What I learned about language and library design by working on Swift

Dave Abrahams | Principal Scientist | STLab

Artwork by **Elise Swopes** / USA

About the artist

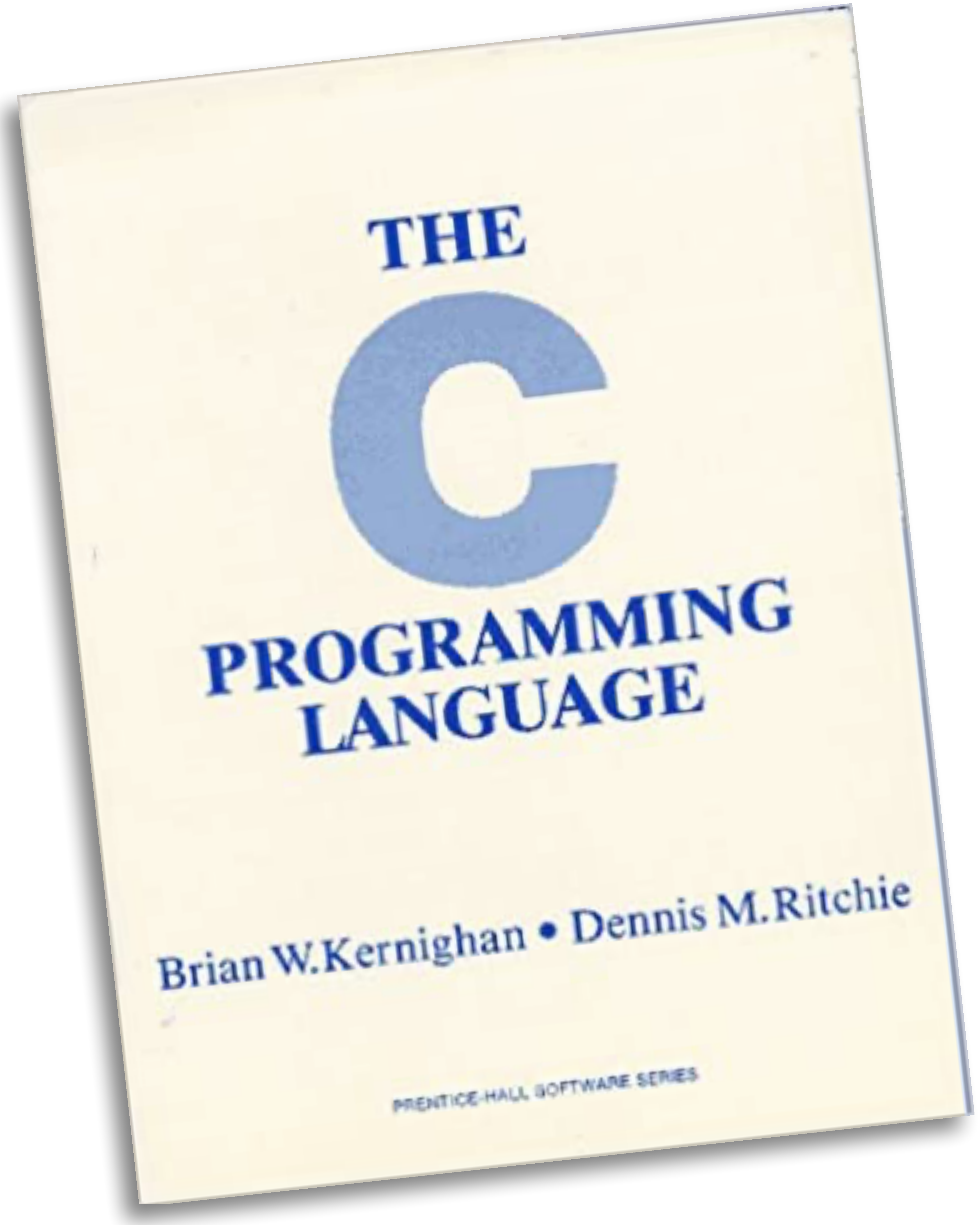
Elise Swopes

New York City-based photographer and graphic designer Elise Swopes manipulates the everyday into unexpected works of art. With her mobile phone, Adobe Photoshop, and Adobe Photoshop Lightroom, she creates whimsical, weird, dreamlike scenes. This piece was inspired from a recent visit to Copenhagen, where the bold colors and shapes of Danish architecture made quite an impression. A brilliant yellow apartment building inspired Swopes to create another entry in her surrealistic series featuring giraffes in unusual settings.

