Smalltalk Virtual Machines to JavaScript Engines:

Perspectives on Mainstreaming Dynamic Languages

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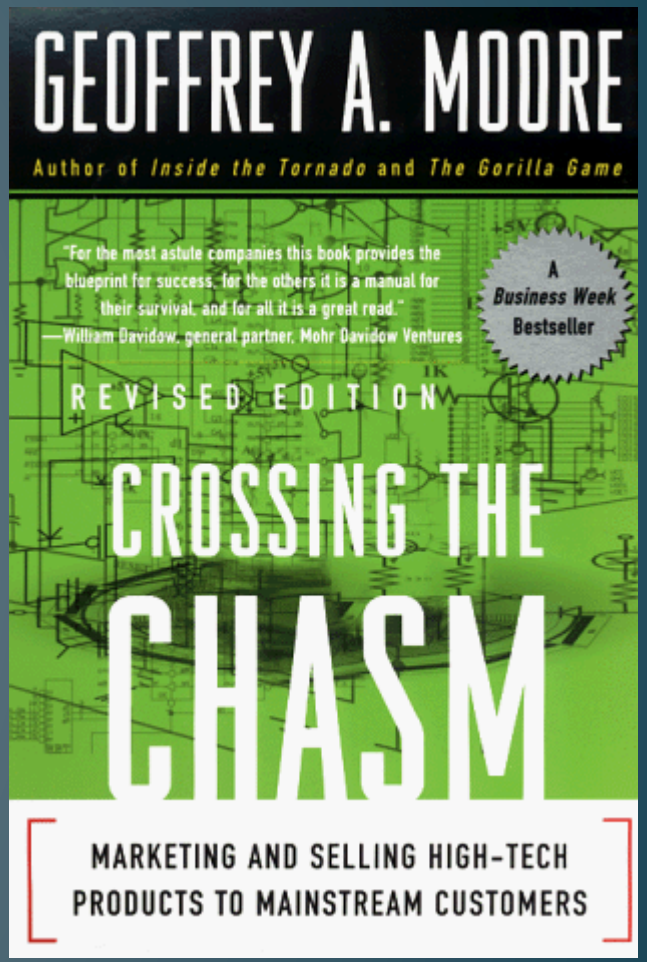
mainstream

1. the principal or dominant course, tendency, or trend: *the mainstream of American culture.*

Random House Dictionary

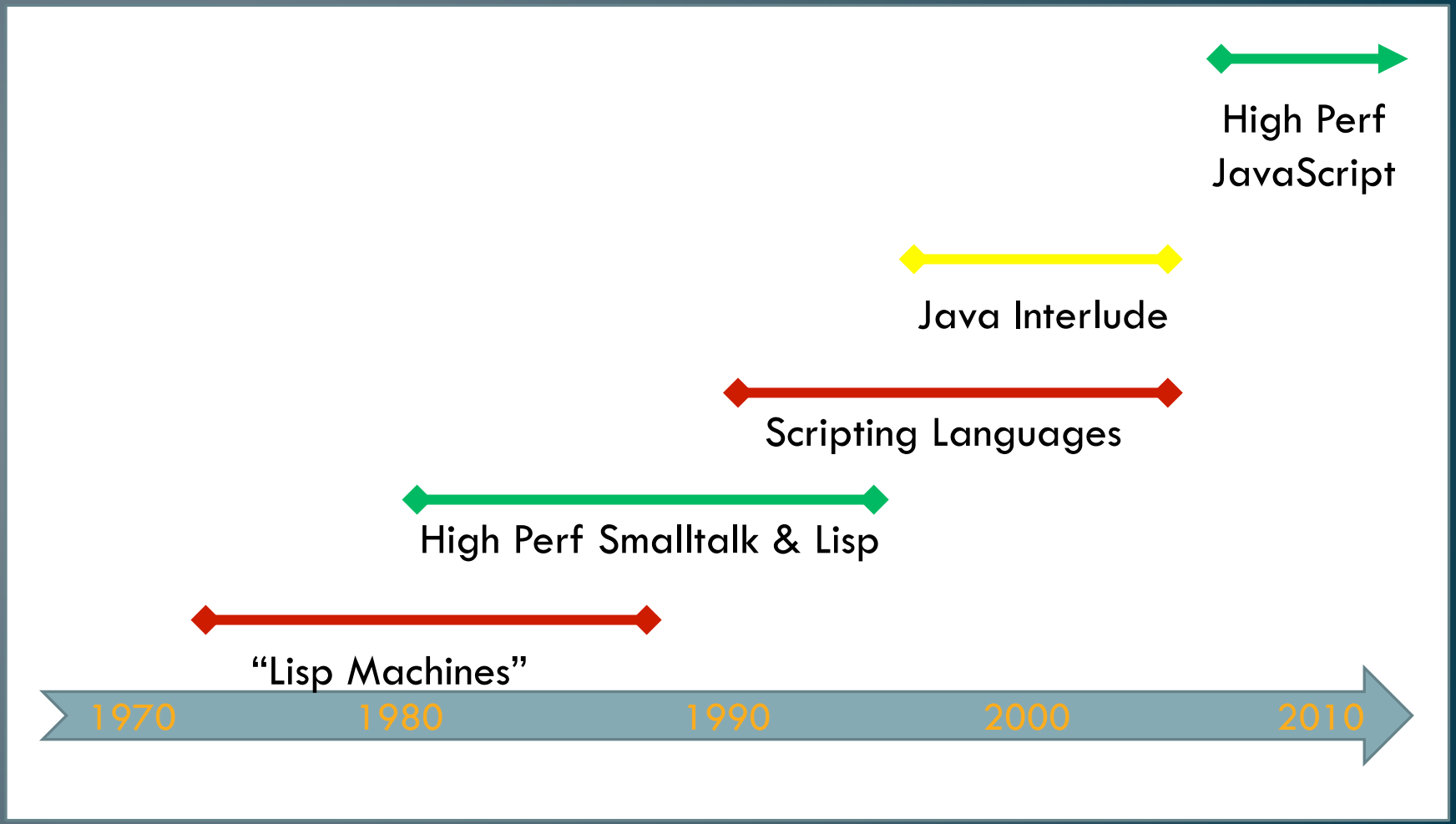


How Do We Get Dynamic Languages Across the Chasm?

