Bugs and errata for *Introduction to Algorithms, Third Edition*.

September 15, 2010

Severity levels
A minor typographical error that should not affect your understanding (22 errors in first printing).
A minor technical or expository error (31 errors in first printing).
A more significant technical or expository error (17 errors in first printing).
A serious error in the exposition of an algorithm, or an error that requires significant change to the text (2 errors in first printing).

Page 39, Exercise 2.3-4. Change the last sentence of the exercise to read Write a recurrence for the worst-case running time of this recursive version of insertion sort. (Add the words worst-case.)
Reported by Peter Drake. Posted 16 February 2010.
Severity level: 2
To be corrected in the third printing.

Page 78, line 25. Change we say that adding two $n2/4 \times n2/4$ matrices takes $\Theta(n2)$ time to we say that adding two $n/2 \times n/2$ matrices takes $\Theta(n2)$ time.
Severity level: 2
To be corrected in the third printing.

Page 87, Exercise 4.3-8. Change the recurrence to $T(n) = 4T(n/2) + n$.
Reported by Alexis Maciel. Posted 17 February 2010.
Severity level: 3
To be corrected in the third printing.
Page 128. In the Termination part of the proof of Lemma 5.5, change the numerator 
\( (n - (n + 1) + 1) \) to \( (n - (n + 1) + 1)! \).

Severity level: 2
To be corrected in the third printing.

Page 159, line 2. Change evalaute to evaluate.

Severity level: 1
To be corrected in the third printing.

Page 201. Interchange the first two lines of the BUCKET-SORT procedure.

Severity level: 2
To be corrected in the third printing.

Page 235, line 1. Change When \( Q.\text{head} = Q.\text{tail} + 1 \), the queue is full to When \( Q.\text{head} = Q.\text{tail} + 1 \) or both \( Q.\text{head} = 1 \) and \( Q.\text{tail} = Q.\text{length} \), the queue is full.

Severity level: 3
To be corrected in the third printing.
Page 314, Exercise 13.2-3. Change in the left tree of Figure 13.2 to in the right tree of Figure 13.2.
   
   Reported by Mladen Miksa. Posted 21 September 2010.
   Severity level: 2
   To be corrected in the third printing.

Page 366, line 8 from the bottom. Change a problem of size $i$ to a subproblem of size $i$.
   
   Reported by Mladen Miksa. Posted 21 September 2010.
   Severity level: 1
   To be corrected in the third printing.

Page 405, Problem 15-3. In line 4 of the problem, change NP-complete to NP-hard.
   Add the assumption that all operations on real numbers take unit time.
   
   Reported by Stephan Kollman. Posted 9 September 2009.
   Severity level: 3
   To be corrected in the second printing.

Page 410, Problem 15-10. Change the last sentence of the first paragraph of the problem to the two sentences At the end of each year, you can leave the money made in the previous year in the same investments, or you can shift money to other investments, by either shifting money between existing investments or moving money to a new investment. If you do not move your money between two consecutive years, you pay a fee of $f_1$ dollars, whereas if you switch your money, you pay a fee of $f_2$ dollars, where $f_2 > f_1$.
   
   Reported by Sharath Gururaj. Posted 4 September 2009.
   Severity level: 3
   To be corrected in the second printing.
Page 411, Problem 15-11. In the last sentence of the first paragraph, change $j \neq 1 \neq D-1$ to $j \neq 1 \neq D-1$.
Severity level: 2
To be corrected in the second printing.

Page 423, line 2 of Section 16.2. Change makes choice that seems best to makes the choice that seems best.
Reported by Meni Rosenfeld. Posted 27 April 2010.
Severity level: 1
To be corrected in the third printing.

Reported by Tom Cormen. Posted 12 August 2009.
Severity level: 1
To be corrected in the second printing.

Page 435, Lemma 16.3. Change the fourth sentence of the lemma to read Define freq for $C'$ as for $C$, except that $z.freq = x.freq + y.freq$. (Change $f$ to $freq$.)
Reported by Lynne Parker. Posted 17 February 2010.
Severity level: 2
To be corrected in the third printing.
Page 448, Problem 16-3. In part (e), change Explain carefully why the results of parts (d) and (e) are not contradictory to Explain carefully why the results of parts (c) and (d) are not contradictory.

Severity level: 3
To be corrected in the third printing.

Page 449. Change part (b) of Problem 16-5 to Show that the off-line caching problem exhibits optimal substructure.

