Breadth–First Search

```
java Run BFS_nav ATM.graph 13 6 7 6 d
vertices=275, edges=641
start=(13,6), goal=(7,6), vertices: 163 and 102
iter=1, frontier=0, popped=163 (13,6), depth=0, dist2goal=6.00
pushed 164 (13,7)
pushed 176 (14,6)
pushed 177 (14,7)
iter=2, frontier=2, popped=164 (13,7), depth=1, dist2goal=6.08
pushed 165 (13,8)
pushed 178 (14,8)
iter=3, frontier=3, popped=176 (14,6), depth=1, dist2goal=7.00
iter=4, frontier=2, popped=177 (14,7), depth=1, dist2goal=7.07
pushed 188 (15,8)
pushed 201 (16,8)
iter=5, frontier=3, popped=165 (13,8), depth=2, dist2goal=6.32
iter=6, frontier=2, popped=178 (14,8), depth=2, dist2goal=7.28
iter=7, frontier=1, popped=188 (15,8), depth=2, dist2goal=8.25
pushed 202 (16,9)
pushed 203 (16,10)
iter=8, frontier=2, popped=201 (16,8), depth=2, dist2goal=9.22
pushed 214 (17,8)
iter=9, frontier=2, popped=202 (16,9), depth=3, dist2goal=9.49
iter=10, frontier=1, popped=203 (16,10), depth=3, dist2goal=9.85
iter=11, frontier=0, popped=214 (17,8), depth=3, dist2goal=10.20
pushed 230 (18,8)
pushed 229 (18,7)
pushed 228 (18,6)
pushed 227 (18,5)
iter=12, frontier=3, popped=230 (18,8), depth=4, dist2goal=11.18
pushed 244 (19,8)
iter=13, frontier=3, popped=229 (18,7), depth=4, dist2goal=11.05
pushed 243 (19,7)
iter=14, frontier=3, popped=228 (18,6), depth=4, dist2goal=11.00
pushed 242 (19,6)
iter=15, frontier=3, popped=227 (18,5), depth=4, dist2goal=11.05
pushed 226 (18,4)
pushed 241 (19,5)
pushed 213 (17,3)
iter=16, frontier=5, popped=244 (19,8), depth=5, dist2goal=12.17
pushed 262 (20,8)
pushed 263 (20,9)
iter=17, frontier=6, popped=243 (19,7), depth=5, dist2goal=12.04
pushed 261 (20,7)
iter=18, frontier=6, popped=242 (19,6), depth=5, dist2goal=12.00
pushed 260 (20,6)
iter=19, frontier=6, popped=226 (18,4), depth=5, dist2goal=11.18
pushed 225 (18,3)
pushed 240 (19,4)
iter=20, frontier=7, popped=241 (19,5), depth=5, dist2goal=12.04
pushed 259 (20,5)
iter=21, frontier=7, popped=213 (17,3), depth=5, dist2goal=10.44
pushed 212 (17,2)
pushed 200 (16,3)
pushed 199 (16,2)
iter=22, frontier=9, popped=262 (20,8), depth=6, dist2goal=13.15
iter=23, frontier=8, popped=263 (20,9), depth=6, dist2goal=13.34
pushed 264 (20,10)
pushed 245 (19,10)
iter=24, frontier=9, popped=261 (20,7), depth=6, dist2goal=13.04
```

```
iter=25, frontier=8, popped=260 (20,6), depth=6, dist2goal=13.00
iter=26, frontier=7, popped=225 (18,3), depth=6, dist2goal=11.40
pushed 224 (18,2)
pushed 239 (19,3)
iter=27, frontier=8, popped=240 (19,4), depth=6, dist2goal=12.17
pushed 258 (20,4)
iter=28, frontier=8, popped=259 (20,5), depth=6, dist2goal=13.04
iter=29, frontier=7, popped=212 (17,2), depth=6, dist2goal=10.77
pushed 211 (17,1)
pushed 198 (16,1)
iter=30, frontier=8, popped=200 (16,3), depth=6, dist2goal=9.49
pushed 187 (15,3)
pushed 186 (15,2)
iter=31, frontier=9, popped=199 (16,2), depth=6, dist2goal=9.85
pushed 185 (15,1)
iter=32, frontier=9, popped=264 (20,10), depth=7, dist2goal=13.60
pushed 265 (20,11)
iter=33, frontier=9, popped=245 (19,10), depth=7, dist2goal=12.65
pushed 246 (19,11)
iter=34, frontier=9, popped=224 (18,2), depth=7, dist2goal=11.70
pushed 223 (18,1)
pushed 238 (19,2)
iter=35, frontier=10, popped=239 (19,3), depth=7, dist2goal=12.37
pushed 257 (20,3)
iter=36, frontier=10, popped=258 (20,4), depth=7, dist2goal=13.15
iter=37, frontier=9, popped=211 (17,1), depth=7, dist2goal=11.18
iter=38, frontier=8, popped=198 (16,1), depth=7, dist2goal=10.30
iter=39, frontier=7, popped=187 (15,3), depth=7, dist2goal=8.54
pushed 175 (14,3)
pushed 174 (14,2)
iter=40, frontier=8, popped=186 (15,2), depth=7, dist2goal=8.94
pushed 173 (14,1)
iter=41, frontier=8, popped=185 (15,1), depth=7, dist2goal=9.43
iter=42, frontier=7, popped=265 (20,11), depth=8, dist2goal=13.93
pushed 266 (20,12)
iter=43, frontier=7, popped=246 (19,11), depth=8, dist2goal=13.00
pushed 247 (19,12)
iter=44, frontier=7, popped=223 (18,1), depth=8, dist2goal=12.08
pushed 237 (19,1)
iter=45, frontier=7, popped=238 (19,2), depth=8, dist2goal=12.65
pushed 256 (20,2)
iter=46, frontier=7, popped=257 (20,3), depth=8, dist2goal=13.34
iter=47, frontier=6, popped=175 (14,3), depth=8, dist2goal=7.62
pushed 162 (13,3)
pushed 161 (13,2)
iter=48, frontier=7, popped=174 (14,2), depth=8, dist2goal=8.06
pushed 160 (13,1)
iter=49, frontier=7, popped=173 (14,1), depth=8, dist2goal=8.60
iter=50, frontier=6, popped=266 (20,12), depth=9, dist2goal=14.32
pushed 267 (20,13)
iter=51, frontier=6, popped=247 (19,12), depth=9, dist2goal=13.42
pushed 248 (19,13)
iter=52, frontier=6, popped=237 (19,1), depth=9, dist2goal=13.00
pushed 255 (20,1)
iter=53, frontier=6, popped=256 (20,2), depth=9, dist2goal=13.60
iter=54, frontier=5, popped=162 (13,3), depth=9, dist2goal=6.71
pushed 157 (12,3)
pushed 156 (12,2)
iter=55, frontier=6, popped=161 (13,2), depth=9, dist2goal=7.21
pushed 155 (12,1)
iter=56, frontier=6, popped=160 (13,1), depth=9, dist2goal=7.81
```

```
iter=57, frontier=5, popped=267 (20,13), depth=10, dist2goal=14.76
pushed 268 (20,14)
iter=58, frontier=5, popped=248 (19,13), depth=10, dist2goal=13.89
iter=59, frontier=4, popped=255 (20,1), depth=10, dist2goal=13.93
iter=60, frontier=3, popped=157 (12,3), depth=10, dist2goal=5.83
pushed 152 (11,3)
pushed 151 (11,2)
iter=61, frontier=4, popped=156 (12,2), depth=10, dist2goal=6.40
pushed 150 (11,1)
iter=62, frontier=4, popped=155 (12,1), depth=10, dist2goal=7.07