A little background about me

- Compilers, Smalltalk virtual machines, GCs, language design, development tools
- Tektronix Smalltalk/4404
- Helped launch OOPSLA and DLS
- Instantiations: OOD Team Dev. Smalltalk,
- Digitalk/Parcplace-Digitalk: Enterprise Scale Smalltalk
- ANSI Smalltalk
- (Re-) Instantiations: JOVE Java optimizing compiler, Eclipse tools
- Microsoft – JavaScript/ECMAScript 5

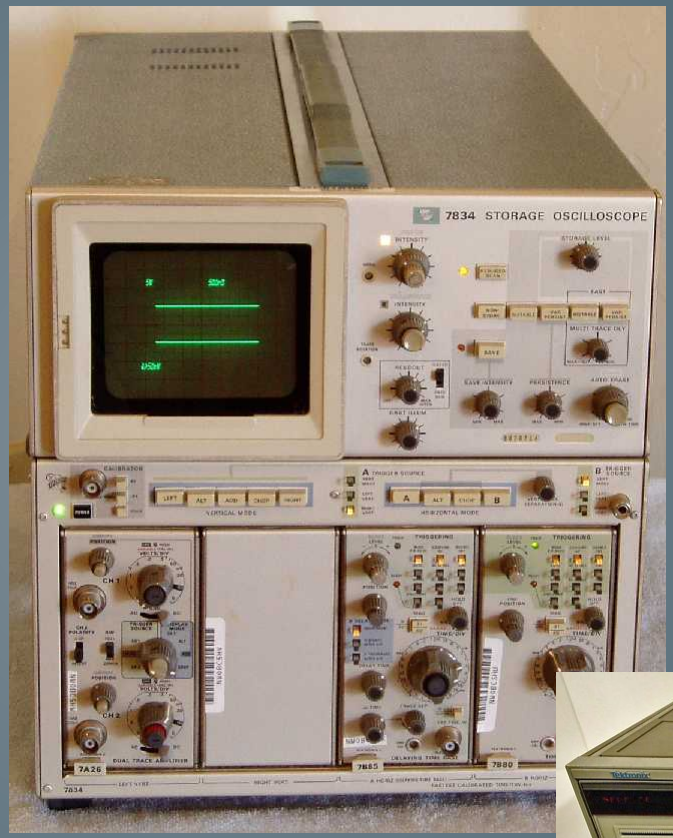
Dynamic Language Technology Waves Towards the Mainstream



Being a Successful Innovator

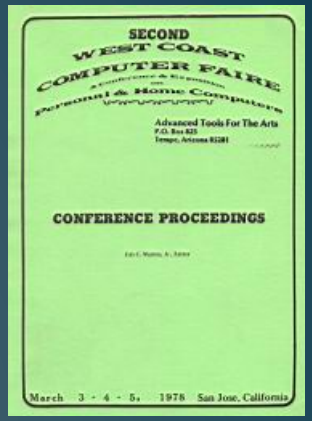
- Have a vision
- Believe it is possible
- Do the right things
- Know your weaknesses
- Adjust to reality
- Don't give up

