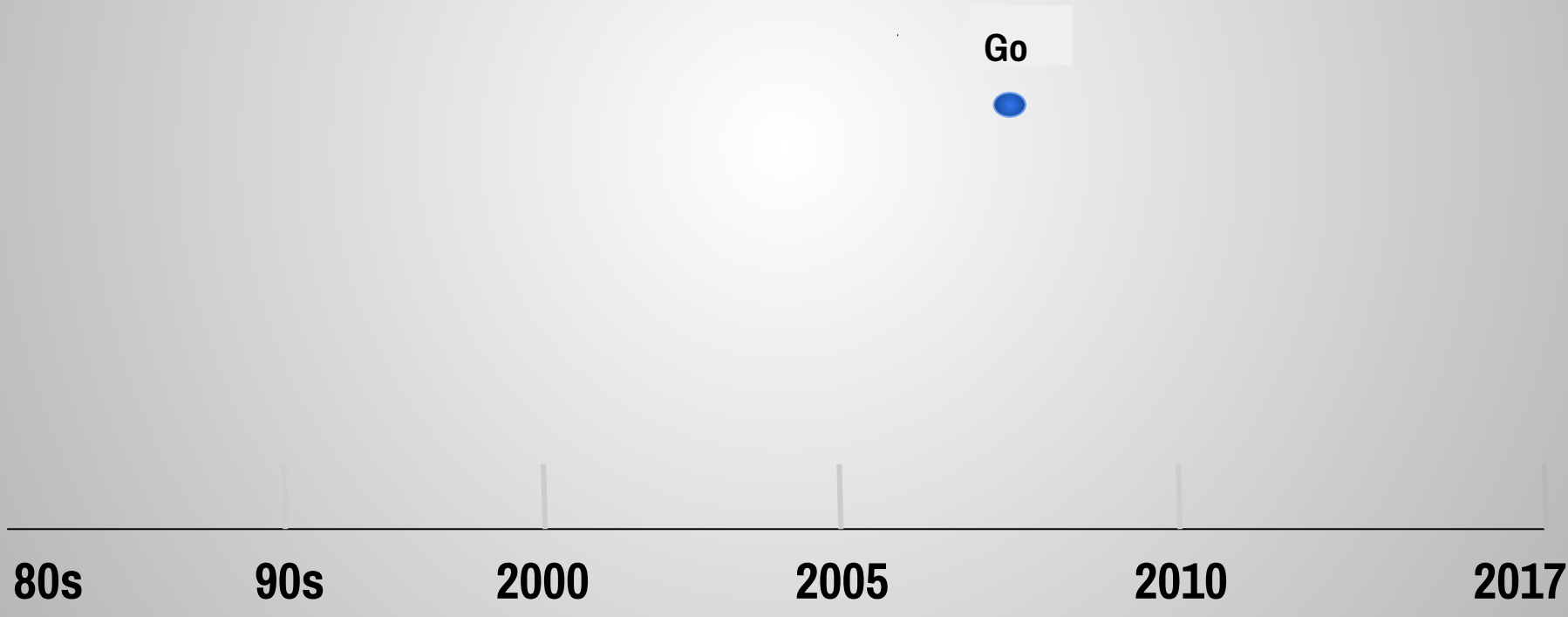
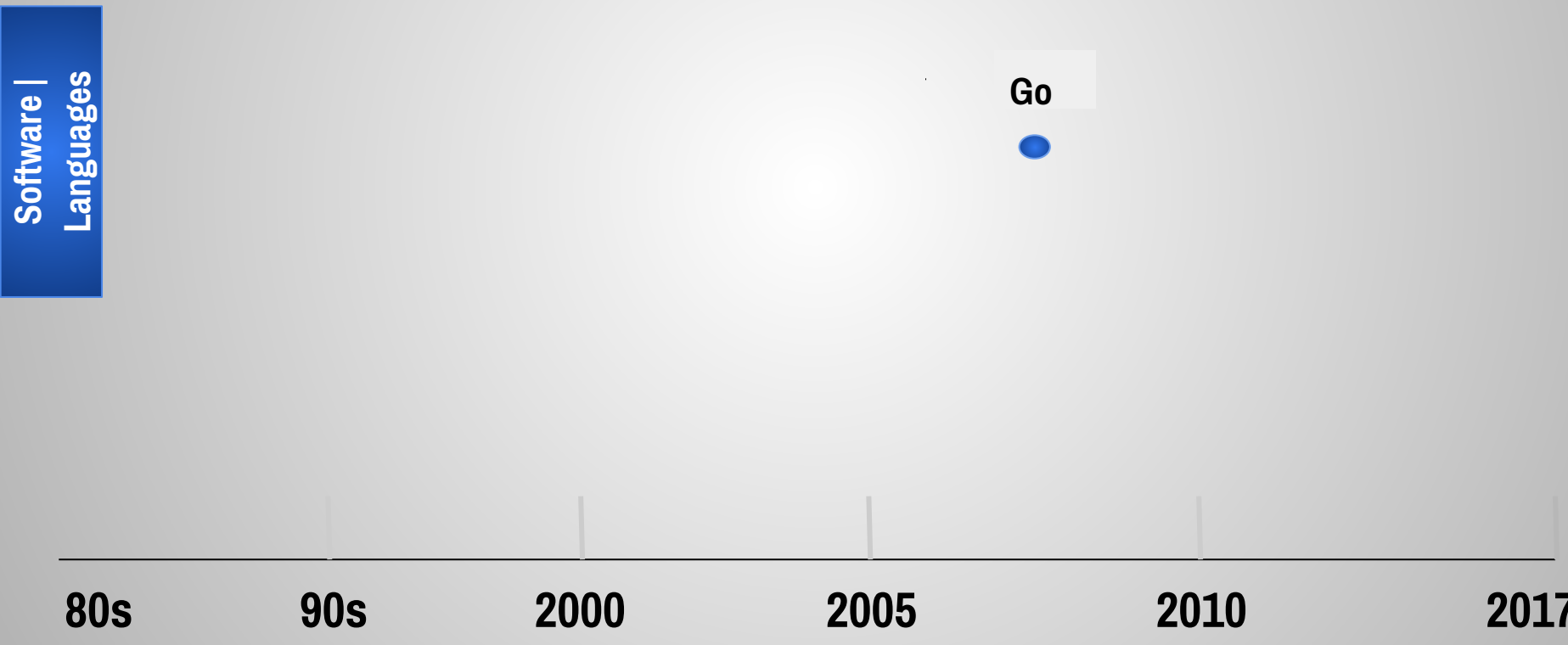
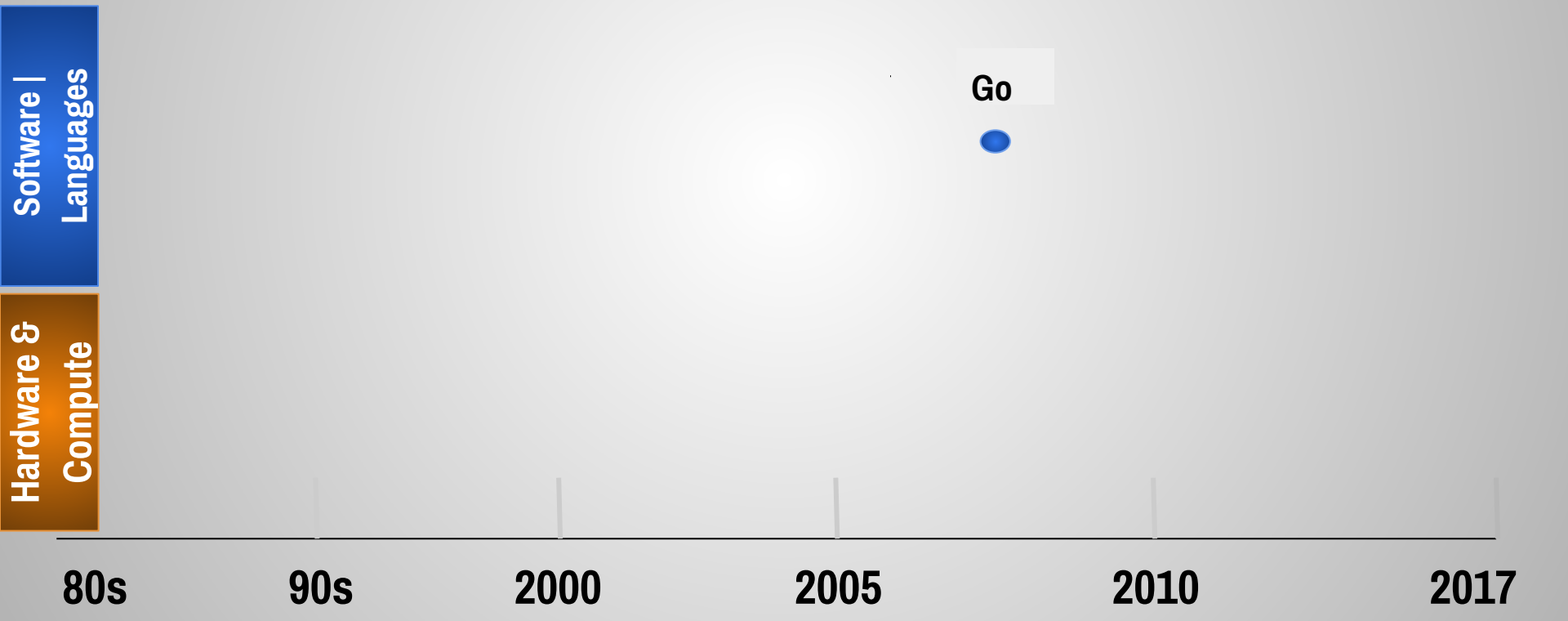
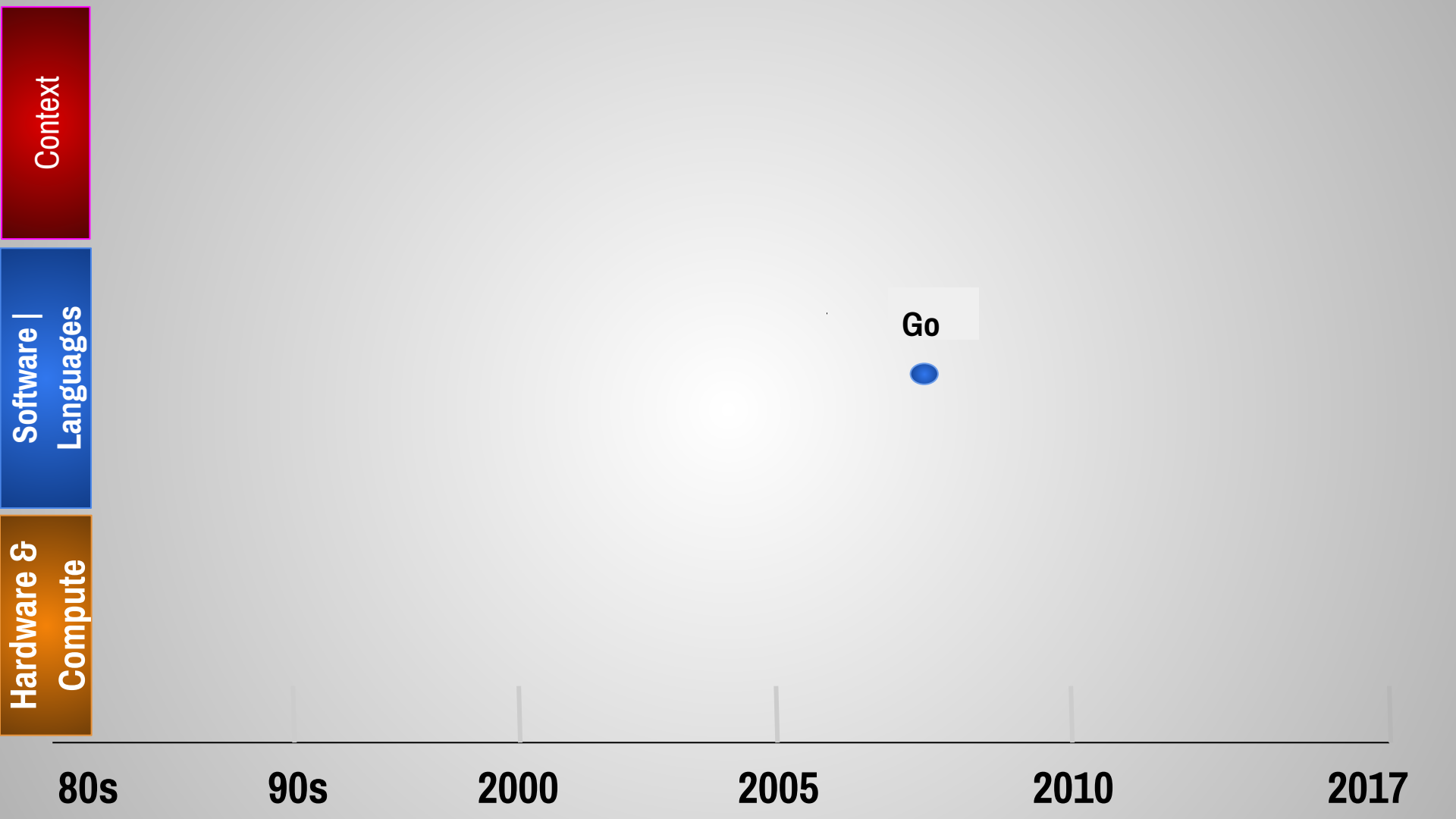
- multicore processors
- networked systems
- massive computation clusters
- web programming model

- hundreds or even thousands of programmers
- large compilation clusters

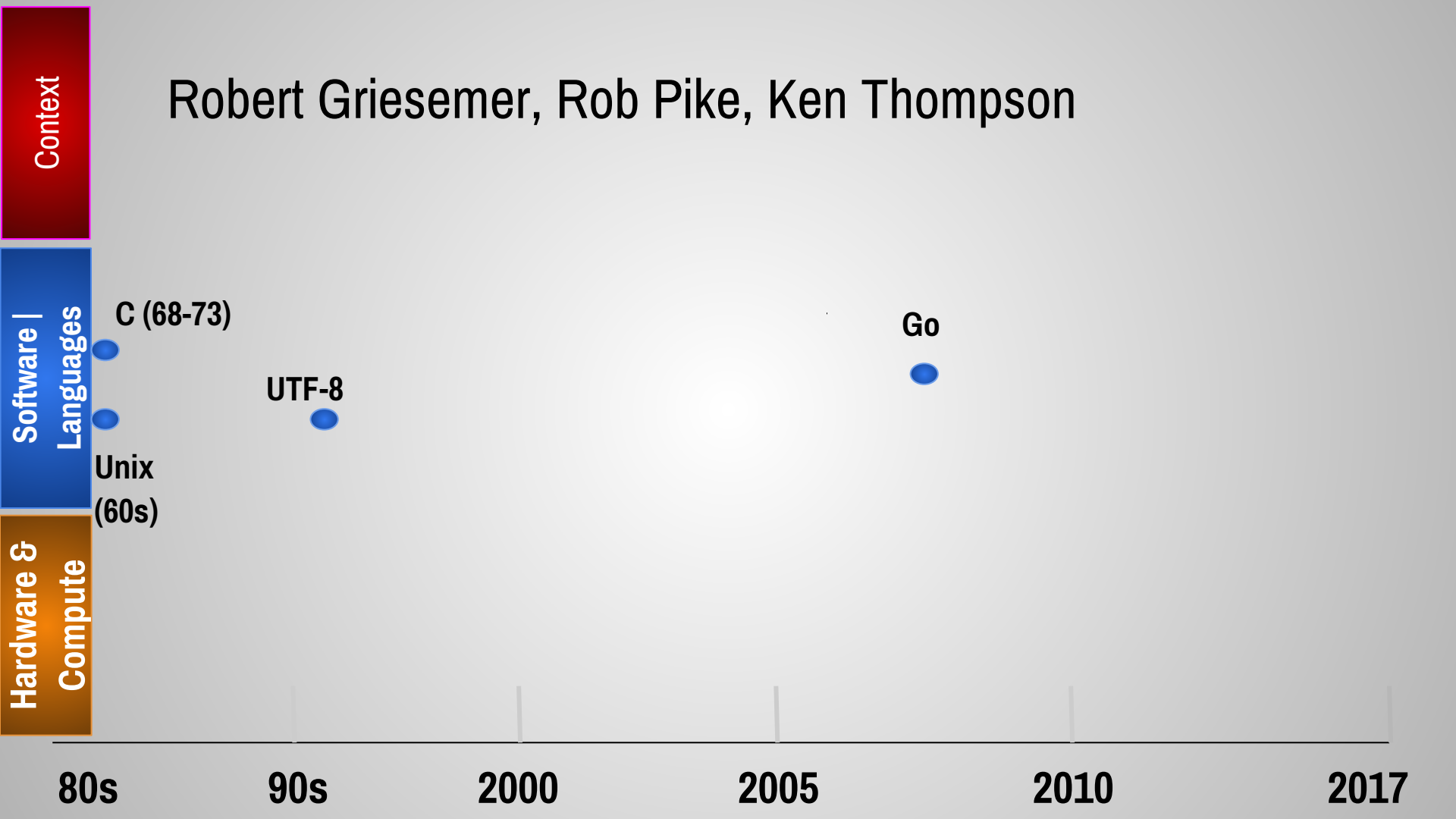

Go
80s
90s
2000
2005
2010
2017

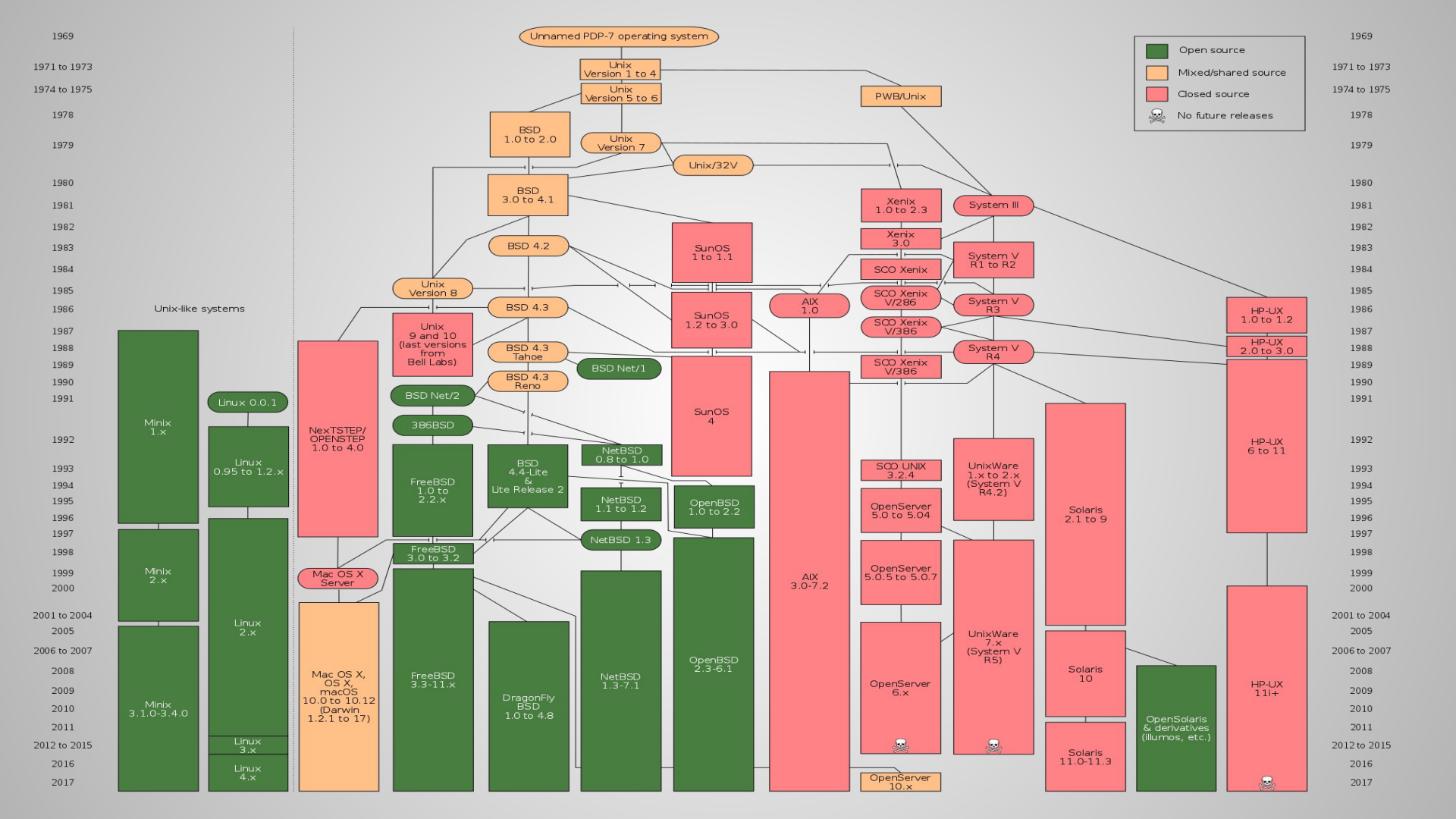

Software | Languages
Go
80s
90s
2000
2005
2010
2017


Software | Languages
Hardware & Compute
Go
80s
90s
2000
2005
2010
2017


Context
Software | Languages
Hardware & Compute
Go
80s
90s
2000
2005
2010
2017

Robert Griesemer, Rob Pike and Ken Thompson


Context
Robert Griesemer, Rob Pike, Ken Thompson
Software | Languages
Hardware & Compute
C (68-73)
Unix (60s)
UTF-8
Go
80s
90s
2000
2005
2010
2017