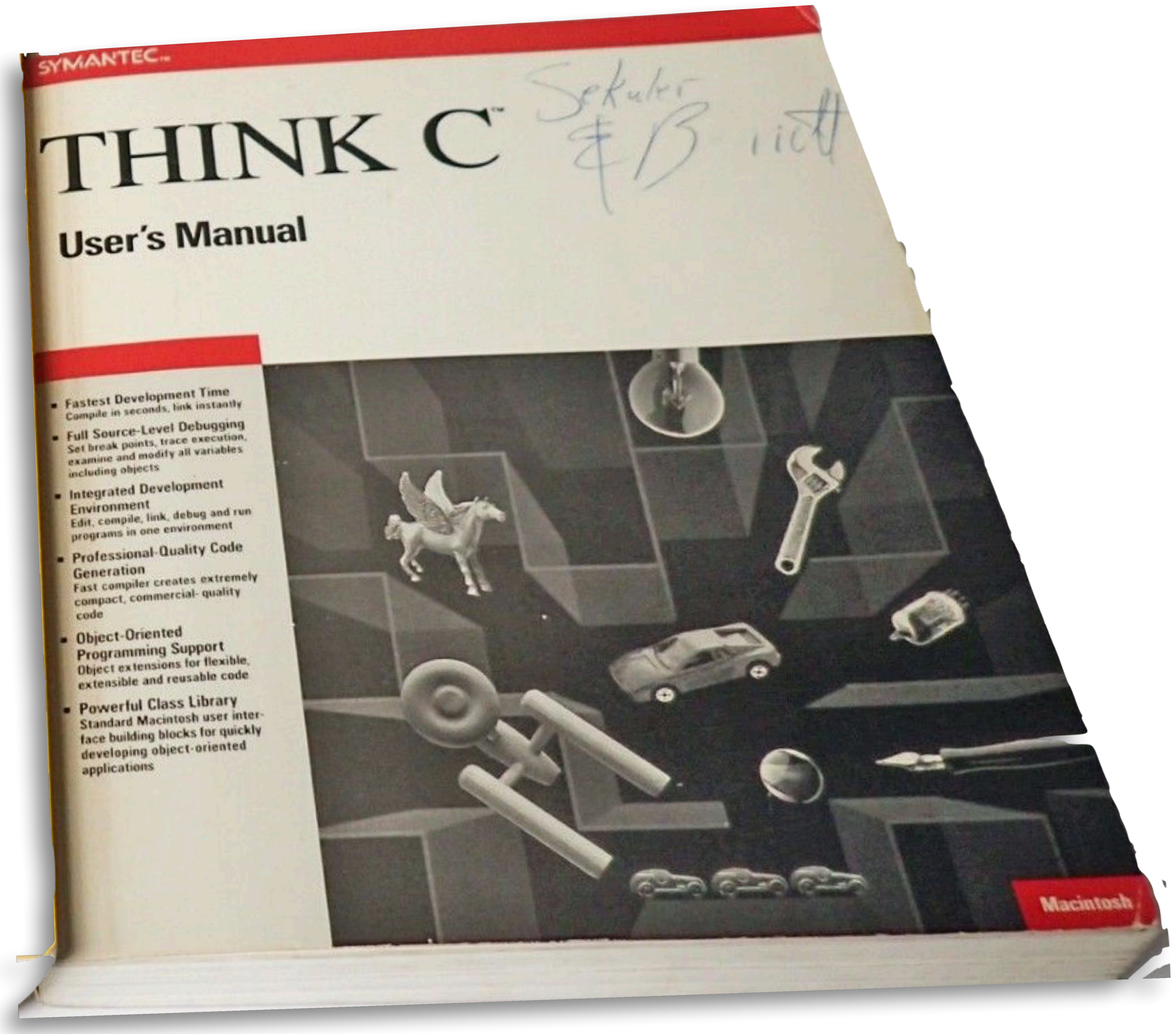
Made with

Ps Adobe Photoshop   Lr Adobe Photoshop Lightroom

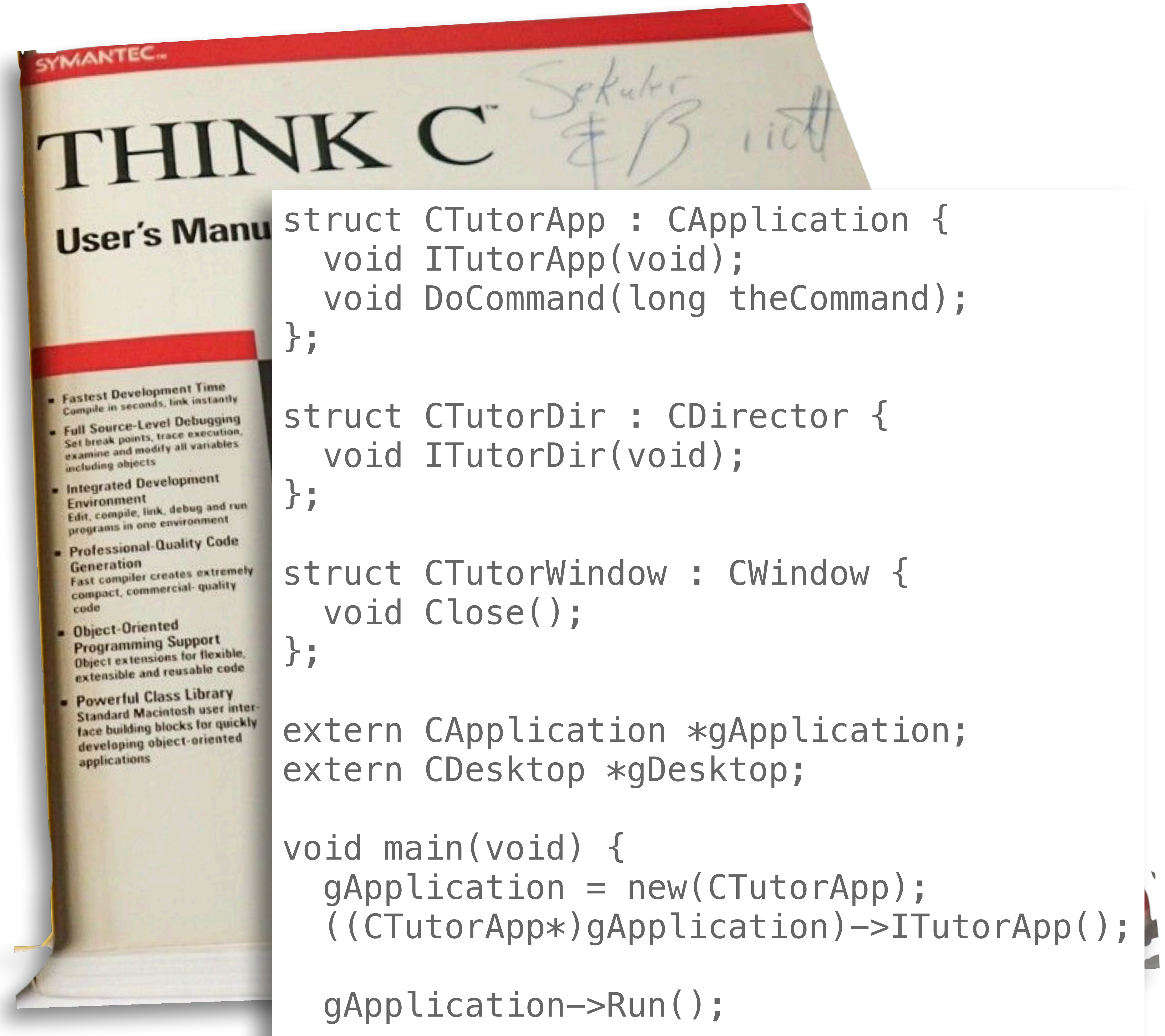
Mark of the Unicorn | 1988



Mark of the Unicorn | 1991

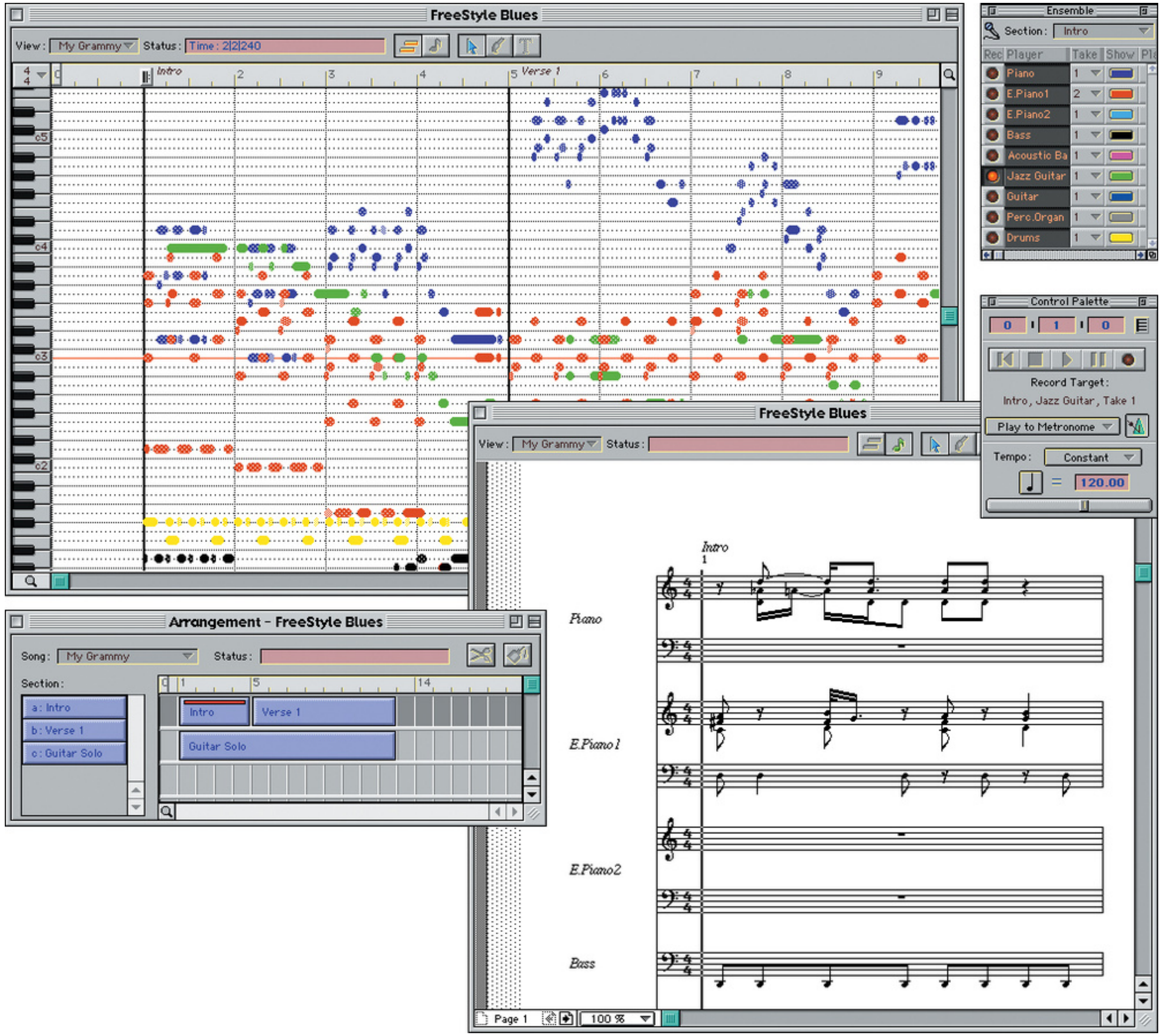


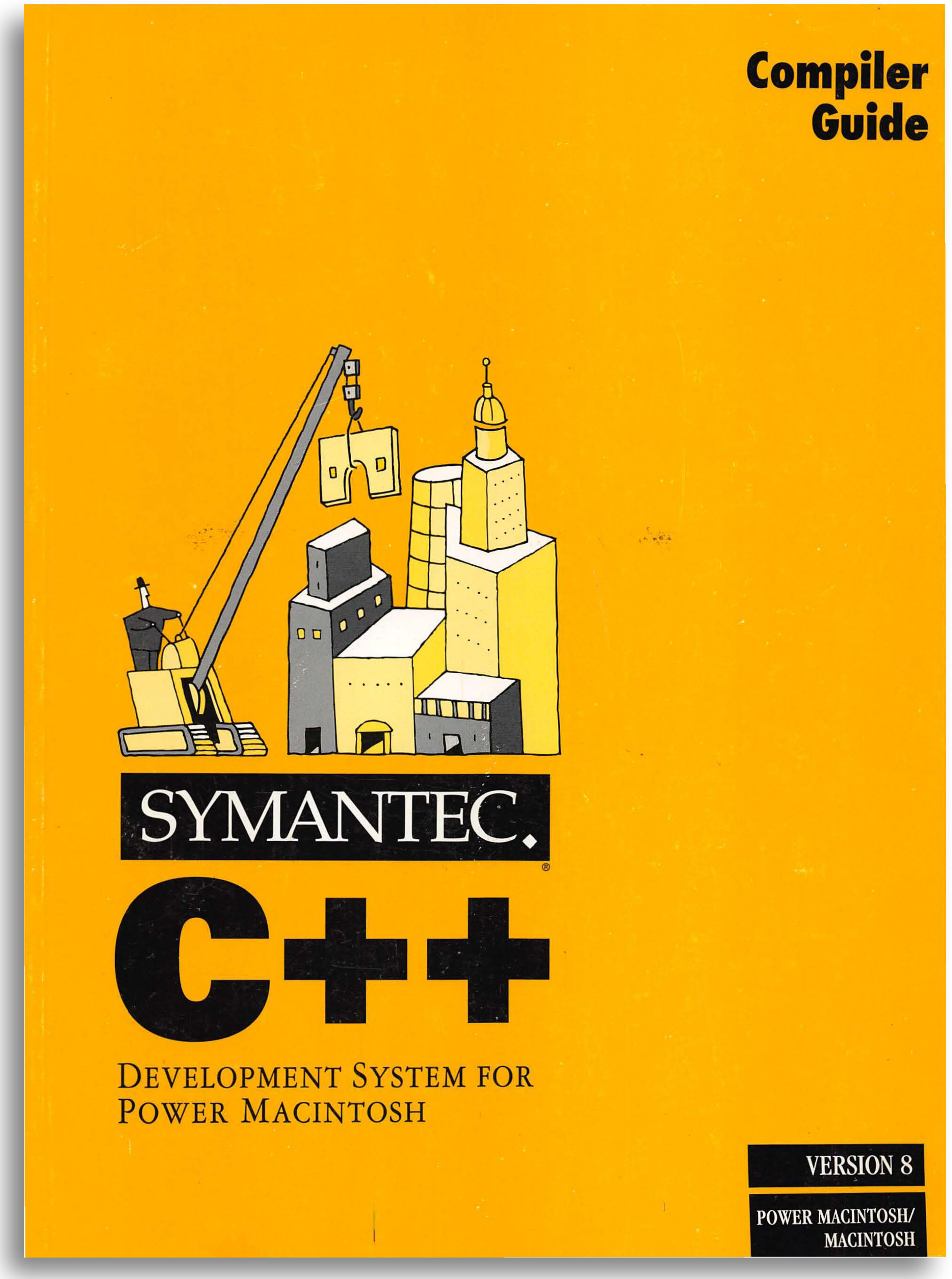
Mark of the Unicorn | 1991




```
struct CTutorApp : CApplication {
  void ITutorApp(void);
  void DoCommand(long theCommand);
};

struct CTutorDir : CDirector {