Reported by Tom Cormen. Posted 7 August 2009.
Severity level: 2
To be corrected in the second printing.

Page 494. Figure 18.5 uses attribute notation from the first two editions, which changed in the third edition. Click here for a corrected version of the figure.

Reported by Carmelo Giarratana. Posted 12 November 2009.
Severity level: 2
To be corrected in the second printing.

Page 510, line 11 of Section 19.2. Change before a EXTRACT-MIN operation to before an EXTRACT-MIN operation.

Severity level: 1
To be corrected in the third printing.

Page 535. Remove the extraneous right bracket at the end of the first sentence of the
third bullet point.
   Reported by Mladen Miksa. Posted 21 September 2010.
   Severity level: 1
   To be corrected in the third printing.

Page 540, line 10 from the bottom. Change MEMBER, MINIMUM, MAXIMUM, and SUCCESSOR to MEMBER, MINIMUM, and SUCCESSOR. (Remove MAXIMUM from the list).
   Reported by Mladen Miksa. Posted 21 September 2010.
   Severity level: 2
   To be corrected in the third printing.

Page 545, line 2 from the bottom. Change the possible values of $u$ an overly sparse set to the possible values of $u$ to an overly sparse set.
   Reported by Meni Rosenfeld. Posted 27 April 2010.
   Severity level: 1
   To be corrected in the third printing.

Page 547. Change the end of the first sentence to read but unless the vEB tree contains just one element (so that the minimum and maximum elements are the same), the element stored in max does.
   Severity level: 2
   To be corrected in the third printing.

Page 549, line 5 in Section 20.3.2. Change minumum to minimum.
Page 552, line 5 after the pseudocode for the VEB-TREE-PREDECESSOR procedure. Change then the successor resides in no cluster at all to then the predecessor resides in no cluster at all.

Severity level: 2
To be corrected in the third printing.

Page 555, line 29. Change highest-numbered cluster to highest-numbered nonempty cluster.

Severity level: 2
To be corrected in the third printing.

Page 558, Problem 20-1(e). Change $O(lg lg u)$ expected time to $O(lg lg u)$ expected amortized time.

Severity level: 3
To be corrected in the third printing.

Page 570, line 5. Change between x and a descendant leaf to from a descendant leaf to x.

Severity level: 2
To be corrected in the third printing.

Page 582, line 1. Change if rank(x) > 0 to if x.rank > 0.
   Reported by Tom Cormen. Posted 7 July 2009.
   Severity level: 1
   To be corrected in the second printing.

Page 593, Exercise 22.1-5. Change if and only G contains a path to if and only if G contains a path.
   Reported by Radu Tuica. Posted 8 July 2010.
   Severity level: 1
   To be corrected in the third printing.

Page 602, Exercise 22.2-3. Change lines 5 and 14 to line 18.
   Reported by Meni Rosenfeld. Posted 7 May 2010.
   Severity level: 3
   To be corrected in the third printing.

Page 611, Exercise 22.3-4. Change line 3 to line 8.
   Reported by Meni Rosenfeld. Posted 7 May 2010.
   Severity level: 3
   To be corrected in the third printing.
Page 615, Exercise 22.4-3. Change contains a cycle to contains a simple cycle.  
Reported by Mladen Miksa. Posted 21 September 2010.  
Severity level: 2  
To be corrected in the third printing.

Page 641, Problem 23-4. Change or prove that T is not a minimum spanning tree to  
or prove that T is not necessarily a minimum spanning tree.  
Reported by Meni Rosenfeld. Posted 16 May 2010.  
Severity level: 2  
To be corrected in the third printing.

Page 717, line 7 of the main text. Change just send 3 creates to just send 3 crates.  
Reported by Meni Rosenfeld. Posted 10 August 2010.  
Severity level: 1  
To be corrected in the third printing.

Page 722, line 6 from the bottom. Change x, y ? V to x, y ? S.  
Reported by Mladen Miksa. Posted 21 September 2010.  
Severity level: 2  
To be corrected in the third printing.

Page 727, Figure 26.6, parts (e) and (f). The residual capacities of edges (s, v2) and  
(v2, s) are reversed. Edge (s, v2) should have residual capacity 2, and edge (v2, s)  
should have residual capacity 11.  
Severity level: 2
To be corrected in the third printing.