1969
1971 to 1973
1974 to 1975
1978
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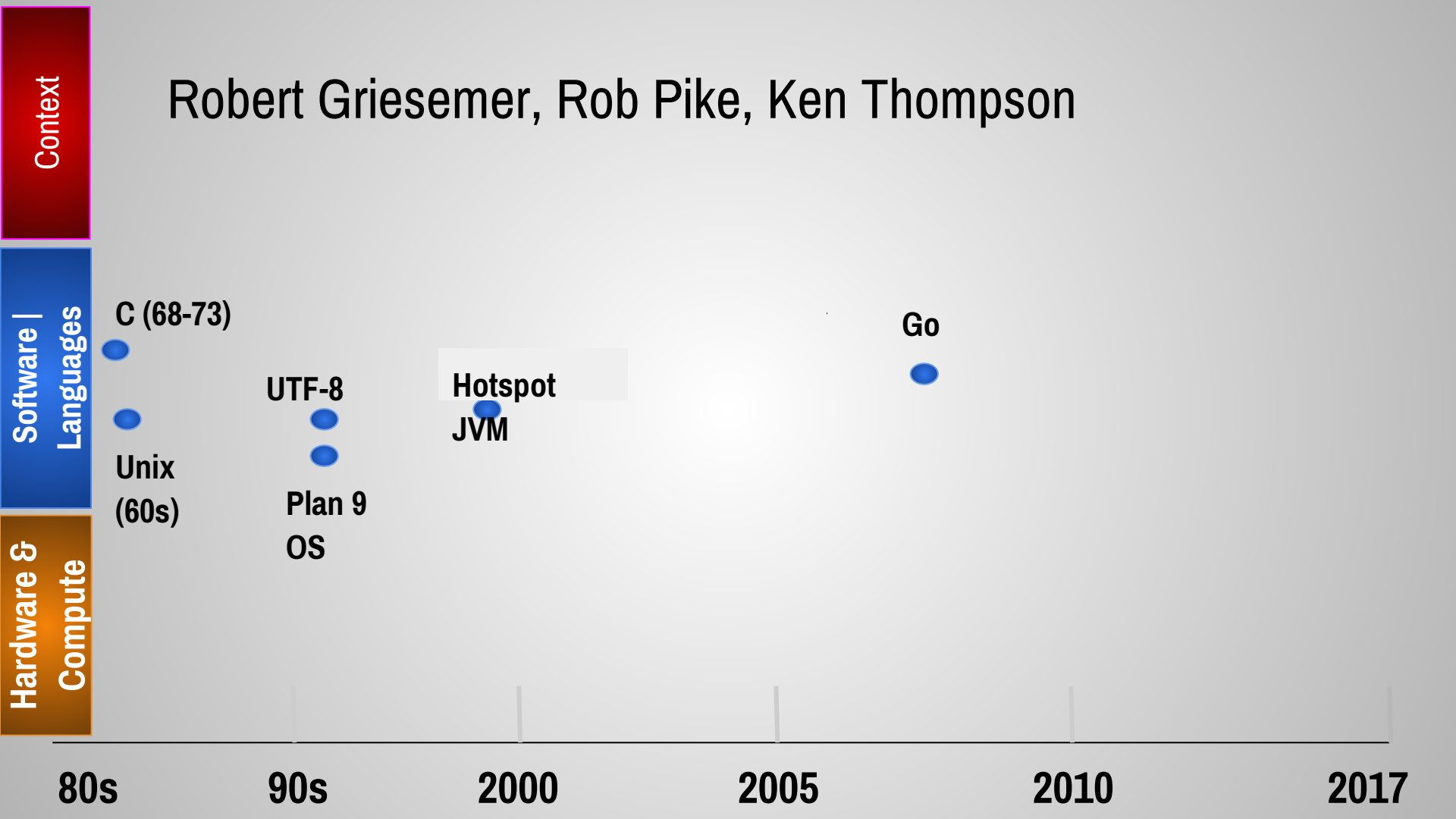
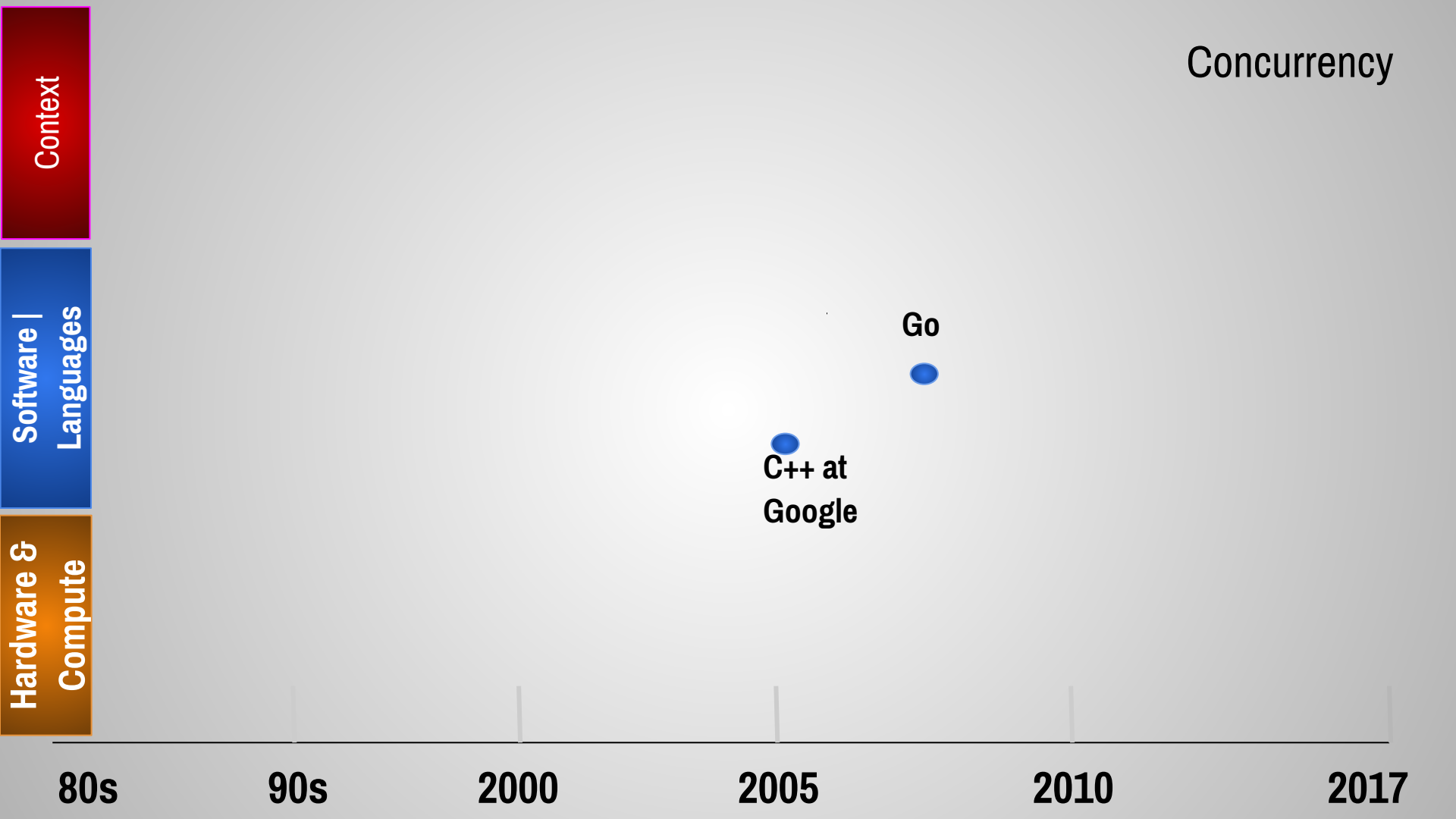
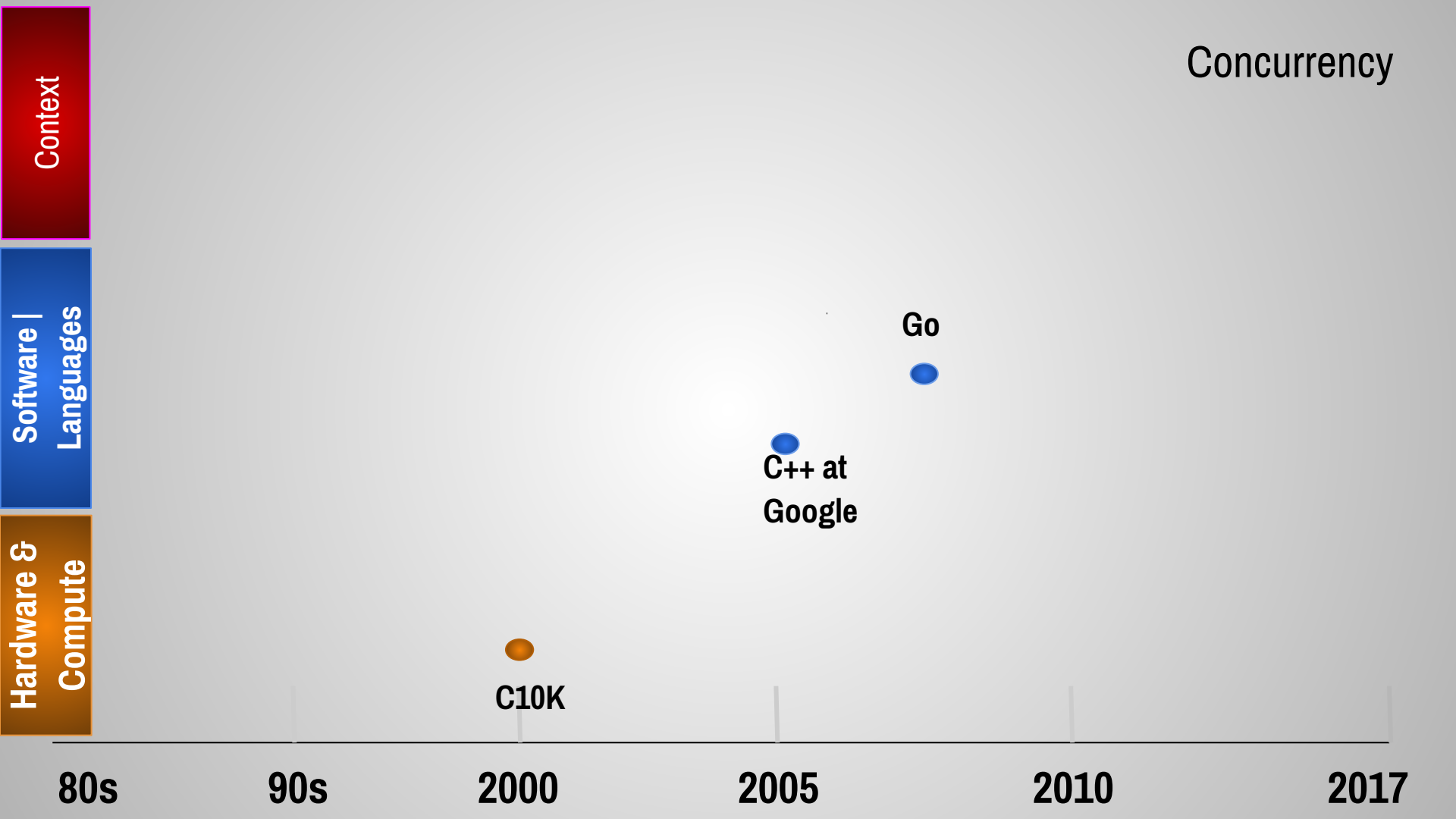
2000
2001 to 2004
2005
2006 to 2007
2008
2009
2010
2011
2012 to 2015
2016
2017
Unix-like systems
Minix 1.x
Minix 2.x
Minix 3.1.0-3.4.0
Linux 0.0.1
Linux 0.95 to 1.2.x
Linux 2.x
Linux 3.x
Linux 4.x
NexTSTEP/ OPENSTEP 1.0 to 4.0
Mac OS X Server
Mac OS X, OS X, macOS 10.0 to 10.12 (Darwin 1.2.1 to 17)
Unnamed PDP-7 operating system
Unix Version 1 to 4
Unix Version 5 to 6
Unix Version 7
Unix Version 8
Unix 9 and 10 (last versions from Bell Labs)
BSD 1.0 to 2.0
BSD 3.0 to 4.1
BSD 4.2
BSD 4.3
BSD 4.3 Tahoe
BSD 4.3 Reno
BSD Net/1
BSD Net/2
386BSD
FreeBSD 1.0 to 2.2.x
FreeBSD 3.0 to 3.2
FreeBSD 3.3-11.x
BSD 4.4-Lite & Lite Release 2
DragonFly BSD 1.0 to 4.8
NetBSD 0.8 to 1.0
NetBSD 1.1 to 1.2
NetBSD 1.3
NetBSD 1.3-7.1
Unix/32V
SunOS 1 to 1.1
SunOS 1.2 to 3.0
SunOS 4
OpenBSD 1.0 to 2.2
OpenBSD 2.3-6.1
PWB/Unix
AIX 1.0
AIX 3.0-7.2
Xenix 1.0 to 2.3
Xenix 3.0
SCO Xenix
SCO Xenix V/286
SCO Xenix V/386
SCO UNIX 3.2.4
OpenServer 5.0 to 5.04
OpenServer 5.0.5 to 5.0.7
OpenServer 6.x
OpenServer 10.x
System III
System V R1 to R2
System V R3
System V R4
UnixWare 1.x to 2.x (System V R4.2)
UnixWare 7.x (System V R5)
Solaris 2.1 to 9
Solaris 10
Solaris 11.0-11.3
OpenSolaris & derivatives (illumos, etc.)
HP-UX 1.0 to 1.2
HP-UX 2.0 to 3.0
HP-UX 6 to 11
HP-UX 11i+
Open source
Mixed/shared source
Closed source
No future releases

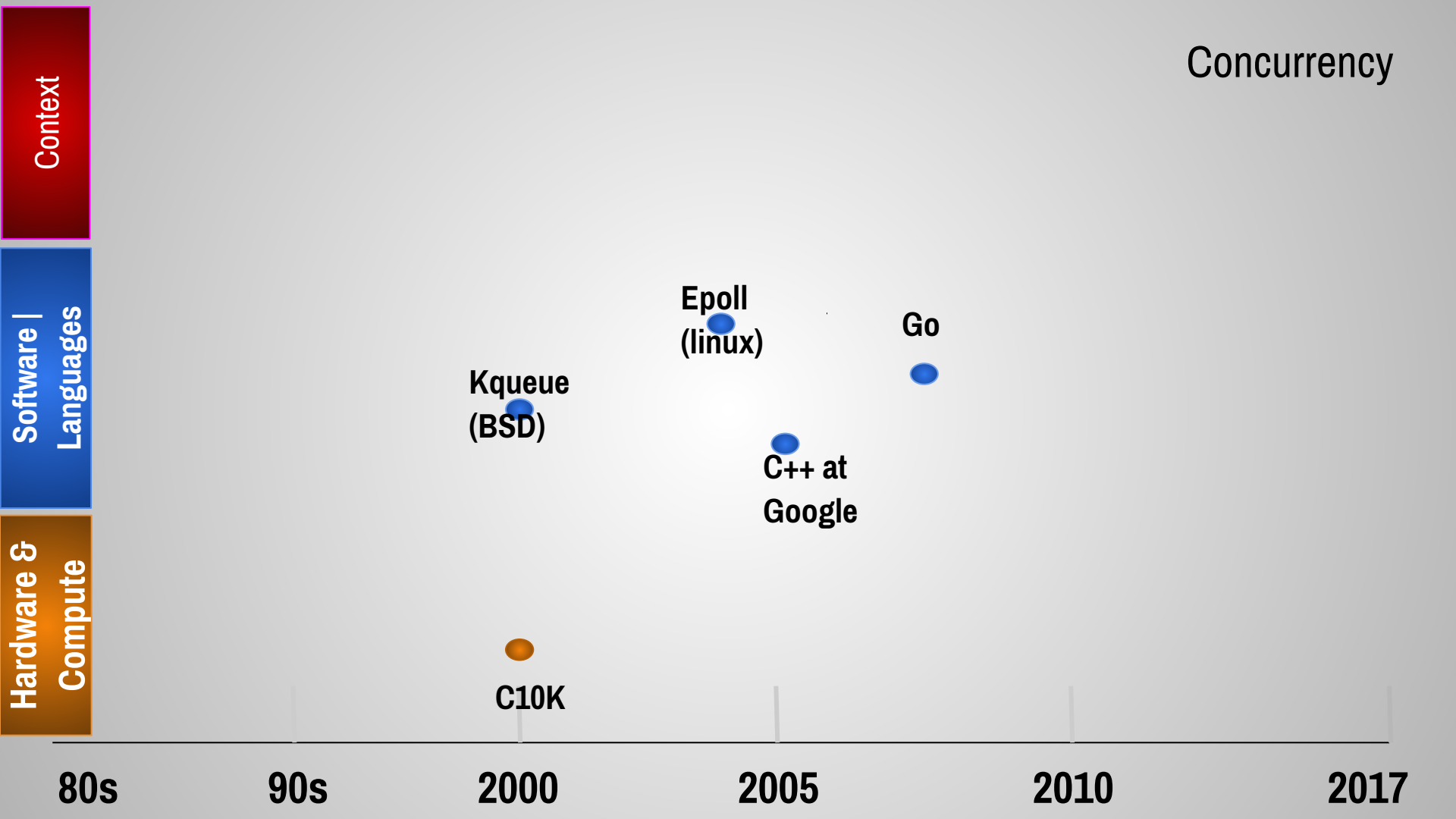

Context
Software | Languages
Hardware & Compute
Robert Griesemer, Rob Pike, Ken Thompson
C (68-73)
Unix (60s)
UTF-8
Plan 9 OS
Hotspot JVM
Go
80s
90s
2000
2005
2010
2017

Go’s 21st Century Characteristics

- Concurrency
- Distributed Systems
- Garbage Collection
- Memory Locality
- Readability


Context
Software | Languages
Hardware & Compute
Concurrency
Go
C++ at Google
80s
90s
2000
2005
2010
2017


Context
Software | Languages
Hardware & Compute
Concurrency
Go
C++ at Google
C10K
80s
90s
2000
2005
2010
2017