  void ITutorDir(void);
};

struct CTutorWindow : CWindow {
  void Close();
};

extern CApplication *gApplication;
extern CDesktop *gDesktop;

void main(void) {
  gApplication = new(CTutorApp);
  ((CTutorApp*)gApplication)->ITutorApp();

  gApplication->Run();

  gApplication->Exit();
}
```

Mark of the Unicorn | 1995





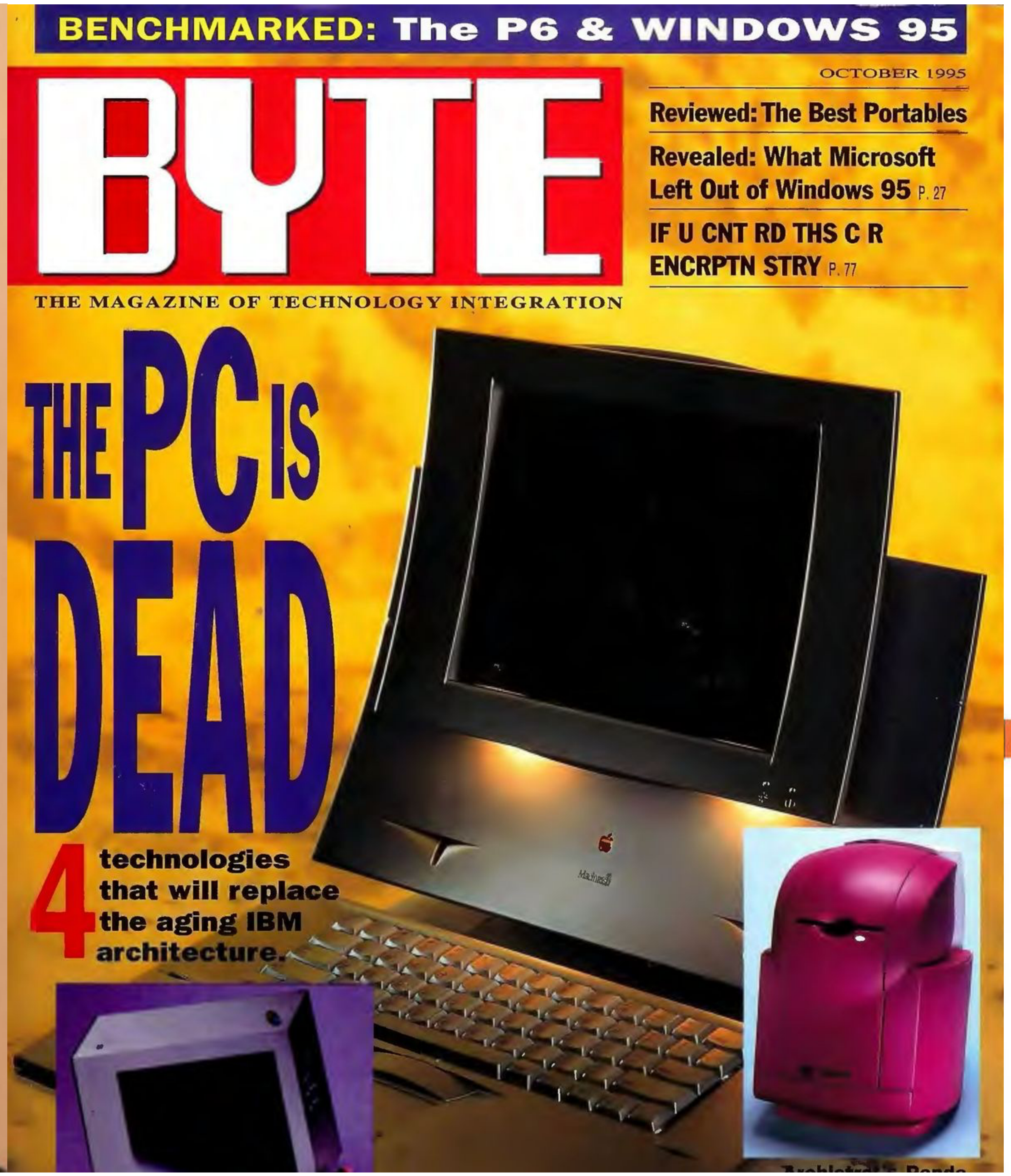
Blame it all on this guy…

Mark Wachsler

Blame it all on this guy...