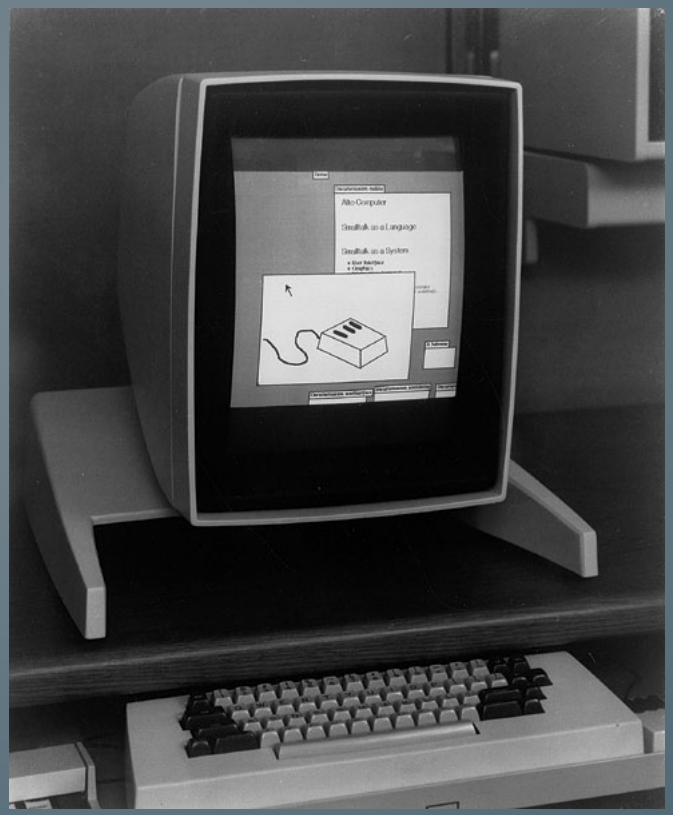
1978 Tektronix

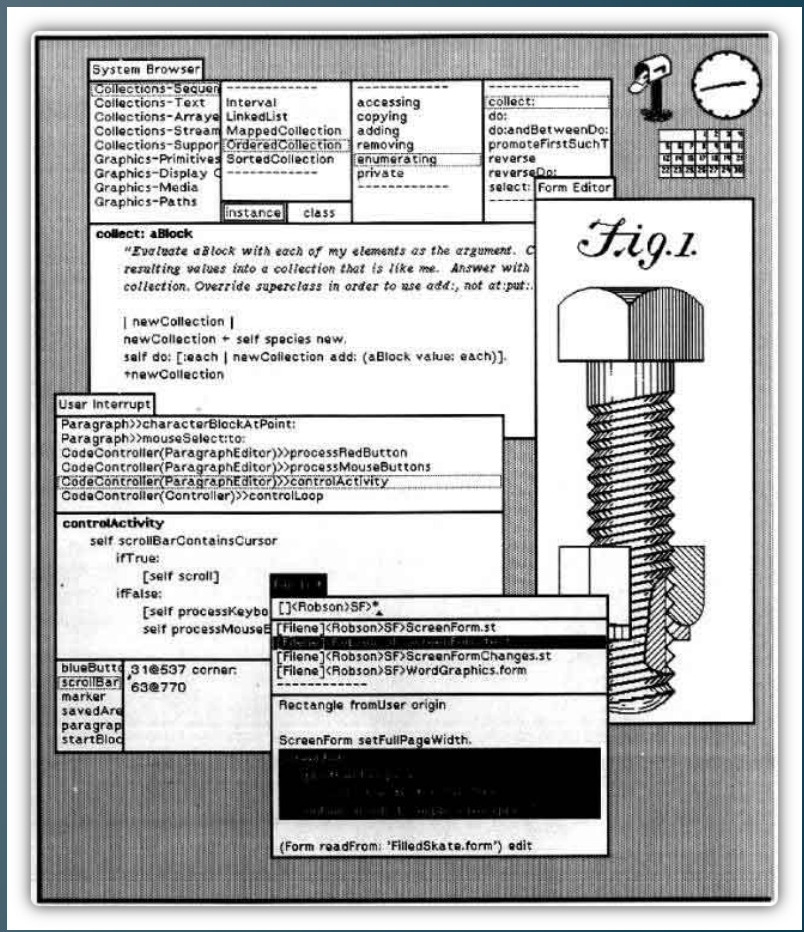


Getting a vision

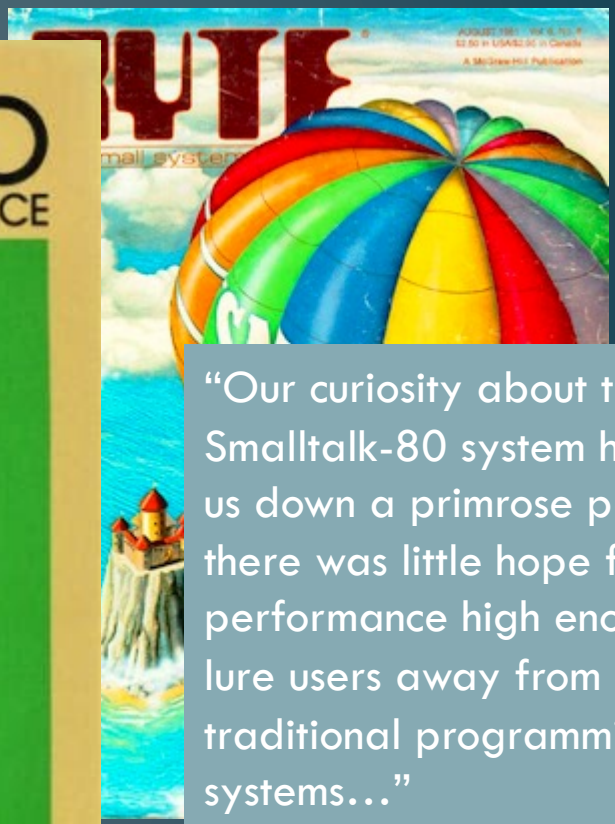
- 2nd West Coast Computer Faire, March 1978
- Alan Kay "Don't Settle for Less"







1980-81 Smalltalk Takes Flight



"Our curiosity about the Smalltalk-80 system had led us down a primrose path … there was little hope for performance high enough to lure users away from traditional programming systems…"

Joseph R. Falcone, "The Analysis of the Smalltalk-80 System at Hewlett-Packard" in *Smalltalk-80: Bits of History, Words of Advice*

Blinded by Metaphors

- The Smalltalk Virtual Machine
  - "Just reimplement the VM using your own hardware and run the virtual image."
- Tweaking wasn't enough
- The key to Smalltalk performance was understanding that you weren't building a computer, but implementing a language.

The true believers didn't give up…
A flowering of innovation

- Tektronix
- Deutsch/Schiffman
- Bosworth/Andersen
- Dave Thomas' OTI crew
- Ungar and the self guys