Context
Software | Languages
Hardware & Compute
Concurrency
Epoll (linux)
Go
Kqueue (BSD)
C++ at Google
C10K
80s
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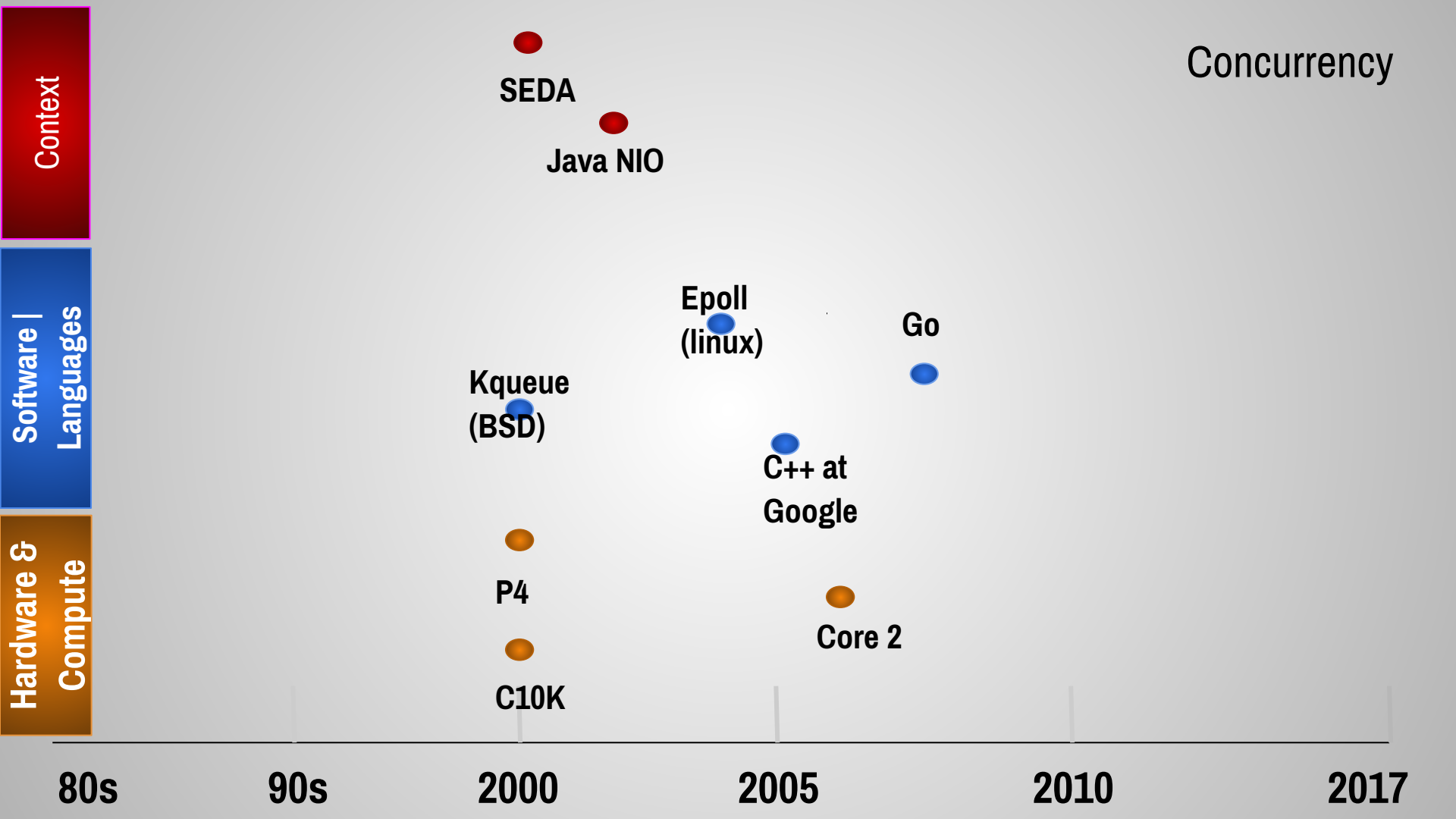
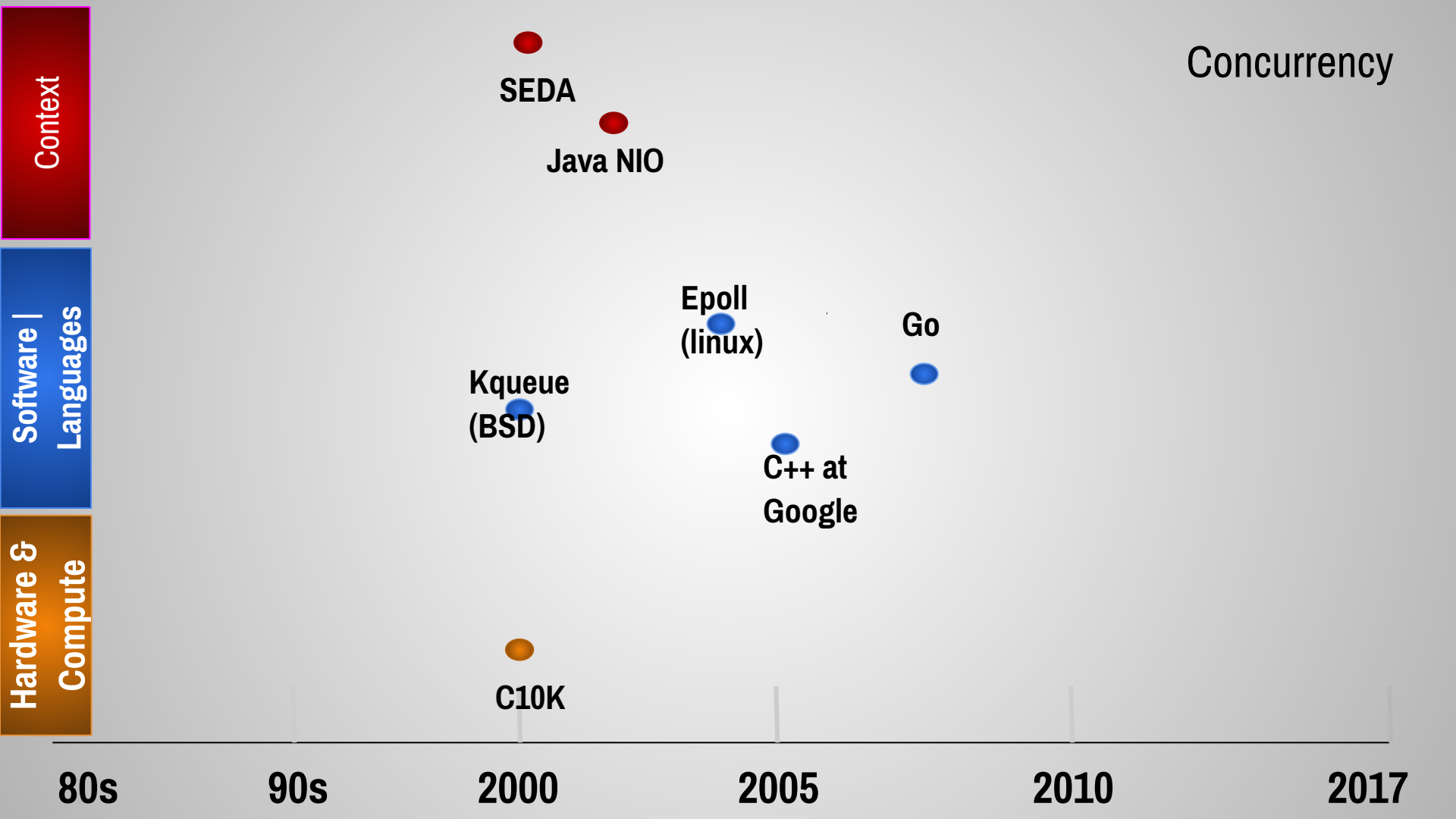

Context
Software | Languages
Hardware & Compute
Concurrency
SEDA
Java NIO
Epoll (linux)
Go
Kqueue (BSD)
C++ at Google
P4
Core 2
C10K
80s
90s
2000
2005
2010
2017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Epoll (linux)
Go
Kqueue (BSD)
C++ at Google
C10K
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90s
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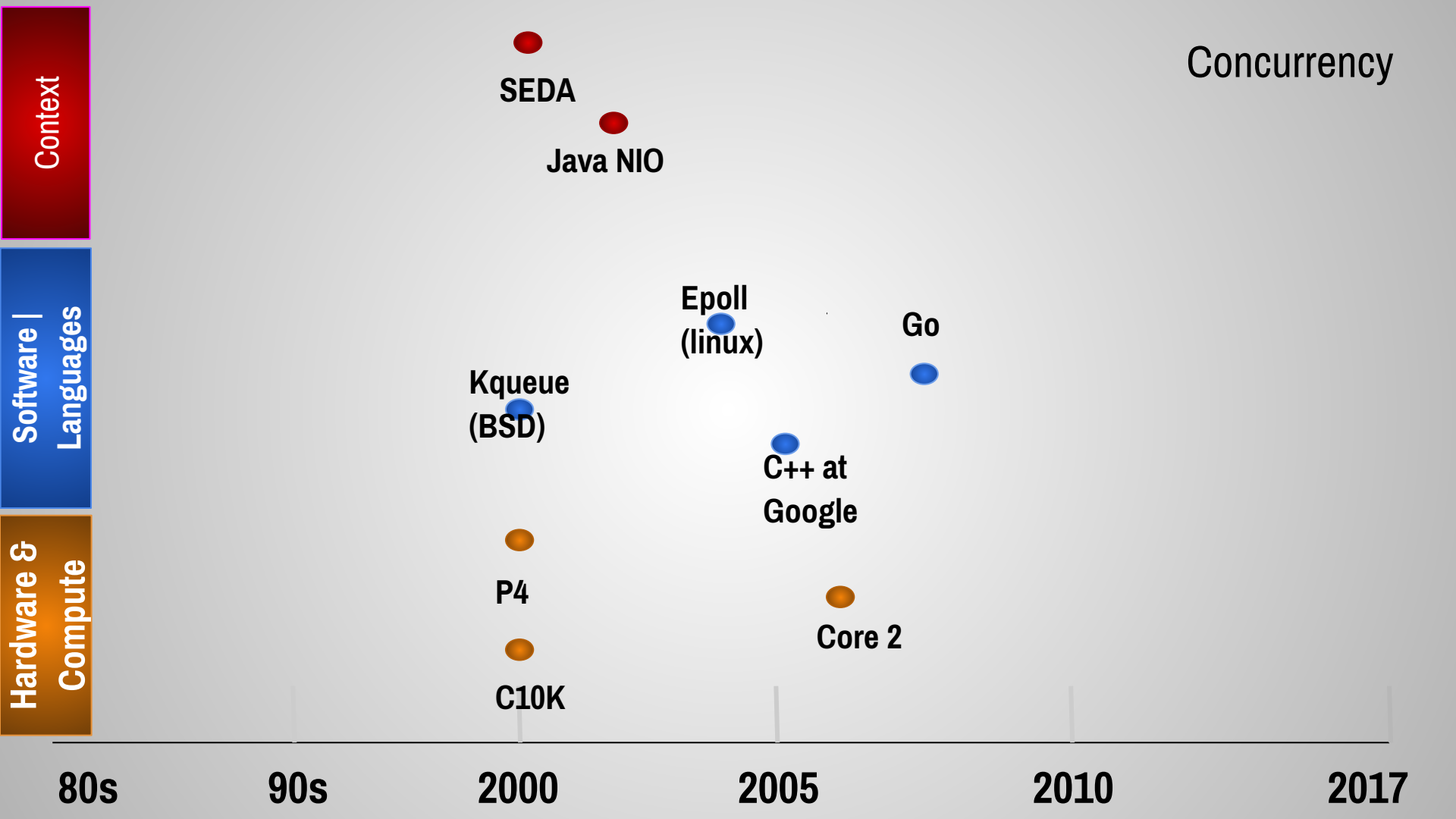
2017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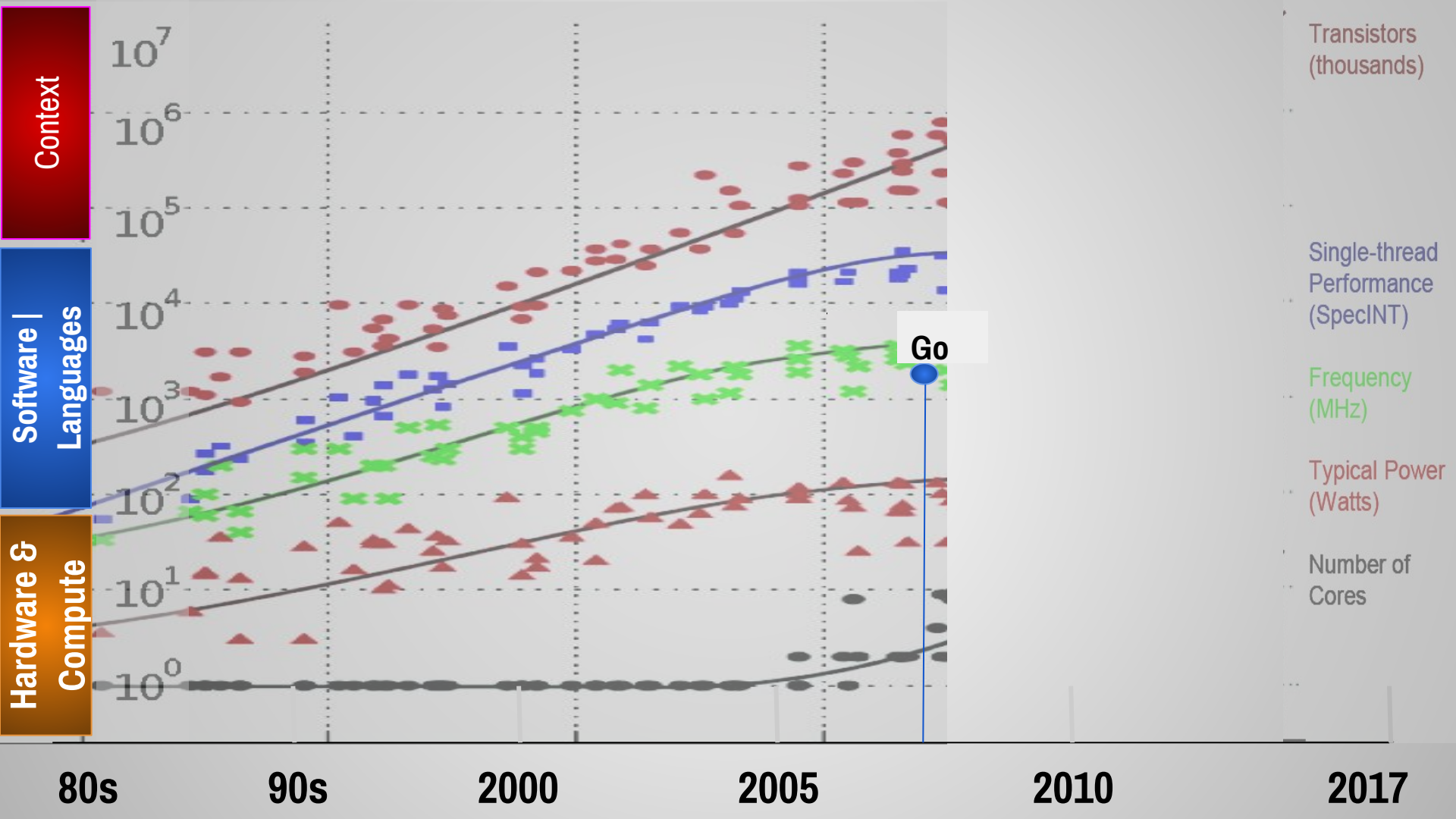
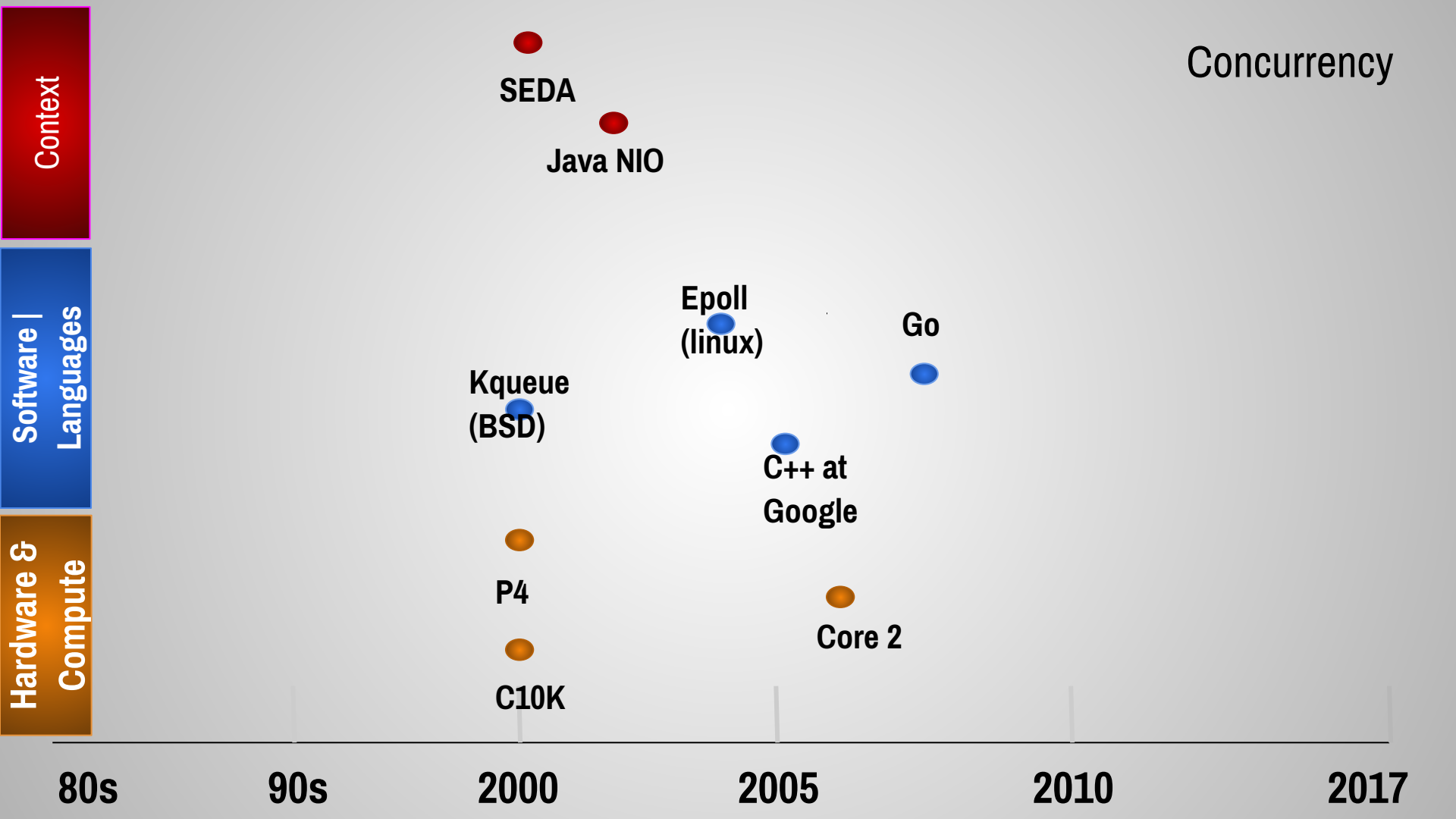

