Errata for *Elements of Programming*

Alexander Stepanov and Paul McJones
Semigroup Press, 2019; Addison-Wesley Professional, 2009
Last edited June 17, 2019

The latest version of this document is available at

Authors' Edition, June 2019

None known; all previous errata have been corrected. Thanks to Fernando Pelliccioni for proofreading the Authors' Edition.

Sixth printing, November 2016 (to be corrected in next printing)

Page xi, second paragraph: Append this sentence just before the final footnote mark: "We thank Jeremy Murphy, Robert Southee, and Yutaka Tsutano for finding errors in the sixth printing."

Page 49, lines 10, 11, and 12: Change "Op" to "R". (Reported by Yutaka Tsutano.)

Page 93, line 3: Change "**property**(I : *Iterator*, N : *Integer*)" to "**property**(I : *Iterator*)". Also, on lines 4 and 6 change "N" to "DistanceType(I)". (Reported by Yutaka Tsutano.)

Page 110, Lemma 6.13: Change the inequality to:

$$\text{cost}_{\mathsf{successor}} < \frac{1}{3}(1 - \frac{2\log_2 \mathsf{n}}{\mathsf{n}})\text{cost}_{\mathrm{predicate}}$$

(Reported by Robert Southee.)

Page 199, last line: Change "`pointer(T) l;`" to "`DistanceType(pointer(T)) n;`".

Page 200, line 2: Change "`l(f)`" to "`n(0)`".

Page 200, lines 6 and 8: Change "`l`" to "`f + n`".

Page 200, line 9: Change both occurences of "`l`" to "`n`".

Page 200, line 33: Change "`c.l`" to "`c.f + c.n`". (Changes to page 199 and 200 reported by Jeremy Murphy.)

Page 204, line -17: Change "(r_0 with r_1 and r_2 with r_3)" to "(r_0 with r_2 and r_1 with r_3)". (This was an error fixing an earlier erratum from the third printing.)

Page 253, left column: Change "find_if_not, 97" to "find_if_not algorithm, 97".

Fifth printing, December 2015

No errata were reported in this printing.

Fourth printing, January 2015 (corrected in fifth printing)

[A number of errata originally reported in the third printing were inadvertently not corrected in the fourth printing.]

Page xi, second paragraph: Append this sentence just before the final footnote mark: "We thank Matt Austern, Robert Jan Harteveld, Daniel Krügler, Volker Lukas, Veljko Miljanic, Doug Morgan, Jeremy Murphy, Qiu Zongyan, Mark Ruzon, Yoshiki Shibata, Sean Silva, Andrej Sprogar, Mitsutaka Takeda, Stefan Vargyas, and Guilliam Xavier for finding errors in the (third and) fourth printing."

Page 17, line 7 from bottom: Delete sentence beginning "The definition space ..." (Reported by Doug Morgan.)

Page 19, line 9: Insert "unsigned" before "integral type of the same size". (Reported by Daniel Krügler.)

Page 22, lines 11 and 17 from bottom, and page 28, line 10: Change the font of "p" to "p". (Reported by Qiu Zongyan.)

Page 31, line 6 from bottom, and page 98, line 7 from bottom: Change "Domain(op)" to "Domain(Op)". (Reported by Guilliam Xavier.)

Page 66, Lemma 5.2: Change "n^3 is the multiplicative inverse modulo 5 of a positive integer $n \neq 0$" to "$f(n) = n^3$ is the multiplicative inverse for the multiplication of non-zero remainders modulo 5". (Reported by Stefan Vargyas.)

Page 112, line 3: Change "half-open on left ranges of the form $(f, l]$" to "the returned value". Also change the precondition for find_backward_if to:

> // *Precondition:* readable_bounded_range(f, l)

(Reported by Veljko Miljanic.)

Page 116, line 11 from bottom: Change "own descendant" to "own proper descendant". (Reported by Matt Austern.)

Page 127, requirements for bifurcate_equivalent_nonempty: Change "`ValueType(I0)`" to "`ValueType(C0)`". (Reported by Sean Silva.)

Page 128, requirements for bifurcate_equivalent: Change "`ValueType(C)`" to "`ValueType(C0)`". (Reported by Sean Silva.)

Page 131, requirements for bifurcate_compare: Change

```
Relation(R) && ValueType(C) == Domain(R)
```

to


```
ValueType(C0) == ValueType(C1) &&
Relation(R) && ValueType(C0) == Domain(R)
```

(Reported by Sean Silva and Mark Ruzon.)