Page 731, Exercise 26.2-12. Add the assumption that all edge capacities are integers.
   Reported by Sharath Gururaj. Posted 4 September 2009.
   Severity level: 3
   To be corrected in the second printing.

Page 731, Exercise 26.2-13. Add the assumption that all capacities are integers.
   Reported by Sharath Gururaj. Posted 4 September 2009.
   Severity level: 3
   To be corrected in the second printing.

Page 746, line 7 from the bottom. Change and nonsaturating push to and nonsaturating pushes.
   Reported by Mladen Miksa. Posted 21 September 2010.
   Severity level: 1
   To be corrected in the third printing.

Page 765, Problem 26-6, part (f). Change both instances of V to |V|.
   Reported by Sharath Gururaj. Posted 31 August 2009.
   Severity level: 1
   To be corrected in the second printing.
Page 766, line 4. Change tend have high capacity to tend to have high capacity.
   Reported by Meni Rosenfeld. Posted 30 August 2010.
   Severity level: 1
   To be corrected in the third printing.

Page 783, line 28. Change inequality 27.4 to inequality (27.4).
   Reported by Tom Cormen. Posted 3 August 2009.
   Severity level: 1
   To be corrected in the second printing.

Page 789, line 6 of the main text. Change \( \langle 1, 2, 3, 4, 5, 6, 7, 8 \rangle \) to \( \langle 1, 2, 3, 7, 4, 5, 6, 8 \rangle \).
   Severity level: 3
   To be corrected in the second printing.

Page 792, Exercise 27.1-9. Change two versions of the chess programs to two versions of the chess program.
   Severity level: 1
   To be corrected in the third printing.

Page 793, line 9 of the first paragraph. Change to obtain a parallelism of \( \Theta(lg n) \) to to obtain a parallelism of \( \Theta(n^3/lg n) \).
Severity level: 3
To be corrected in the second printing.

Page 795, line 1. Change from T into C in using to from T into C using.
Severity level: 1
To be corrected in the third printing.

Page 800, last line. Change all the elements in T[q2..p2] to all the elements in T[q2..r2].
Severity level: 2
To be corrected in the third printing.

Page 812. Change the first sentence of the first paragraph to the two sentences
Graham [149] and Brent [55] showed that there exist schedulers achieving the bound of Theorem 27.1. Eager, Zahorjan, and Lazowska [98] showed that any greedy scheduler achieves this bound and proposed the methodology of using work and span (although not by those names) to analyze parallel algorithms. Citation [98] is new: Derek L. Eager, John Zahorjan, and Edward D. Lazowska. Speedup versus efficiency in parallel systems. IEEE Transactions on Computers, 38(3):408–423, 1989.
Reported by Charles Leiserson. Posted 4 September 2009.
Severity level: 3
To be corrected in the second printing.

Page 817, line 2 of the LUP-SOLVE procedure. Change the line to read let x and y be
new vectors of length $n$.
Reported by Priya Natarajan. Posted 7 September 2010.
Severity level: 2
To be corrected in the third printing.

Page 832, Exercise 28.2-2. Eliminate one direction of the exercise, so that the exercise should read: Let $M(n)$ be the time to multiply two $n \times n$ matrices. Show that an $M(n)$-time matrix-multiplication algorithm implies an $O(M(n))$-time LUP-decomposition algorithm.
Severity level: 4
To be corrected in the third printing.

Page 859, last line before the "Shortest paths" subheading. Change $c(u.v)$ to $c(u,v)$. (Change the dot to a comma.)
Severity level: 1
To be corrected in the third printing.

Page 861, line 8 from the bottom. Change constraints (29.48)–(29.49) to constraints (29.48)–(29.50).
Severity level: 2
To be corrected in the third printing.

Page 871. Line 2 of the SIMPLEX procedure should read: let $\Delta$ be a new vector of
length m. (Change n to m.)

Reported by Mladen Miksa. Posted 21 September 2010.
Severity level: 3
To be corrected in the third printing.

Page 877, line 8. Change Since \( \alpha_i = \beta_i \) to Since \( \alpha_j = \beta_j \).

Severity level: 2
To be corrected in the third printing.

Page 900, lines 8–9. Change The straightforward methods for multiplying polynomials—equations (30.1) and (30.2)—take \( \Theta(n^2) \) time to The straightforward method for multiplying polynomials—equations (30.1) and (30.2)—takes \( \Theta(n^2) \) time.

Severity level: 1
To be corrected in the third printing.