Mark Wachsler

...and his tendency to learn...



...and to share

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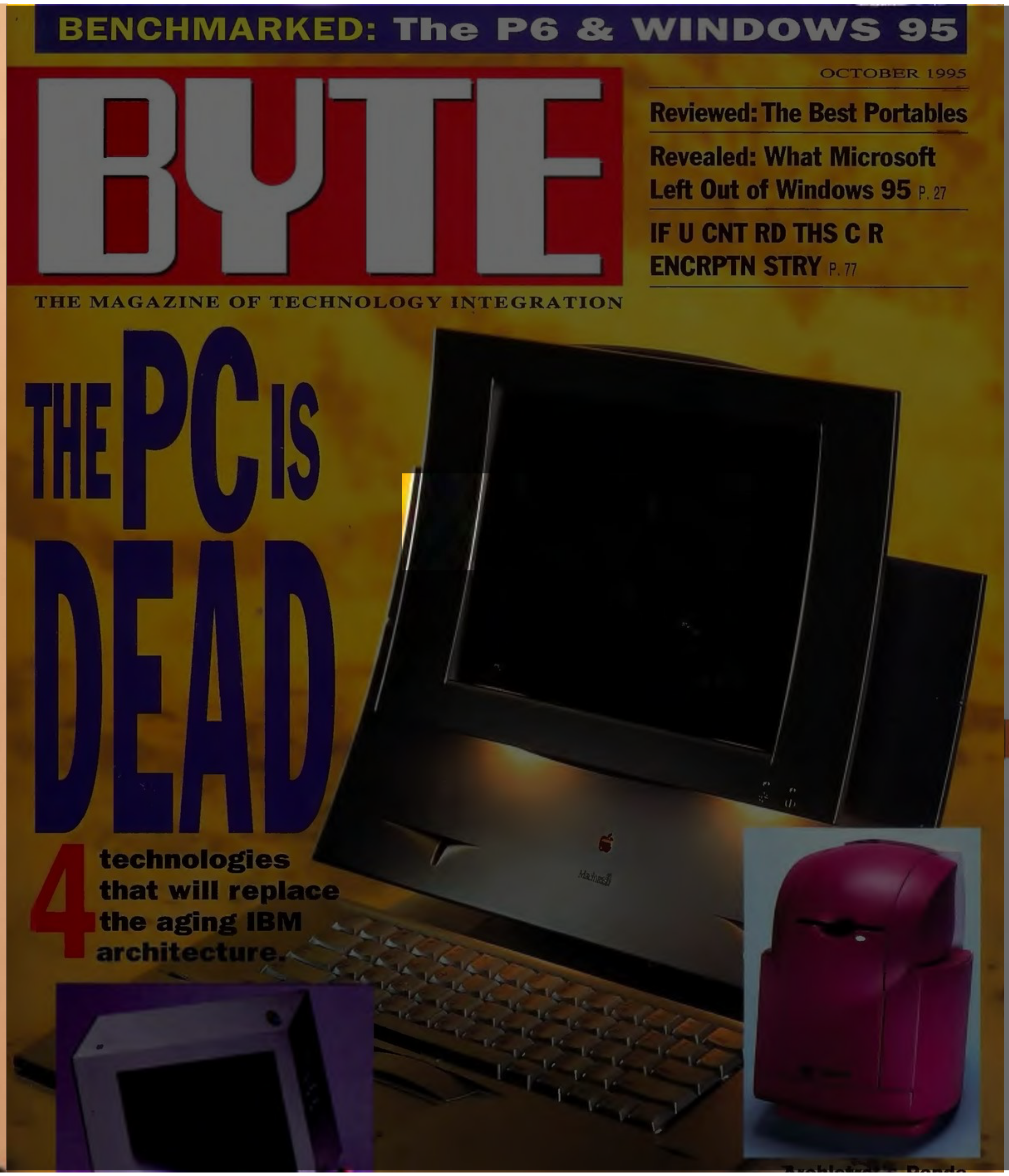
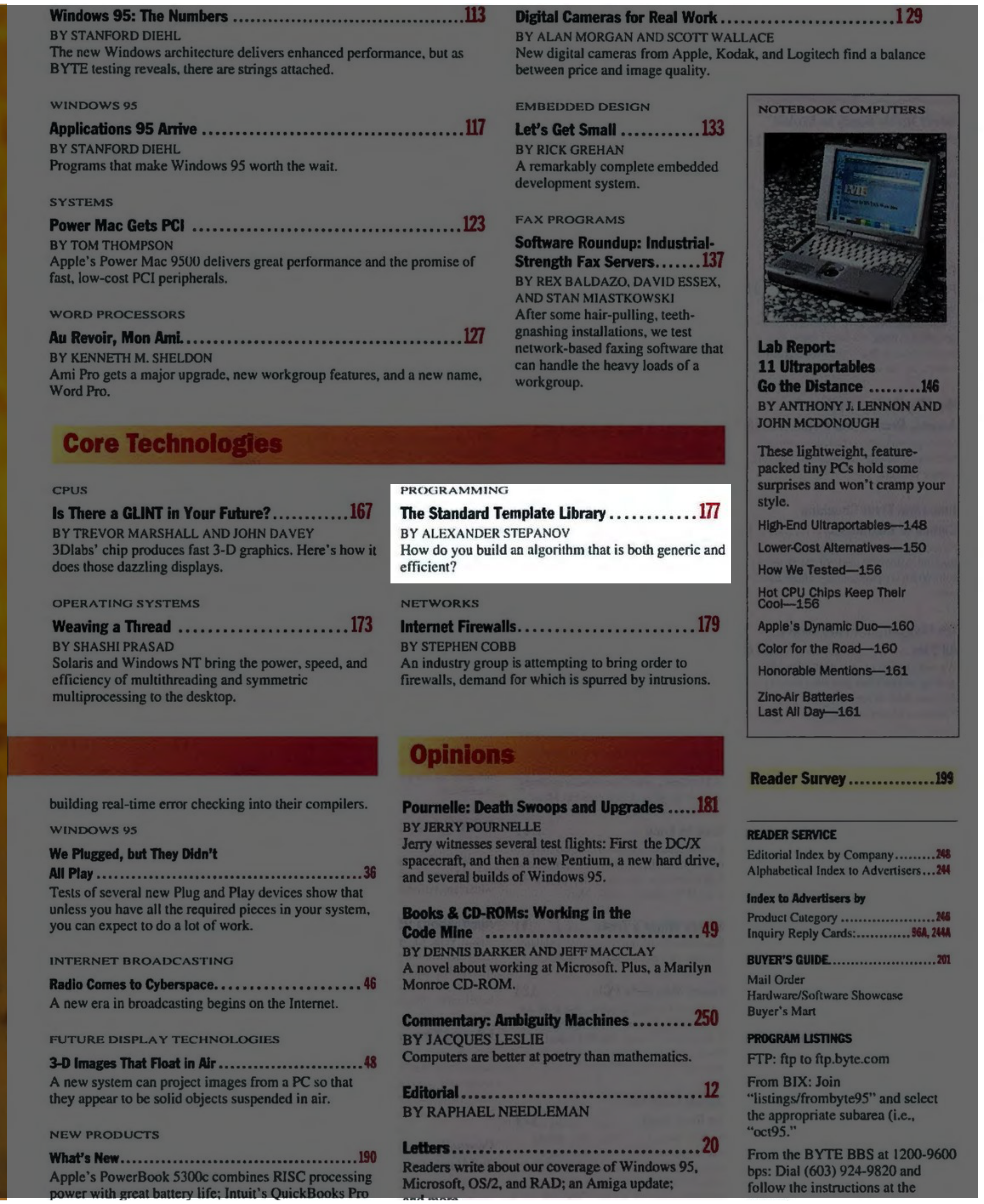
FTP: ftp to ftp.byte.com
From BIX: Join "listings/frombyte95" and select the appropriate subarea (i.e., "oct95."
From the BYTE BBS at 1200-9600 bps: Dial (603) 924-9820 and follow the instructions at the