Context
Software | Languages
Hardware & Compute
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
Go
Transistors (thousands)
Single-thread Performance (SpecINT)
Frequency (MHz)
Typical Power (Watts)
Number of Cores
80s
90s
2000
2005
2010
2017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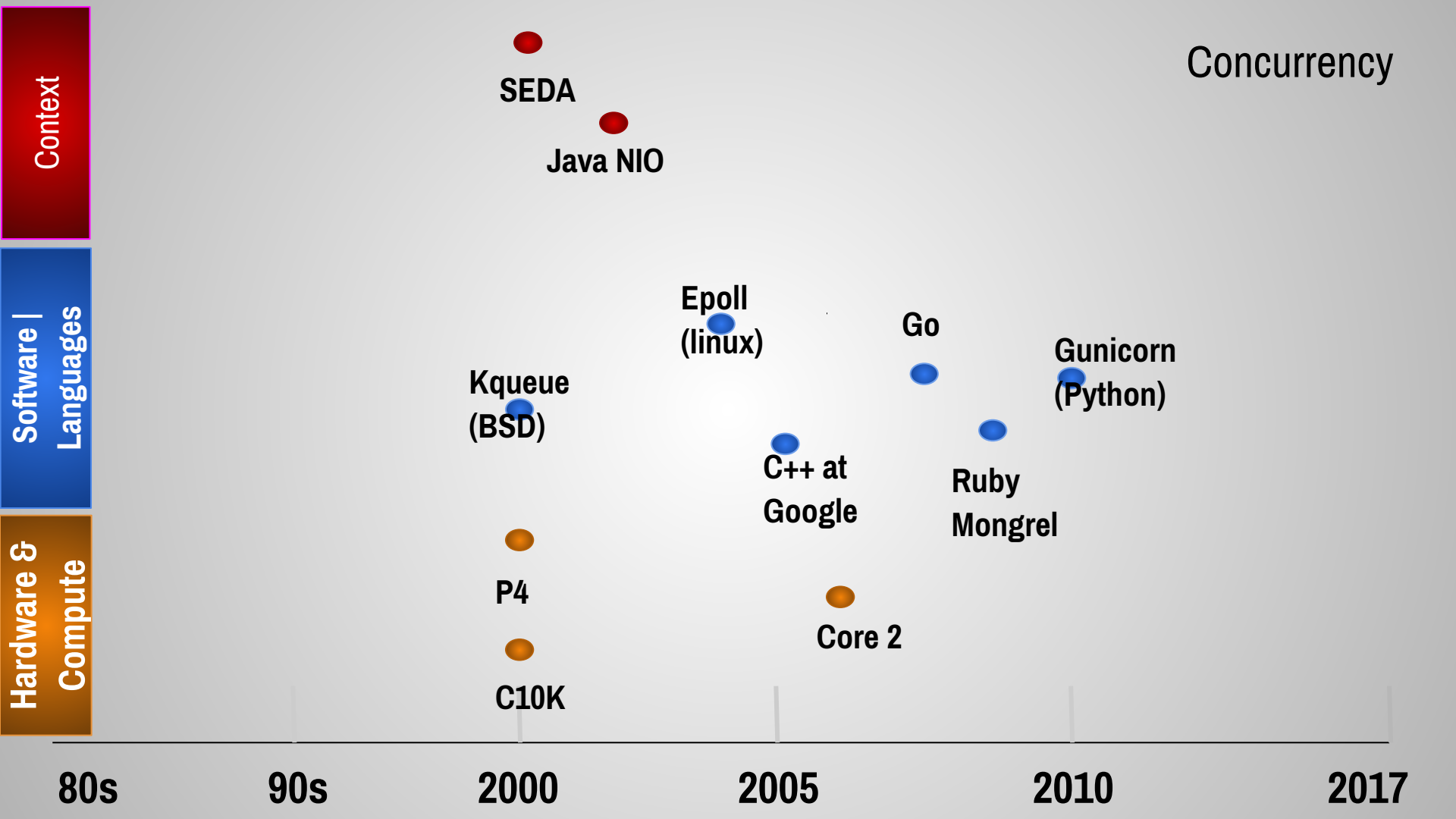
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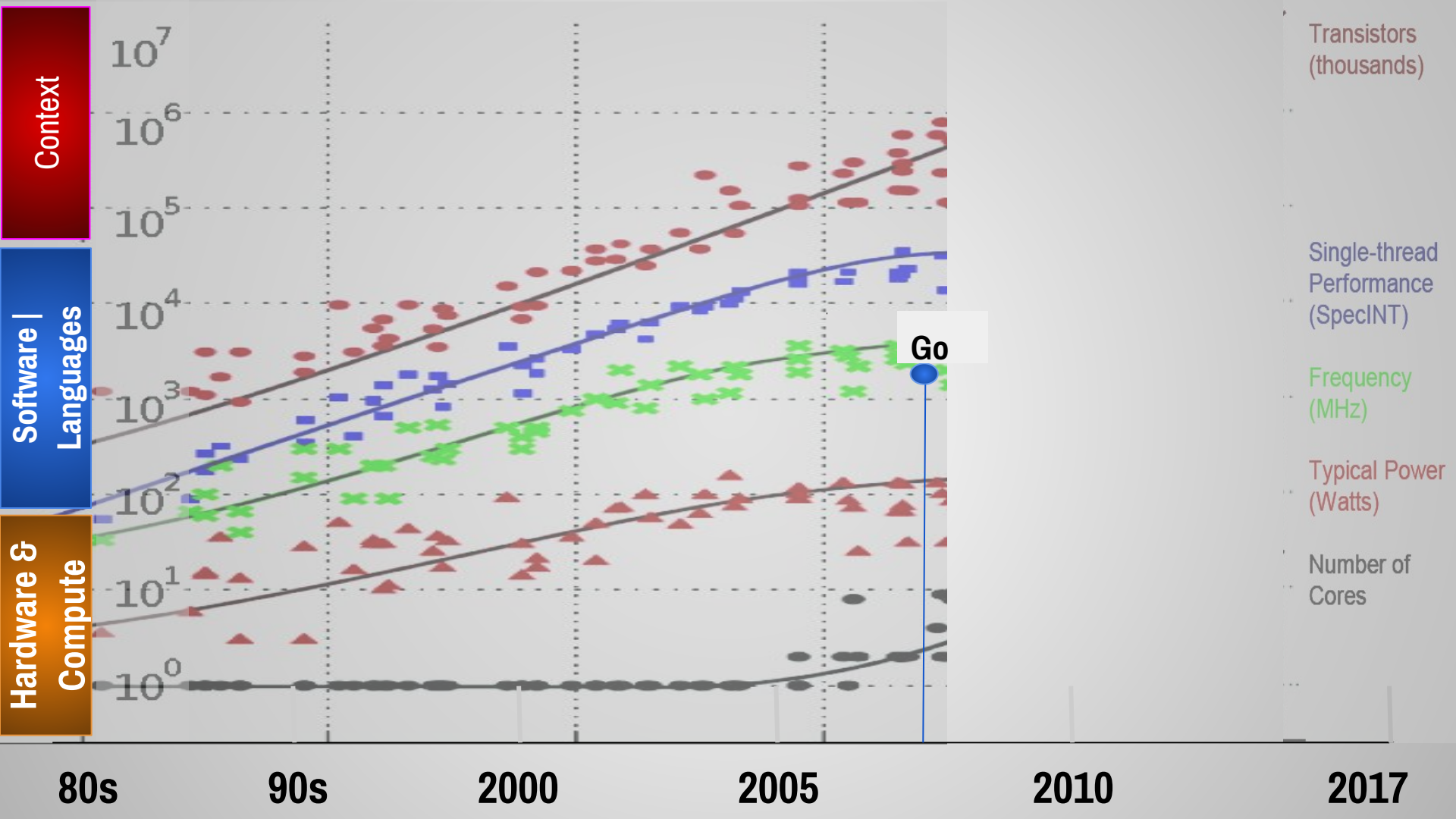
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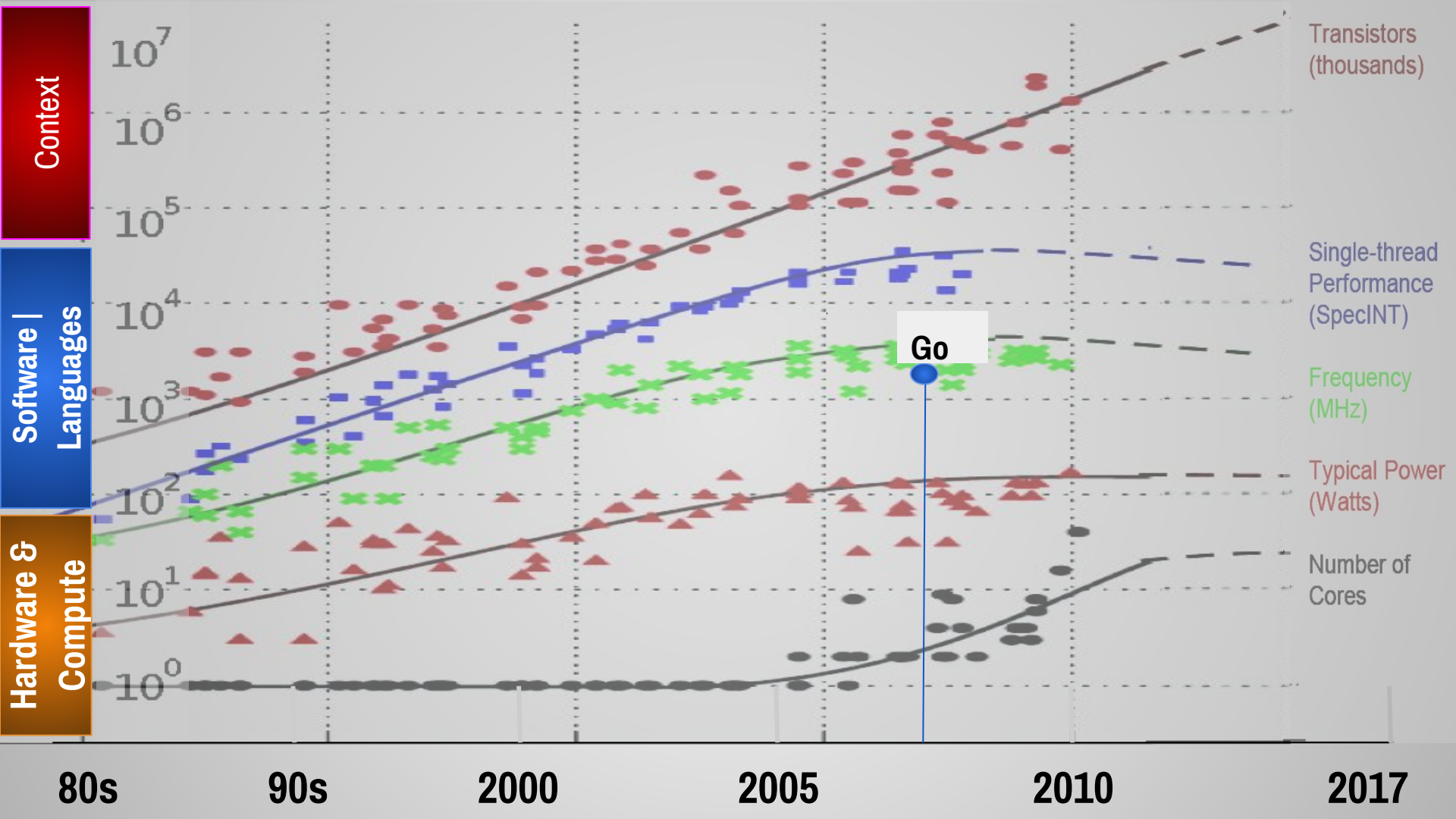
Context
Software | Languages
Hardware & Compute
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
Transistors (thousands)
Single-thread Performance (SpecINT)
Frequency (MHz)
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Go
80s
90s
2000
2005
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Events, Threads and Goroutines

Nginx - event loop plus state machine model

Events, Threads and Goroutines

Nginx - event loop plus state machine model

Events, Threads and Goroutines

Nginx - event loop plus state machine model

Events, Threads and Goroutines

Nginx - event loop plus state machine model

App

Events, Threads and Goroutines

Nginx - event loop plus state machine model

Events, Threads and Goroutines

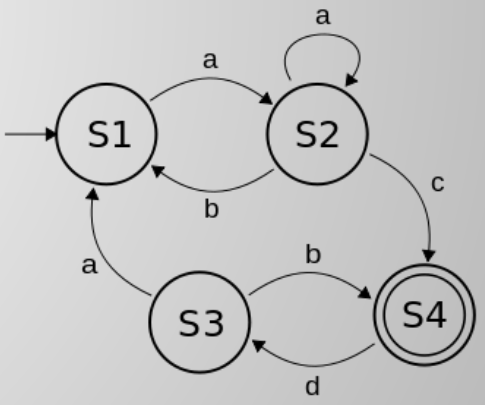
Nginx - event loop plus state machine model

App

Events, Threads and Goroutines

Nginx - event loop plus state machine model

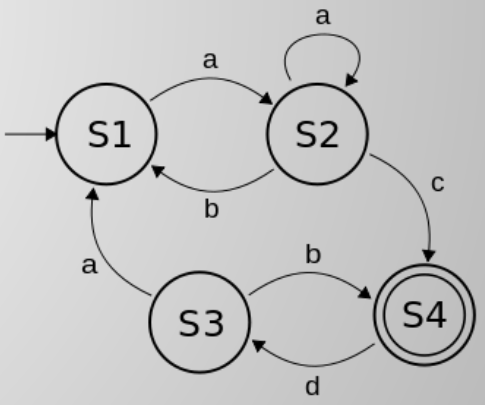
App



Events, Threads and Goroutines

Nginx - event loop plus state machine model

App



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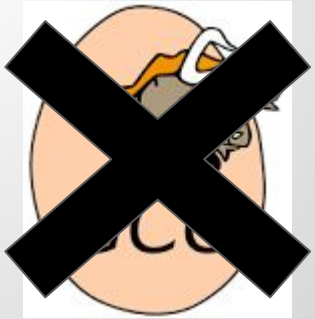
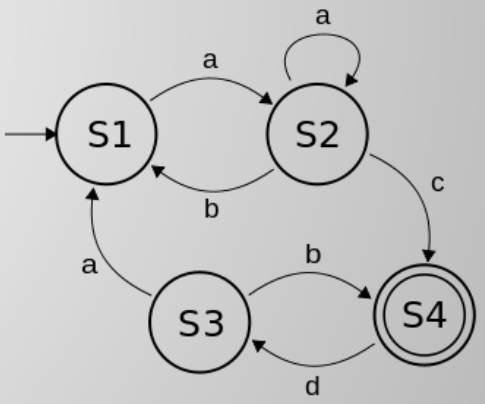
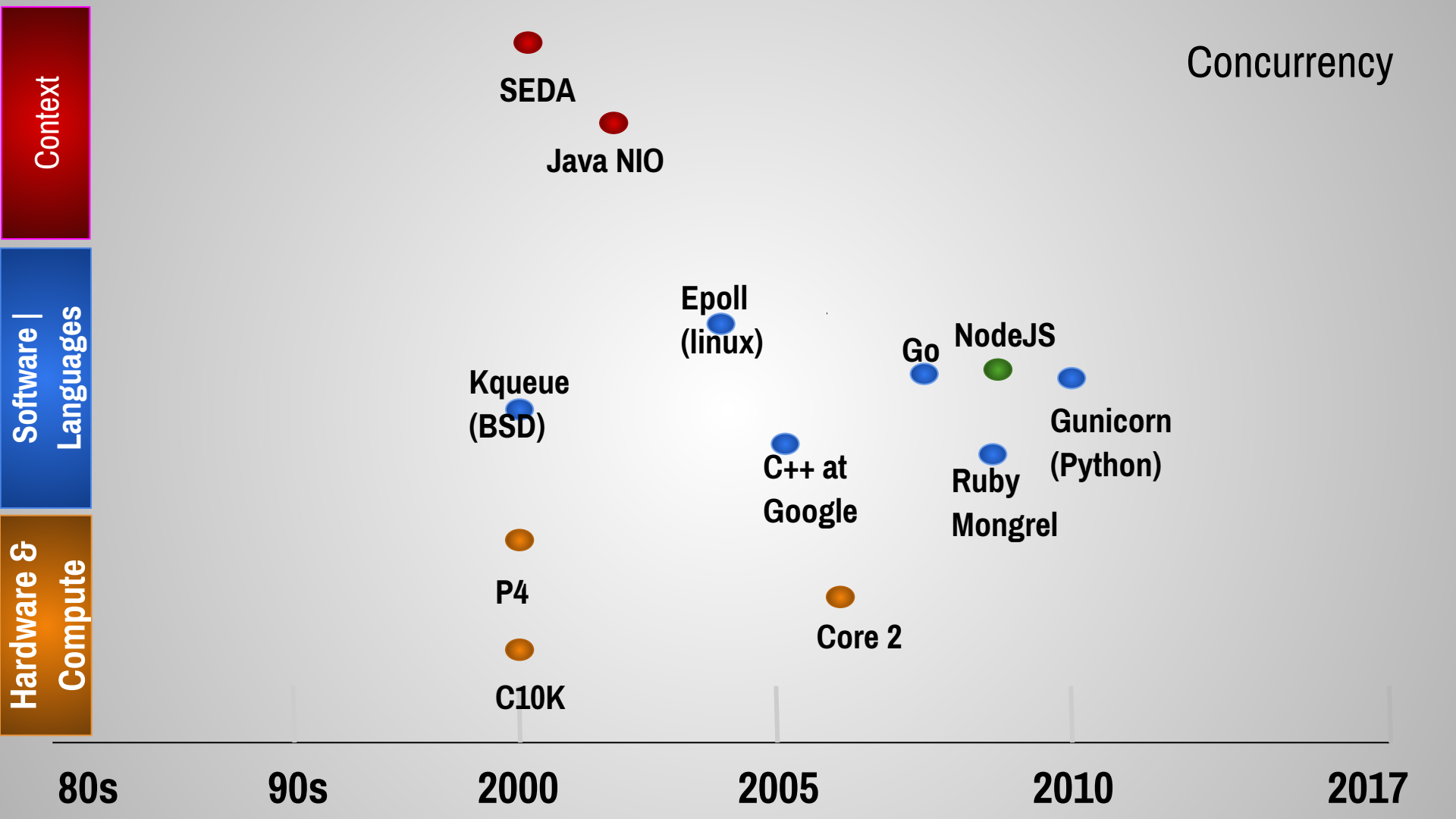
Nginx - event loop plus state machine model