iter=63, frontier=3, popped=268 (20,14), depth=11, dist2goal=15.26
pushed 269 (20,15)
pushed 249 (19,15)
pushed 231 (18,15)
iter=64, frontier=5, popped=152 (11,3), depth=11, dist2goal=5.00
pushed 147 (10,3)
pushed 146 (10,2)
iter=65, frontier=6, popped=151 (11,2), depth=11, dist2goal=5.66
pushed 145 (10,1)
iter=66, frontier=6, popped=150 (11,1), depth=11, dist2goal=6.40
iter=67, frontier=5, popped=269 (20,15), depth=12, dist2goal=15.81
pushed 270 (20,16)
iter=68, frontier=5, popped=249 (19,15), depth=12, dist2goal=15.00
pushed 250 (19,16)
iter=69, frontier=5, popped=231 (18,15), depth=12, dist2goal=14.21
pushed 232 (18,16)
pushed 217 (17,15)
pushed 204 (16,14)
iter=70, frontier=7, popped=147 (10,3), depth=12, dist2goal=4.24
pushed 132 (9,3)
pushed 131 (9,2)
iter=71, frontier=8, popped=146 (10,2), depth=12, dist2goal=5.00
pushed 130 (9,1)
iter=72, frontier=8, popped=145 (10,1), depth=12, dist2goal=5.83
iter=73, frontier=7, popped=270 (20,16), depth=13, dist2goal=16.40
pushed 271 (20,17)
iter=74, frontier=7, popped=250 (19,16), depth=13, dist2goal=15.62
pushed 251 (19,17)
iter=75, frontier=7, popped=232 (18,16), depth=13, dist2goal=14.87
pushed 233 (18,17)
pushed 218 (17,16)
iter=76, frontier=8, popped=217 (17,15), depth=13, dist2goal=13.45
pushed 205 (16,15)
iter=77, frontier=8, popped=204 (16,14), depth=13, dist2goal=12.04
pushed 191 (15,14)
pushed 190 (15,13)
pushed 216 (17,13)
pushed 215 (17,12)
iter=78, frontier=11, popped=132 (9,3), depth=13, dist2goal=3.61
pushed 115 (8,3)
pushed 114 (8,2)
iter=79, frontier=12, popped=131 (9,2), depth=13, dist2goal=4.47
pushed 113 (8,1)
iter=80, frontier=12, popped=130 (9,1), depth=13, dist2goal=5.39
iter=81, frontier=11, popped=271 (20,17), depth=14, dist2goal=17.03
pushed 272 (20,18)
iter=82, frontier=11, popped=251 (19,17), depth=14, dist2goal=16.28
pushed 252 (19,18)
iter=83, frontier=11, popped=233 (18,17), depth=14, dist2goal=15.56
pushed 234 (18,18)
pushed 219 (17,17)
```

```
iter=84, frontier=12, popped=218 (17,16), depth=14, dist2goal=14.14
pushed 206 (16,16)
iter=85, frontier=12, popped=205 (16,15), depth=14, dist2goal=12.73
pushed 192 (15,15)
iter=86, frontier=12, popped=191 (15,14), depth=14, dist2goal=11.31
iter=87, frontier=11, popped=190 (15,13), depth=14, dist2goal=10.63
pushed 189 (15,12)
iter=88, frontier=11, popped=216 (17,13), depth=14, dist2goal=12.21
iter=89, frontier=10, popped=215 (17,12), depth=14, dist2goal=11.66
iter=90, frontier=9, popped=115 (8,3), depth=14, dist2goal=3.16
pushed 101 (7,3)
pushed 100 (7,2)
iter=91, frontier=10, popped=114 (8,2), depth=14, dist2goal=4.12
pushed 99 (7,1)
iter=92, frontier=10, popped=113 (8,1), depth=14, dist2goal=5.10
iter=93, frontier=9, popped=272 (20,18), depth=15, dist2goal=17.69
pushed 273 (20,19)
iter=94, frontier=9, popped=252 (19,18), depth=15, dist2goal=16.97
pushed 253 (19,19)
iter=95, frontier=9, popped=234 (18,18), depth=15, dist2goal=16.28
pushed 235 (18,19)
pushed 220 (17,18)
iter=96, frontier=10, popped=219 (17,17), depth=15, dist2goal=14.87
pushed 207 (16,17)
iter=97, frontier=10, popped=206 (16,16), depth=15, dist2goal=13.45
pushed 193 (15,16)
iter=98, frontier=10, popped=192 (15,15), depth=15, dist2goal=12.04
pushed 179 (14,15)
iter=99, frontier=10, popped=189 (15,12), depth=15, dist2goal=10.00
iter=100, frontier=9, popped=101 (7,3), depth=15, dist2goal=3.00
pushed 89 (6,3)
pushed 88 (6,2)
iter=101, frontier=10, popped=100 (7,2), depth=15, dist2goal=4.00
pushed 87 (6,1)
iter=102, frontier=10, popped=99 (7,1), depth=15, dist2goal=5.00
iter=103, frontier=9, popped=273 (20,19), depth=16, dist2goal=18.38
pushed 274 (20,20)
iter=104, frontier=9, popped=253 (19,19), depth=16, dist2goal=17.69
pushed 254 (19,20)
iter=105, frontier=9, popped=235 (18,19), depth=16, dist2goal=17.03
pushed 236 (18,20)
pushed 221 (17,19)
iter=106, frontier=10, popped=220 (17,18), depth=16, dist2goal=15.62
pushed 208 (16,18)
iter=107, frontier=10, popped=207 (16,17), depth=16, dist2goal=14.21
pushed 194 (15,17)
iter=108, frontier=10, popped=193 (15,16), depth=16, dist2goal=12.81
pushed 180 (14,16)
iter=109, frontier=10, popped=179 (14,15), depth=16, dist2goal=11.40
pushed 170 (13,15)
iter=110, frontier=10, popped=89 (6,3), depth=16, dist2goal=3.16
pushed 77 (5,3)
pushed 76 (5,2)
iter=111, frontier=11, popped=88 (6,2), depth=16, dist2goal=4.12
pushed 75 (5,1)
iter=112, frontier=11, popped=87 (6,1), depth=16, dist2goal=5.10
iter=113, frontier=10, popped=274 (20,20), depth=17, dist2goal=19.10
iter=114, frontier=9, popped=254 (19,20), depth=17, dist2goal=18.44
iter=115, frontier=8, popped=236 (18,20), depth=17, dist2goal=17.80
pushed 222 (17,20)
iter=116, frontier=8, popped=221 (17,19), depth=17, dist2goal=16.40
```

```
pushed 209 (16,19)
iter=117, frontier=8, popped=208 (16,18), depth=17, dist2goal=15.00
pushed 195 (15,18)
iter=118, frontier=8, popped=194 (15,17), depth=17, dist2goal=13.60
pushed 181 (14,17)
iter=119, frontier=8, popped=180 (14,16), depth=17, dist2goal=12.21
iter=120, frontier=7, popped=170 (13,15), depth=17, dist2goal=10.82
iter=121, frontier=6, popped=77 (5,3), depth=17, dist2goal=3.61
pushed 61 (4,3)
pushed 60 (4,2)
iter=122, frontier=7, popped=76 (5,2), depth=17, dist2goal=4.47
pushed 59 (4,1)
iter=123, frontier=7, popped=75 (5,1), depth=17, dist2goal=5.39
iter=124, frontier=6, popped=222 (17,20), depth=18, dist2goal=17.20
pushed 210 (16,20)