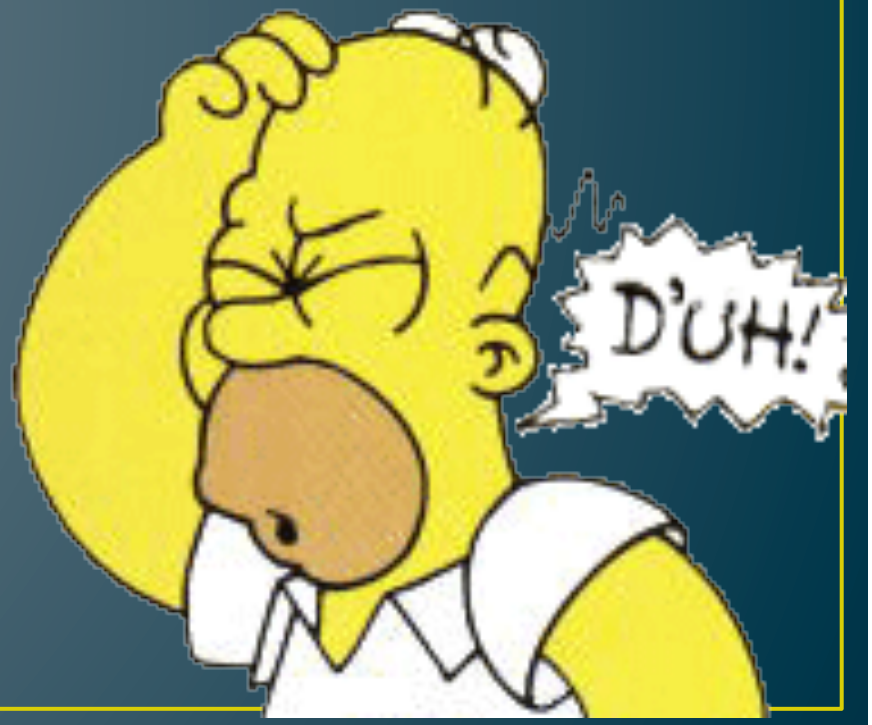
Tektronix 4404
Tektronix Smalltalk

Built 1984
Demo Oct. 2010

Things you never want to see in coding guidelines for your language:

"Avoid allocating objects"

"Minimize how many function/method calls you make"



Holistic Design → High Performance

Retrofits seldom achieve satisfactory results

Data representations
Register usage
Code sequences
Activation Records
Closure representation
Memory allocation
GC approach

Procedure encodings
Interp/jit/native code
Caching strategies
Cache invalidation
Encodings
Algorithms
Fast paths and fallbacks

Start with the Fundamentals

- Basic data encodings: values/atoms/OOPs
  - Tagged/untagged, hit bit/low bits, arithmetic instruction sequences
  - Cycle counts on target processors (x86, x64, ARM)
- How fast can you allocate
- Tiny write-barriers
- Fast-path polymorphic resolution
- 0/1/2 argument call/returns
- Minimizing loads/stores

- ❖ Common usage statistics and traces are very valuable
- ❖ Don't let the exceptional cases get too slow

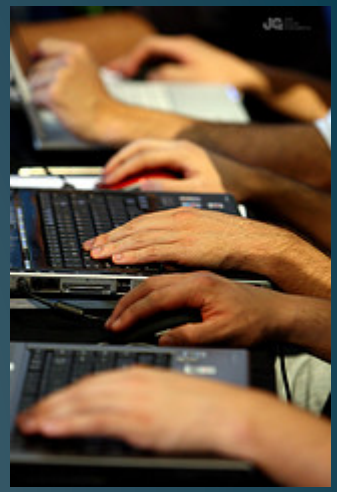
  They are probably what makes your language unique

It Takes Three to Become an Expert

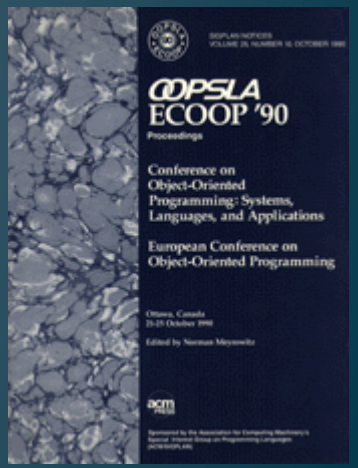
- One to learn the problem space
  - What are the key features and semantics of this language
  - What makes it slow
- One to explore the solution space
  - Study the literature
  - Experiment with design alternatives
  - Gain key insights and innovative solutions
- One to "put it all together"
  - Implement a clean, holistic design

Do Some Reading

Dude, I know you just want to write some code, but first you might want to take a look at:



- *Representing Type Information in Dynamically Typed Languages*, David Gudeman, University of Arizona, TR 93-27, October 1993
- OOPSLA Proceedings, particularly OOPSLA 86 → ≈ 2000
- ACM Lisp and Functional Programming Conference Proceedings, 1980 → ≈1994
- The Implementation Techniques section of the Online Scheme Bibliography http://library.readscheme.org/page8.html
- "*the* Garbage Collection Page", Richard Jones, http://www.cs.kent.ac.uk/people/staff/rej/gc.html (and Richard's book and the ISMM back proceedings)



A Programming Language is a “means” not an “end”

TEK 4406

SPECIFICATIONS
ORDERING INFORMATION

ARTIFICAL INTELLIGENCE SYSTEM

A top of the line, single-user Artificial Intelligence System supporting the four most popular AI languages in use today. Featuring very powerful standalone processing capabilities and ability to access host computing systems.

- High-performance 68020 32-bit CPU, 68881 floating point co-processor
- Smalltalk-80™ Artificial intelligence programming language provided standard
- Tek™ Common Lisp, MPROLOG™ and Franz Lisp available as options
- 19-inch, 1280 × 1024 bit-mapped display

The Tektronix 4406 Artificial Intelligence System is the highest performance member in the compatible Tek 4400 AI Series. Offering a high speed 16 Mhz Motorola 68020 32-bit microprocessor and a 68881 co-processor for floating point operations, the Tek 4406 is clearly state-of-the art. It has the power and memory to handle even the most complex AI programs with speed and efficiency. The system includes a 32 Mbyte virtual memory address space, a full 2 megabytes of dynamic RAM (expandable to 6 Mbytes) and a 90 Mbyte hard disk with accompanying 320 Kbyte 5¼" floppy. The optional 4944 Mass Storage Unit further enhances 4406 performance by providing incremental 90 Mbyte hard disk backup.

The Tek 4406 inherits the innovative design and advanced manufacturing techniques pioneered by the Tek 4404 AI System. Employing VLSI architecture and 32-bit data paths, the Tek 4406 is nearly twice as powerful as the Tek 4404. It is equally appropriate for AI research, application development, or as a cost effective delivery system.

Optimized display and graphic input

At the user interface, the 4406 incorporates high quality Tektronix display technology in a large 19" CRT operating at 60 Hz, non-interlaced. A 1280 × 1024 bit-mapped screen offers sharp text, graphics and icons. Screen interaction is accomplished with a 3 button mouse or with the keyboard's integral joystick.