App






Context
Software | Languages
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Concurrency
SEDA
Java NIO
Epoll (linux)
Kqueue (BSD)
Go
NodeJS
Gunicorn (Python)
C++ at Google
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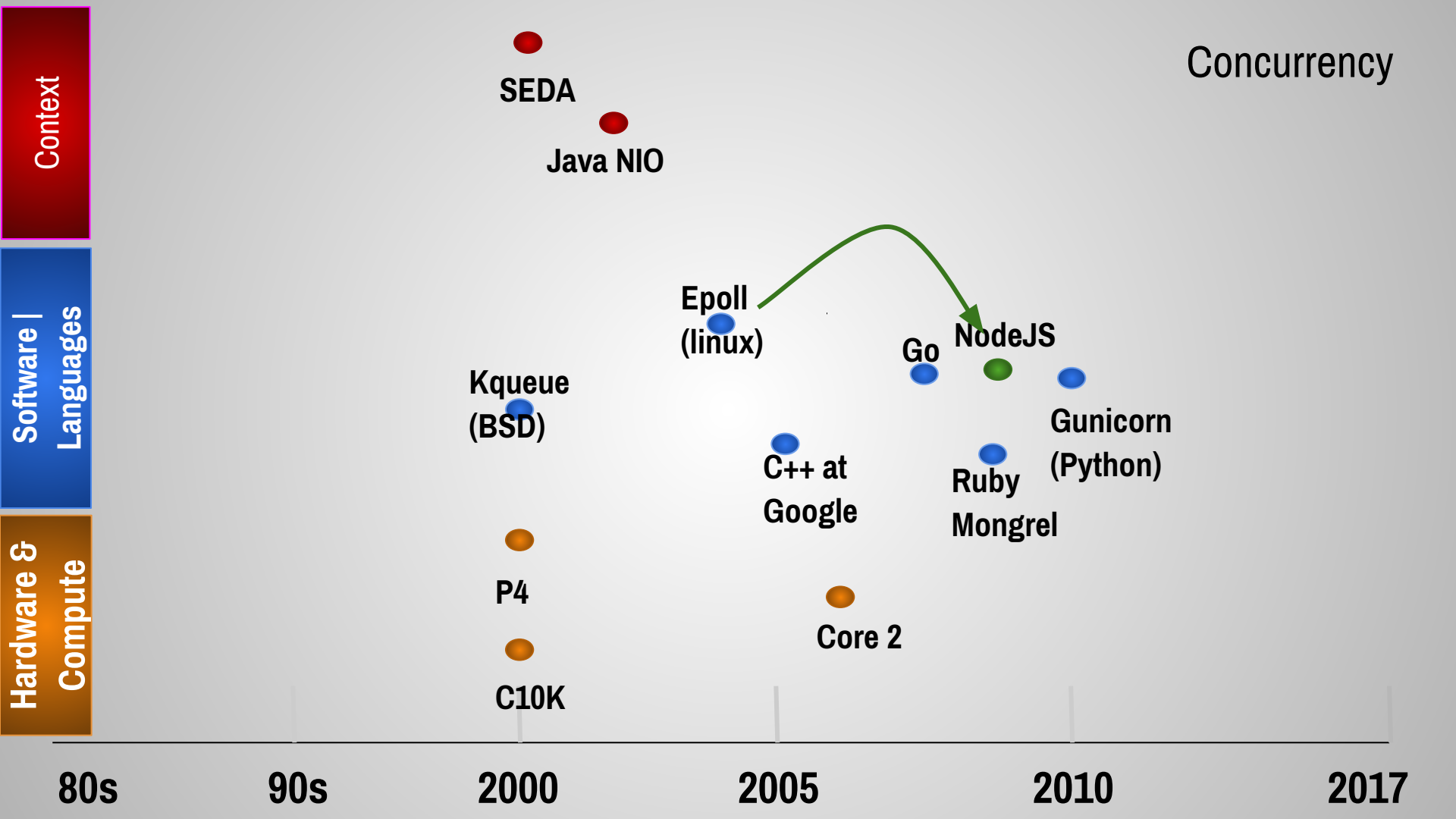
P4
Core 2
C10K
80s
90s
2000
2005
2010
2017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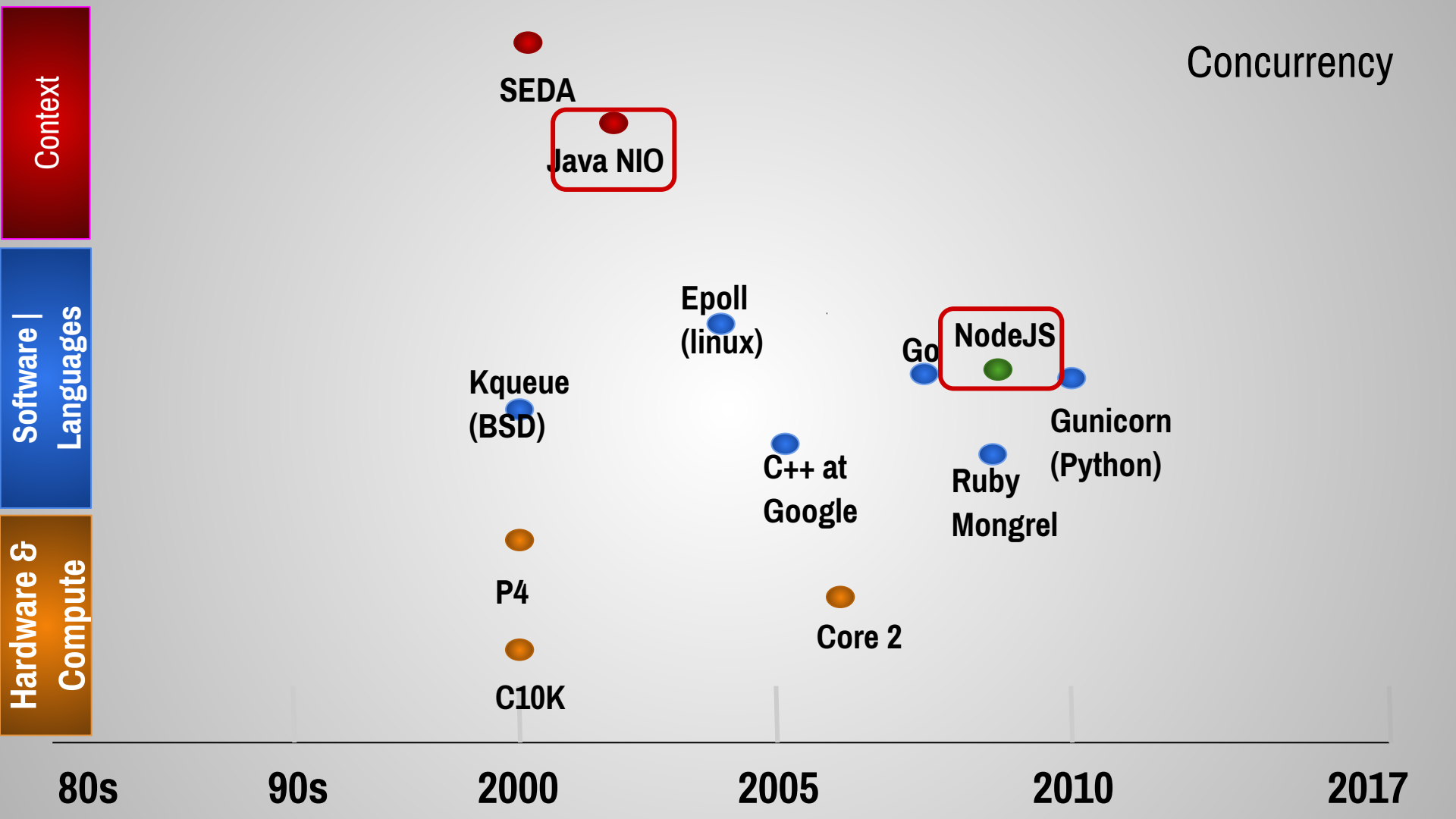
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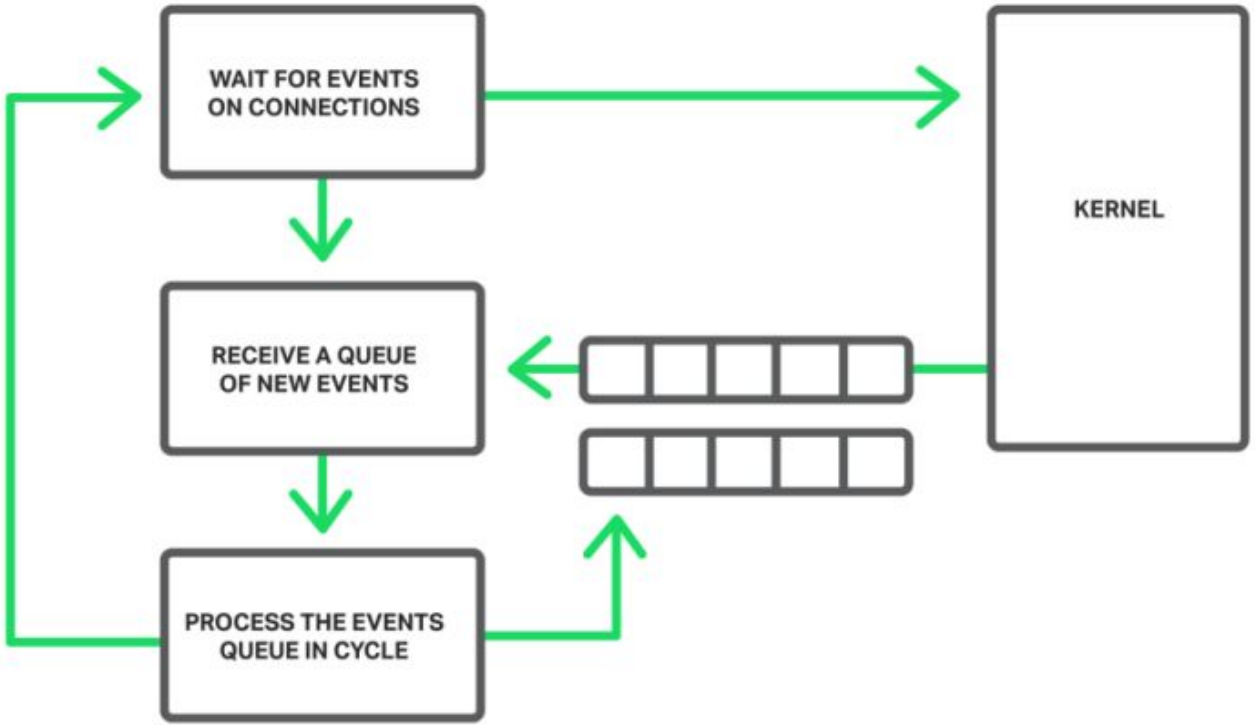
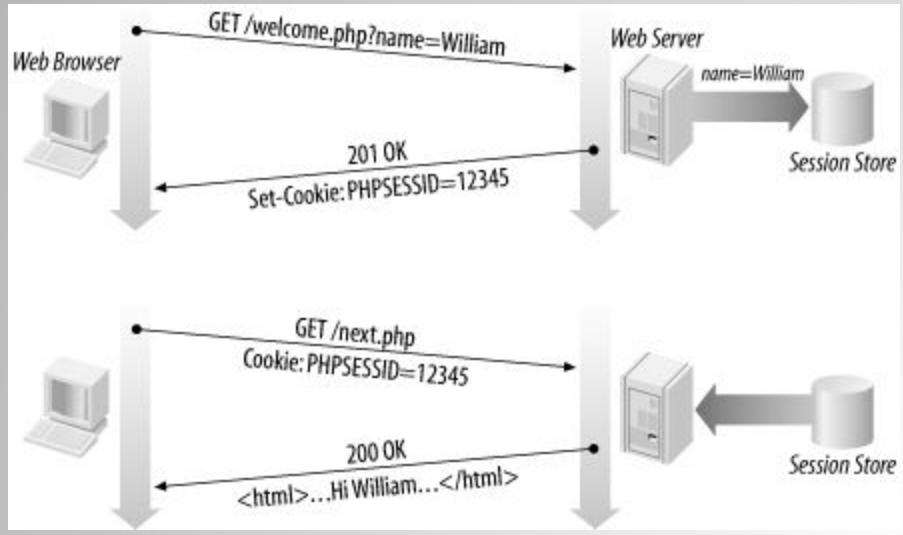
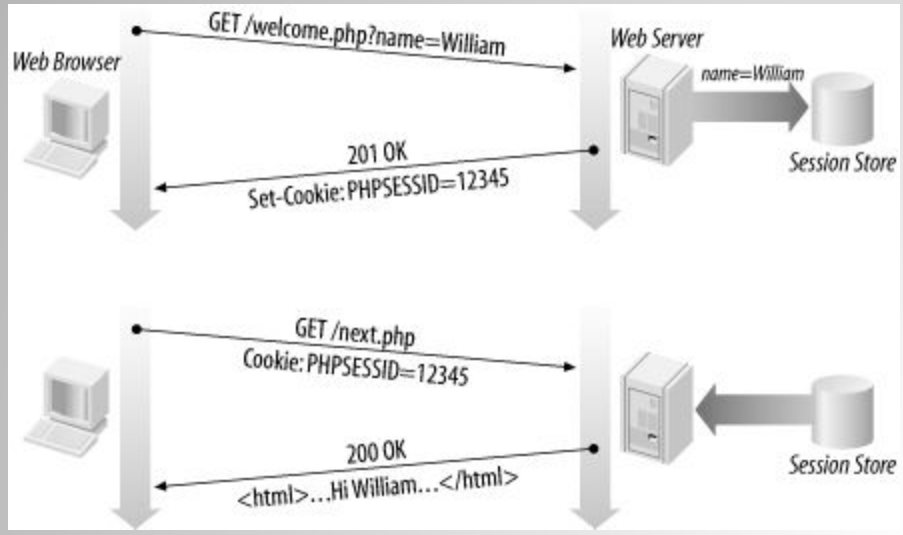
NGINX EVENT LOOP




GET /welcome.php?name=William
Web Browser
Web Server
name=William
Session Store
201 OK
Set-Cookie: PHPSESSID=12345
GET /next.php
Cookie: PHPSESSID=12345
Session Store
200 OK
<html>…Hi William…</html>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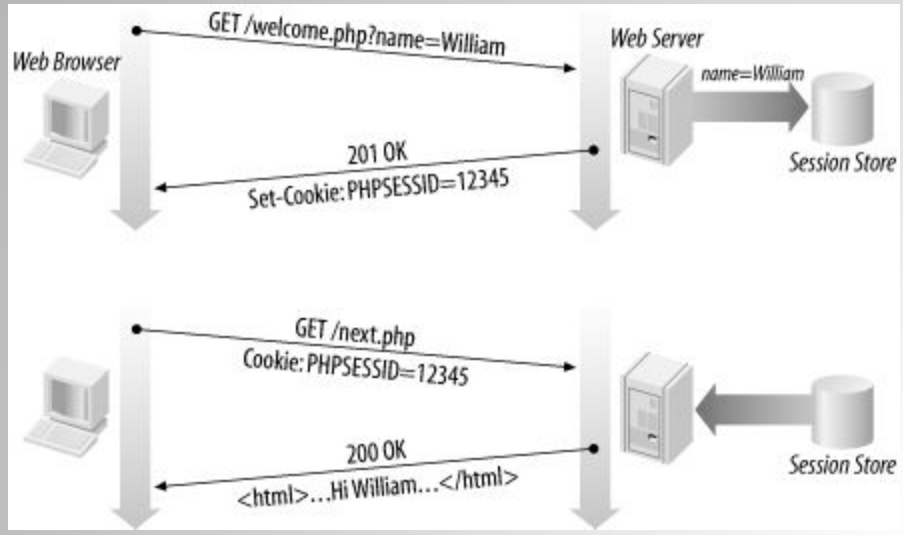
Session Store


WWW.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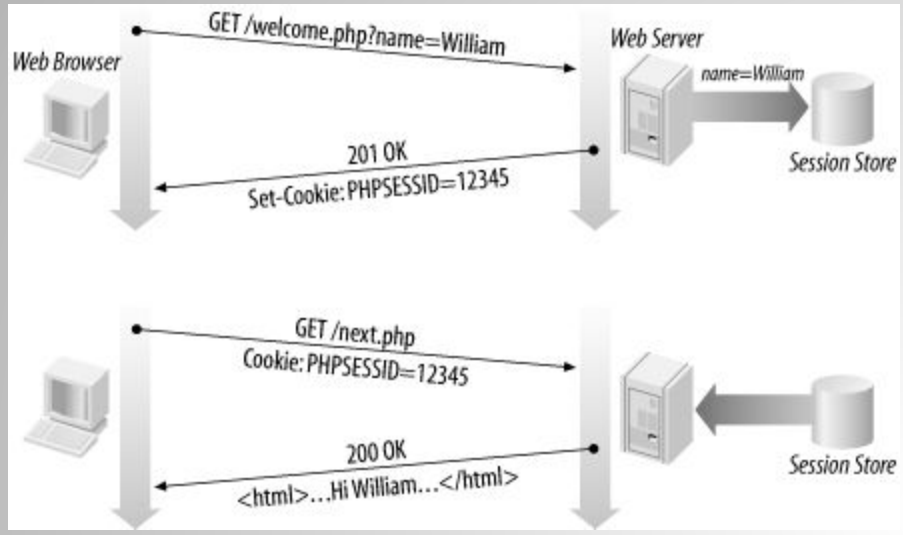
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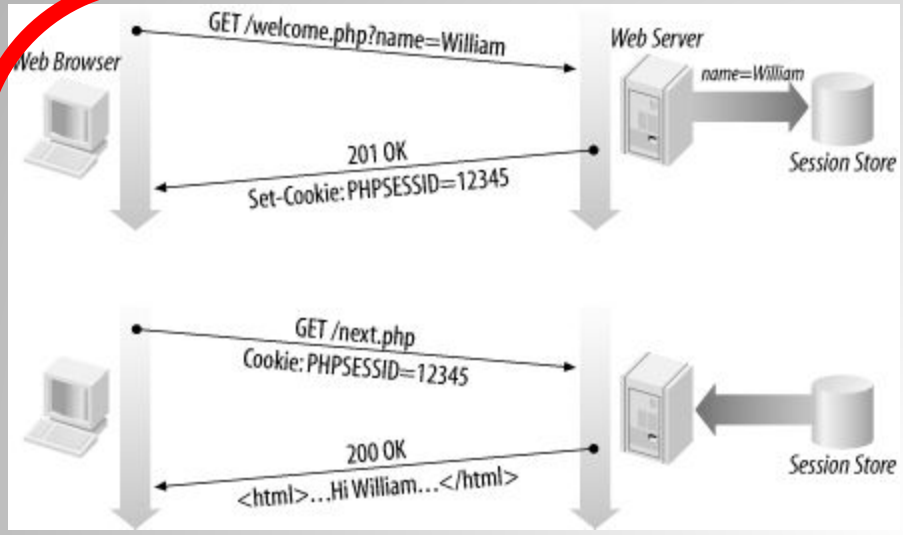
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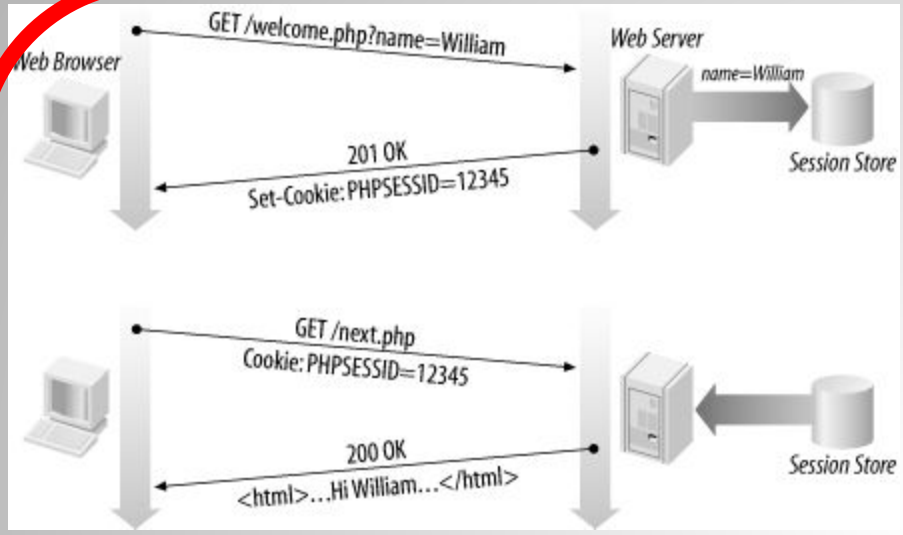
Session Store


WWW.

App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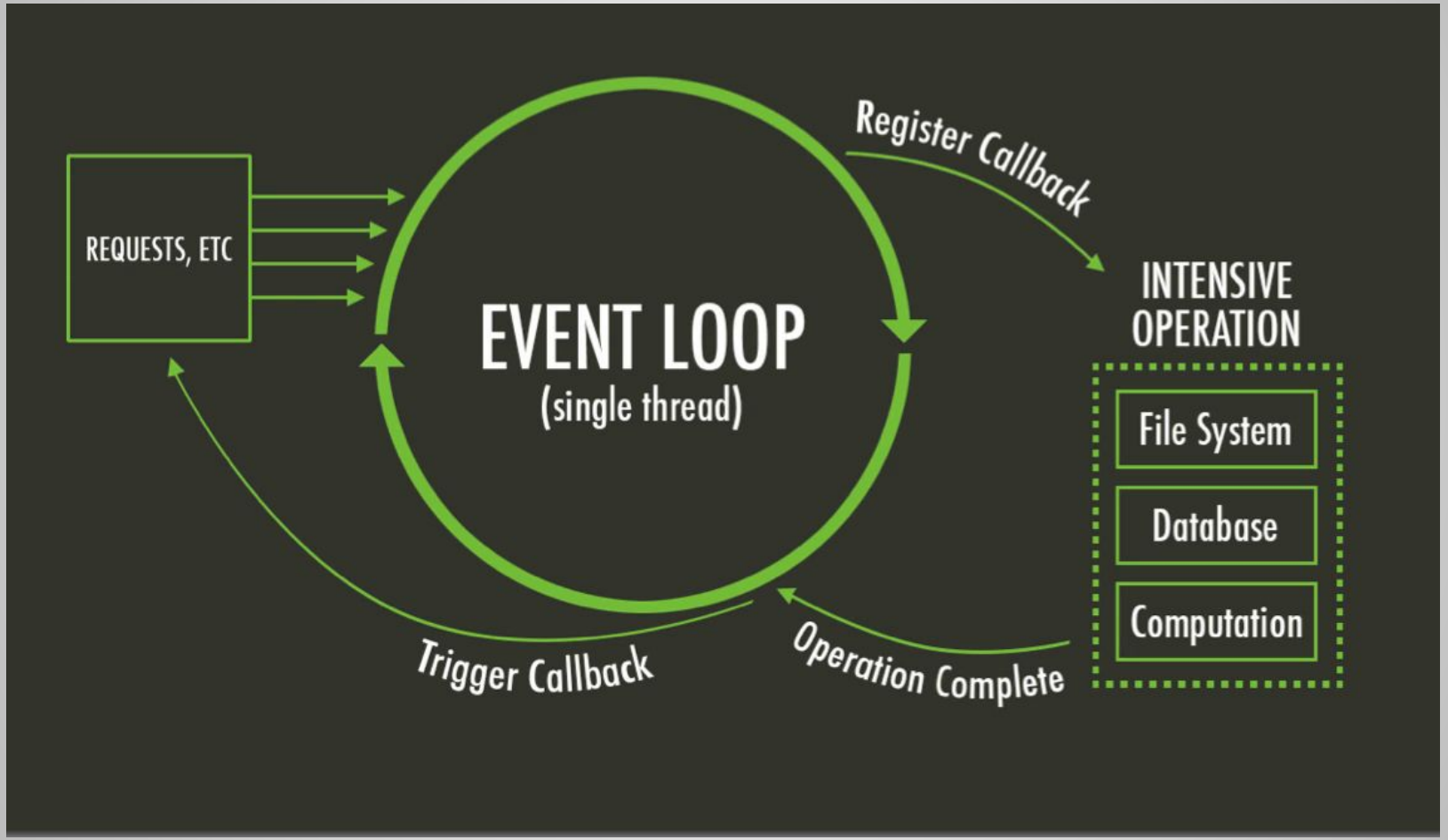
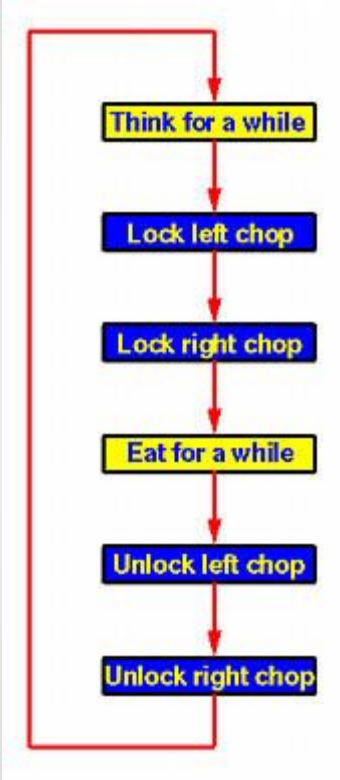
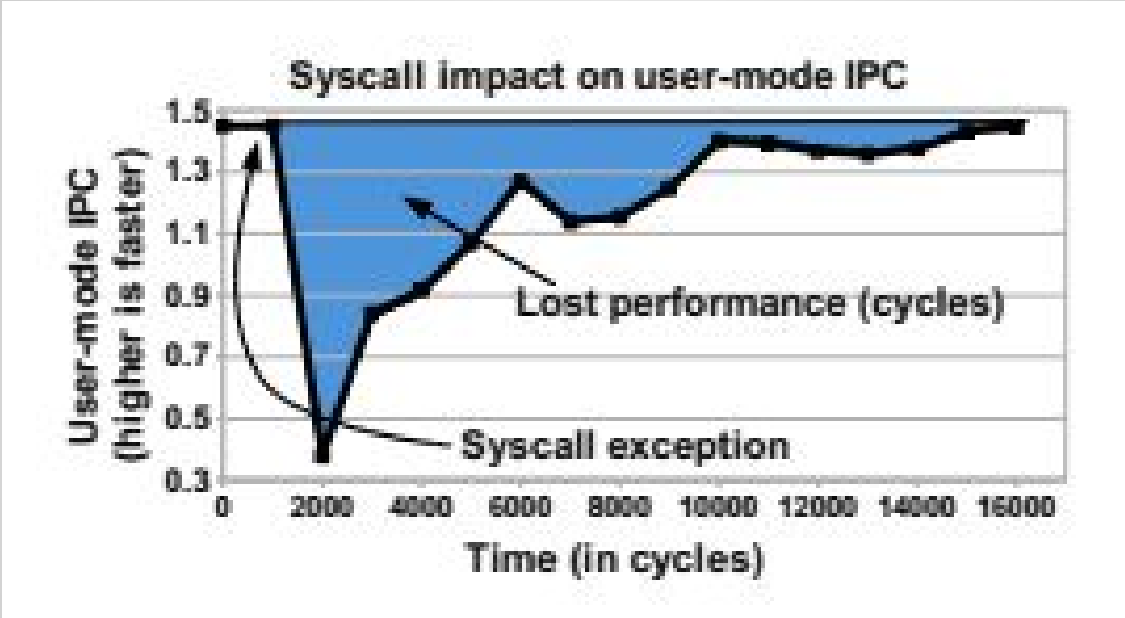
WWW.