Page 143, line 10 from bottom: Change "`};`" to "`}`". (Reported by Guilliam Xavier.)

Page 154, copy_n precondition: "f_{i+n}" should be "$f_i + n$" and "f_{o+n}" should be "$f_o + n$". (Reported by Mitsutaka Takeda.)

Page 155, line 9: Change "postcondition" to "precondition". (Reported by Yoshiki Shibata.)

Page 162, line 7: Change "$(l_{i_0} - f_{i_0}) + (l_{i_1} - f_{i_1})$" to "$(l_{i_0} - f_{i_0}) - (l_{i_1} - f_{i_1})$". (Reported by Yoshiki Shibata.)

Page 174, Exercise 10.4: Change "representive" to "representative". (Reported by Qiu Zongyan.)

Page 182, Lemma 10.24: Change "and $3(n-2)$ otherwise" to "and $3(n-1)$ otherwise". (Reported by Volker Lukas.)

Page 189, line 5: Change "$3(n-2)$" to "$3(n-1)$". (Reported by Guilliam Xavier.)

Page 211, line 18: Change "`addressof(x.a[k])`" to "`begin(x) + k`". (Reported by Jeremy Murphy.)

Page 213, line 19: Change "$0 \leqslant i \leqslant \mathsf{size}(w)$" to "$0 \leqslant i < \mathsf{size}(w)$". (Reported by Sean Silva.)

Page 213, last line: Change "`int`" to "`DistanceType(I)`". (Reported by Daniel Krügler.)

Page 217, line 17: Change "$n-k$ values in the open interval $[0, n-k)$" to "$n-k+1$ values in the closed interval $[0, n-k]$" (Reported by Qiu Zongyan.)

Page 218, line 12 from bottom: Change "The cost of insert before or after an erase at an arbitrary iterator is constant." to "The cost of insert (both before or after an iterator) or erase is always constant." (Reported by Qiu Zongyan.)

Page 234, line 6 and page 236, line 26: Change "`identifer`" to "`identifier`". Also, page 235, last 2 lines: Change "`identifer_list`" to "`identifier_list`"

(two occurrences). (Reported by Guilliam Xavier.)

Page 249, first column and page 259, first column: Change "reverse_with_temporary_buffer" to "reverse_n_with_temporary_buffer". (Reported by Guilliam Xavier.)

Also, on same pages and columns: Drop page number 140 from entries for "reverse_append" and add new entries after "reverse_indexed" for "reverse_linked, 140" on page 249 and for "reverse_linked algorithm, 140" on page 259. (Reported by Yoshiki Shibata.)

Page 257, second column: Change "properly partial object state" to "properly partial object type". (Reported by Qiu Zongyan.)

Page 260, second column: Change "total object state" to "total object type". (Reported by Qiu Zongyan.)

Third printing, June 2010 (corrected in fourth printing)

Page xi, second paragraph: Append this sentence just before the final footnote mark: "We thank Shinji Dosaka, Ryan Ernst, Steven Gratton, and Abraham Sebastian for finding errors in the third printing."

Page 14: Change line 6 to:

$$n \mapsto (|n| \neq 1) \wedge (\forall u, v \in \mathsf{N})\, uv = n \Rightarrow (|u| = 1 \vee |v| = 1)$$

(Reported by Steven Gratton.)

Page 29, line 4: Change "1979" to "1982".

Page 76, footnote 5: Insert "Volume 3," before "pages 14–22".

Page 105, Lemma 6.8: Insert a right parenthesis after each of the two occurrences of "$(\forall m \in [f, l)$" and change the typeface of all occurrences of m, f, l, j, and p in these two formulas to match the p, f, and l in the first line.

Page 133, first line of section 8.1: Change "interator" to "iterator". (Reported by Abraham Sebastian.)

Page 183, line 5: Change "If $p.m0 = m \wedge p.m0 = l$" to "If $p.m0 = m \wedge p.m1 = l$". (Reported by Ryan Ernst.)

Page 203, sort_n_with_buffer precondition: $n/2$ should be $\lceil n/2 \rceil$. (Reported by Ryan Ernst.)

Page 204, sentence before merge_n_step_0: Change "Rotating the ranges r_2 and r_3" to "Rotating the ranges r_1 and r_2". (Reported by Shinji Dosaka.)

Page 246, entry for Sedgewick et al.: Change "1979" to "1982" and change "In *Proc. 11th SIGACT Meeting*, ed. Michael J. Fischer, pages 376–390" to "*SIAM Journal on Computing* 11(2): 376–390".