Blame it all on this guy…

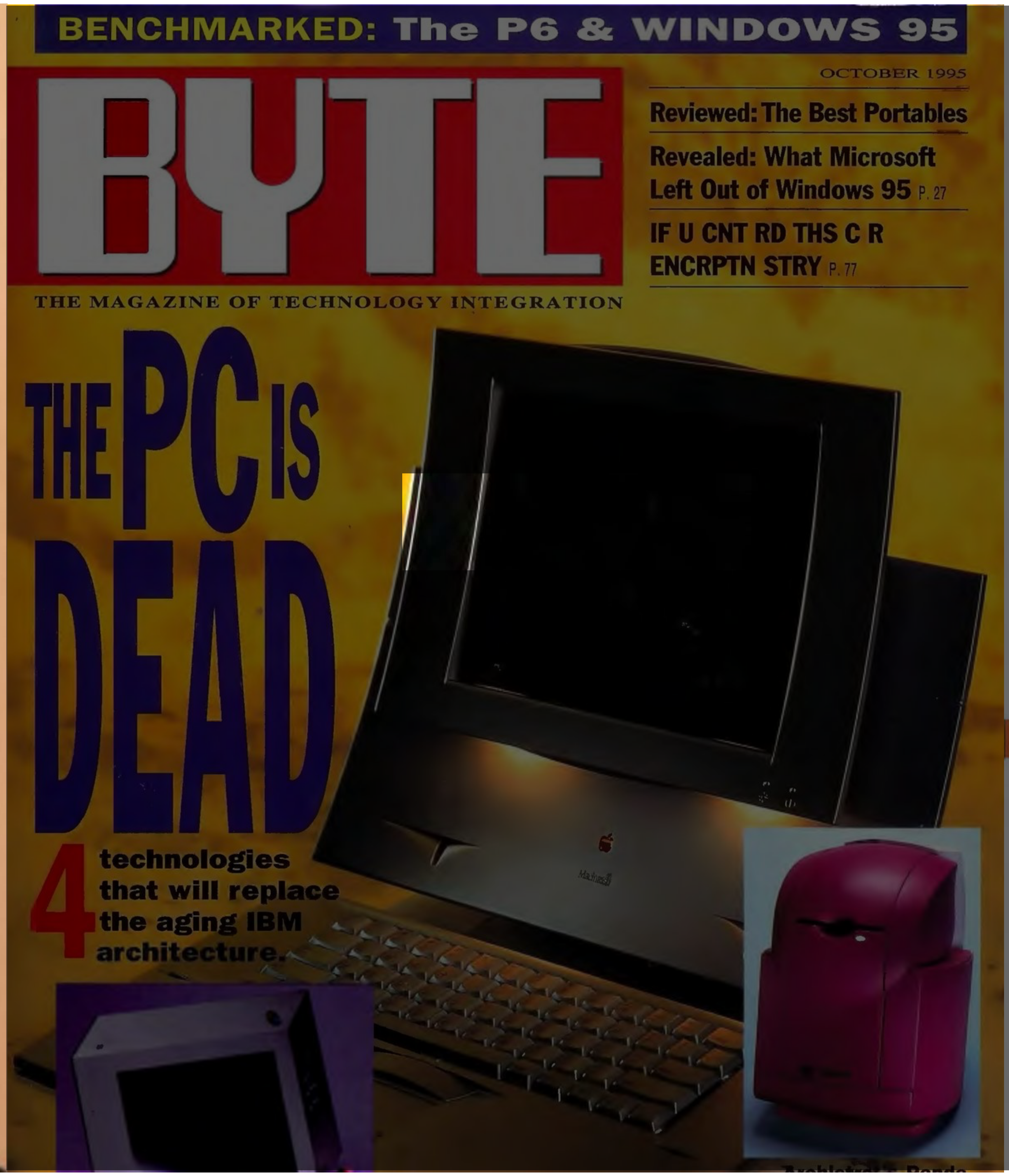
Mark Wachsler | **…and his tendency to learn…** | **…and to share**