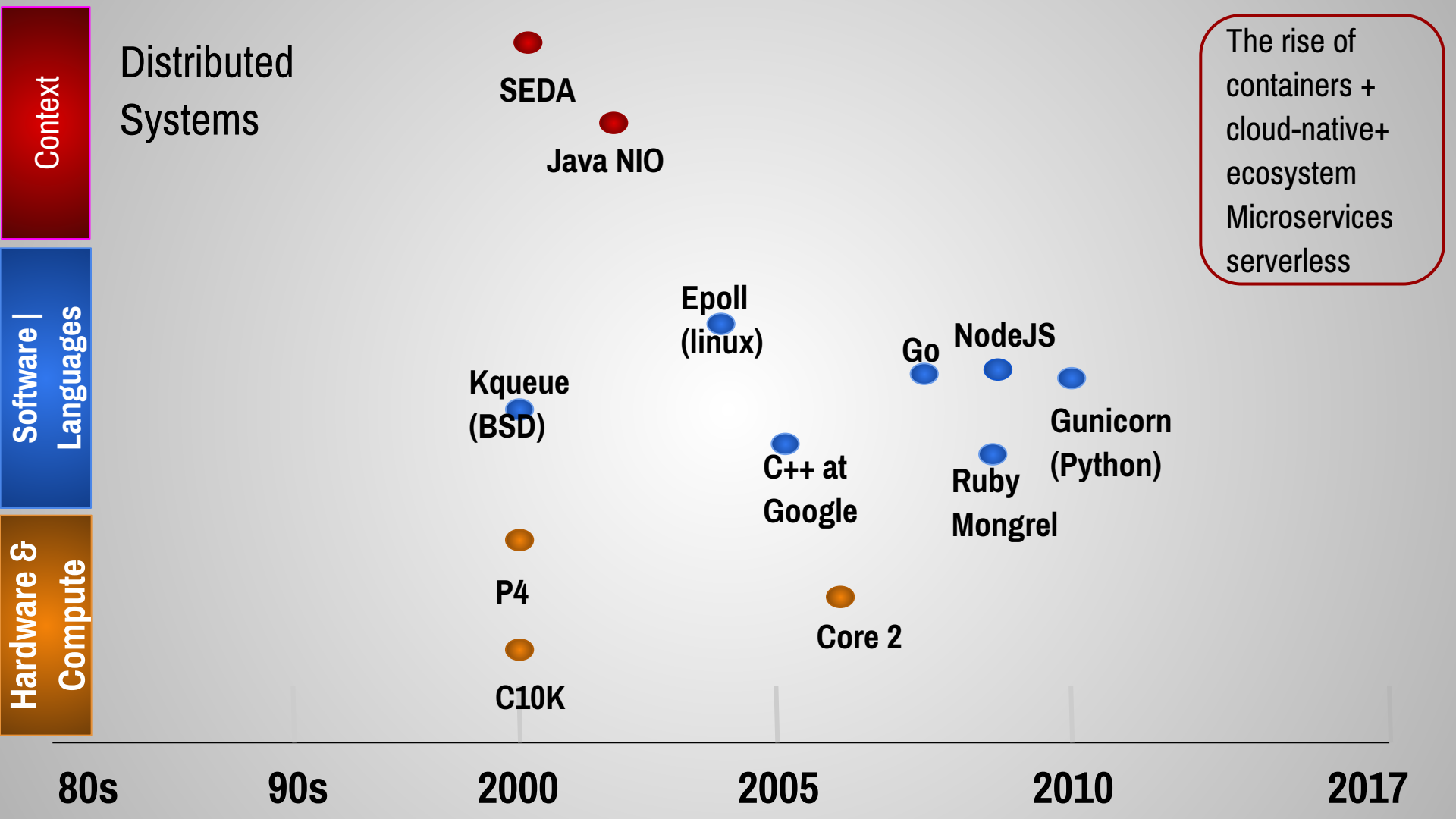
= Threads

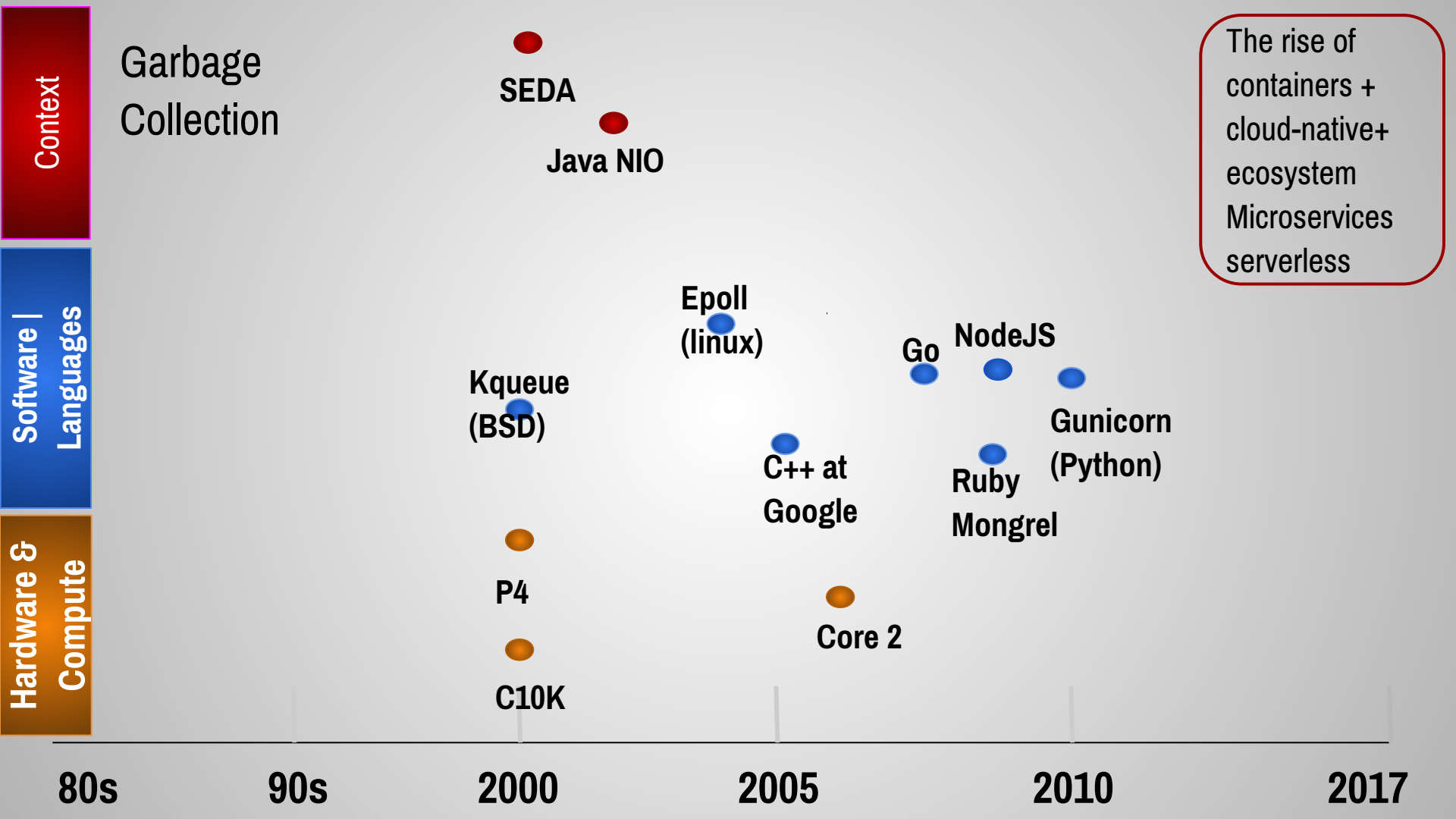
App


REQUESTS, ETC
EVENT LOOP
(single thread)
Register Callback
INTENSIVE OPERATION
File System
Database
Computation
Trigger Callback
Operation Complete


Think for a while
Lock left chop
Lock right chop
Eat for a while
Unlock left chop
Unlock right chop


Syscall impact on user-mode IPC
User-mode IPC
(higher is faster)
1.5
1.3
1.1
0.9
0.7
0.5
0.3
0
2000
4000
6000
8000
10000
12000
14000
16000
Time (in cycles)
Lost performance (cycles)
Syscall exception


Context
Software | Languages
Hardware & Compute
Distributed Systems
SEDA
Java NIO
Epoll (linux)
Kqueue (BSD)
C++ at Google
Go
NodeJS
Gunicorn (Python)
Ruby Mongrel
P4
C10K
Core 2
The rise of containers + cloud-native+ ecosystem Microservices serverless
80s
90s
2000
2005
2010
2017


Context
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Garbage Collection
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Gunicorn (Python)
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Core 2
The rise of containers + cloud-native+ ecosystem Microservices serverless
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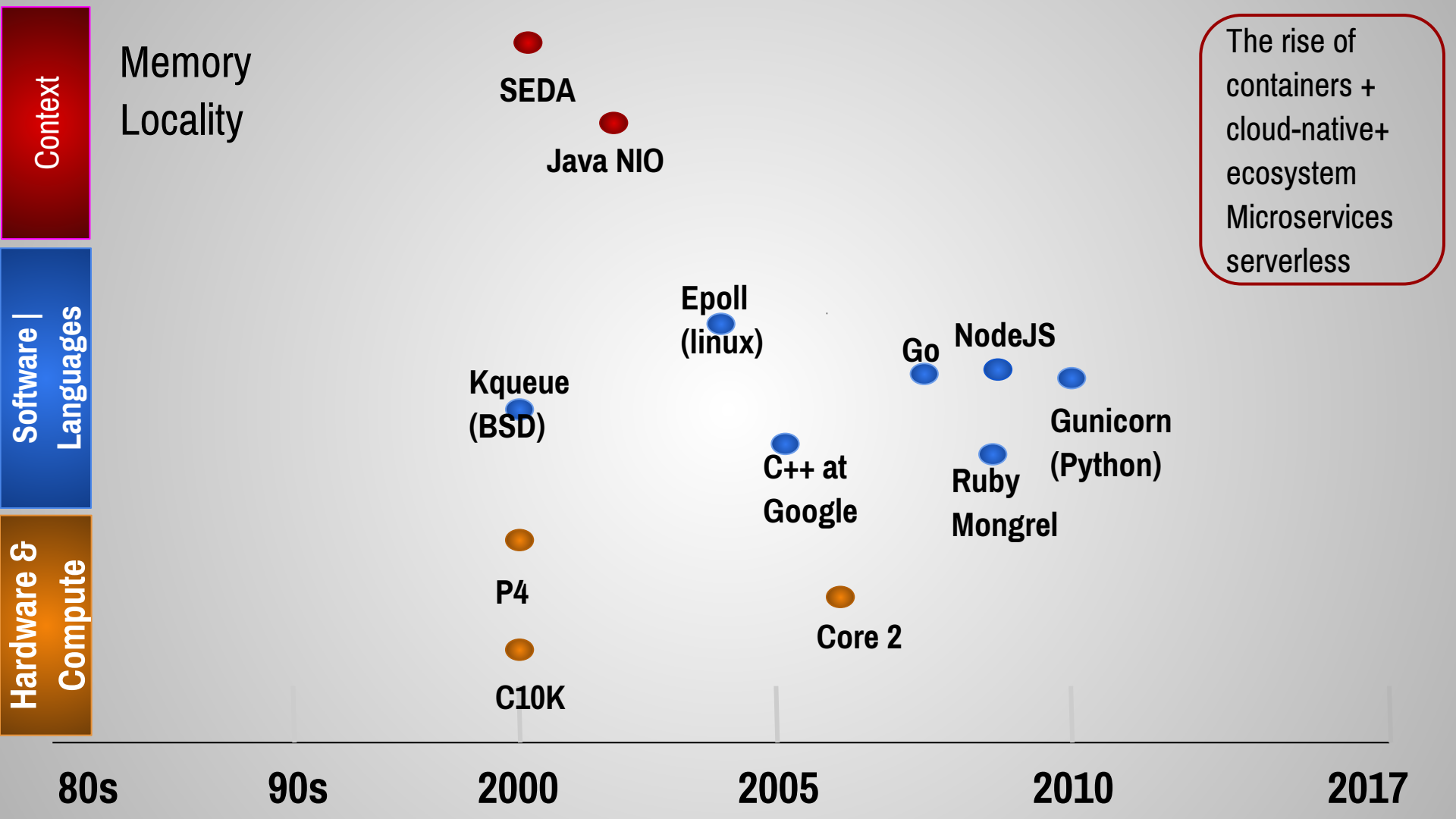
2017


Context
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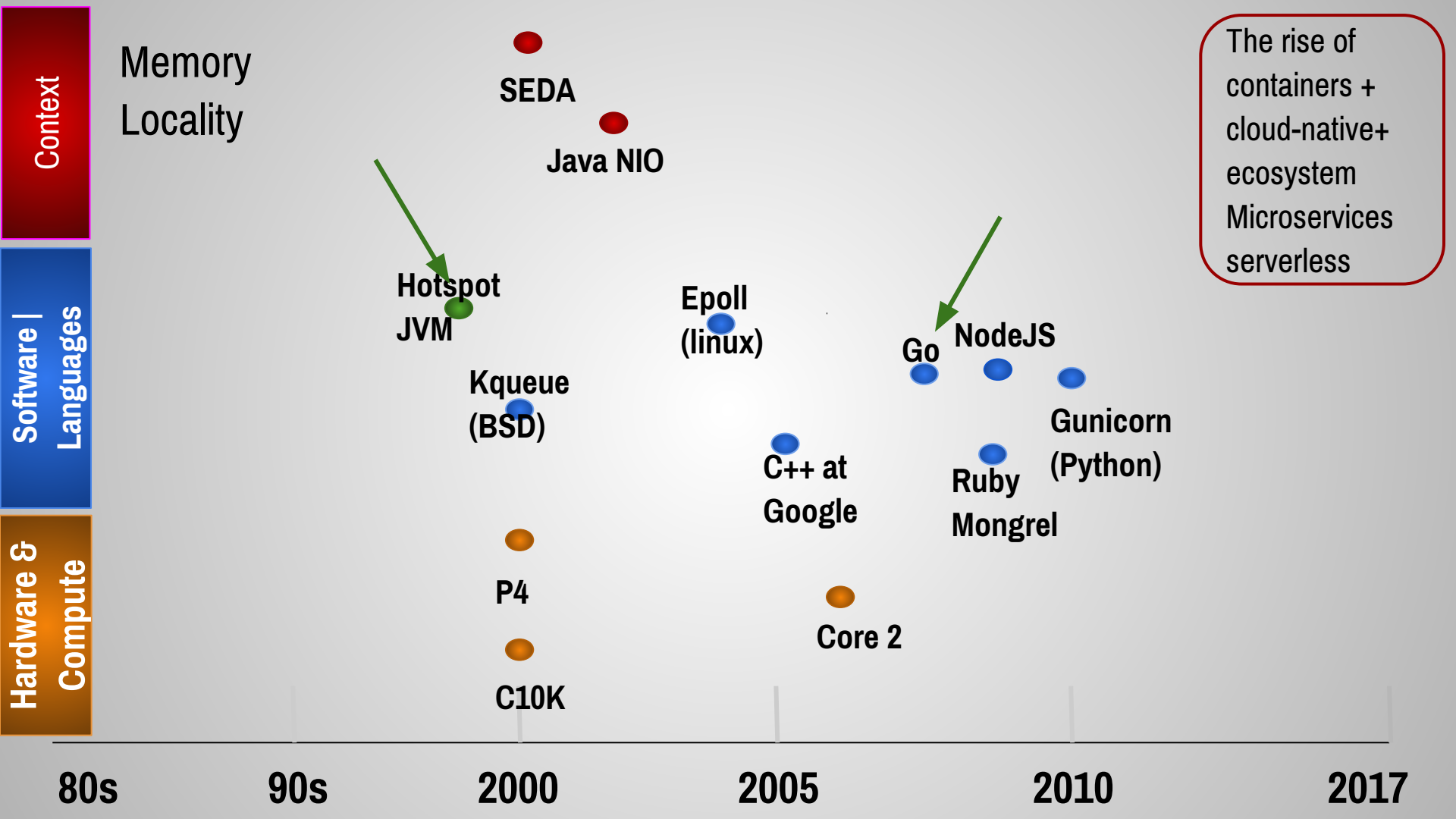
2017


Context
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2017

Memory Locality

Memory Locality

Java

Memory Locality

Java

No value types

Everything Allocated

Memory Locality

Java

No value types

Everything Allocated

Go

Memory Locality

Java

No value types

Everything Allocated

Go

Structs

True Value types

Memory Locality

Java

No value types

Everything Allocated

Can’t return multiple values

Go

Structs

True Value types

Context

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Hardware & Compute

Memory Locality

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Hotspot JVM

Kqueue (BSD)

P4

C10K

Epoll (linux)

C++ at Google

Core 2

Go

NodeJS

Gunicorn (Python)

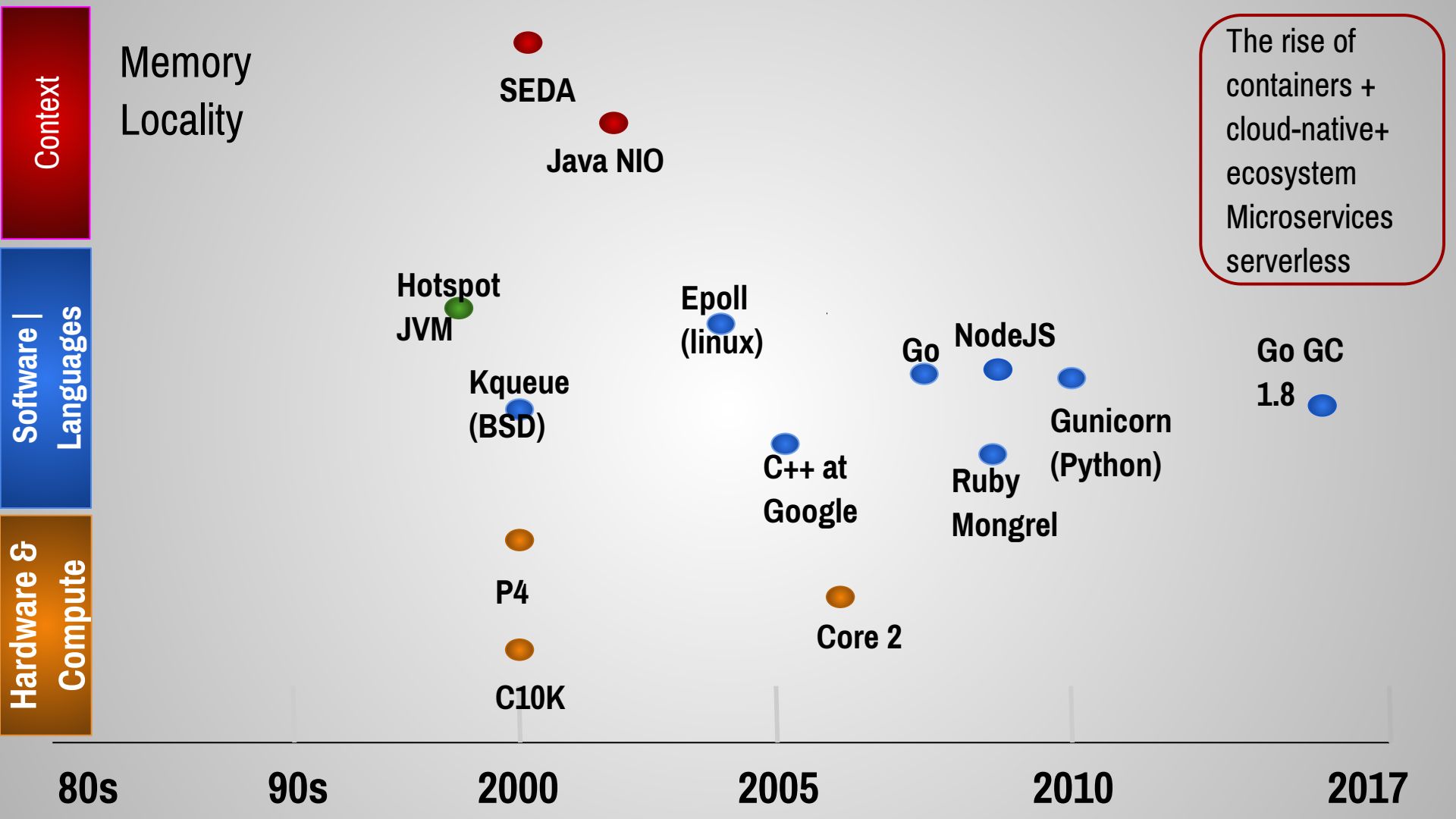
Ruby Mongrel

Go GC 1.8

The rise of containers + cloud-native+ ecosystem Microservices serverless

80s 90s 2000 2005 2010 2017

When the three of us [Ken Thompson, Rob Pike, and Robert Griesemer] got started, it was pure research. The three of us got together and decided that we hated C++. [laughter] ... [Returning to Go,] we started off with the idea that all three of us had to be talked into every feature in the language, so there was no extraneous garbage put into the language for any reason.