Page 926, first paragraph. Change the end of the third sentence of the paragraph to read because we do not know how to factor the product of large primes (or solve related problems, such as computing discrete logarithms) efficiently.

Reported by Ron Rivest. Posted 4 September 2009.
Severity level: 2
To be corrected in the second printing.

Page 983, lines 24–29. Change the second half of this paragraph, starting from
Randomization appears to be necessary ... to For many years primality-testing was the classic example of a problem where randomization appeared to be necessary to obtain an efficient (polynomial-time) algorithm. In 2002, however, Agrawal, Kayal, and Saxema [4] surprised everyone with their deterministic polynomial-time primality-testing algorithm. Until then, the fastest deterministic primality testing algorithm known, due to Cohen and Lenstra [73], ran in time (lg n)O(lg lg lg n) on input n, which is just slightly superpolynomial. Nonetheless, for practical purposes randomized primality-testing algorithms remain more efficient and are preferred. Citation [4] is new: Manindra Agrawal, Neeraj Kayal, and Nitin Saxena. PRIMES is in P. Annals of Mathematics, 160(2):781–793, 2004.

 Reported by Sharath Gururaj. Posted 4 September 2009.
 Severity level: 3
 To be corrected in the second printing.

Page 996, lines 8–9 from the bottom. Change Figure 32.7 illustrates how we construct the automaton to Figure 32.7 illustrates the automaton.

 Severity level: 2
 To be corrected in the third printing.

Page 997, lines 5–6 of the Figure 32.7 caption. Change The left-going edges correspond to failing matches to Except for the edge from state 7 to state 2, the left-going edges correspond to failing matches.

 Severity level: 3
 To be corrected in the third printing.

Page 1011, line 2. Change but although Pq \( \neq \) Ti to but although Pq \( \neq \) Ti–1.

 Reported by Mladen Miksa. Posted 21 September 2010.
Severity level: 2
To be corrected in the third printing.

Page 1031, GRAHAM-SCAN procedure. After line 2, add a test that if m < 2, then return "convex hull is empty". The remainder of the procedure is the else case. (The keyword else is not strictly necessary, since the then-clause returns to the caller.) The two added lines of pseudocode add 2 to the line numbers of lines 3–11 and affect references to line numbers appearing in pages 1031–1036.

Reported by Joshua Goldstein. Posted 3 July 2010.
Severity level: 4
To be corrected in the third printing.

Page 1095, line 4. Change 1 ? i ? degree(uj) to 1 \( \leq i \leq \) degree(uj)–1.

Reported by Jeongho Nah. Posted 1 July 2009.
Severity level: 2
To be corrected in the second printing.

Page 1096. In the formal definition of TSP, change both instances of ? to ?.

Severity level: 2
To be corrected in the third printing.

Page 1147. After equation (A.6), insert the sentence Because we assume that 00 = 1, these formulas apply even when x = 0. Page 1149. In Exercise A.1-3, change the restriction from 0 < |x| < 1 to |x| < 1.

Severity level: 2
To be corrected in the third printing.

Page 1149, Exercise A.1-5. Add the condition for $|x| < 1$.
Severity level: 2
To be corrected in the third printing.

Page 1170, line 25. Change A graph with no cycles is acyclic to A graph with no simple cycles is acyclic. On line 27 of the same page, change The connected components of a graph to The connected components of an undirected graph.
Severity level: 2
To be corrected in the third printing.

Page 1172, line 7 from the bottom. Change incident on u or v to adjacent to u or v.
Severity level: 2
To be corrected in the third printing.

Page 1214, Exercise C.5-5. Change the exercise to read as follows: Use Theorem C.8 to show that $Pr\{\mu - X \geq r\} \geq ((n - \mu)e / r)r$ for $r > n - \mu$. Similarly, use Corollary C.9 to show that $Pr\{np - X \geq r\} \geq (nqe / r)r$ for $r > n - np$.
Reported by Neville Campbell. Posted 17 May 2010.
Severity level: 3
To be corrected in the third printing.
   Severity level: 1
   To be corrected in the third printing.

Page 1231, citation [8]. The paper by Ahuja, Mehlhorn, Orlin, and Tarjan is in volume 37, number 2 of Journal of the ACM. (Add that the issue is number 2.)
   Severity level: 1
   To be corrected in the third printing.

Page 1235, citation [75]. The author should be listed as Douglas Comer.
   Severity level: 1
   To be corrected in the third printing.