AI programming environments

The Tek 4406 supports all of the popular AI programming languages in use today. Smalltalk-80, Tek Common Lisp, MPROLOG and Franz Lisp all run on the 4406. Programs developed on the Tek 4404 and 4405 are upwardly compatible with the 4406.

The Tek 4406 is supplied with a powerfully enhanced, proprietary version of the Smalltalk-80 language. This exploratory programming environment is well integrated, object-oriented and very extensible. It offers support for quick prototyping and simulation of user interfaces and complex, graphics-oriented applications. A text and graphics editor, incremental compiler, debugger and multiple window capabilities are all included standard.

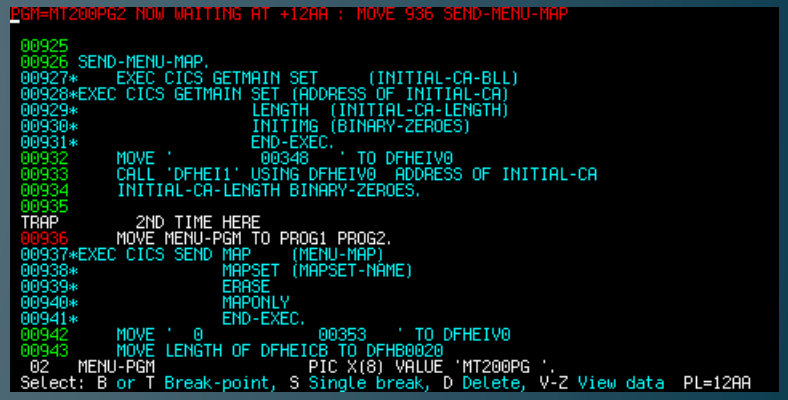
The optional Tek Common Lisp is a full implementation of the new industry standard for AI languages. It offers powerful manipulations of lists and symbolic expressions while providing a rich set of data types. Tek Common Lisp on the 4406 is a high performance, completely optimized, proprietary implementation.

Another optionally available programming environment, MPROLOG, is a dialect of Prolog. It is widely used for its logic programming orientation. The optional Franz Lisp language offers recursive programming techniques to facilitate building natural language interfaces and expert systems. It has the added benefit of a large base of existing applications, especially in UNIX environments. An optional EMACS visual text editor interfaces easily with all four languages available on the 4406. It allows rapid code entry which may be freely manipulated by the user.

Tektronix

What problems do your users really have?

- Client-side of client/server apps with rich UIs
  - From green screen to “modern” UIs
- Complex analytical business apps for rapidly evolving business sectors
  - Airline pricing
  - Insurance rating engines
  - Trading
  - Intelligence community



“Smalltalk - the Natural Successor to COBOL”

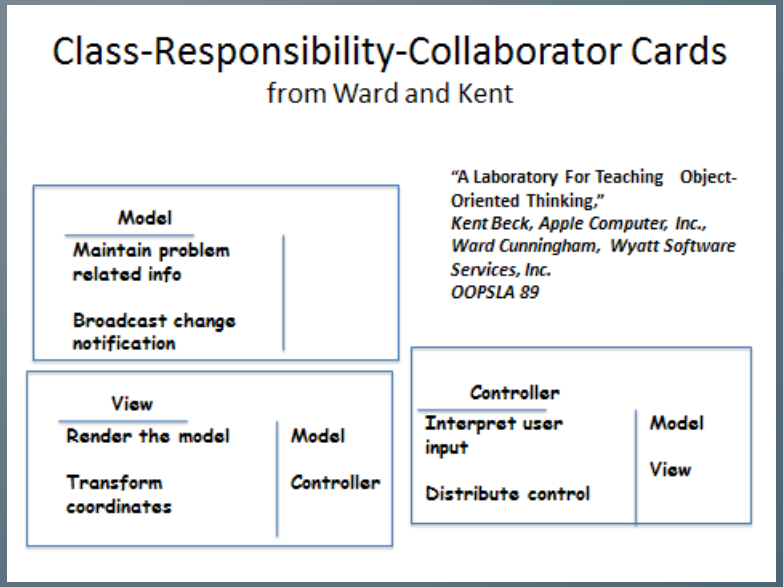
PC AI Mag circa 1994

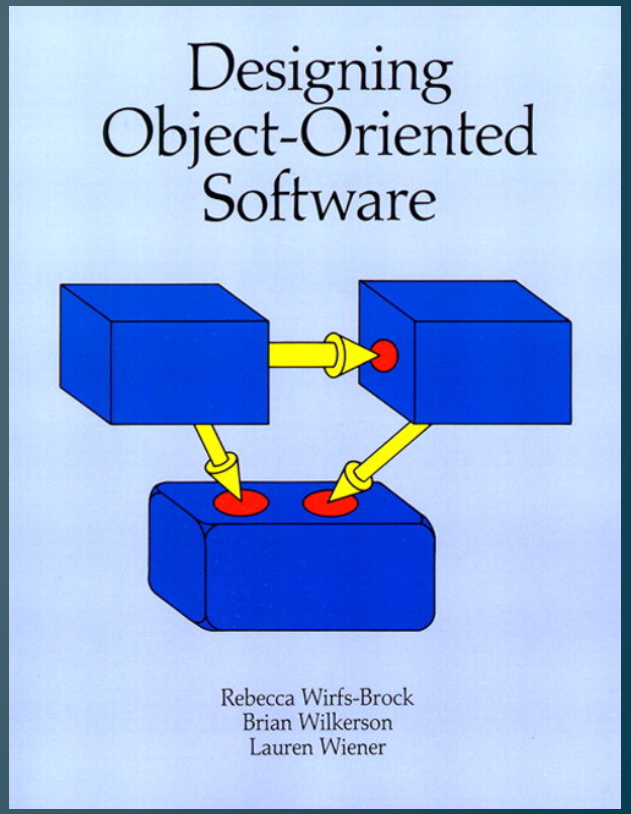
http://www.pcai.com/web/ai_info/pcai_smalltalk.html

