## INDEX

## Numbers

2001: A Space Odyssey, 142
2D graphics, 61-69
3D graphics, 69. See also rendering

## A

acquire operation, 168, 170
adder circuit, 164
additive color mixing, 60
AES (Advanced Encryption Standard), 9-18, 55
block chaining, 15, 55
combining with RSA, 48-49
data organization under, 11
key expansion, 13-14
overview, 12
performance vs. RSA, 48
possible weaknesses, 17-18
S-box, 13, 14
security of, 16
aliasing, 66, 80, 99
all-pairs shortest path, 183. See also Floyd's algorithm
alpha blending, 67-68, 82
alpha channel, 68, 78, 82
alpha level, 67
ambient lighting, 96-97
ambient occlusion, 96
American Standard Code for Information Interchange (ASCII), 12, 20-22, 119-120
AND (bitwise operation), 23, 25
angle of incidence, 74, 75
angle of reflectance, 74
animation
cel, 59
ink and paint, 59, 65
interpolation, 63
anti-aliasing, 66-67
alpha blending, 67-68
full-screen, 80
FXAA, 111
multisampling, 111
post-process, 111
real-time, 108-113
supersampling, 109
ASCII (American Standard Code for Information Interchange), 12, 20-22, 119-120
atomic operation, 169
attacks, 2
brute-force, 5, 16, 20, 47
collision, 26
dictionary, 28
frequency analysis, $6,9,15,17$
known-plaintext, 6
man-in-the-middle, 52, 56
related-key, 17
timing, 17
authentication, 19, 26, 34. See also RSA
authority, 51, 53
avalanche, 17, 21
Avatar, 69
axis, 61

## B

best-first search, 178-181
marked points, $178,179,180$
reusing results, 181-182
surplus information, 181
B-frame, 139
bidirectional frame, 139
bilinear filtering, 101
in FXAA, 112
binary, 10
ASCII, 12
bit, 10
byte, 10
search, 151
binary addition, 22
binary search, 151-152, 153
binary semaphore, 168
bit, 10
bitmap, 61, 116
alpha channel, 68, 78, 82
coordinate, 61
depth buffer, 91, 95, 96
display buffer, 61
height map, 106
bitmap (continued)
mipmap, 102
origin, 61
resolution, 61
shadow map, 95
texture, 97
translucency, 68, 78
bitwise operations, 11
AND, 23, 25
binary addition, 22
NOT, 23, 25
OR, 23, 25
rotation, 14
XOR, 11, 14, 15
bitwise rotation, 14
Blair Witch Project, The, 142
block chaining, 15
blue difference (Cb), 124
Blu-ray, 116, 143
brute force attack, 5, 16, 20, 47
buffer, shared, 163
buffering, 143
bump mapping, 106, 107
byte, 10

Cb (blue difference), 124
cel animation, 59
central processing unit. See CPU (central processing unit)
certificate, 53
CGI (computer-generated imagery), 57-59, 82-83. See also
3D graphics; rendering
chain merging, 31
cipher key. See key (encryption)
ciphertext, 2, 3, 8
circular wait, 172
clear reflection, 103
client, 52
Cloverfield, 142
code book, 9
coefficient, 126
collision, 20, 26
collision attack, 26
color
additive, 60
RGB, 60, 116, 124
subtractive, 60,76
YCbCr, 124
composite number, 40
compression, 116
deflate, 122
dictionary, 118-122

Huffman encoding, 120, 134
of JPEG pixel blocks, 132
lossless, 116
lossy, 116, 124
MPEG-2, 138
predictive encoding, 122
quantization, 123, 132
run-length encoding, 117, 123, 133, 142
sliding window, 122
temporal, 138
TGA file format, 117
.zip file format, 122
compression ratio, 118
dictionary compression, 120
JPEG, 135
MPEG-4, 143
TGA, 118
.zip file, 122
computer security. See security
computer vision, 160
computer-generated imagery (CGI), 57-59, 82-83. See also 3D graphics; rendering
concurrency, 161
atomic operation, 169
deadlock, 172
multitasking, 162-163, 174
multiuser environments, 162
performance, 162
print spooling, 162
problems of, 163-166
race condition, 165-169
read-only data, 166, 173
semaphore, 168-174
shared buffer, 163
starvation, 170, 172, 173
transaction, 166-167
control point, 62
coordinates, 61
axis, 61
control point, 62
conversion, 61, 71, 88, 96
interpolation, 63
local, 62
model, 62
origin, 61
projection, 71
scaling, 64
screen, $61,88,96$
translation, 64
world, 70,88
$\mathrm{x}, 61$
y, 61
z, 69
coprime number, 40
core, $86,162,174$
cost, $175,178,183,184$
computing route cost, 179, 182
defining per problem, 175
CPU (central processing unit), 86
adder, 164
core, $86,162,174$
performance characteristics, 86
test-and-set, 169
updating data, 163, 165
Cr (red difference), 124
crack, 17
crib, $6,9,16$
cut scene, 86