Context
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2000
2005
2010
2017

Memory Locality

Java

No value types

Everything Allocated

Can’t return multiple values

Go

Structs

True Value types

Memory Locality

Java	Go
No value types	Structs
Everything Allocated	True Value types
Can’t return multiple values	compact object layout
	No object headers

Memory Locality

Java

No value types

Everything Allocated

Can’t return multiple values

Go

UTF-8

Structs

True Value types

compact object layout

No object headers

Memory Locality

Java **UTF-16**

No value types

Everything Allocated

Can’t return multiple values

Go **UTF-8**

Structs

True Value types

compact object layout

No object headers

Memory Locality

Java **UTF-16**

No value types

Everything Allocated

Can’t return multiple values

Go **UTF-8**

Structs
True Value types
Compact object layout
No object headers
Lazy initialization of collections

Memory Locality (conclusion)

Memory Locality (conclusion)

- Go gives programmers the tools to talk about memory efficiently ***if they need it.***

Memory Locality (conclusion)

- Go gives programmers the tools to talk about memory efficiently ***if they need it.***
- Flexible

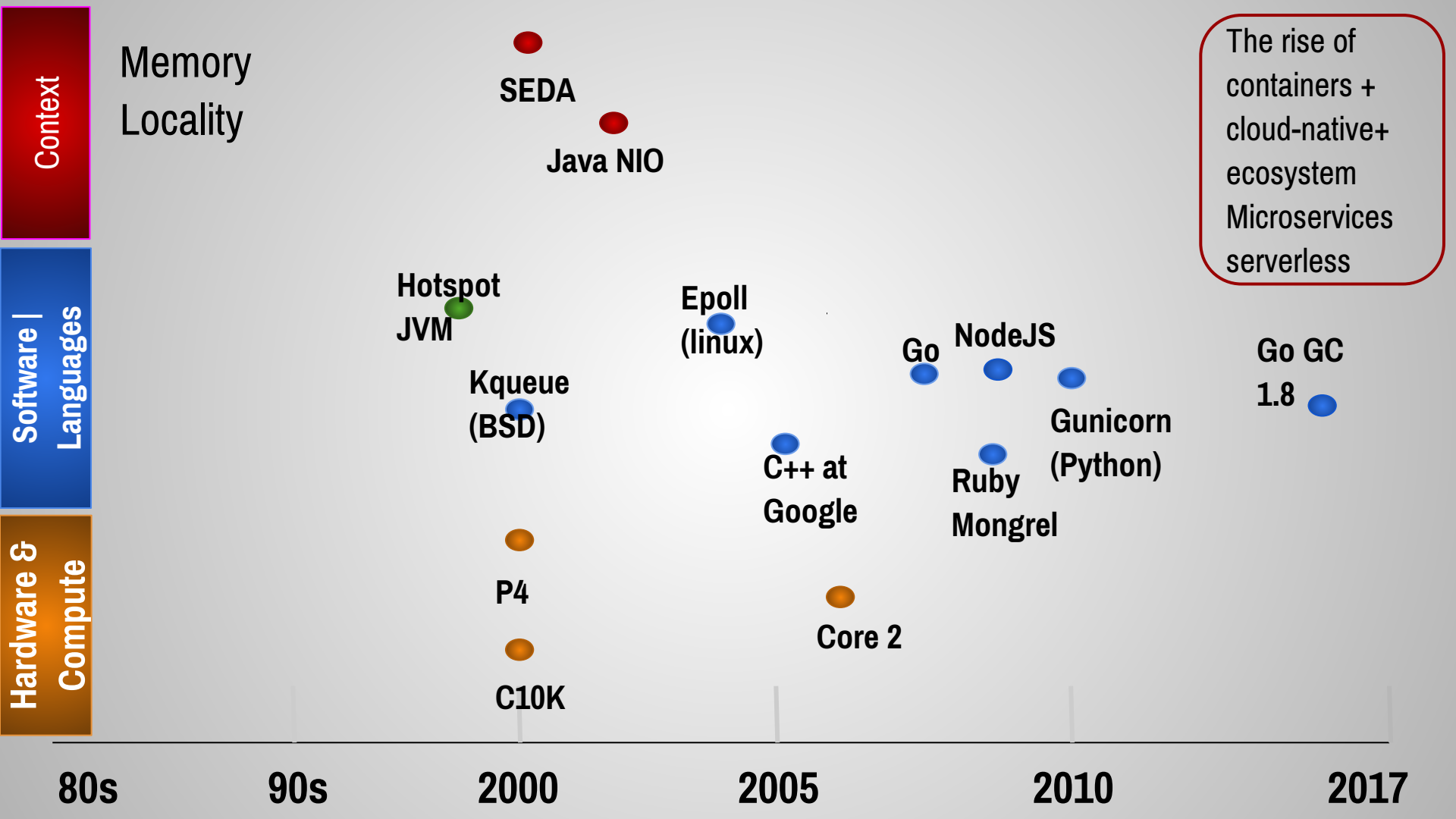
Memory Locality (conclusion)

- Go gives programmers the tools to talk about memory efficiently ***if they need it.***
- Flexible
- Memory management (not an all-or-nothing like in C++ or Rust)

Readability

Readability

> *“ Debugging is twice as hard as writing the code in the first place. Therefore, if you write the code as cleverly as possible, you are, by definition, not smart enough to debug it. ”*—Brian Kernighan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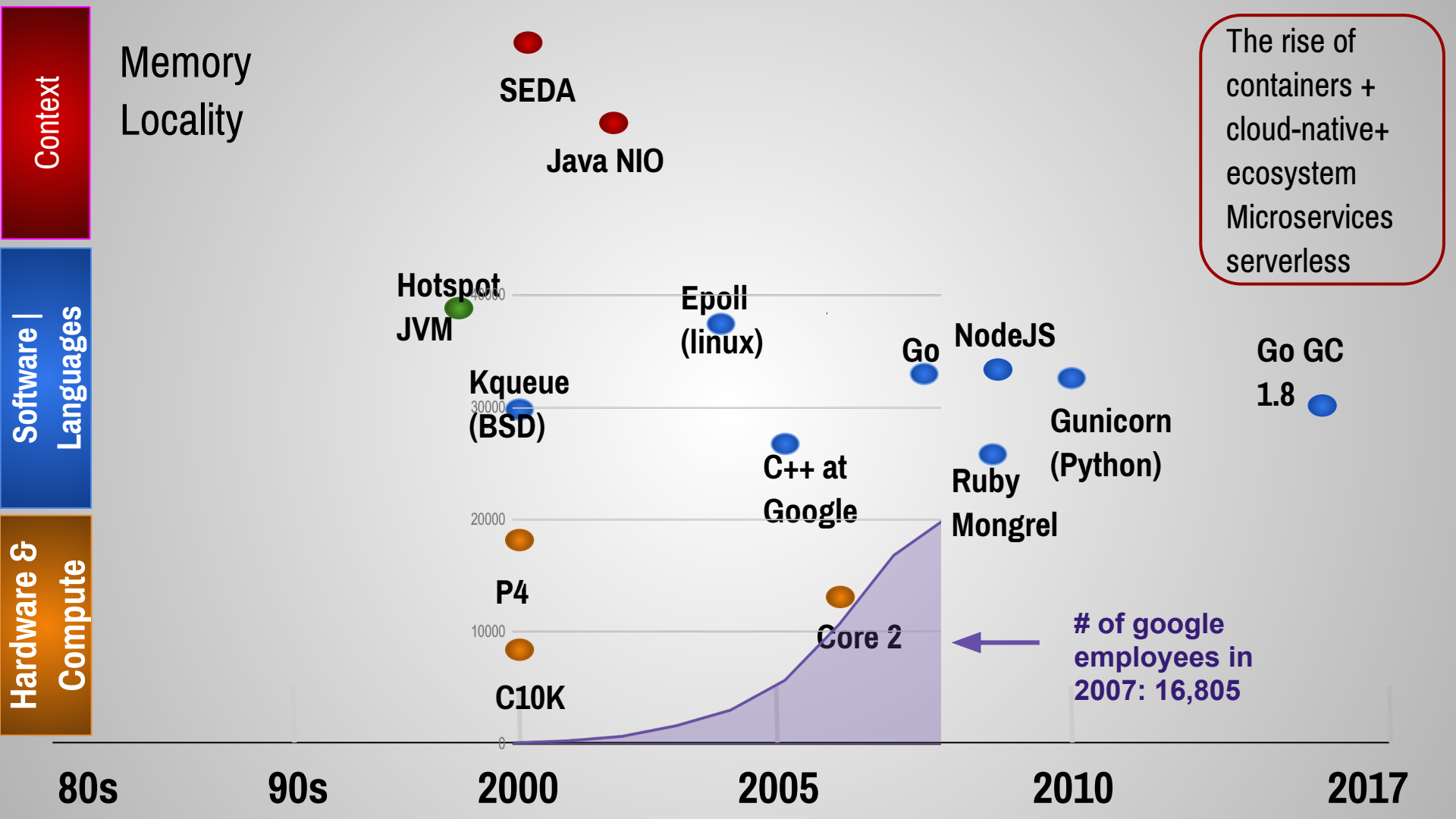
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P4
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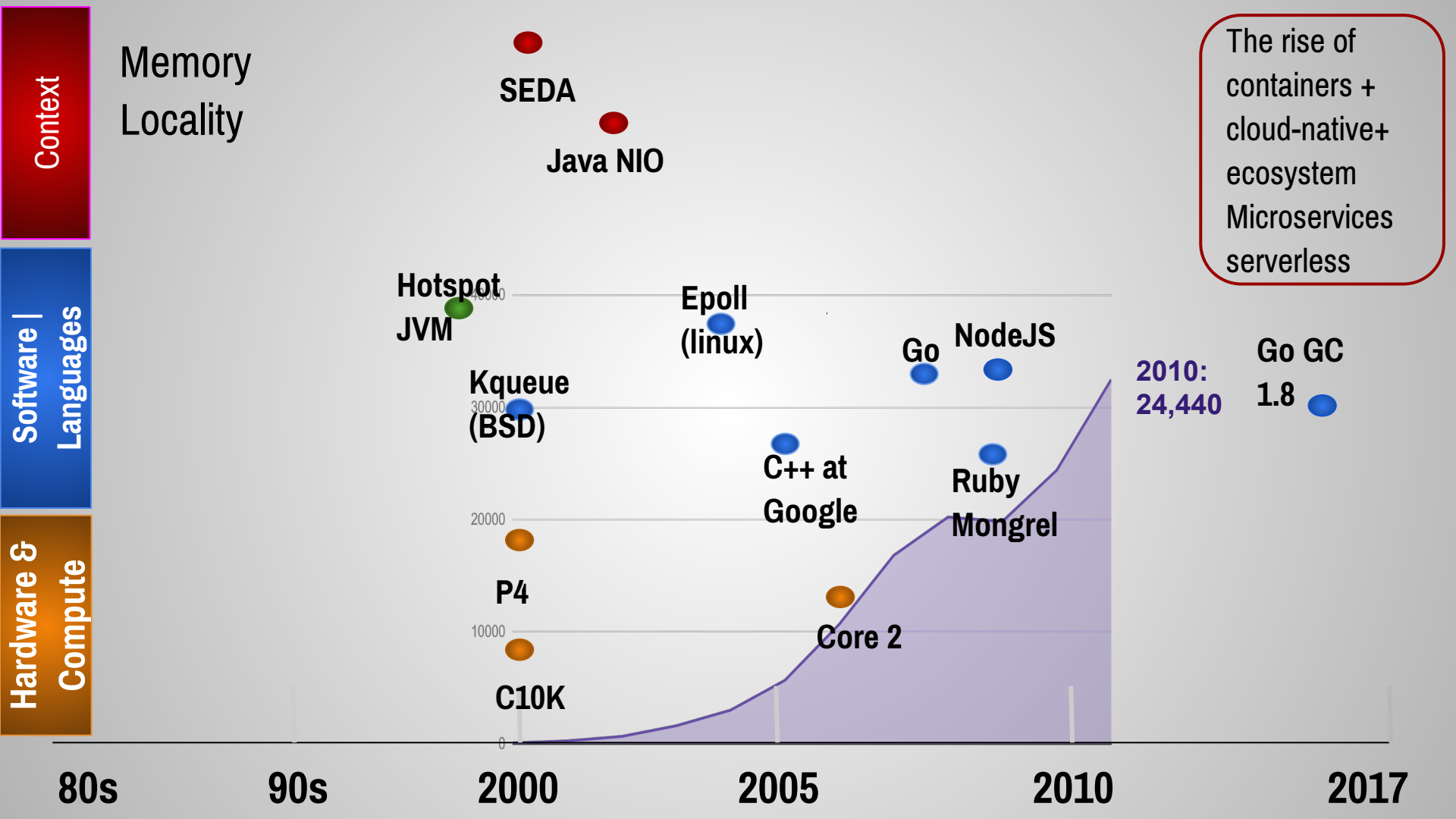
Go
NodeJS
Ruby Mongrel
Gunicorn (Python)
Go GC 1.8
The rise of containers + cloud-native+ ecosystem Microservices serverless
# of google employees in 2007: 16,805
40000
30000
20000
10000
0
80s
90s
2000
2005
2010
2017


Context
Software | Languages
Hardware & Compute
Memory Locality
SEDA
Java NIO
Hotspot JVM
Epoll (linux)
Kqueue (BSD)
Go
NodeJS
2010: 24,440
Go GC 1.8
C++ at Google
Ruby Mongrel
P4
Core 2
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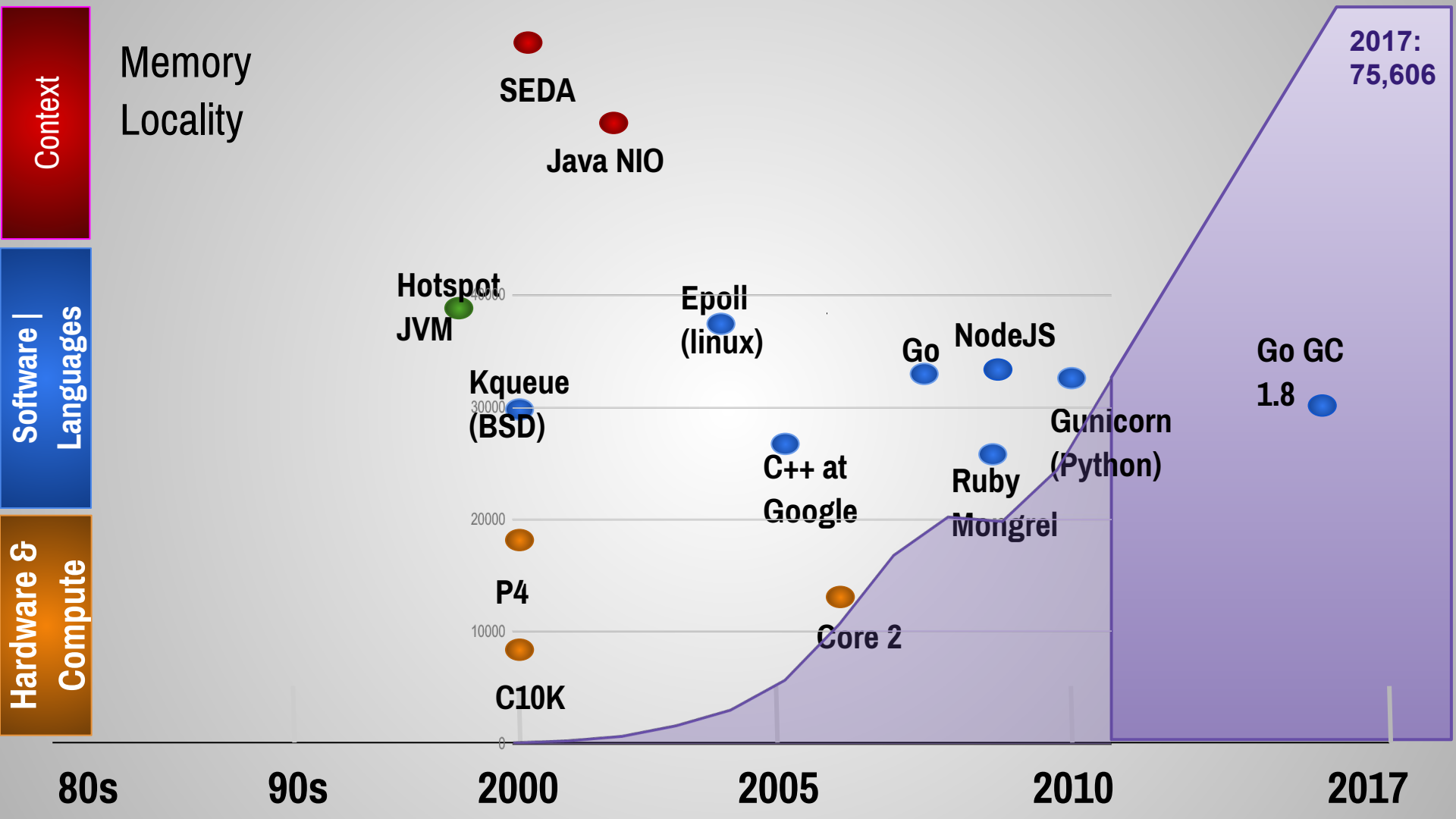
2010
2017
The rise of containers + cloud-native+ ecosystem Microservices serverless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Gunicorn (Python)
C++ at Google
Ruby
Mongrel
P4
Core 2
C10K
2017: 75,606
40000
30000
20000
10000
0
80s
90s
2000
2005
2010
2017

Readability

simplicity

Readability

simplicity

“simple is better”

Readability

simplicity

“simple is better”

“this is an insult to intelligent programmers”

Readability

simplicity

“simple is better”

“you’re trying to commodify programming and create a situation where our bosses can replace us at will”

“You’re not paid to program, you’re not even paid to maintain someone else’s program, you’re paid to deliver solutions to the business.”