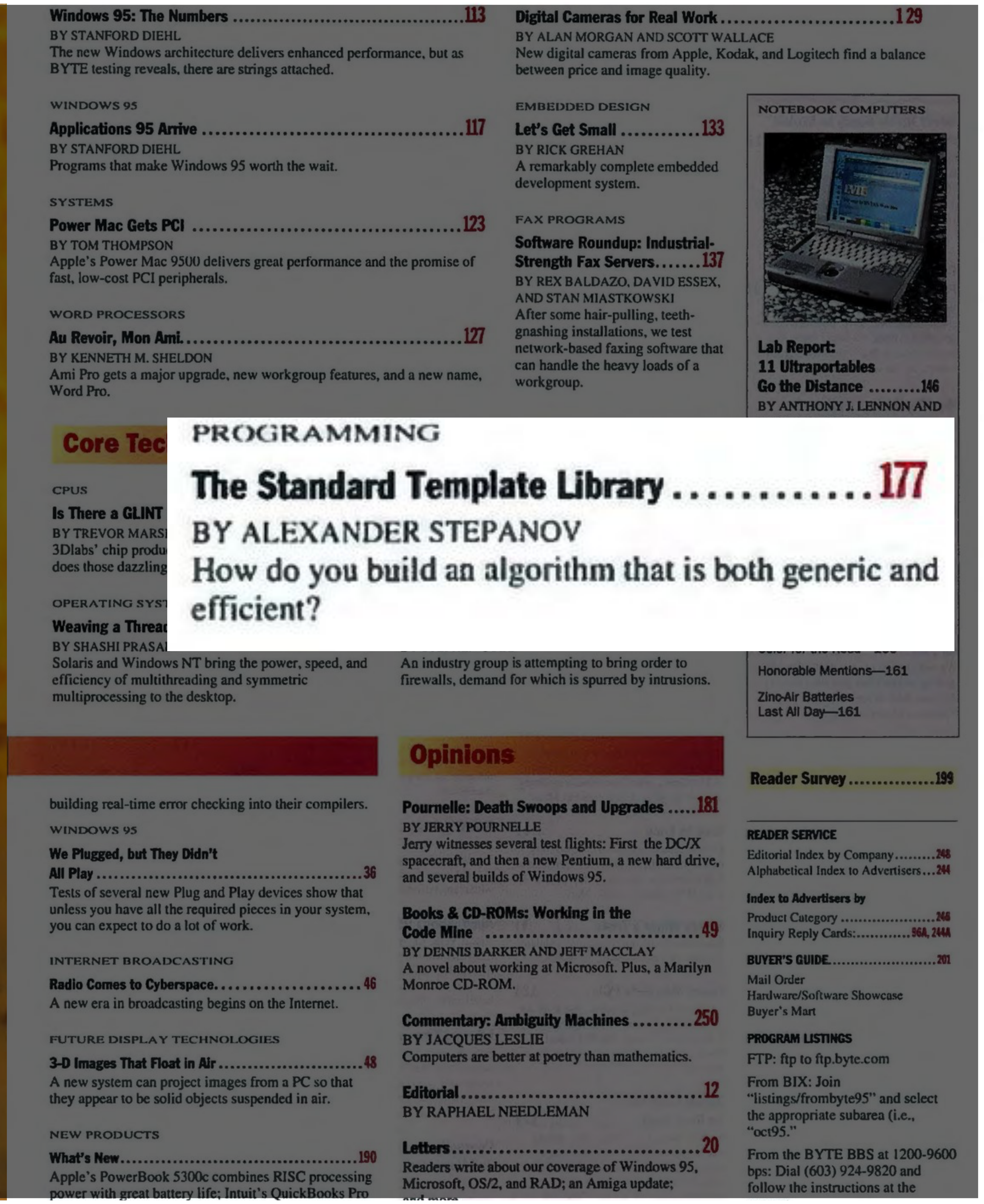




Blame it all on this guy…

Mark Wachsler | **…and his tendency to learn…** | **…and to share**

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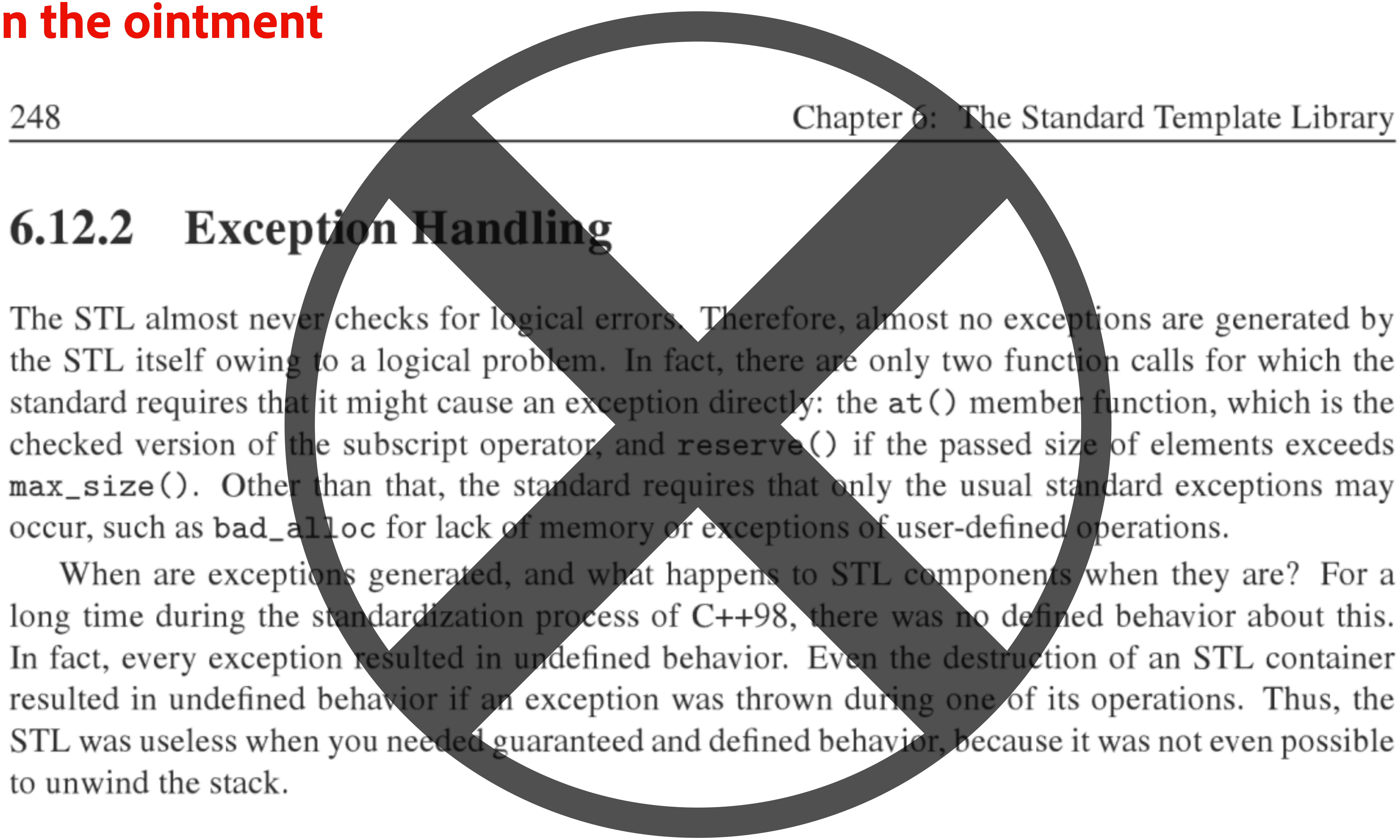
A fly in the ointment


248 Chapter 6: The Standard Template Library

6.12.2 Exception Handling

The STL almost never checks for logical errors. Therefore, almost no exceptions are generated by the STL itself owing to a logical problem. In fact, there are only two function calls for which the standard requires that it might cause an exception directly: the `at()` member function, which is the checked version of the subscript operator, and `reserve()` if the passed size of elements exceeds `max_size()`. Other than that, the standard requires that only the usual standard exceptions may occur, such as `bad_alloc` for lack of memory or exceptions of user-defined operations.

When are exceptions generated, and what happens to STL components when they are? For a long time during the standardization process of C++98, there was no defined behavior about this. In fact, every exception resulted in undefined behavior. Even the destruction of an STL container resulted in undefined behavior if an exception was thrown during one of its operations. Thus, the STL was useless when you needed guaranteed and defined behavior, because it was not even possible to unwind the stack.

A fly in the ointment

6.12.2 Exception Handling

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Dave's chain of custody

Alexander Stepanov

Greg Colvin

Andrew Koenig

C++ Committee Papers | 1997-2013

- N1075 | STL Exception Handling Contract | Dave Abrahams | 1997
- N1086 | Making the C++ Standard Library Exception-Safe | Dave Abrahams and Greg Colvin | 1997
- N1086 | Making the C++ Standard Library Exception Safe | Dave Abrahams and Greg Colvin | 1997
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- N3560 | Proposal for Assorted Extensions to Lambda Expressions | F. Vali, H. Sutter, D. Abrahams | 2013-03-17
- N3649 Generic (Polymorphic) Lambda Expressions (Revision 3) | F. Vali, H. Sutter, D. Abrahams | 2013-04-19

boost C++ LIBRARIES | 1998-?

Beman Dawes, R.I.P.