## D

data collection, 146
dynamic, 154
hash table, 154
static, 154
data compression. See compression
DCT (discrete cosine transform), 125-131, 141
deadlock, 172
deblocking filter, 143
decimal, 10
decryption, 2
deep web, 157
deflate, 122
depth buffer, 91, 95, 96
depth buffering, 91-92
dictionary, 28
dictionary attack, 28
dictionary compression, 118-122
diffuse reflection, $74,77,92,93,107$
diffusion, 16
digital composition, 82
digital image, 59
digital signature, 25-26, 53
validation, 53
weaknesses, 26
direct lighting, 76
directed graph, 176
coverting to table, 176
edge, 176
point, 176
discrete cosine transform (DCT), 125-131, 141
display buffer, 61
dissolve, 82
distance effect, 72-73, 92
distant impostor, 106, 108
dynamic data collection, 154

## E

edge, 176
encryption, 2
avalanche, 17
crack, 17
diffusion, 16
key. See key (encryption)
one-time pad, 9
public-key, 38
RSA. See RSA
shared key problem, 18, 37
substitution, 6
symmetric key, 18
transposition, 2
environment mapping, 103-105
exclusive-or. See XOR

## F

factor, 40, 41
fast approximate anti-aliasing
(FXAA), 111
field of view, 89
finding the shortest path, 175
fixed-size storage, 152, 153
Floyd's algorithm, 183-189
connecting routes, 183, 187
grid, 183, 186
improving routes, 185
route directions, 186-189
focus, 79
fps (frames per second), 59, 116, 144
frame, 59, 116
buffering, 143
macroblock, 139
frame rate, 59
frames per second (fps), 59, 116, 144
frequency analysis, $6,9,15,17$
full-screen anti-aliasing, 80
functions, 39
hash, 20-21
invertible, 39-42
one-way, 39,42
square, 39
square root, 39
trapdoor, 40
FXAA (fast approximate anti-aliasing), 111

## G

geographic information systems (GIS), 189
global illumination model, 76

GPU (graphics processing unit), 87, 90 granularity, 173
graph, directed. See directed graph
graphics accelerator, 86
graphics processing unit (GPU), 87, 90
group of pictures, 138

## H

H. 264 standard, 143
handshaking, 52-54
hash chaining, 29-31
chain merging, 31
reduction function, 29, 31
hash table, 29, 31
hashing, 20-23, 154-156
avalanche, 17, 21
collision, 20, 26
desirable properties, 20-21
digital signature. See digital signature
encoded password, 21
irreversibility, 20, 25
iterative, 32-33
keyed, 55
MAC, 55
MD5. See MD5
reduction function, 29, 31
rehashing, 156
salt, 34, 35
slot, 154
tombstone, 156
height map, 106
HTTPS, 52-56
authority, 53
certificate, 53
handshaking, 52-54
issuer, 53
MAC, 55
master secret, 54
premaster secret, 53
security of, 55-56
session, 52
transmission, 54-56
Huffman encoding, 120, 142
code creation, 120
in JPEG, 134

## I

IDCT (inverse discrete cosine transform), 127
I-frame, 138, 139
images
digital, 51-60
searching for, 160
inbound link, 158
indexing, 152-154
indirect lighting, 76
ink and paint, 59, 65
interpolation, 63
intracoded frame, 138
inverse discrete cosine transform
(IDCT), 127
issuer, 53
iterative hashing, 32-33

## J

jaggies, 66, 80, 89, 109, 112
Joint Photography Experts Group, 123
JPEG, 123-136
adjusting quality, 135
compressing pixel blocks, 132
compression ratio, 135
DCT, 125
picture quality, 135-136
Jurassic Park, 57-58

## K

Kerckhoffs's principle, 4, 5, 27, 33
key (encryption), 4
AES, 9-14
asymmetric, 38
code book, 9
expansion, 9
keyed hashing, 55
MAC, 55
private, $38,44,45,50$
public, $38,43,44,45,50$
related-key attack, 17
shared key problem, 18, 37
size, 20, 47
symmetric, 18
key (search), 146, 151
key expansion, 9
keyframe, 59
known-plaintext attack, 6