iter=125, frontier=6, popped=209 (16,19), depth=18, dist2goal=15.81
pushed 196 (15,19)
iter=126, frontier=6, popped=195 (15,18), depth=18, dist2goal=14.42
pushed 182 (14,18)
iter=127, frontier=6, popped=181 (14,17), depth=18, dist2goal=13.04
pushed 171 (13,19)
iter=128, frontier=6, popped=61 (4,3), depth=18, dist2goal=4.24
pushed 62 (4,4)
pushed 42 (3,3)
pushed 41 (3,2)
iter=129, frontier=8, popped=60 (4,2), depth=18, dist2goal=5.00
pushed 40 (3,1)
iter=130, frontier=8, popped=59 (4,1), depth=18, dist2goal=5.83
iter=131, frontier=7, popped=210 (16,20), depth=19, dist2goal=16.64
pushed 197 (15,20)
iter=132, frontier=7, popped=196 (15,19), depth=19, dist2goal=15.26
pushed 183 (14,19)
iter=133, frontier=7, popped=182 (14,18), depth=19, dist2goal=13.89
iter=134, frontier=6, popped=171 (13,19), depth=19, dist2goal=14.32
pushed 172 (13,20)
pushed 158 (12,19)
pushed 184 (14,20)
iter=135, frontier=8, popped=62 (4,4), depth=19, dist2goal=3.61
pushed 63 (4,5)
pushed 43 (3,4)
iter=136, frontier=9, popped=42 (3,3), depth=19, dist2goal=5.00
pushed 22 (2,3)
pushed 21 (2,2)
iter=137, frontier=10, popped=41 (3,2), depth=19, dist2goal=5.66
pushed 20 (2,1)
iter=138, frontier=10, popped=40 (3,1), depth=19, dist2goal=6.40
iter=139, frontier=9, popped=197 (15,20), depth=20, dist2goal=16.12
iter=140, frontier=8, popped=183 (14,19), depth=20, dist2goal=14.76
iter=141, frontier=7, popped=172 (13,20), depth=20, dist2goal=15.23
pushed 159 (12,20)
iter=142, frontier=7, popped=158 (12,19), depth=20, dist2goal=13.93
pushed 153 (11,19)
iter=143, frontier=7, popped=184 (14,20), depth=20, dist2goal=15.65
iter=144, frontier=6, popped=63 (4,5), depth=20, dist2goal=3.16
pushed 64 (4,6)
pushed 44 (3,5)
iter=145, frontier=7, popped=43 (3,4), depth=20, dist2goal=4.47
pushed 23 (2,4)
iter=146, frontier=7, popped=22 (2,3), depth=20, dist2goal=5.83
pushed 2 (1,3)
pushed 1 (1,2)
```

```
iter=147, frontier=8, popped=21 (2,2), depth=20, dist2goal=6.40
pushed 0 (1,1)
iter=148, frontier=8, popped=20 (2,1), depth=20, dist2goal=7.07
iter=149, frontier=7, popped=159 (12,20), depth=21, dist2goal=14.87
pushed 154 (11,20)
iter=150, frontier=7, popped=153 (11,19), depth=21, dist2goal=13.60
pushed 148 (10,19)
pushed 127 (8,18)
iter=151, frontier=8, popped=64 (4,6), depth=21, dist2goal=3.00
pushed 65 (4,7)
pushed 45 (3,6)
iter=152, frontier=9, popped=44 (3,5), depth=21, dist2goal=4.12
pushed 24 (2,5)
iter=153, frontier=9, popped=23 (2,4), depth=21, dist2goal=5.39
pushed 3 (1,4)
iter=154, frontier=9, popped=2 (1,3), depth=21, dist2goal=6.71
iter=155, frontier=8, popped=1 (1,2), depth=21, dist2goal=7.21
iter=156, frontier=7, popped=0 (1,1), depth=21, dist2goal=7.81
iter=157, frontier=6, popped=154 (11,20), depth=22, dist2goal=14.56
pushed 149 (10,20)
iter=158, frontier=6, popped=148 (10,19), depth=22, dist2goal=13.34
pushed 143 (9,19)
iter=159, frontier=6, popped=127 (8,18), depth=22, dist2goal=12.04
pushed 128 (8,19)
pushed 126 (8,17)
pushed 110 (7,18)
pushed 109 (7,17)
iter=160, frontier=9, popped=65 (4,7), depth=22, dist2goal=3.16
pushed 66 (4,8)
pushed 46 (3,7)
iter=161, frontier=10, popped=45 (3,6), depth=22, dist2goal=4.00
pushed 25 (2,6)
iter=162, frontier=10, popped=24 (2,5), depth=22, dist2goal=5.10
pushed 4 (1,5)
iter=163, frontier=10, popped=3 (1,4), depth=22, dist2goal=6.32
iter=164, frontier=9, popped=149 (10,20), depth=23, dist2goal=14.32
pushed 144 (9,20)
iter=165, frontier=9, popped=143 (9,19), depth=23, dist2goal=13.15
iter=166, frontier=8, popped=128 (8,19), depth=23, dist2goal=13.04
pushed 129 (8,20)
pushed 111 (7,19)
iter=167, frontier=9, popped=126 (8,17), depth=23, dist2goal=11.05
pushed 125 (8,16)
pushed 108 (7,16)
iter=168, frontier=10, popped=110 (7,18), depth=23, dist2goal=12.00
pushed 96 (6,18)
pushed 95 (6,17)
iter=169, frontier=11, popped=109 (7,17), depth=23, dist2goal=11.00
pushed 94 (6,16)
iter=170, frontier=11, popped=66 (4,8), depth=23, dist2goal=3.61
pushed 67 (4,9)
pushed 78 (5,8)
pushed 47 (3,8)
iter=171, frontier=13, popped=46 (3,7), depth=23, dist2goal=4.12
pushed 26 (2,7)
iter=172, frontier=13, popped=25 (2,6), depth=23, dist2goal=5.00
pushed 5 (1,6)
iter=173, frontier=13, popped=4 (1,5), depth=23, dist2goal=6.08
iter=174, frontier=12, popped=144 (9,20), depth=24, dist2goal=14.14
iter=175, frontier=11, popped=129 (8,20), depth=24, dist2goal=14.04
pushed 112 (7,20)
```

```
iter=176, frontier=11, popped=111 (7,19), depth=24, dist2goal=13.00
pushed 97 (6,19)
iter=177, frontier=11, popped=125 (8,16), depth=24, dist2goal=10.05
pushed 124 (8,15)
pushed 107 (7,15)
iter=178, frontier=12, popped=108 (7,16), depth=24, dist2goal=10.00
pushed 93 (6,15)
iter=179, frontier=12, popped=96 (6,18), depth=24, dist2goal=12.04
pushed 84 (5,18)
pushed 83 (5,17)
iter=180, frontier=13, popped=95 (6,17), depth=24, dist2goal=11.05
pushed 82 (5,16)
iter=181, frontier=13, popped=94 (6,16), depth=24, dist2goal=10.05
pushed 81 (5,15)
iter=182, frontier=13, popped=67 (4,9), depth=24, dist2goal=4.24
pushed 68 (4,10)
pushed 48 (3,9)
iter=183, frontier=14, popped=78 (5,8), depth=24, dist2goal=2.83
pushed 90 (6,8)
iter=184, frontier=14, popped=47 (3,8), depth=24, dist2goal=4.47
pushed 27 (2,8)
iter=185, frontier=14, popped=26 (2,7), depth=24, dist2goal=5.10
pushed 6 (1,7)
iter=186, frontier=14, popped=5 (1,6), depth=24, dist2goal=6.00
iter=187, frontier=13, popped=112 (7,20), depth=25, dist2goal=14.00