Basic Technology isn't Enough

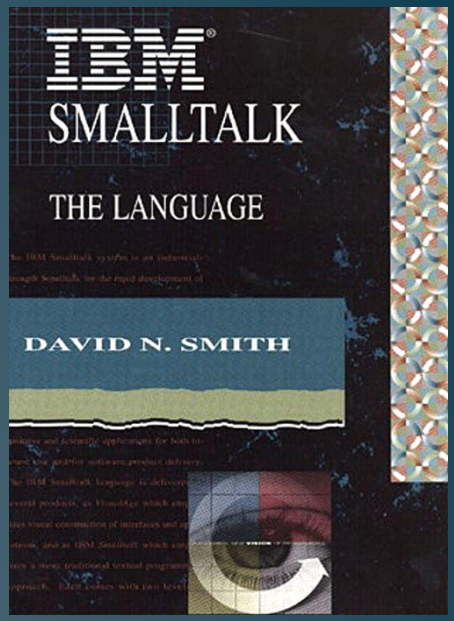
- *We will never be able to use your languages if you can't teach our guys how to go about designing object-oriented software*

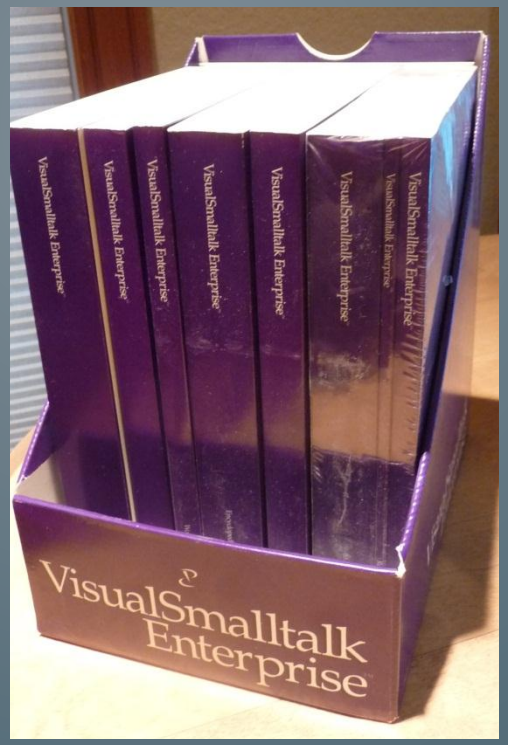
Hallway comment by an early adopter from a large enterprise at OOPSLA'88

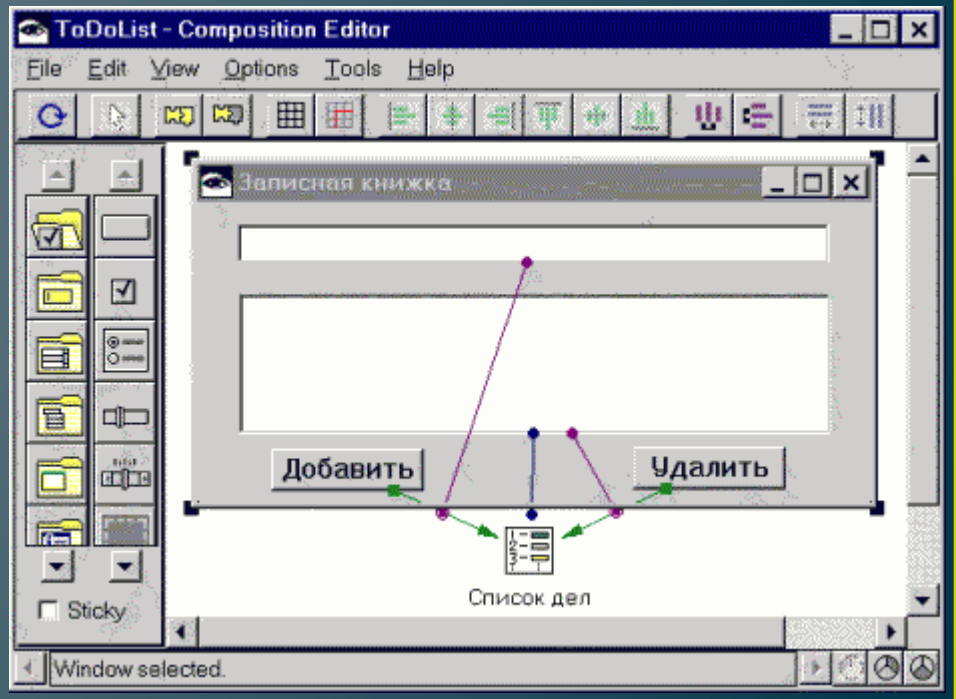




Smalltalk became an "Enterprise Class" Development Tool







Cargill Lynx System

Lynx is a global grain trading system that supports over 1,500 users at 150 sites around the U.S. and has been in production for over 15 years.