- Dave Cheney

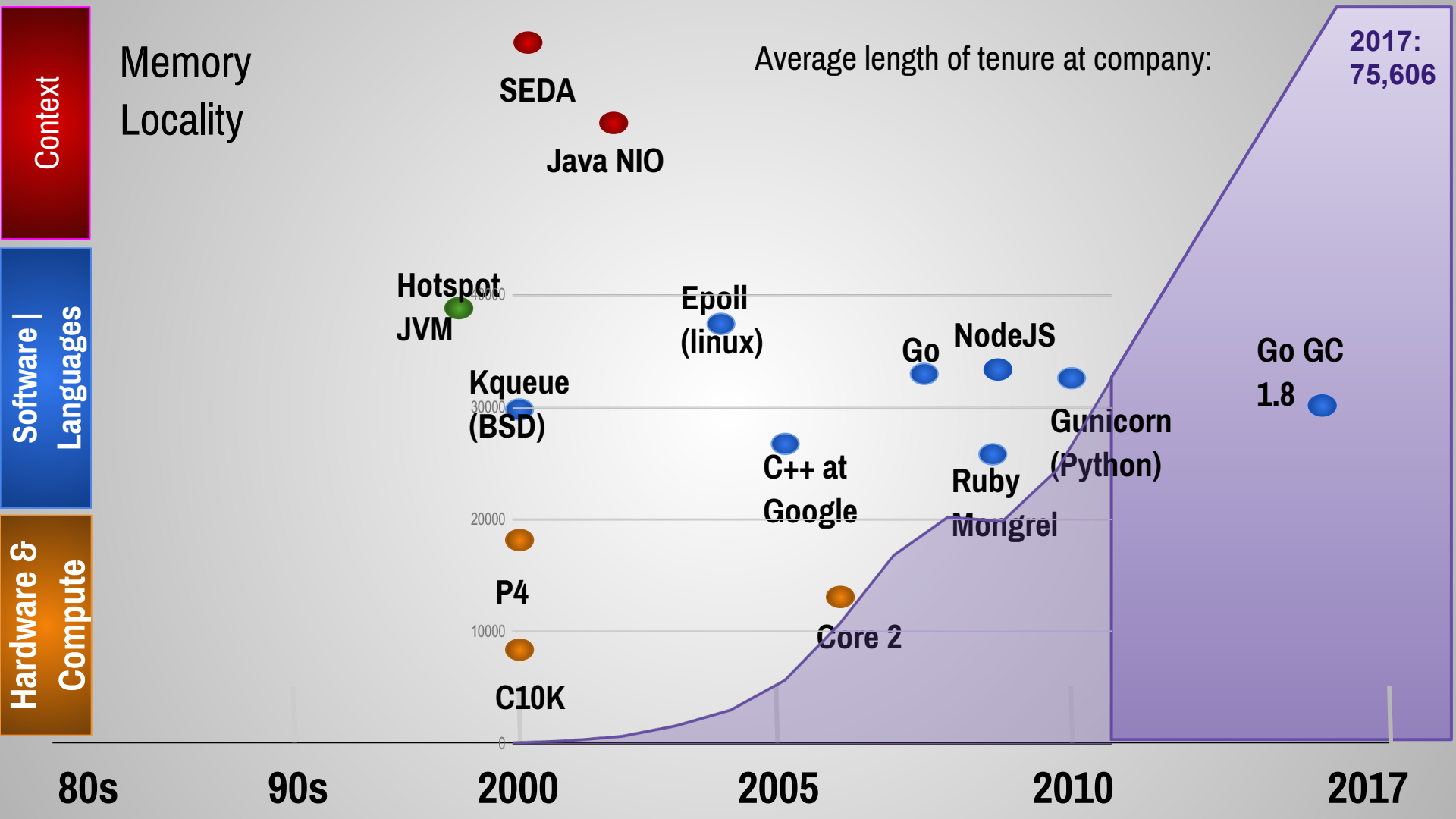
Readability

Programs which cannot be maintained will be rewritten

Readability

Programs which cannot be maintained will be rewritten

“If you can’t be replaced, you cannot be promoted”


Context
Software | Languages
Hardware & Compute
Memory
Locality
Average length of tenure at company:
2017:
75,606
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(BSD)
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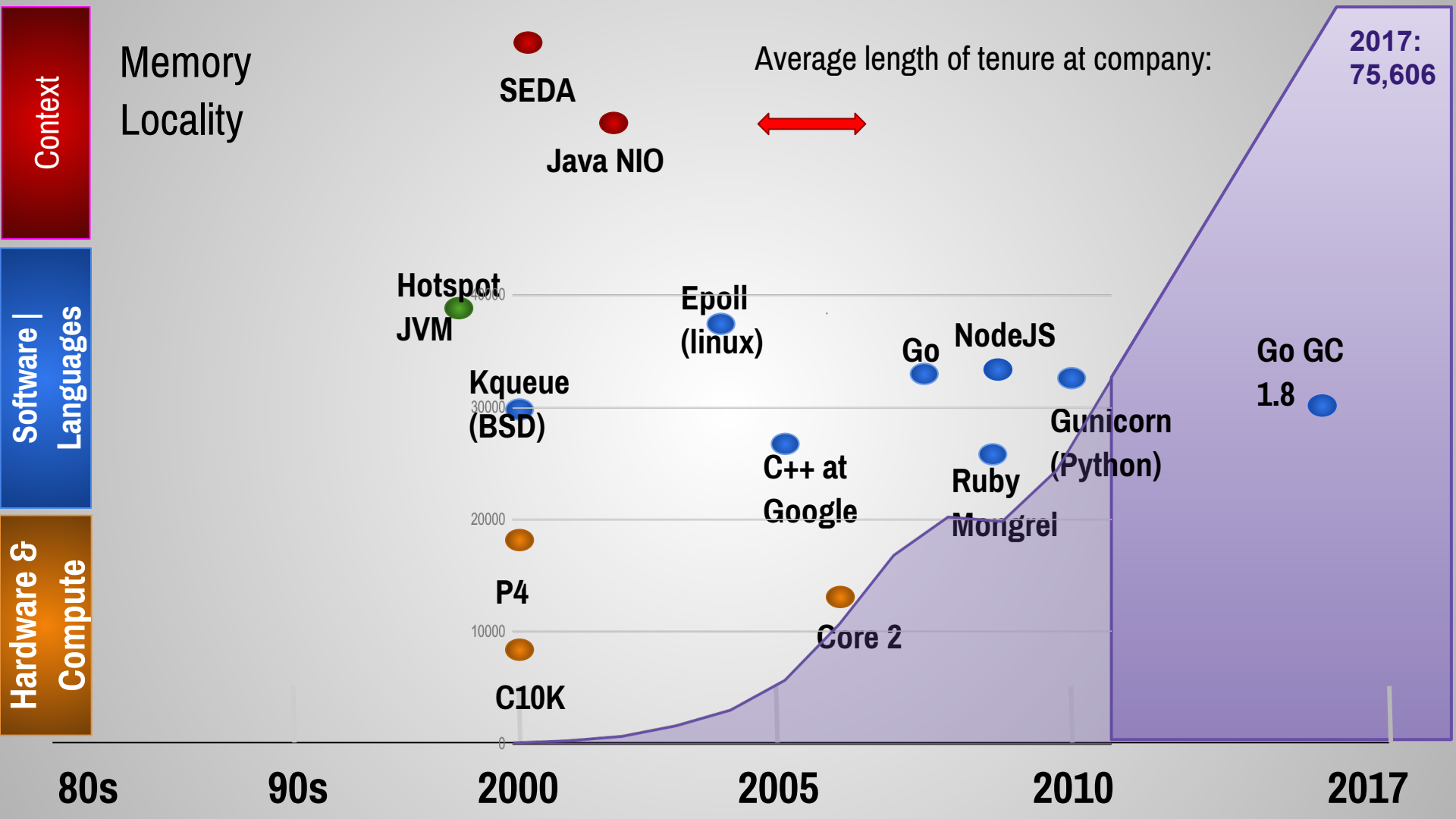
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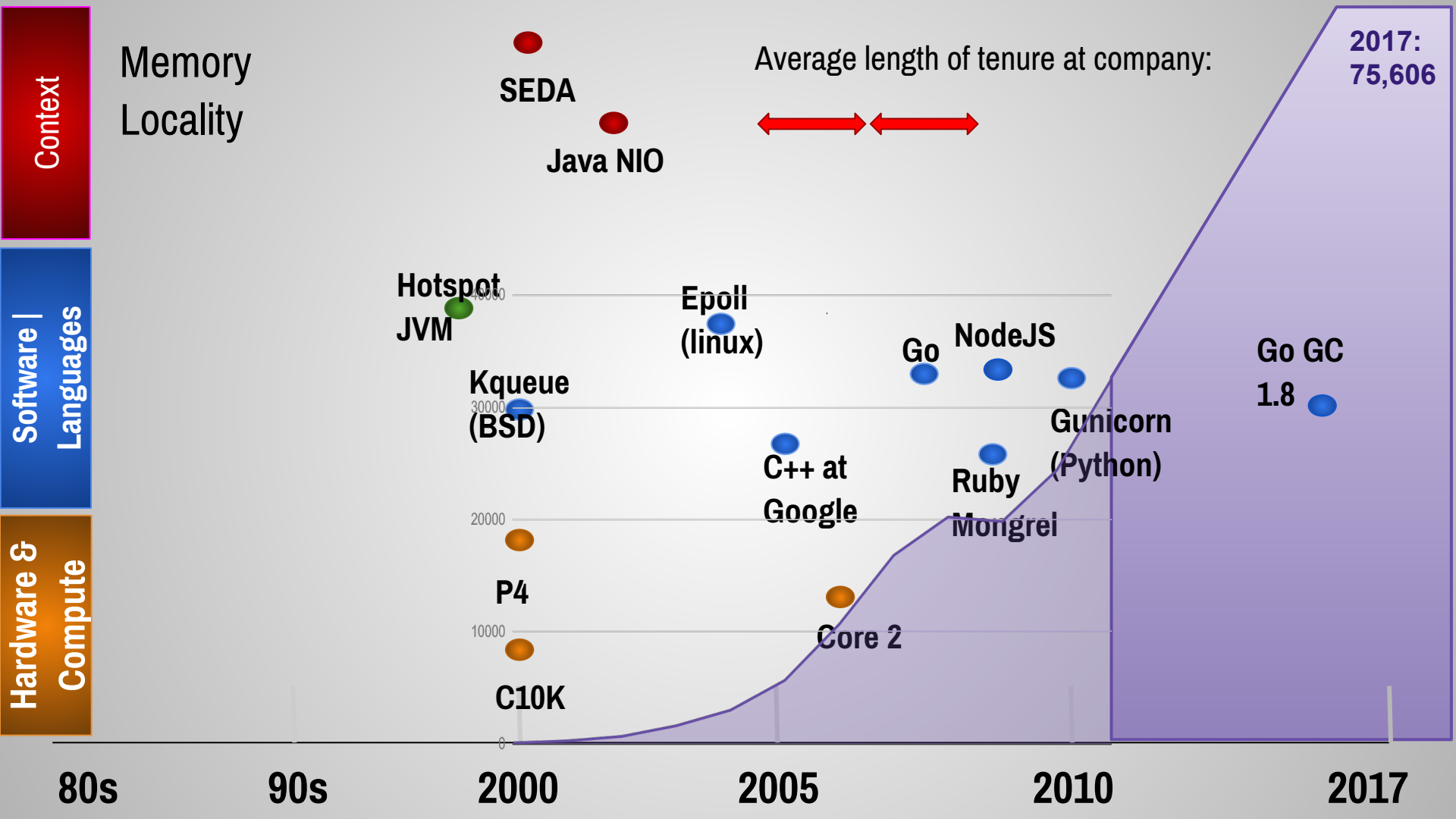
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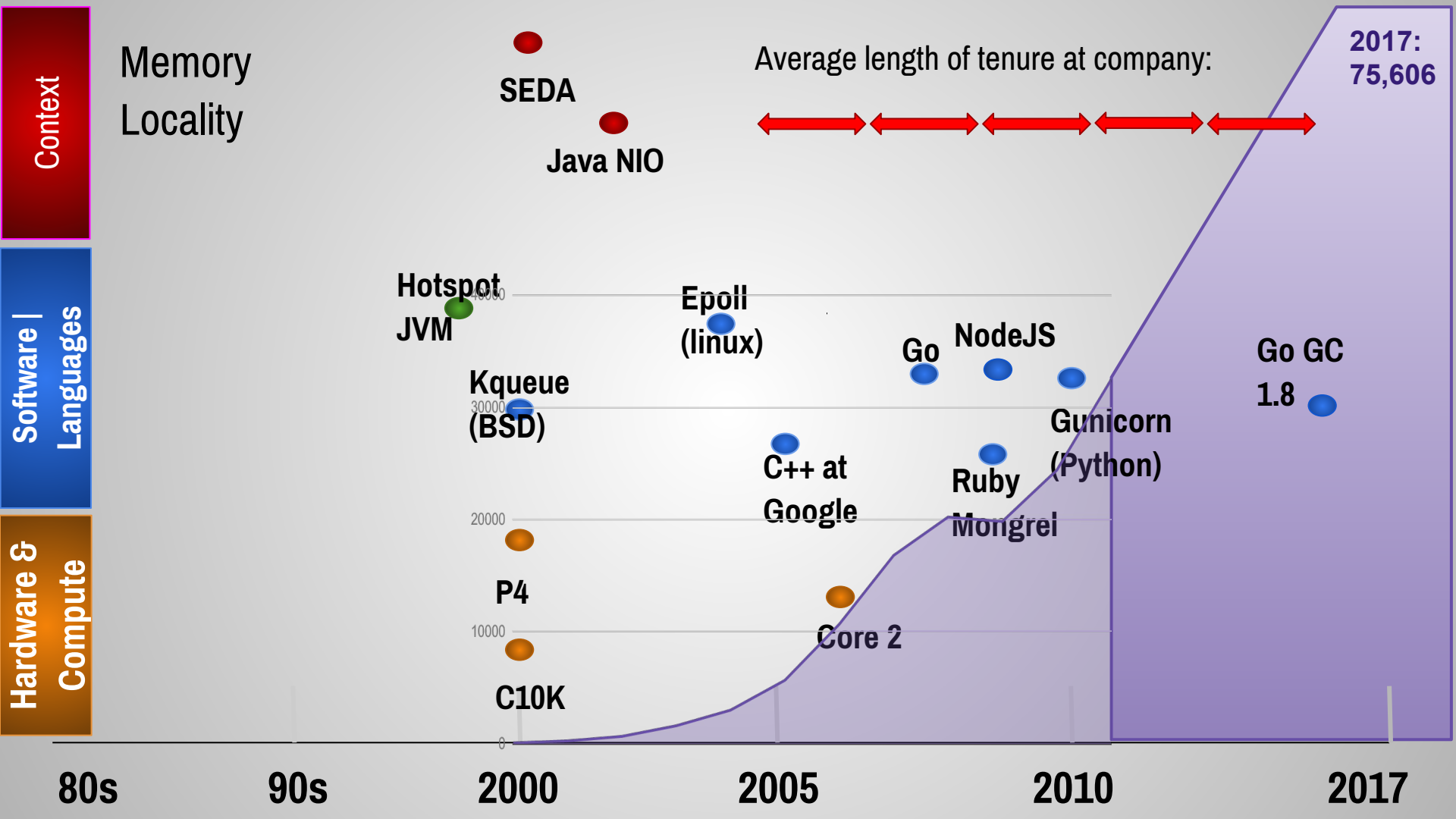
Context
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Google
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20000
10000
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80s
90s
2000
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2010
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Software Engineering

Software Engineering

Software Engineering vs Programming

Software Engineering

Software Engineering vs Programming

Software Engineering = Programming integrated over time.

Software Engineering

Software Engineering vs Programming

Software Engineering = Programming integrated over time.

Engineering is what happens when things need to live longer and influence of time starts creeping in. -Titus Winters

Software Engineering

Software Engineering vs Programming

Software Engineering = Programming integrated over time.

Engineering is what happens when things need to live longer and influence of time starts creeping in. -Titus Winters

All this complexity is fundamentally a different flavor than programming.

Software Engineering

focus on sustaining engineering (readability)

Software Engineering

focus on sustaining engineering (readability)

continuance of many different engineers over a long period of time

Software Engineering

focus on sustaining engineering (readability)

continuance of many different engineers over a long period of time

clear module boundaries

Software Engineering

focus on sustaining engineering (readability)

continuance of many different engineers over a long period of time

clear module boundaries

keeping import dependencies between packages linear, thus keeping compile times down.

Simplicity and the Greater Good


STOP
Stop Sign
YIELD
RIGHT
OF
WAY
Yield Right of Way
No Left Turn
Straight Only
Turn Left
Turn Right
P
Parking Permitted
30
Speed Limit
End of Speed Limit
TAXI
Taxi Rank
Pedestrian Street
Clearway

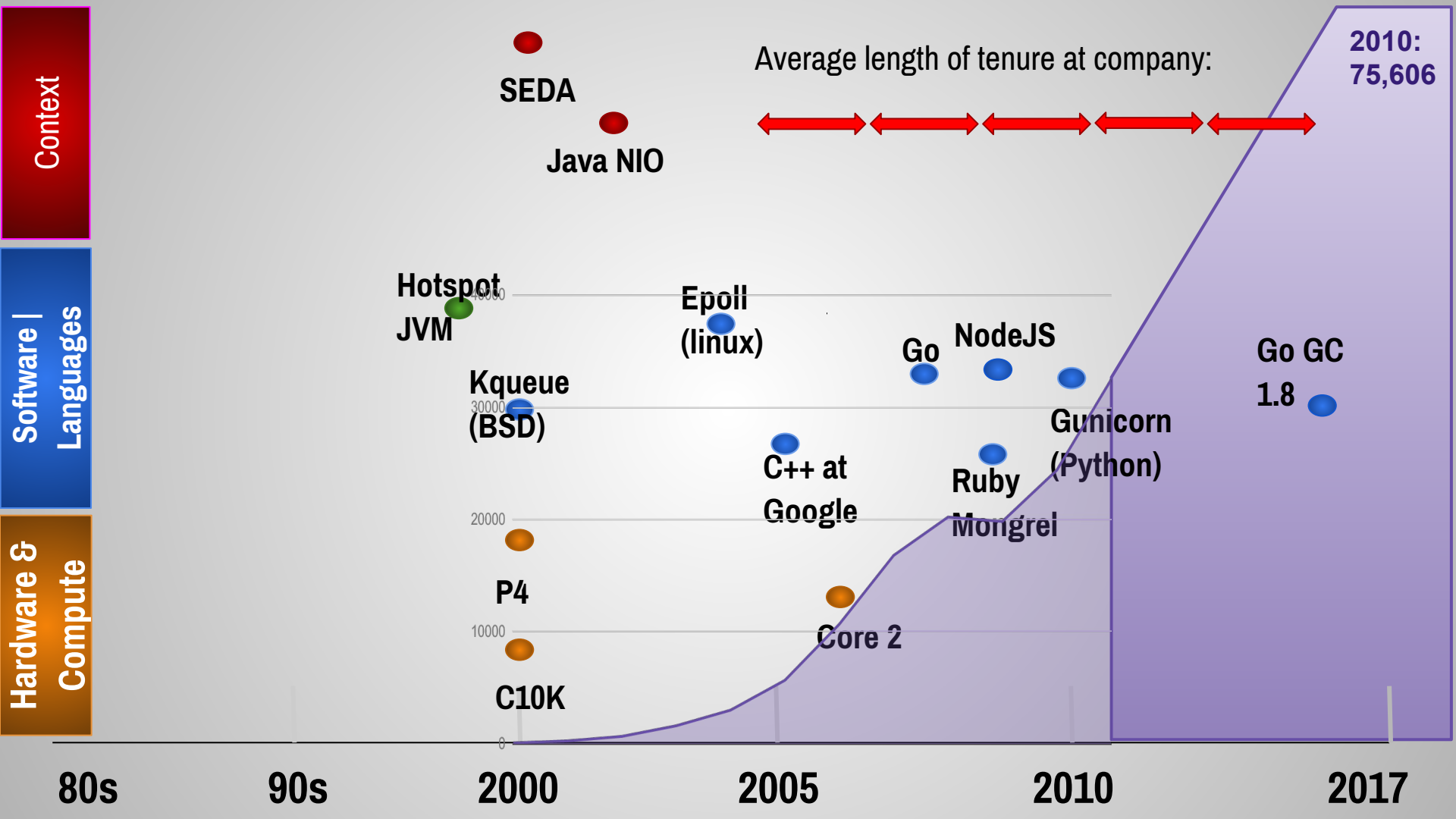

KEEP
LEFT
NO
ENTRY
NO
RIGHT
TURN


GIVE
WAY
SPEED
HUMP
STOP
GO
30
DIVERSION

“Simplicity is a great virtue but it requires hard work to achieve it and education to appreciate it. And to make matters worse: complexity sells better.”

— **Edsger W. Dijkstra**

The Future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Context

Software | Languages

Hardware & Compute

The Future?

Context

Software | Languages

Hardware & Compute

The Future?

The problems we have today were not there 20 years ago, nor will be problems we face 20 years from now.

Context

Software | Languages

Hardware & Compute

The Future?

...it may surprise you

Thank you!

Carmen Andoh @carmatrocity

QCon San Francisco

21st Century Languages Track

November 2017