pushed 98 (6,20)
iter=188, frontier=13, popped=97 (6,19), depth=25, dist2goal=13.04
pushed 85 (5,19)
iter=189, frontier=13, popped=124 (8,15), depth=25, dist2goal=9.06
pushed 142 (9,15)
iter=190, frontier=13, popped=107 (7,15), depth=25, dist2goal=9.00
pushed 92 (6,14)
iter=191, frontier=13, popped=93 (6,15), depth=25, dist2goal=9.06
pushed 80 (5,14)
iter=192, frontier=13, popped=84 (5,18), depth=25, dist2goal=12.17
pushed 72 (4,18)
pushed 71 (4,17)
iter=193, frontier=14, popped=83 (5,17), depth=25, dist2goal=11.18
pushed 70 (4,16)
iter=194, frontier=14, popped=82 (5,16), depth=25, dist2goal=10.20
pushed 69 (4,15)
iter=195, frontier=14, popped=81 (5,15), depth=25, dist2goal=9.22
iter=196, frontier=13, popped=68 (4,10), depth=25, dist2goal=5.00
pushed 49 (3,10)
pushed 50 (3,11)
pushed 51 (3,12)
pushed 52 (3,13)
iter=197, frontier=16, popped=48 (3,9), depth=25, dist2goal=5.00
pushed 28 (2,9)
iter=198, frontier=16, popped=90 (6,8), depth=25, dist2goal=2.24
pushed 104 (7,8)
iter=199, frontier=16, popped=27 (2,8), depth=25, dist2goal=5.39
pushed 7 (1,8)
iter=200, frontier=16, popped=6 (1,7), depth=25, dist2goal=6.08
iter=201, frontier=15, popped=98 (6,20), depth=26, dist2goal=14.04
pushed 86 (5,20)
iter=202, frontier=15, popped=85 (5,19), depth=26, dist2goal=13.15
pushed 73 (4,19)
iter=203, frontier=15, popped=142 (9,15), depth=26, dist2goal=9.22
pushed 141 (9,14)
iter=204, frontier=15, popped=92 (6,14), depth=26, dist2goal=8.06
```

```
pushed 91 (6,13)
pushed 79 (5,13)
iter=205, frontier=16, popped=80 (5,14), depth=26, dist2goal=8.25
iter=206, frontier=15, popped=72 (4,18), depth=26, dist2goal=12.37
pushed 56 (3,18)
pushed 55 (3,17)
iter=207, frontier=16, popped=71 (4,17), depth=26, dist2goal=11.40
pushed 54 (3,16)
iter=208, frontier=16, popped=70 (4,16), depth=26, dist2goal=10.44
pushed 53 (3,15)
iter=209, frontier=16, popped=69 (4,15), depth=26, dist2goal=9.49
iter=210, frontier=15, popped=49 (3,10), depth=26, dist2goal=5.66
pushed 29 (2,10)
iter=211, frontier=15, popped=50 (3,11), depth=26, dist2goal=6.40
pushed 30 (2,11)
iter=212, frontier=15, popped=51 (3,12), depth=26, dist2goal=7.21
pushed 31 (2,12)
iter=213, frontier=15, popped=52 (3,13), depth=26, dist2goal=8.06
pushed 32 (2,13)
iter=214, frontier=15, popped=28 (2,9), depth=26, dist2goal=5.83
pushed 8 (1,9)
iter=215, frontier=15, popped=104 (7,8), depth=26, dist2goal=2.00
pushed 103 (7,7)
pushed 105 (7,9)
pushed 118 (8,8)
pushed 119 (8,9)
iter=216, frontier=18, popped=7 (1,8), depth=26, dist2goal=6.32
iter=217, frontier=17, popped=86 (5,20), depth=27, dist2goal=14.14
pushed 74 (4,20)
iter=218, frontier=17, popped=73 (4,19), depth=27, dist2goal=13.34
pushed 57 (3,19)
iter=219, frontier=17, popped=141 (9,14), depth=27, dist2goal=8.25
pushed 140 (9,13)
iter=220, frontier=17, popped=91 (6,13), depth=27, dist2goal=7.07
iter=221, frontier=16, popped=79 (5,13), depth=27, dist2goal=7.28
iter=222, frontier=15, popped=56 (3,18), depth=27, dist2goal=12.65
pushed 37 (2,18)
pushed 36 (2,17)
iter=223, frontier=16, popped=55 (3,17), depth=27, dist2goal=11.70
pushed 35 (2,16)
iter=224, frontier=16, popped=54 (3,16), depth=27, dist2goal=10.77
pushed 34 (2,15)
iter=225, frontier=16, popped=53 (3,15), depth=27, dist2goal=9.85
pushed 33 (2,14)
iter=226, frontier=16, popped=29 (2,10), depth=27, dist2goal=6.40
pushed 9 (1,10)
iter=227, frontier=16, popped=30 (2,11), depth=27, dist2goal=7.07
pushed 10 (1,11)
iter=228, frontier=16, popped=31 (2,12), depth=27, dist2goal=7.81
pushed 11 (1,12)
iter=229, frontier=16, popped=32 (2,13), depth=27, dist2goal=8.60
pushed 12 (1,13)
iter=230, frontier=16, popped=8 (1,9), depth=27, dist2goal=6.71
iter=231, frontier=15, popped=103 (7,7), depth=27, dist2goal=1.00
pushed 102 (7,6)
pushed 117 (8,7)
iter=232, frontier=16, popped=105 (7,9), depth=27, dist2goal=3.00
pushed 106 (7,10)
pushed 120 (8,10)
iter=233, frontier=17, popped=118 (8,8), depth=27, dist2goal=2.24
pushed 135 (9,8)
```

```
pushed 136 (9,9)
iter=234, frontier=18, popped=119 (8,9), depth=27, dist2goal=3.16
pushed 137 (9,10)
iter=235, frontier=18, popped=74 (4,20), depth=28, dist2goal=14.32
pushed 58 (3,20)
iter=236, frontier=18, popped=57 (3,19), depth=28, dist2goal=13.60
pushed 38 (2,19)
iter=237, frontier=18, popped=140 (9,13), depth=28, dist2goal=7.28
pushed 139 (9,12)
pushed 123 (8,13)
pushed 122 (8,12)
iter=238, frontier=20, popped=37 (2,18), depth=28, dist2goal=13.00
pushed 17 (1,18)
pushed 16 (1,17)
iter=239, frontier=21, popped=36 (2,17), depth=28, dist2goal=12.08
pushed 15 (1,16)
iter=240, frontier=21, popped=35 (2,16), depth=28, dist2goal=11.18
pushed 14 (1,15)
iter=241, frontier=21, popped=34 (2,15), depth=28, dist2goal=10.30
pushed 13 (1,14)
iter=242, frontier=21, popped=33 (2,14), depth=28, dist2goal=9.43
iter=243, frontier=20, popped=9 (1,10), depth=28, dist2goal=7.21
iter=244, frontier=19, popped=10 (1,11), depth=28, dist2goal=7.81
iter=245, frontier=18, popped=11 (1,12), depth=28, dist2goal=8.49
iter=246, frontier=17, popped=12 (1,13), depth=28, dist2goal=9.22
iter=247, frontier=16, popped=102 (7,6), depth=28, dist2goal=0.00
Solution Path:
Vertex 163 (13,6)
Vertex 177 (14,7)
Vertex 201 (16,8)
Vertex 214 (17,8)
Vertex 227 (18,5)
Vertex 213 (17,3)
Vertex 200 (16,3)
Vertex 187 (15,3)
Vertex 175 (14,3)
Vertex 162 (13,3)
Vertex 157 (12,3)
Vertex 152 (11,3)
Vertex 147 (10,3)
Vertex 132 (9,3)