1997 Smalltalk R.I.P.

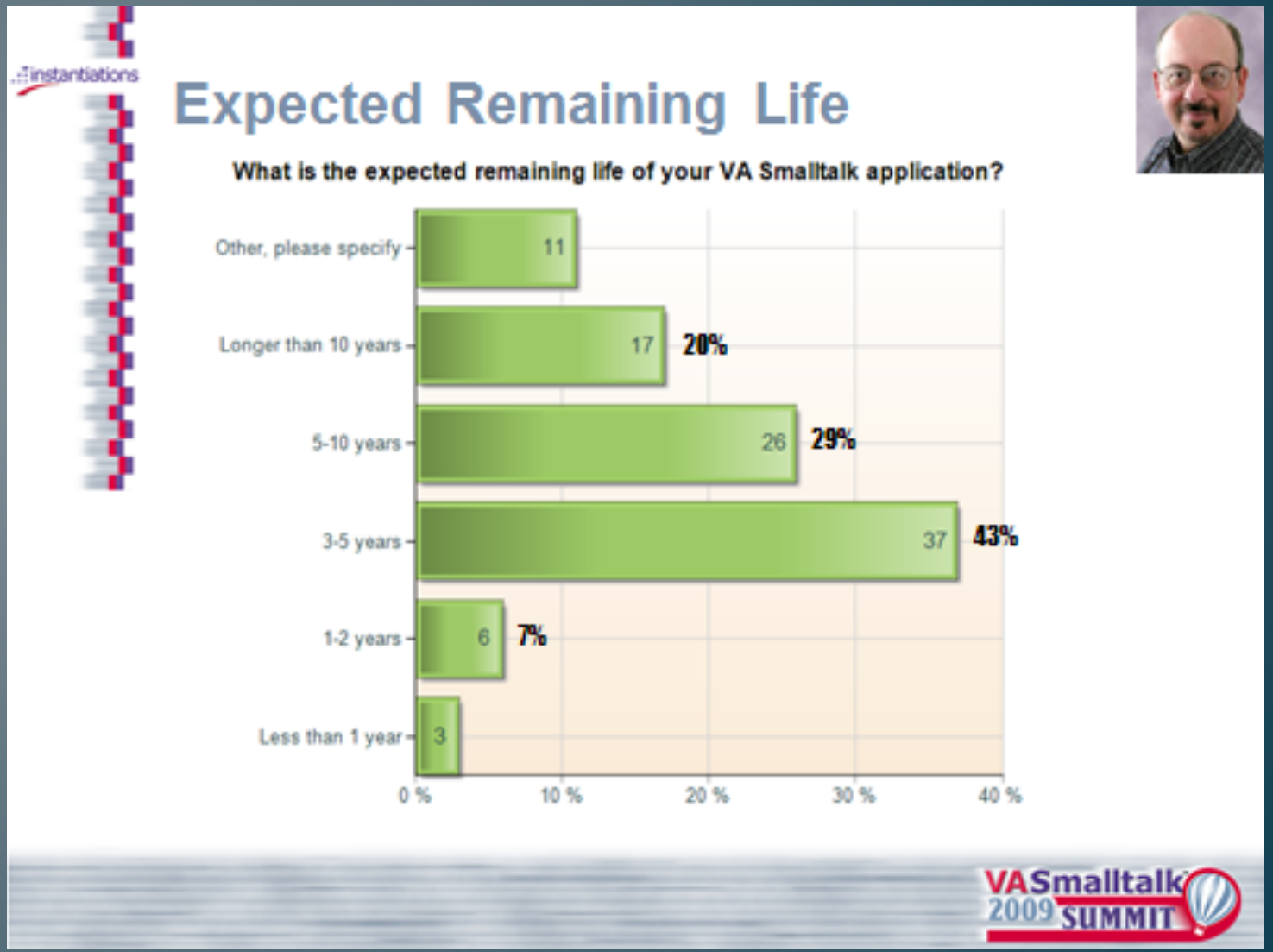
- 1995 IBM “bets” on Smalltalk
- 1997 Smalltalk is “dead” for new enterprise developments
- How could things go so wrong so fast?
  - A fad is not the mainstream
  - Solving the wrong problems

    GUI designers and visual programming instead of deployment
  - New problems require new solutions

    The Web
- Java happened!

  The solution that appears to be ready gets adopted (whether it really is or not)

Even so,
Smalltalk Lives on in the Enterprise

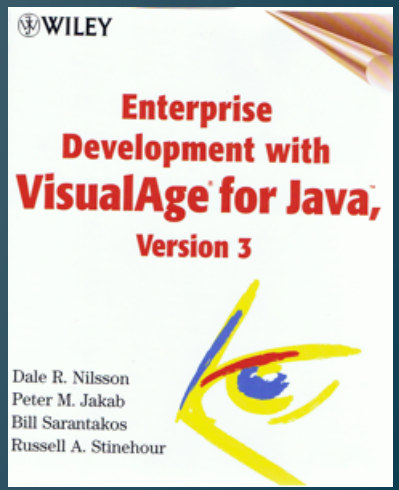


Smalltalk's Mark on the Mainstream

- "JIT" runtime techniques
- Generational garbage collection
- IDEs
- Frameworks
- Model-View-Controller
- Object-orient design methodologies and practices
- Software design patterns
- Refactoring and refactoring tools
- Agile development practices
- Test-driven development

The Java (and .NET) Era 1996-2005

- New problem requires new solutions
- Java starts as a fad and blows its browser client opportunity
- Even so, Java and .NET work their way into the server side mainstream
  - Familiar syntax
  - Conventional tools
  - More conventional deployment
- Smalltalk and Lisp language engineers and researchers “defect” to Java and .NET



Dynamic Languages 1995-2005
Retreating Into the Nooks and Crannies

- Ousterhot's "Scripting: Higher-Level Programming for the 21st Century", 1998
  - "Scripting language … are intended not for writing applications from scratch but rather for combining components"
- Perl
- Python
- Ruby
- Lua
- Early JavaScript

Why no progress in DL performance 1995-2005?

- Starting from simple, unsophisticated interpreters
- Undemanding users and uses
- Coasting on Moore's law
- Many implementers didn't believe better performance was possible?
- Mostly unaware of past dynamic language achievements
- The experts and researchers were all working on Java

2005 – AJAX is "Discovered"

- People want to build highly interactive browser apps
- Highly interactive code needs to run close to the user
- The only language that is ubiquitous to all browsers is JavaScript
- Web developers start creating frameworks and doing "real programming" using JavaScript

Fast JavaScript "Engines" Became Important!!