Brainchild of Beman Dawes

I was a co-founder

Spun off BoostPro Computing

Started BoostCon/C++Now conference

I was a total C++-head…

…and I was starting over

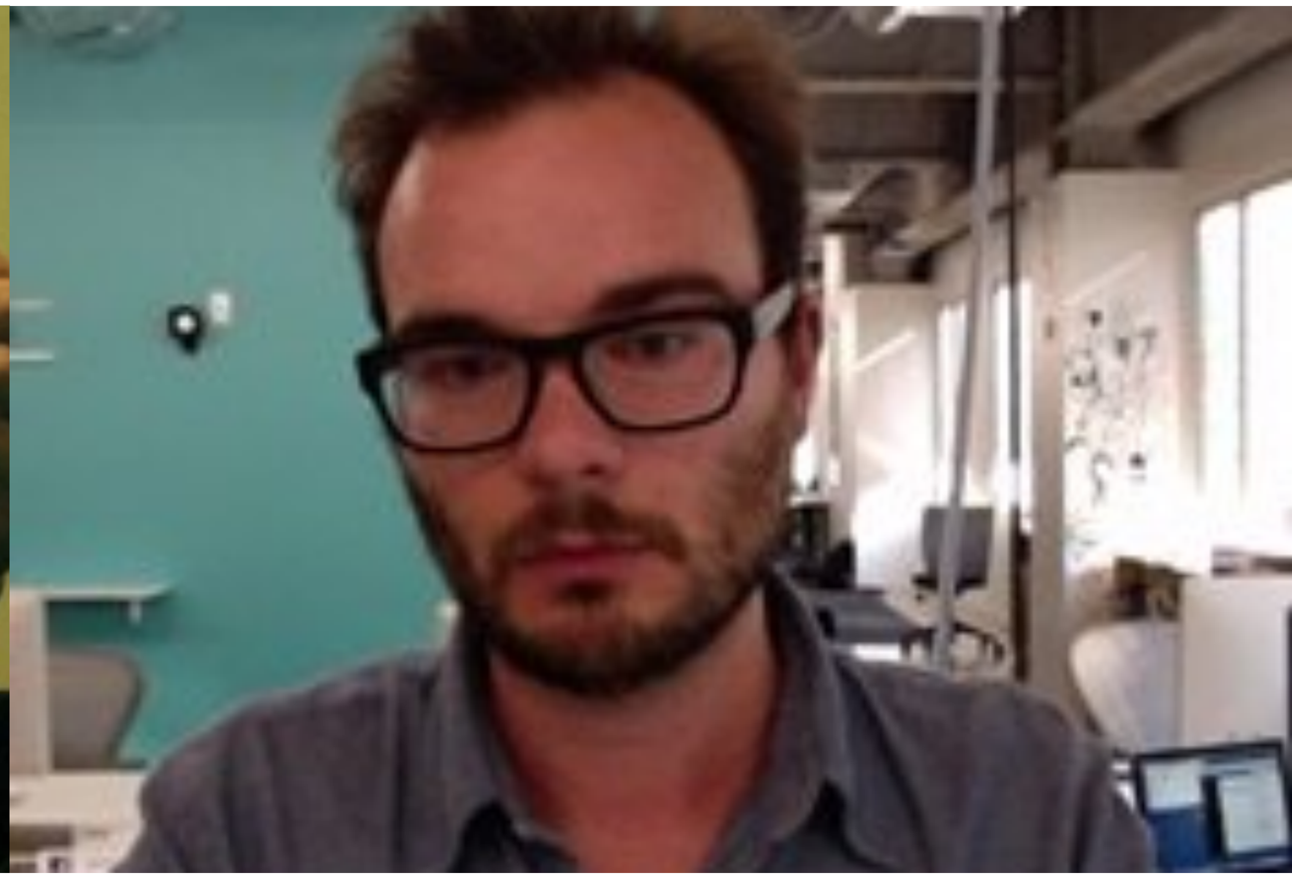
The (rest of the) design team

Dave Zarzycki

Doug Gregor

John McCall

Joe Pamer



Jordan Rose

Chris Lattner

Ted Kremenek

Joe Groff

Value Semantics

Spooky action at a distance

```
intro = "hello"
message = intro
message.append(", world")
```

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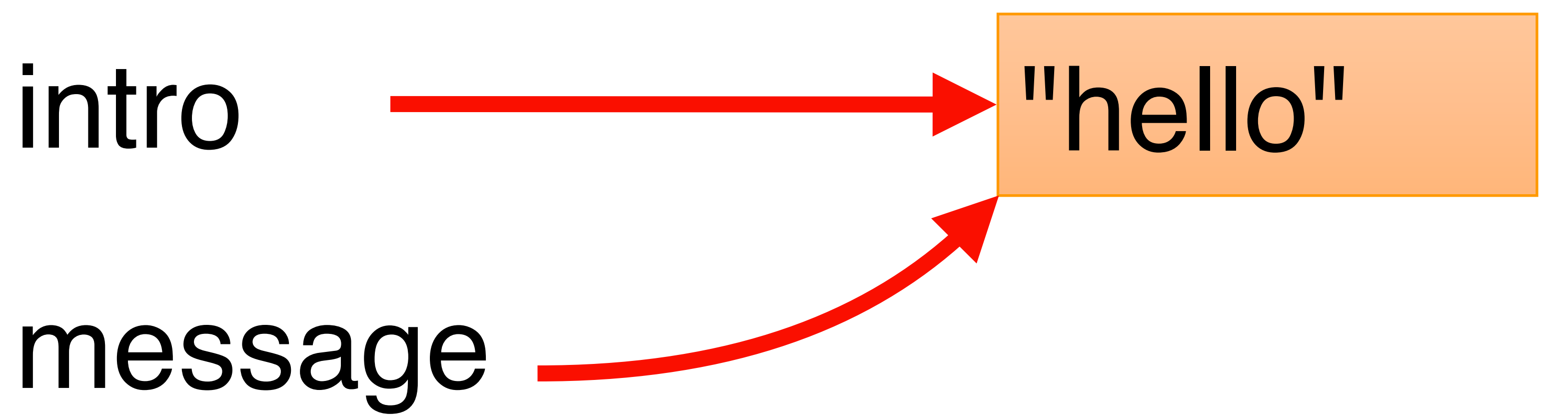

Spooky action at a distance

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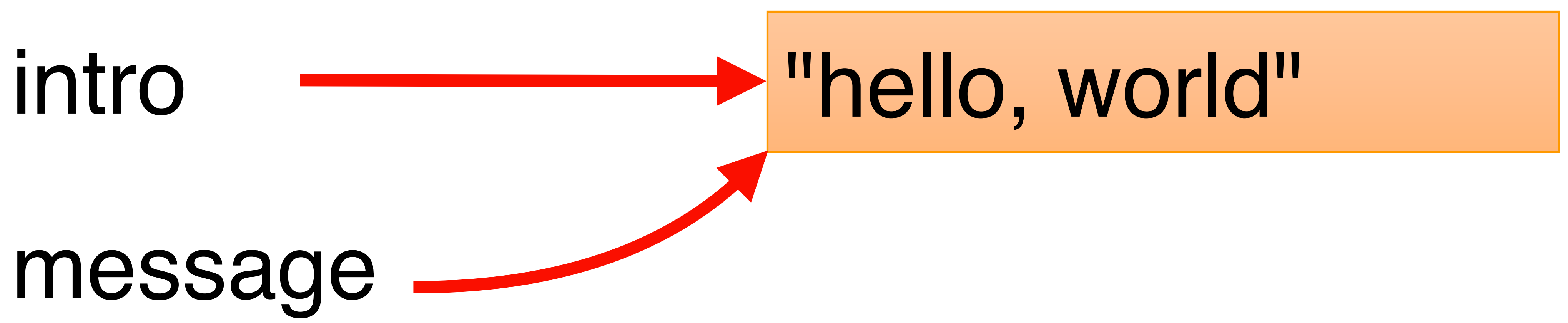

Immutable string is less spooky

```
intro = "hello"
message = intro
message = message.concat(", world")
```

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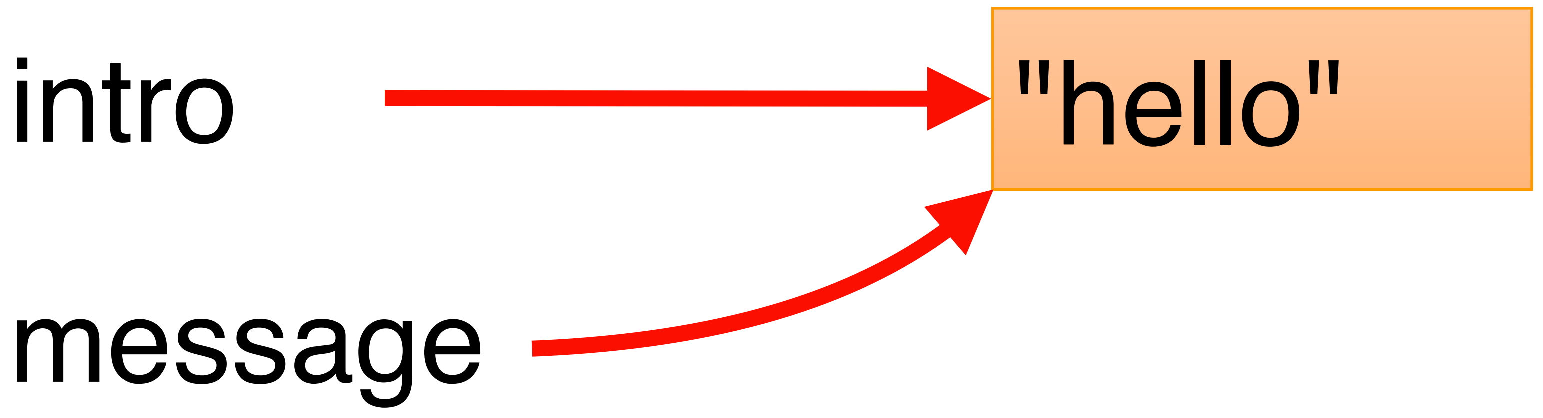