Vertex 115 (8,3)
Vertex 101 (7,3)
Vertex 89 (6,3)
Vertex 77 (5,3)
Vertex 61 (4,3)
Vertex 62 (4,4)
Vertex 63 (4,5)
Vertex 64 (4,6)
Vertex 65 (4,7)
Vertex 66 (4,8)
Vertex 78 (5,8)
Vertex 90 (6,8)
Vertex 104 (7,8)
Vertex 103 (7,7)
Vertex 102 (7,6)
==============================
Search Algorithm BFS
Total iterations 247
Maximum Frontier size: 22
Vertices visited: 263/275
```

Path Length: 28

A&M Path

Fig: BFS from (13,6) to (7,6)

==

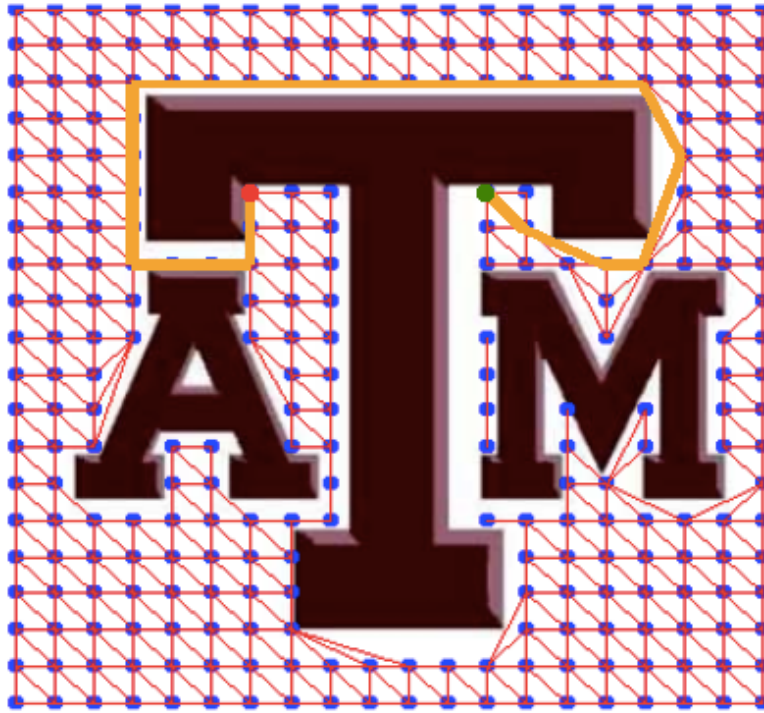## Depth-First Search

```
java Run DFS_nav ATM.graph 13 6 7 6 d
vertices=275, edges=641
start=(13,6), goal=(7,6), vertices: 163 and 102
iter=1, frontier=0, popped=163 (13,6), depth=0, dist2goal=6.00
pushed 164 (13,7)
pushed 176 (14,6)
pushed 177 (14,7)
iter=2, frontier=2, popped=177 (14,7), depth=1, dist2goal=7.07
pushed 178 (14,8)
pushed 188 (15,8)
pushed 201 (16,8)
iter=3, frontier=4, popped=201 (16,8), depth=2, dist2goal=9.22
pushed 202 (16,9)
pushed 214 (17,8)
iter=4, frontier=5, popped=214 (17,8), depth=3, dist2goal=10.20
pushed 230 (18,8)
pushed 229 (18,7)
pushed 203 (16,10)
pushed 228 (18,6)
```

```
pushed 227 (18,5)
iter=5, frontier=9, popped=227 (18,5), depth=4, dist2goal=11.05
pushed 226 (18,4)
pushed 241 (19,5)
pushed 242 (19,6)
pushed 213 (17,3)
iter=6, frontier=12, popped=213 (17,3), depth=5, dist2goal=10.44
pushed 212 (17,2)
pushed 200 (16,3)
pushed 225 (18,3)
pushed 199 (16,2)
iter=7, frontier=15, popped=199 (16,2), depth=6, dist2goal=9.85
pushed 198 (16,1)
pushed 186 (15,2)
pushed 185 (15,1)
iter=8, frontier=17, popped=185 (15,1), depth=7, dist2goal=9.43
pushed 173 (14,1)
iter=9, frontier=17, popped=173 (14,1), depth=8, dist2goal=8.60
pushed 174 (14,2)
pushed 160 (13,1)
iter=10, frontier=18, popped=160 (13,1), depth=9, dist2goal=7.81
pushed 161 (13,2)
pushed 155 (12,1)
iter=11, frontier=19, popped=155 (12,1), depth=10, dist2goal=7.07
pushed 156 (12,2)
pushed 150 (11,1)
iter=12, frontier=20, popped=150 (11,1), depth=11, dist2goal=6.40
pushed 151 (11,2)
pushed 145 (10,1)
iter=13, frontier=21, popped=145 (10,1), depth=12, dist2goal=5.83
pushed 146 (10,2)
pushed 130 (9,1)
iter=14, frontier=22, popped=130 (9,1), depth=13, dist2goal=5.39
pushed 131 (9,2)
pushed 113 (8,1)
iter=15, frontier=23, popped=113 (8,1), depth=14, dist2goal=5.10
pushed 114 (8,2)
pushed 99 (7,1)
iter=16, frontier=24, popped=99 (7,1), depth=15, dist2goal=5.00
pushed 100 (7,2)
pushed 87 (6,1)
iter=17, frontier=25, popped=87 (6,1), depth=16, dist2goal=5.10
pushed 88 (6,2)
pushed 75 (5,1)
iter=18, frontier=26, popped=75 (5,1), depth=17, dist2goal=5.39
pushed 76 (5,2)
pushed 59 (4,1)
iter=19, frontier=27, popped=59 (4,1), depth=18, dist2goal=5.83
pushed 60 (4,2)
pushed 40 (3,1)
iter=20, frontier=28, popped=40 (3,1), depth=19, dist2goal=6.40
pushed 41 (3,2)
pushed 20 (2,1)
iter=21, frontier=29, popped=20 (2,1), depth=20, dist2goal=7.07
pushed 21 (2,2)
pushed 0 (1,1)
iter=22, frontier=30, popped=0 (1,1), depth=21, dist2goal=7.81
pushed 1 (1,2)
iter=23, frontier=30, popped=1 (1,2), depth=22, dist2goal=7.21
pushed 2 (1,3)
pushed 22 (2,3)
```

```
iter=24, frontier=31, popped=22 (2,3), depth=23, dist2goal=5.83
pushed 23 (2,4)
pushed 42 (3,3)
pushed 43 (3,4)
iter=25, frontier=33, popped=43 (3,4), depth=24, dist2goal=4.47
pushed 44 (3,5)
pushed 62 (4,4)
pushed 63 (4,5)
iter=26, frontier=35, popped=63 (4,5), depth=25, dist2goal=3.16
pushed 64 (4,6)
iter=27, frontier=35, popped=64 (4,6), depth=26, dist2goal=3.00
pushed 65 (4,7)
pushed 45 (3,6)
iter=28, frontier=36, popped=45 (3,6), depth=27, dist2goal=4.00
pushed 46 (3,7)
pushed 25 (2,6)
pushed 24 (2,5)
iter=29, frontier=38, popped=24 (2,5), depth=28, dist2goal=5.10
pushed 4 (1,5)
pushed 3 (1,4)
iter=30, frontier=39, popped=3 (1,4), depth=29, dist2goal=6.32
iter=31, frontier=38, popped=4 (1,5), depth=29, dist2goal=6.08
pushed 5 (1,6)
iter=32, frontier=38, popped=5 (1,6), depth=30, dist2goal=6.00
pushed 6 (1,7)
pushed 26 (2,7)
iter=33, frontier=39, popped=26 (2,7), depth=31, dist2goal=5.10
pushed 27 (2,8)
pushed 47 (3,8)
iter=34, frontier=40, popped=47 (3,8), depth=32, dist2goal=4.47
pushed 48 (3,9)
pushed 66 (4,8)
pushed 67 (4,9)
iter=35, frontier=42, popped=67 (4,9), depth=33, dist2goal=4.24
pushed 68 (4,10)
iter=36, frontier=42, popped=68 (4,10), depth=34, dist2goal=5.00
pushed 49 (3,10)
pushed 50 (3,11)
pushed 51 (3,12)
pushed 52 (3,13)
iter=37, frontier=45, popped=52 (3,13), depth=35, dist2goal=8.06
pushed 32 (2,13)
pushed 31 (2,12)
iter=38, frontier=46, popped=31 (2,12), depth=36, dist2goal=7.81
pushed 30 (2,11)
pushed 11 (1,12)
pushed 10 (1,11)
iter=39, frontier=48, popped=10 (1,11), depth=37, dist2goal=7.81
pushed 9 (1,10)
iter=40, frontier=48, popped=9 (1,10), depth=38, dist2goal=7.21
pushed 8 (1,9)
pushed 29 (2,10)
iter=41, frontier=49, popped=29 (2,10), depth=39, dist2goal=6.40
pushed 28 (2,9)
iter=42, frontier=49, popped=28 (2,9), depth=40, dist2goal=5.83
pushed 7 (1,8)
iter=43, frontier=49, popped=7 (1,8), depth=41, dist2goal=6.32
iter=44, frontier=48, popped=8 (1,9), depth=39, dist2goal=6.71
iter=45, frontier=47, popped=11 (1,12), depth=37, dist2goal=8.49
pushed 12 (1,13)
iter=46, frontier=47, popped=12 (1,13), depth=38, dist2goal=9.22
```

```
pushed 13 (1,14)
pushed 33 (2,14)
iter=47, frontier=48, popped=33 (2,14), depth=39, dist2goal=9.43
pushed 34 (2,15)
pushed 53 (3,15)
iter=48, frontier=49, popped=53 (3,15), depth=40, dist2goal=9.85
pushed 54 (3,16)