- Some initial tweaking of existing engines but they quickly "hit the wall"
- Lars Bak and the V8 team show that "fast" is actually possible
- Today every major browser is devoting significant resources to a high-performance JavaScript engine
- JavaScript performance for major browsers has generally improved by an order of magnitude or more compared to 2005

A Dynamic Language is again making a run for the mainstream.

Some Observations on the New JavaScript Engines

- Most teams haven't yet reach that 3rd implementation where it all comes together
  - Some teams are still on their 1st
- The performance bar is still too low
  - It isn't clear that they yet match the 1995 level of Smalltalk performance
  - Everybody needs to stop chasing Sunspider
- JavaScript is harder to make fast than Smalltalk was
  - Some really new ideas would be helpful
- Why are the memory footprints so large?
- Memory management designs are generally weak
  - Build a great GC and then use it everywhere
- The JS engine needs to be part of a holistic browser design

JavaScript Seems Poised for the Software Development Mainstream

- JavaScript is the only "built-in" programming language for the ubiquitous browser/web application platform
- It isn't clear how any other language or universal runtime can gain a similar position

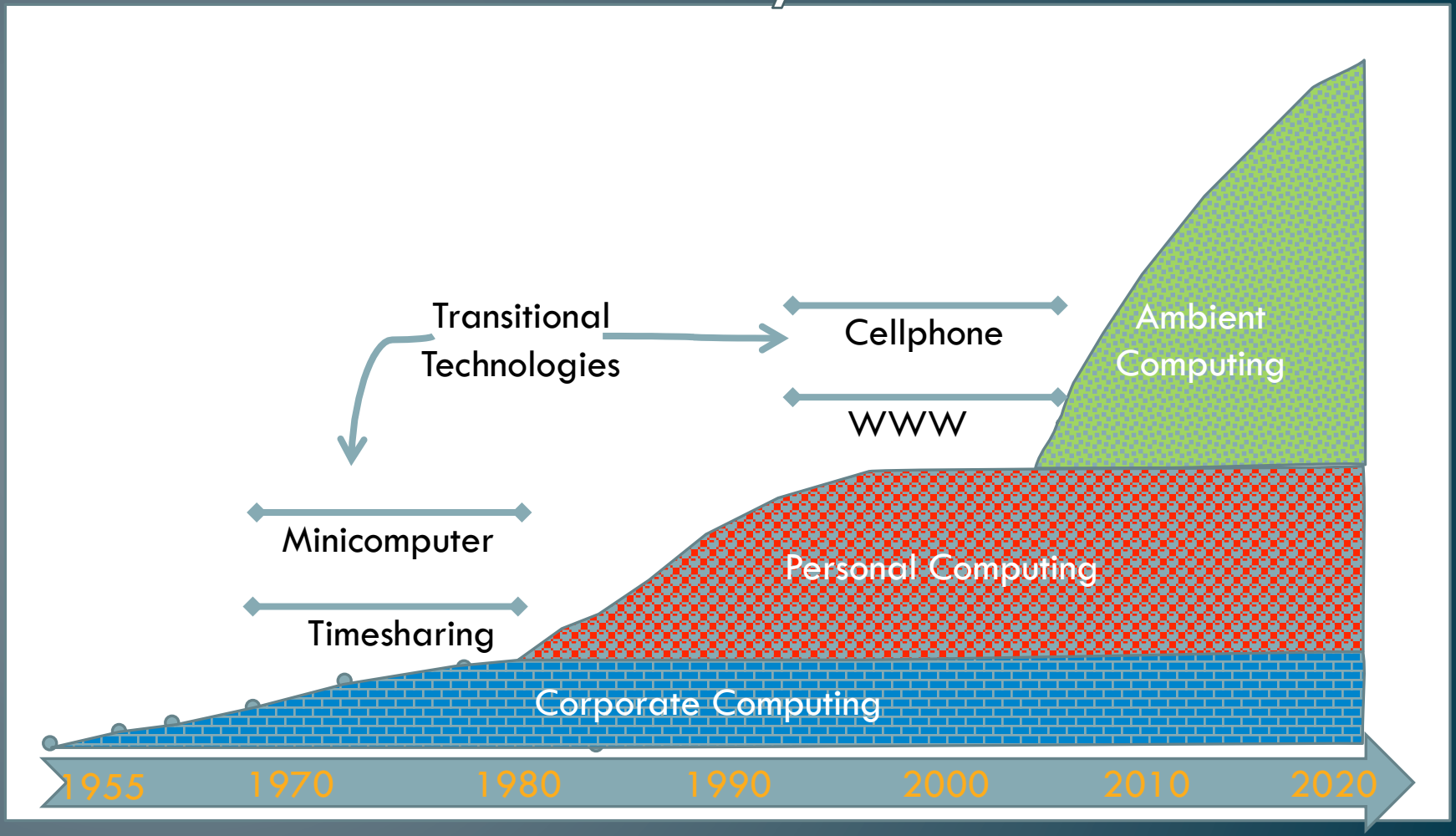
JavaScript is the "VM" of the web-client platform

- But remember: *We will never be able to use your languages if you can't …*
- What are the "can'ts" for JavaScript?
  - Make it scalable for large programs
  - Improvie it without breaking it
  - Continue improving on the performance, footprint, and power issues
  - Provide a great development experience
  - …

Onward with JavaScript Innovation

- This is the beginning, not the end of opportunities for JavaScript innovation
- It's not just about JavaScript, it's the entire web-client technology stack
- Industry needs research contributions to support and feed the pragmatic engineering of the production implementations
- Researchers need clean, accessible, but realistic and usable research platforms to build within and upon
  - Not just a JavaScript engine but an entire browser technology stack

The Next Era of Computing Has Already Started



Dynamic Languages Are a Mainstream Technology for This Era