## L

Lady and the Tramp, 59
LaserDisc, 116
LCD (liquid crystal display), 60
light-emitting diode (LED), 60
lighting, 71-80
ambient, 96-97
angle of incidence, 74, 75
angle of reflectance, 74
bump mapping, 106, 107
diffuse reflection, 74, 77, 92, 93, 107
direct, 76
distance effect, 72-73, 92
indirect, 76
model, 72
normal, 92, 93, 107
ray tracing. See ray tracing
real-time, 92-97
reflection, 80
clear, 103
environment mapping, 103-105
shadow. See shadow
specular reflection, $75,77,92,107$
link farming, 159
links
farming, 159
inbound, 158
pass-through, 159
liquid-crystal display (LCD), 60
local coordinate, 62
lossless compression, 116
lossy compression, 116, 124
luminance, 124

## M

MAC, 55
macroblock, 139
deblocking filter, 143
man-in-the-middle attack, 52, 56
map
converting to table, 176
directed graph, 176
routing. See routing
massively multiplayer online game (MMO), 164
master secret, 54
matrix, 128
matrix multiplication, 126
MD5, 21-25
digital signature, 25-26
encoding password for, 21-22
quality of, 25
round, 24-25
message authentication code, 55
mipmap, 102
MMO (massively multiplayer
online game), 164
model, 61-63, 70, 87
ambient light, 96
bump mapping, 106
control point, 62
distant impostor, 106
drawing, transforming into, 62,88 , 93, 105
global illumination, 76
interpolation, 63
lighting, 72
line, 62
scaling, 64
tessellation, 107-108
translation, 64
Mortal Kombat, 85
movie-quality rendering, 70, 82-83
MPEG-2, 138-142
adjusting quality, 139
B-frame, 139
GOP, 138, 142
I-frame, 138, 139
macroblock, 139
P-frame, 139
MPEG-4, 143
multisample anti-aliasing (MSAA), 110-111
vs. supersampling, 111
multitasking, 162-163, 174

## N

nearest-neighbor sampling, 99-100, 101, 143
normal, 92, 93, 107
NOT (bitwise operation), 23, 25
numerical address, 153

## 0

offset, 139
one-time pad, 9
one-way function, 39, 42
optical printer, 82
OR (bitwise operation), 23, 25
origin, 61

## P

packet, 118
painter's algorithm, 90
partition, 147
pass-through link, 159
password, 6, 19
common, 28, 29
encoding, 21-22
hashing, 20-23
salt, 34, 35
storage service, 35-36
table, 26, 27
performance scaling, 150
persistence of vision, 59
P-frame, 139

Phineas and Ferb, 69
pivot, 147
pixel, 59, 66
alpha channel, 68
alpha level, 67, 78, 82
bitmap, 61
contrast, 112
depth, $91,95,96$
luminance, 124
raw, 117
run, 117
sampling, 97
shader, 92. See also lighting
subpixel, 110
texel, 98
variation in photographs, 123
plaintext, 2, 3, 4, 8, 27, 28
known-plaintext attack, 6
polyalphabetic substitution, 7-9
polygon, 88. See also triangle
post-process anti-aliasing, 111
precomputed hash table, 29, 31
predicted frame, 139
predictive encoding, 122
prefix code, 121
premaster secret, 53
prime number, 40
as factor, 41
coprime, 40
prime-product, 42, 44, 45
print spooling, 162
private key, $38,44,45,50$
process, 162
projection, 71, 88, 96
field of view, 89
ray tracing, 77
public key, 38, 43, 44, 45, 50

## Q

quantization, 123, 132, 141
queue, 163, 170
quicksort, 147-150
partition, 147
pivot, 147
sublist, 149