pushed 69 (4,15)
pushed 70 (4,16)
iter=49, frontier=51, popped=70 (4,16), depth=41, dist2goal=10.44
pushed 71 (4,17)
pushed 82 (5,16)
pushed 83 (5,17)
iter=50, frontier=53, popped=83 (5,17), depth=42, dist2goal=11.18
pushed 84 (5,18)
pushed 95 (6,17)
pushed 96 (6,18)
iter=51, frontier=55, popped=96 (6,18), depth=43, dist2goal=12.04
pushed 97 (6,19)
pushed 110 (7,18)
pushed 111 (7,19)
iter=52, frontier=57, popped=111 (7,19), depth=44, dist2goal=13.00
pushed 112 (7,20)
pushed 128 (8,19)
pushed 129 (8,20)
iter=53, frontier=59, popped=129 (8,20), depth=45, dist2goal=14.04
pushed 144 (9,20)
iter=54, frontier=59, popped=144 (9,20), depth=46, dist2goal=14.14
pushed 143 (9,19)
pushed 149 (10,20)
iter=55, frontier=60, popped=149 (10,20), depth=47, dist2goal=14.32
pushed 148 (10,19)
pushed 154 (11,20)
iter=56, frontier=61, popped=154 (11,20), depth=48, dist2goal=14.56
pushed 153 (11,19)
pushed 159 (12,20)
iter=57, frontier=62, popped=159 (12,20), depth=49, dist2goal=14.87
pushed 158 (12,19)
pushed 172 (13,20)
iter=58, frontier=63, popped=172 (13,20), depth=50, dist2goal=15.23
pushed 171 (13,19)
pushed 184 (14,20)
iter=59, frontier=64, popped=184 (14,20), depth=51, dist2goal=15.65
pushed 183 (14,19)
pushed 197 (15,20)
iter=60, frontier=65, popped=197 (15,20), depth=52, dist2goal=16.12
pushed 196 (15,19)
pushed 210 (16,20)
iter=61, frontier=66, popped=210 (16,20), depth=53, dist2goal=16.64
pushed 209 (16,19)
pushed 222 (17,20)
iter=62, frontier=67, popped=222 (17,20), depth=54, dist2goal=17.20
pushed 221 (17,19)
pushed 236 (18,20)
iter=63, frontier=68, popped=236 (18,20), depth=55, dist2goal=17.80
pushed 235 (18,19)
pushed 254 (19,20)
iter=64, frontier=69, popped=254 (19,20), depth=56, dist2goal=18.44
pushed 253 (19,19)
pushed 274 (20,20)
iter=65, frontier=70, popped=274 (20,20), depth=57, dist2goal=19.10
```

```
pushed 273 (20,19)
iter=66, frontier=70, popped=273 (20,19), depth=58, dist2goal=18.38
pushed 272 (20,18)
pushed 252 (19,18)
iter=67, frontier=71, popped=252 (19,18), depth=59, dist2goal=16.97
pushed 251 (19,17)
pushed 234 (18,18)
pushed 233 (18,17)
iter=68, frontier=73, popped=233 (18,17), depth=60, dist2goal=15.56
pushed 232 (18,16)
pushed 219 (17,17)
pushed 218 (17,16)
iter=69, frontier=75, popped=218 (17,16), depth=61, dist2goal=14.14
pushed 217 (17,15)
pushed 206 (16,16)
pushed 205 (16,15)
iter=70, frontier=77, popped=205 (16,15), depth=62, dist2goal=12.73
pushed 204 (16,14)
pushed 192 (15,15)
pushed 191 (15,14)
iter=71, frontier=79, popped=191 (15,14), depth=63, dist2goal=11.31
pushed 190 (15,13)
iter=72, frontier=79, popped=190 (15,13), depth=64, dist2goal=10.63
pushed 189 (15,12)
iter=73, frontier=79, popped=189 (15,12), depth=65, dist2goal=10.00
iter=74, frontier=78, popped=192 (15,15), depth=63, dist2goal=12.04
pushed 193 (15,16)
pushed 179 (14,15)
iter=75, frontier=79, popped=179 (14,15), depth=64, dist2goal=11.40
pushed 180 (14,16)
pushed 170 (13,15)
iter=76, frontier=80, popped=170 (13,15), depth=65, dist2goal=10.82
iter=77, frontier=79, popped=180 (14,16), depth=65, dist2goal=12.21
pushed 181 (14,17)
pushed 194 (15,17)
iter=78, frontier=80, popped=194 (15,17), depth=66, dist2goal=13.60
pushed 195 (15,18)
pushed 207 (16,17)
pushed 208 (16,18)
iter=79, frontier=82, popped=208 (16,18), depth=67, dist2goal=15.00
pushed 220 (17,18)
iter=80, frontier=82, popped=220 (17,18), depth=68, dist2goal=15.62
iter=81, frontier=81, popped=207 (16,17), depth=67, dist2goal=14.21
iter=82, frontier=80, popped=195 (15,18), depth=67, dist2goal=14.42
pushed 182 (14,18)
iter=83, frontier=80, popped=182 (14,18), depth=68, dist2goal=13.89
iter=84, frontier=79, popped=181 (14,17), depth=66, dist2goal=13.04
iter=85, frontier=78, popped=193 (15,16), depth=64, dist2goal=12.81
iter=86, frontier=77, popped=204 (16,14), depth=63, dist2goal=12.04
pushed 216 (17,13)
pushed 215 (17,12)
pushed 231 (18,15)
iter=87, frontier=79, popped=231 (18,15), depth=64, dist2goal=14.21
pushed 249 (19,15)
pushed 250 (19,16)
pushed 268 (20,14)
iter=88, frontier=81, popped=268 (20,14), depth=65, dist2goal=15.26
pushed 269 (20,15)
pushed 267 (20,13)
pushed 248 (19,13)
iter=89, frontier=83, popped=248 (19,13), depth=66, dist2goal=13.89
```

```
pushed 247 (19,12)
iter=90, frontier=83, popped=247 (19,12), depth=67, dist2goal=13.42
pushed 246 (19,11)
pushed 266 (20,12)
iter=91, frontier=84, popped=266 (20,12), depth=68, dist2goal=14.32
pushed 265 (20,11)
iter=92, frontier=84, popped=265 (20,11), depth=69, dist2goal=13.93
pushed 264 (20,10)
pushed 245 (19,10)
iter=93, frontier=85, popped=245 (19,10), depth=70, dist2goal=12.65
pushed 263 (20,9)
iter=94, frontier=85, popped=263 (20,9), depth=71, dist2goal=13.34
pushed 262 (20,8)
pushed 244 (19,8)
iter=95, frontier=86, popped=244 (19,8), depth=72, dist2goal=12.17
pushed 243 (19,7)
iter=96, frontier=86, popped=243 (19,7), depth=73, dist2goal=12.04
pushed 261 (20,7)
iter=97, frontier=86, popped=261 (20,7), depth=74, dist2goal=13.04
pushed 260 (20,6)
iter=98, frontier=86, popped=260 (20,6), depth=75, dist2goal=13.00
pushed 259 (20,5)
iter=99, frontier=86, popped=259 (20,5), depth=76, dist2goal=13.04
pushed 258 (20,4)
pushed 240 (19,4)
iter=100, frontier=87, popped=240 (19,4), depth=77, dist2goal=12.17
pushed 239 (19,3)
iter=101, frontier=87, popped=239 (19,3), depth=78, dist2goal=12.37
pushed 238 (19,2)
pushed 257 (20,3)
pushed 224 (18,2)