Immutable string is less spooky

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intro = "hello"
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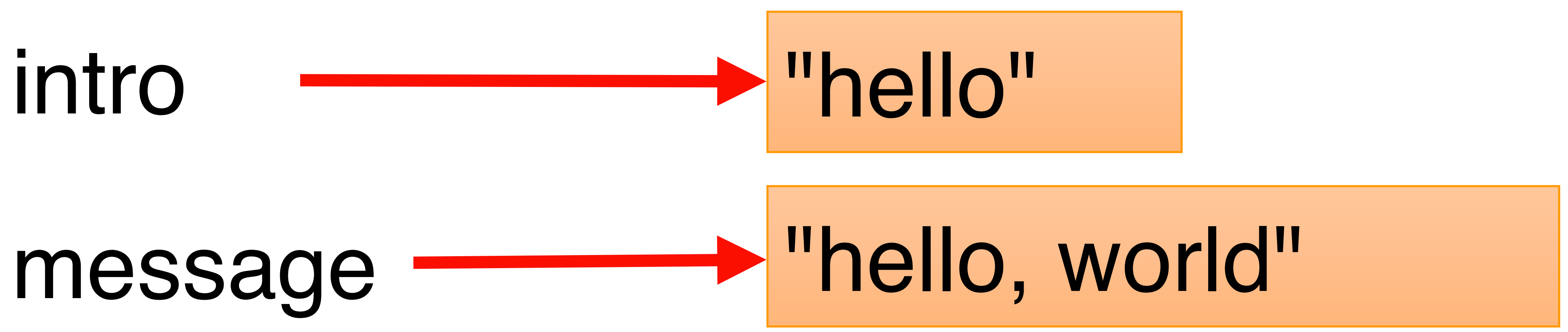

Philosophy of value semantics

Maybe the problem isn't mutation by itself, but mutation of shared state?

A deeper idea than I thought.

Philosophy of value semantics

Maybe the problem isn't mutation by itself, but mutation of shared state?

A deeper idea than I thought.

Problems with the immutable string scheme:

- Creating a new string buffer for every mutation step is expensive — $O(N^2)$.
- Add StringBuilder to manage mutating string buffers in place.
- StringBuilder ends up duplicating string's non-mutating API.
- One more type for the user to learn.

Dave's declaration

"Over my dead body will Swift have a StringBuilder!"

No rule of five

Array

Was a hack for testing the compiler, but not a design.

Had reference semantics!

Copy/assignment operators not implemented… yet?

Array

Was a hack for testing the compiler, but not a design.

Had reference semantics!

Copy/assignment operators not implemented… yet?

Time to bother Doug

Doug Gregor's declaration

"No rule-of-five programming for you!"

Doug Gregor's declaration

"No rule-of-five programming for you!"

🤷🏻‍♂️

Doug Gregor's declaration

“No rule-of-five programming for you!”

🤷‍♂️

“Use copy-on-write.”

Doug Gregor's declaration

"No rule-of-five programming for you!"

🤷🏻‍♂️

"Use copy-on-write."

"Go away and don't bother me; I need to code."

https://gist.github.com/alf-p-steinbach/c53794c3711eb74e7558bb514204e755

alf-p-steinbach / **strings 1 - Why COW is ungood for std string\strings 1 - Why COW is ungood for std string .md**

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Why COW was deemed ungood for std::string

strings 1 – Why COW is ungood for std string\strings 1 – Why COW is ungood for std string .md Raw

Why COW was deemed ungood for std::string.

COW, short for *copy on write*, is a way to implement mutable strings so that creating strings and logically copying strings, is reduced to almost nothing; conceptually they become free operations like no-ops.

Basic idea: to share a data buffer among string instances, and only make a copy for a specific instance (the *copy on write*) when that instance's data is modified. The general cost of this is only an extra indirection for accessing the value of a string, so a COW

No rule of five | Consequences

All variable-sized value types use CoW

Copy and assignment never have to allocate memory

Copy and assignment is always O(1)

Copy and assignment can never fail

Optimizer was taught to remove redundant reference counting.

Optimizer was taught to hoist uniqueness checks

We fearlessly pass arrays, strings, and dictionaries by value

Chris Lattner's Observation

"C++ has value semantics, but nobody uses it."

Parameter passing

Say what you mean? | Sincere parameter passing

```
// Returns the sum of elements in `x` and calls `dump` on each one.
auto sumAndDump(std::vector<int> const x, void(*dump)(int)) -> int {
    ranges::for_each(x, dump);
    return std::accumulate(x.begin(), x.end(), 0);
}
```

Say what you mean? | Sincere parameter passing

```
// Returns the sum of elements in `x` and calls `dump` on each one.
auto sumAndDump(std::vector<int> const x, void(*dump)(int)) -> int {
    ranges::for_each(x, dump);
    return std::accumulate(x.begin(), x.end(), 0);
}

std::vector x = {0, 1, 2, 3};
void d(int) { x[e] += 1; }
int main() {
    std::cout << f(x, d); // Prints "6"
}
```

Say what you mean? | Facetious parameter passing

```
// Returns the sum of elements in `x` and calls `dump` on each one.
auto sumAndDump(std::vector<int> const& x, void(*dump)(int)) -> int {
    ranges::for_each(x, dump);
    return std::accumulate(x.begin(), x.end(), 0);
}

std::vector x = {0, 1, 2, 3};
void d(int) { x[e] += 1; }
int main() {
    std::cout << f(x, d); // Prints "10"
}
```

Say what you mean? | Facetious parameter passing

```
// Returns the sum of elements in `x` and calls `dump` on each one.
auto sumAndDump(std::vector<int> const& x, void(*dump)(int)) -> int {
    ranges::for_each(x, dump);
    return std::accumulate(x.begin(), x.end(), 0);
}

std::vector x = {0, 1, 2, 3};
void d(int) { x[e] += 1; }
int main() {
    std::cout << f(x, d); // Prints "10", not "6"
}
```

Mutation

Facetious | Pass by reference

```
X y;

auto frob(X& y) -> void {
  foo();
  bar(y);

}

frob(y);
```

Sincere | Functional update

```
X y;

auto frob(X y) -> X {
  foo();
  bar(y);
  return y;
}

y = frob(y);
```

Mutation

Facetious | Pass by reference

```
X y;

auto frob(X& y) -> void {
  foo();
  bar(y);
}


frob(y);
```

Sincere | Functional update

```
X y;

auto frob(X y) -> X {
  foo();
  bar(y);
  return y;
}

y = frob(y);
```

Mutation in Swift

```
var y: X;

func frob(_ y: inout X) -> Void {
  foo();
  bar(&y);
}


frob(y);
```

Dave's last theorem

Swift's model of parameter passing can be extended to allow noncopyable types to be efficently passed "by value" or by move with minimal complexity, and the model could be applied to a future version of C++.


Adobe
Artwork by Elise Swopes / USA
Ps
Lr