Page 251, second column: Insert "*Mutable*, 150" after "*MultiplicativeSemigroup*,

66", "*Readable*, 90" after "*RandomAccessIterator*, 113" and "*Writable*, 149" after "weakening, 11".

Page 255, second column: Insert "*Mutable*, 150" after "Musser, David, 13".

Page 258, second column: Insert "*Readable*, 90" after "reachable algorithm, 121".

Page 262, second column: Insert "*Writable*, 149" after "words in memory, 4".

Second printing, October 2009 (corrected in third printing)

Page xi, second paragraph: Append these two sentences (including footnote mark): We thank John Banning, Bob English, Steven Gratton, Max Hailperin, Eugene Kirpichov, Alexei Nekrassov, Mark Ruzon, and Hao Song for finding errors in the first printing. We thank Foster Brereton, Gabriel Dos Reis, Ryan Ernst, Abraham Sebastian, Mike Spertus, Henning Thielemann, and Carla Villoria Burgazzi for finding errors in the second printing.[6]

Page xi, bottom of page: Add this footnote:

─────────────────────

6. See www.elementsofprogramming.com for the up-to-date errata.

page xiii, first paragraph: Change "and, since 2002, Adobe" to "and Adobe". page xiii, second paragraph: Change "and, since 2003, Adobe" to "and Adobe".

Page 12, line 21: Change $x \mapsto \mathcal{F}(x)$ to $x \mapsto \mathcal{F}(x)$. (Reported by Abraham Sebastian.)

Page 12, concept *UnaryFunction*: Add a definition of Domain similar to the one in *HomogeneousFunction* later on the same page:

$\wedge$ Domain : *UnaryFunction* $\rightarrow$ *Regular*
　　　$F \mapsto$ InputType$(F, 0)$

(Reported by Carla Villoria Burgazzi, who detected the problem using her Liz interpreter.)

Page 25, convergent_point: Add this precondition:

　　// Precondition: $(\exists n \in \mathsf{DistanceType}(F))\, n \geqslant 0 \wedge f^n(x0) = f^n(x1)$

Page 26: Change Exercise 2.3 to:

The precondition of convergent_point ensures termination. Implement an algorithm convergent_point_guarded for use when that precondition is not known to hold, but there is an element in common to the orbits of both x0 and x1.

(Reported by Abraham Sebastian.)

Page 33, bottom of page: Change the case for n odd from $(a^2)^{n/2}a$ to $(a^2)^{\lfloor n/2 \rfloor}a$. (Reported by Ryan Ernst.)

Page 44, line 5: Change x_{x-k+1} to x_{n-k+1}. (Reported by Foster Brereton.)

Page 49, the *Relation* concept should be:

$$Relation(\mathsf{Op}) \triangleq$$
$$HomogeneousPredicate(\mathsf{Op})$$
$$\wedge\ \mathsf{Arity}(\mathsf{Op}) = 2$$

(Reported by Foster Brereton.)

Page 54, line 12: Change "jth largest of k arguments" to "jth element from k arguments according to the given ordering." (Reported by Abraham Sebastian.)

Page 66: Change the first sentence to: "A transformation is called an *inverse operation* of a binary operation with respect to a given element (usually the identity element of the binary operation) if it satisfies the following:". (Reported by Mike Spertus.)

Page 71, first sentence of section 5.3: Change "an integer" to "a non-negative integer". (Reported by Abraham Sebastian.)

Page 74, line 13: Change the final colon to a period. (Reported by Ryan Ernst.)

Page 87, quotient_remainder_extended: change the signature to:

$$\mathsf{quotient\_remainder\_extended} : U_n \times U_n \to U_n \times U_n$$

(Reported by Henning Thielemann.)

Page 101, find_n: The precondition should be $\mathsf{readable\_weak\_range}(f, n)$ rather than $\mathsf{weak\_range}(f, n)$.

Page 121, reachable: The requirement should be *BidirectionalBifurcateCoordinate* rather than *BifurcateCoordinate*, and the precondition should be $\mathsf{tree}(x)$ rather than $\mathsf{tree}(c)$. (The requirement error was reported by the GHC compiler when the concepts and functions in this chapter were translated to Haskell type classes and functions.)

Page 178: Change the sentence beginning "Since m is the smallest" to "Since m is the smallest positive number such that $mk \bmod n = 0$, $\mathrm{lcm}(k, n) = mk$, where $\mathrm{lcm}(a, b)$ is the *least common multiple* of a and b."