iter=102, frontier=89, popped=224 (18,2), depth=79, dist2goal=11.70
pushed 223 (18,1)
pushed 211 (17,1)
iter=103, frontier=90, popped=211 (17,1), depth=80, dist2goal=11.18
iter=104, frontier=89, popped=223 (18,1), depth=80, dist2goal=12.08
pushed 237 (19,1)
iter=105, frontier=89, popped=237 (19,1), depth=81, dist2goal=13.00
pushed 255 (20,1)
pushed 256 (20,2)
iter=106, frontier=90, popped=256 (20,2), depth=82, dist2goal=13.60
iter=107, frontier=89, popped=255 (20,1), depth=82, dist2goal=13.93
iter=108, frontier=88, popped=257 (20,3), depth=79, dist2goal=13.34
iter=109, frontier=87, popped=238 (19,2), depth=79, dist2goal=12.65
iter=110, frontier=86, popped=258 (20,4), depth=77, dist2goal=13.15
iter=111, frontier=85, popped=262 (20,8), depth=72, dist2goal=13.15
iter=112, frontier=84, popped=264 (20,10), depth=70, dist2goal=13.60
iter=113, frontier=83, popped=246 (19,11), depth=68, dist2goal=13.00
iter=114, frontier=82, popped=267 (20,13), depth=66, dist2goal=14.76
iter=115, frontier=81, popped=269 (20,15), depth=66, dist2goal=15.81
pushed 270 (20,16)
iter=116, frontier=81, popped=270 (20,16), depth=67, dist2goal=16.40
pushed 271 (20,17)
iter=117, frontier=81, popped=271 (20,17), depth=68, dist2goal=17.03
iter=118, frontier=80, popped=250 (19,16), depth=65, dist2goal=15.62
iter=119, frontier=79, popped=249 (19,15), depth=65, dist2goal=15.00
iter=120, frontier=78, popped=215 (17,12), depth=64, dist2goal=11.66
iter=121, frontier=77, popped=216 (17,13), depth=64, dist2goal=12.21
iter=122, frontier=76, popped=206 (16,16), depth=62, dist2goal=13.45
iter=123, frontier=75, popped=217 (17,15), depth=62, dist2goal=13.45
iter=124, frontier=74, popped=219 (17,17), depth=61, dist2goal=14.87
```

```
iter=125, frontier=73, popped=232 (18,16), depth=61, dist2goal=14.87
iter=126, frontier=72, popped=234 (18,18), depth=60, dist2goal=16.28
iter=127, frontier=71, popped=251 (19,17), depth=60, dist2goal=16.28
iter=128, frontier=70, popped=272 (20,18), depth=59, dist2goal=17.69
iter=129, frontier=69, popped=253 (19,19), depth=57, dist2goal=17.69
iter=130, frontier=68, popped=235 (18,19), depth=56, dist2goal=17.03
iter=131, frontier=67, popped=221 (17,19), depth=55, dist2goal=16.40
iter=132, frontier=66, popped=209 (16,19), depth=54, dist2goal=15.81
iter=133, frontier=65, popped=196 (15,19), depth=53, dist2goal=15.26
iter=134, frontier=64, popped=183 (14,19), depth=52, dist2goal=14.76
iter=135, frontier=63, popped=171 (13,19), depth=51, dist2goal=14.32
iter=136, frontier=62, popped=158 (12,19), depth=50, dist2goal=13.93
iter=137, frontier=61, popped=153 (11,19), depth=49, dist2goal=13.60
pushed 127 (8,18)
iter=138, frontier=61, popped=127 (8,18), depth=50, dist2goal=12.04
pushed 126 (8,17)
pushed 109 (7,17)
iter=139, frontier=62, popped=109 (7,17), depth=51, dist2goal=11.00
pushed 108 (7,16)
pushed 94 (6,16)
iter=140, frontier=63, popped=94 (6,16), depth=52, dist2goal=10.05
pushed 93 (6,15)
pushed 81 (5,15)
iter=141, frontier=64, popped=81 (5,15), depth=53, dist2goal=9.22
pushed 80 (5,14)
iter=142, frontier=64, popped=80 (5,14), depth=54, dist2goal=8.25
pushed 79 (5,13)
pushed 92 (6,14)
iter=143, frontier=65, popped=92 (6,14), depth=55, dist2goal=8.06
pushed 91 (6,13)
pushed 107 (7,15)
iter=144, frontier=66, popped=107 (7,15), depth=56, dist2goal=9.00
pushed 124 (8,15)
pushed 125 (8,16)
iter=145, frontier=67, popped=125 (8,16), depth=57, dist2goal=10.05
iter=146, frontier=66, popped=124 (8,15), depth=57, dist2goal=9.06
pushed 142 (9,15)
iter=147, frontier=66, popped=142 (9,15), depth=58, dist2goal=9.22
pushed 141 (9,14)
iter=148, frontier=66, popped=141 (9,14), depth=59, dist2goal=8.25
pushed 140 (9,13)
iter=149, frontier=66, popped=140 (9,13), depth=60, dist2goal=7.28
pushed 139 (9,12)
pushed 123 (8,13)
pushed 122 (8,12)
iter=150, frontier=68, popped=122 (8,12), depth=61, dist2goal=6.08
pushed 121 (8,11)
pushed 106 (7,10)
iter=151, frontier=69, popped=106 (7,10), depth=62, dist2goal=4.00
pushed 105 (7,9)
pushed 120 (8,10)
iter=152, frontier=70, popped=120 (8,10), depth=63, dist2goal=4.12
pushed 119 (8,9)
pushed 137 (9,10)
pushed 138 (9,11)
iter=153, frontier=72, popped=138 (9,11), depth=64, dist2goal=5.39
iter=154, frontier=71, popped=137 (9,10), depth=64, dist2goal=4.47
pushed 136 (9,9)
iter=155, frontier=71, popped=136 (9,9), depth=65, dist2goal=3.61
pushed 135 (9,8)
pushed 118 (8,8)
```

```
iter=156, frontier=72, popped=118 (8,8), depth=66, dist2goal=2.24
pushed 117 (8,7)
pushed 104 (7,8)
pushed 103 (7,7)
iter=157, frontier=74, popped=103 (7,7), depth=67, dist2goal=1.00
pushed 102 (7,6)
iter=158, frontier=74, popped=102 (7,6), depth=68, dist2goal=0.00
Solution Path:
Vertex 163 (13,6)
Vertex 177 (14,7)
Vertex 201 (16,8)
Vertex 214 (17,8)
Vertex 227 (18,5)
Vertex 213 (17,3)
Vertex 199 (16,2)
Vertex 185 (15,1)
Vertex 173 (14,1)
Vertex 160 (13,1)
Vertex 155 (12,1)
Vertex 150 (11,1)
Vertex 145 (10,1)
Vertex 130 (9,1)
Vertex 113 (8,1)
Vertex 99 (7,1)
Vertex 87 (6,1)
Vertex 75 (5,1)
Vertex 59 (4,1)
Vertex 40 (3,1)
Vertex 20 (2,1)
Vertex 0 (1,1)
Vertex 1 (1,2)
Vertex 22 (2,3)
Vertex 43 (3,4)
Vertex 63 (4,5)
Vertex 64 (4,6)
Vertex 45 (3,6)
Vertex 24 (2,5)
Vertex 4 (1,5)
Vertex 5 (1,6)
Vertex 26 (2,7)
Vertex 47 (3,8)
Vertex 67 (4,9)
Vertex 68 (4,10)
Vertex 52 (3,13)
Vertex 31 (2,12)
Vertex 11 (1,12)
Vertex 12 (1,13)
Vertex 33 (2,14)
Vertex 53 (3,15)
Vertex 70 (4,16)
Vertex 83 (5,17)