## R

race condition, 165-169
rasterization, 65-68, 89
raw pixel, 117
ray tracing, 77-81, 105
anti-aliasing, 80
focus, 79
laws of optics, 79
performance, 87
projection, 77
reflection, 80
shadow, 79
read semaphore, 173
read-only data, 166, 173
real-time lighting, 92-97
record, 146
red difference ( Cr ), 124
reduction function, 29, 31
reflection, 80
clear, 103
environment mapping, 103-105
rehashing, 156
related-key attack, 17
release operation, 168
renderer, 69
rendering, 69
2D, 61-69
budget, 113
depth buffering, 91-92
depth ordering, 89-92
field of view, 89
focus, 79
lighting, 71-80
movie-quality, 70, 82-83
pixel shader, 92
polygon, 88
projection, 71
rasterization, 89
ray tracing, 77-81
realism, $72,79,94,96,105$
reflection, 80
translucency, 78
triangle, 88,90
viewpoint, 71
resolution, 61
RGB color system, 60, 124
vs. YCbCr, 124
Rivest, Shamir, and Adleman method. See RSA (Rivest, Shamir, and Adleman method)
robot, 157, 160
rotation, 14
routing
cost, $175,178,179,182,183,184$
directed graph, 176
finding the shortest path, 175
using real-time data, 189
RSA (Rivest, Shamir, and Adleman method), 42-51
authentication, 49-51
authority, 51
bidirectional transmission, 47
combining with AES, 48-49
effectiveness, 45-47
encryption process, 44-45
key creation, 42-44
key size, 47
performance, 47-48
prime-product, 42, 44, 45
real-world use, 47-49
totient, 43, 45
run of pixels, 117
run-length encoding, 117, 123, 133, 142

## S

salt method, 34, 35
sampling, 97
bilinear filtering, 101, 112
mipmap, 102
nearest-neighbor, 99-100, 101, 143
trilinear filtering, 102-103
S-box, 13, 14
scaling, 64, 150
screen coordinate, $61,88,96$
screen space ambient occlusion (SSAO), 96-97
search, 29, 145
all-pairs shortest path, 183
best-first, 178-181
binary, 151-152, 153
engine, 157
images, 160
location use, 160
page ranking, 158-159
robot, 157, 160
sequential, 146, 153
Sitemap, 157
storage requirements, 153
term, 159-160
Web, 157-160
security, $1,17,19,35$
of AES, 16
best practices, $6,27,29,34,56$
single point of defense, 27
Web, 52-56
selection sort, 146
performance scaling, 150
semaphore, 168-174
acquire, 168,170
binary, 168
circular wait, 172
granularity, 173
implementation, 169
performance, 172-174
read, 173
release, 168
spin lock, 169
test-and-set, 169
wait list, 170
write, 173
sequential search, 146,153
server, 52
session, 52
shadow, 79, 94-97
ambient occlusion, 96
mapping, 94-95
quality, 95
shadow map, 95
shared buffer, 163
shared key problem, 18, 37
signature. See digital signature
simple substitution, 6
Simpsons, The, 69
single point of defense, 27
Sitemap, 157
sliding window, 122
slot, 154
sort, 146
quicksort, 147
selection sort, 146
specular reflection, 75, 77, 92, 107
spin lock, 169
square function, 39
square root function, 39
SSAA (supersampling anti-aliasing), 109-110
vs. multisampling, 111
SSAO (screen space ambient occlusion), 96-97
starting variable, 15
starvation, 170, 172, 173
static data collection, 154
storage
address, 153
fixed-size, 152, 153
requirements for search, 153
variable-size, 152, 153
subpixel, 110
substitution, 6-9
polyalphabetic, 7
S-box, 13
simple, 6
tabula recta, 7
subtractive color mixing, 60, 76
supersampling anti-aliasing (SSAA), 109-110
vs. multisampling, 111
surface normal. See normal
symmetric key, 18

## T

tabula recta, 7
temporal compression, 138
temporal redundancy, 138, 142
tessellation, 107-108
test-and-set, 169
texel, 98
texture mapping, 97-103, 143
bump mapping, 106
sampling, 97
TGA file format, 117
compression ratio, 118
packet, 118
Theora, 143
timing attack, 17
tombstone, 156
Toon Boom, 69
Toonz, 69
totient, 43, 45
transaction, 164, 166-167
translation, 64
translucency, 68, 78
transposition, 2-6
rotation, 14
trapdoor function, 40
triangle, $88,90,107$
trilinear filtering, 102-103, 143
trivial factor, 40
tweening, 59
automatic, 63-64

## U

ultra high definition video (UHD), 144

## V

variable-size storage, 152, 153
vector, 126
video streaming, 116
videocassette, 115
view angle, 74
viewpoint, 71
virtual camera, 71

## W

War and Peace, 122
web search, 157-160
web session, 52
world coordinate, 70,88
write semaphore, 173

## X

x-axis, 61
x-coordinate, 61
XOR (bitwise operation), 11, 14, 15

## Y

y-axis, 61
YCbCr color system, 124
vs. RGB, 124
y-coordinate, 61
Y (luminance), 124

## Z

z-coordinate, 69
.zip file format, 122