Page 235, paragraph beginning "Prefix const": Append this sentence: "When applied to a reference type, the resulting type is a reference to a constant version of the reference base type." (Reported by Gabriel Dos Reis.)

Page 237: Replace the production for control_statement with:

```
control_statement = return | conditional | switch | while | do
                    | compound | break | goto.
```

(Reported by Carla Villoria Burgazzi.)

First printing, June 2009 (corrected in second printing)

Page 14, regular_unary_function: The f to the left of $\mapsto$ should be f. (Reported by Mark Ruzon.)

Page 18, power_unary precondition: The superscript should be i rather than n:

$$\textit{// Precondition: } n \geqslant 0 \wedge (\forall i \in \mathsf{N})\, 0 < i \leqslant n \Rightarrow f^i(x) \textit{ is defined}$$

(Reported by Alexei Nekrassov.)

Page 24, fourth line: Change "$q \geqslant 0$" to "$q > 0$" and "when $slow$ enters the cycle" to "when it collides with $slow$". (Reported by Bob English and John Banning.)

Page 52: The weak_ordering property should be:

property$(\mathsf{R} : \textit{Relation}, \mathsf{E} : \textit{Relation})$ **requires**$(\mathsf{Domain}(\mathsf{R}) = \mathsf{Domain}(\mathsf{E}))$
weak_ordering : R
$\quad r \mapsto \mathsf{transitive}(r) \wedge (\exists e \in \mathsf{E})\, \mathsf{equivalence}(e) \wedge$
$\qquad (\forall a, b \in \mathsf{Domain}(\mathsf{R}))$ exactly one of the following holds:
$\qquad\qquad r(a, b), r(b, a), \text{ or } e(a, b)$

(Reported by Eugene Kirpichov.)

Page 59, select_2_5_ab_cd: The first statement should be:

```
compare_strict_or_reflexive<(ia < ic), R> cmp;
```

(Reported by Hao Song.)

Page 74: The sentence "While we believe that there is no logarithmic time, constant-space algorithm for remainder on Archimedean monoids, an iterative constant-space algorithm exists when we can divide by 2.[3]" should be changed to "Floyd and Knuth [1990] give a constant-space algorithm for remainder on Archimedean monoids that performs about 31% more operations than remainder_nonnegative, but when we can divide by 2 an algorithm exists that does not increase the operation count.[3]" (Reported by Max Hailperin.)

Page 95: The definition of *limit* of a range: the brackets should be hollow:

An iterator $f + n$ is the limit of a half-open weak range $[\![f, n)\!)$.

(Reported by Eugene Kirpichov.)

Page 135, in line 9: "$t = \mathsf{successor}(f)$" should be "$f = \mathsf{successor}(t)$". (Reported by Max Hailperin.)

Page 221: "performs reallocation only when $\mathsf{size}(\mathfrak{a}) \leqslant \mathsf{capacity}(\mathfrak{a})$" should be "performs reallocation only when the size after the insertion is greater than the capacity before the insertion". (Reported by Max Hailperin.)

Page 244, [Fiduccia 1985]: Change "*SIAM Journal of Computing*" to "*SIAM Journal on Computing*".

Page 244: After [Fletcher and Silver 1966] insert "Floyd, Robert W. and Donald E. Knuth. 1990. Addition Machines. *SIAM Journal on Computing* 19(2): 329-340."

The following index items should all refer to page 40 rather than page 41:

page 250, second column:	binary_scale_down_nonnegative and binary_scale_up_nonnegative
page 253, first column:	even
page 253, second column:	half_nonnegative
page 255, second column:	negative, odd, and one
page 256, second column:	positive and predecessor, of integer
page 260, second column:	successor, of integer
page 261, first column:	twice
page 262, second column:	zero

Also, on page 262, second column: the heading letter "X" should be "Z".

Code on web site (corrected as soon as reported)

eop.h: A bug in bifurcate_copy has been fixed, and a citation for the algorithm has been added. (Reported by Andrej Sprogar.)

type_functions.h: The incorrect line:

```
#define NeedsDestruction(T) typename needs_construction_type<T>::type
```

has been corrected to:

```
#define NeedsDestruction(T) typename needs_destruction_type<T>::type
```

(Reported by Steven Gratton.)

pointers.h, eop.h: The return type of source is now const, and a const version of underlying_ref has been added. (Reported by Robert Jan Harteveld.)