Vertex 96 (6,18)
Vertex 111 (7,19)
Vertex 129 (8,20)
Vertex 144 (9,20)
Vertex 149 (10,20)
Vertex 154 (11,20)
Vertex 153 (11,19)
Vertex 127 (8,18)
Vertex 109 (7,17)
Vertex 94 (6,16)
```

```
Vertex 81 (5,15)
Vertex 80 (5,14)
Vertex 92 (6,14)
Vertex 107 (7,15)
Vertex 124 (8,15)
Vertex 142 (9,15)
Vertex 141 (9,14)
Vertex 140 (9,13)
Vertex 122 (8,12)
Vertex 106 (7,10)
Vertex 120 (8,10)
Vertex 137 (9,10)
Vertex 136 (9,9)
Vertex 118 (8,8)
Vertex 103 (7,7)
Vertex 102 (7,6)
================================
Search Algorithm DFS
Total iterations 158
Maximum Frontier size: 91
Vertices visited: 232/275
Path Length: 68
```

A&M Path

Fig: DFS from (13,6) to (7,6)

==

Greedy Best First Search

```
java Run GBFS_nav ATM.graph 13 6 7 6 d
vertices=275, edges=641
start=(13,6), goal=(7,6), vertices: 163 and 102
iter=1, frontier=0, popped=163 (13,6), depth=0, dist2goal=6.00
pushed 164 (13,7)
pushed 176 (14,6)
pushed 177 (14,7)
iter=2, frontier=2, popped=164 (13,7), depth=1, dist2goal=6.08
pushed 165 (13,8)
pushed 178 (14,8)
iter=3, frontier=3, popped=165 (13,8), depth=2, dist2goal=6.32
iter=4, frontier=2, popped=176 (14,6), depth=1, dist2goal=7.00
iter=5, frontier=1, popped=177 (14,7), depth=1, dist2goal=7.07
pushed 188 (15,8)
pushed 201 (16,8)
iter=6, frontier=2, popped=178 (14,8), depth=2, dist2goal=7.28
iter=7, frontier=1, popped=188 (15,8), depth=2, dist2goal=8.25
pushed 202 (16,9)
pushed 203 (16,10)
iter=8, frontier=2, popped=201 (16,8), depth=2, dist2goal=9.22
pushed 214 (17,8)
iter=9, frontier=2, popped=202 (16,9), depth=3, dist2goal=9.49
iter=10, frontier=1, popped=203 (16,10), depth=3, dist2goal=9.85
iter=11, frontier=0, popped=214 (17,8), depth=3, dist2goal=10.20
pushed 230 (18,8)
pushed 229 (18,7)
pushed 228 (18,6)
pushed 227 (18,5)
iter=12, frontier=3, popped=228 (18,6), depth=4, dist2goal=11.00
pushed 242 (19,6)
pushed 243 (19,7)
iter=13, frontier=4, popped=227 (18,5), depth=4, dist2goal=11.05
pushed 226 (18,4)
pushed 241 (19,5)
pushed 213 (17,3)
iter=14, frontier=6, popped=213 (17,3), depth=5, dist2goal=10.44
pushed 212 (17,2)
pushed 200 (16,3)
pushed 225 (18,3)
pushed 199 (16,2)
iter=15, frontier=9, popped=200 (16,3), depth=6, dist2goal=9.49
pushed 187 (15,3)
pushed 186 (15,2)
iter=16, frontier=10, popped=187 (15,3), depth=7, dist2goal=8.54
pushed 175 (14,3)
pushed 174 (14,2)
iter=17, frontier=11, popped=175 (14,3), depth=8, dist2goal=7.62
pushed 162 (13,3)
pushed 161 (13,2)
iter=18, frontier=12, popped=162 (13,3), depth=9, dist2goal=6.71
pushed 157 (12,3)
pushed 156 (12,2)
iter=19, frontier=13, popped=157 (12,3), depth=10, dist2goal=5.83
```

```
pushed 152 (11,3)
pushed 151 (11,2)
iter=20, frontier=14, popped=152 (11,3), depth=11, dist2goal=5.00
pushed 147 (10,3)
pushed 146 (10,2)
iter=21, frontier=15, popped=147 (10,3), depth=12, dist2goal=4.24
pushed 132 (9,3)
pushed 131 (9,2)
iter=22, frontier=16, popped=132 (9,3), depth=13, dist2goal=3.61
pushed 115 (8,3)
pushed 114 (8,2)
iter=23, frontier=17, popped=115 (8,3), depth=14, dist2goal=3.16
pushed 101 (7,3)
pushed 100 (7,2)
iter=24, frontier=18, popped=101 (7,3), depth=15, dist2goal=3.00
pushed 89 (6,3)
pushed 88 (6,2)
iter=25, frontier=19, popped=89 (6,3), depth=16, dist2goal=3.16
pushed 77 (5,3)
pushed 76 (5,2)
iter=26, frontier=20, popped=77 (5,3), depth=17, dist2goal=3.61
pushed 61 (4,3)
pushed 60 (4,2)
iter=27, frontier=21, popped=100 (7,2), depth=15, dist2goal=4.00
pushed 99 (7,1)
pushed 87 (6,1)
iter=28, frontier=22, popped=114 (8,2), depth=14, dist2goal=4.12
pushed 113 (8,1)
iter=29, frontier=22, popped=88 (6,2), depth=16, dist2goal=4.12
pushed 75 (5,1)
iter=30, frontier=22, popped=61 (4,3), depth=18, dist2goal=4.24
pushed 62 (4,4)
pushed 42 (3,3)
pushed 41 (3,2)
iter=31, frontier=24, popped=62 (4,4), depth=19, dist2goal=3.61
pushed 63 (4,5)
pushed 43 (3,4)
iter=32, frontier=25, popped=63 (4,5), depth=20, dist2goal=3.16
pushed 64 (4,6)
pushed 44 (3,5)
iter=33, frontier=26, popped=64 (4,6), depth=21, dist2goal=3.00
pushed 65 (4,7)
pushed 45 (3,6)
iter=34, frontier=27, popped=65 (4,7), depth=22, dist2goal=3.16
pushed 66 (4,8)
pushed 46 (3,7)
iter=35, frontier=28, popped=66 (4,8), depth=23, dist2goal=3.61
pushed 67 (4,9)
pushed 78 (5,8)
pushed 47 (3,8)
iter=36, frontier=30, popped=78 (5,8), depth=24, dist2goal=2.83
pushed 90 (6,8)
iter=37, frontier=30, popped=90 (6,8), depth=25, dist2goal=2.24
pushed 104 (7,8)
iter=38, frontier=30, popped=104 (7,8), depth=26, dist2goal=2.00
pushed 103 (7,7)
pushed 105 (7,9)
pushed 118 (8,8)
pushed 119 (8,9)
iter=39, frontier=33, popped=103 (7,7), depth=27, dist2goal=1.00
pushed 102 (7,6)
```

pushed 117 (8,7)
iter=40, frontier=34, popped=102 (7,6), depth=28, dist2goal=0.00
Solution Path:
Vertex 163 (13,6)
Vertex 177 (14,7)
Vertex 201 (16,8)
Vertex 214 (17,8)
Vertex 227 (18,5)
Vertex 213 (17,3)
Vertex 200 (16,3)
Vertex 187 (15,3)
Vertex 175 (14,3)
Vertex 162 (13,3)
Vertex 157 (12,3)
Vertex 152 (11,3)
Vertex 147 (10,3)
Vertex 132 (9,3)
Vertex 115 (8,3)
Vertex 101 (7,3)
Vertex 89 (6,3)
Vertex 77 (5,3)
Vertex 61 (4,3)
Vertex 62 (4,4)
Vertex 63 (4,5)
Vertex 64 (4,6)
Vertex 65 (4,7)
Vertex 66 (4,8)
Vertex 78 (5,8)
Vertex 90 (6,8)
Vertex 104 (7,8)
Vertex 103 (7,7)
Vertex 102 (7,6)
==============================
Search Algorithm GBFS
Total iterations 40
Maximum Frontier size: 35
Vertices visited: 74/275
Path Length: 28

A&M Path

Fig: GBFS from (13,6) to (7,6)

==