

COIN-OR stands for Computational INfrastructure for Operations Research. Check out their website at <http://www.coin-or.org/>. It is open source and free to use.

CBC stands for COIN-OR Branch and Cut. Branch and Cut is a hybrid methodology of solving mixed integer/linear programs (MILPs), i.e., linear optimization problems in which some (or all) variables are binary or integers, and others (or none) are continuous. I believe the copyright is held by IBM, but it is nonetheless open source and free to use.

## 1 Installing COIN-OR CBC

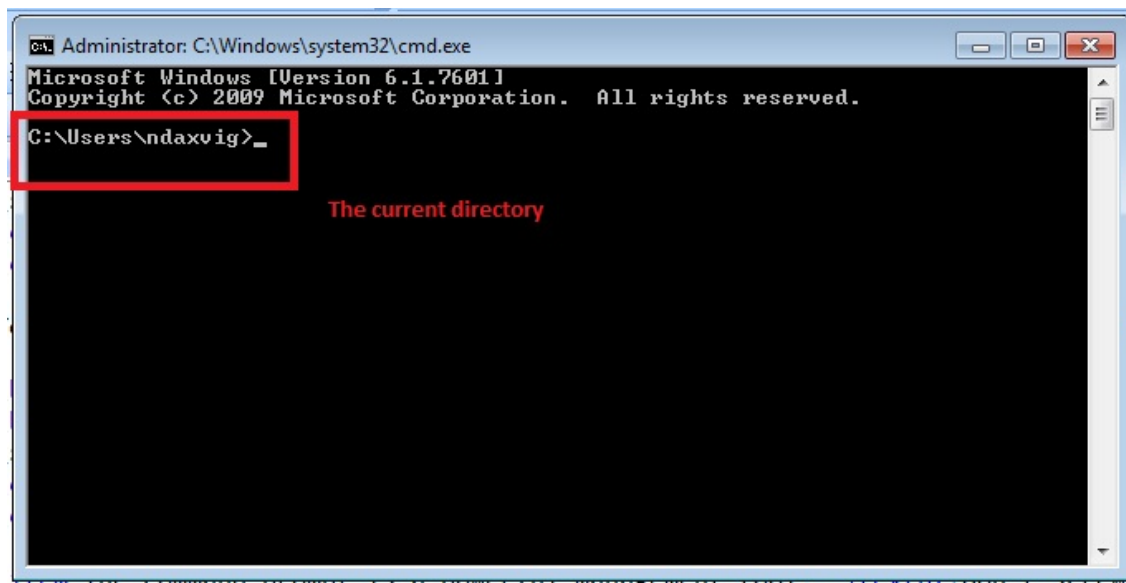
1. Go to <http://www.coin-or.org/download/binary/Cbc/> and download the compressed version associated to your operating system (mac, linux, windows) with the highest version number.
2. Unzip/decompress the file, and note the folder in which the uncompressed/unzipped file is located. For me, I have it in

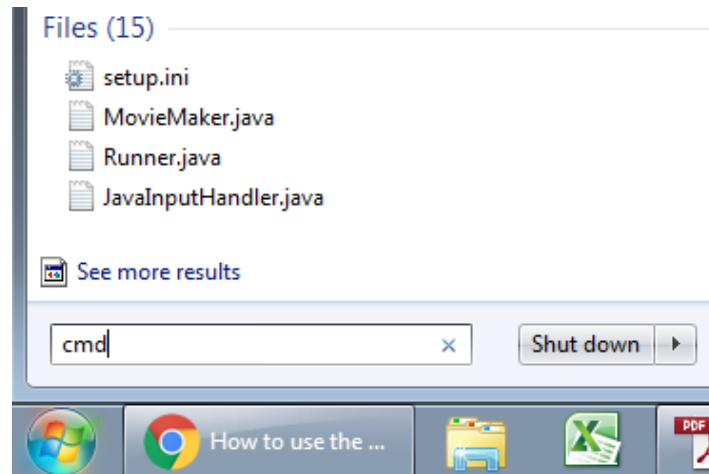
C:\Users\ndaxvig

## 2 Getting to know the command prompt

*This is specific to Windows. Linux and Apple systems are a bit different in syntax, but essentially the same. Let me know if you have questions.*

1. Open a command prompt window (also known as a terminal). For Windows, Command Prompt is in the Accessories menu. It looks like this:





You can also open a command prompt window by hitting the Windows Start button, and typing “cmd” into the Run/Search box.

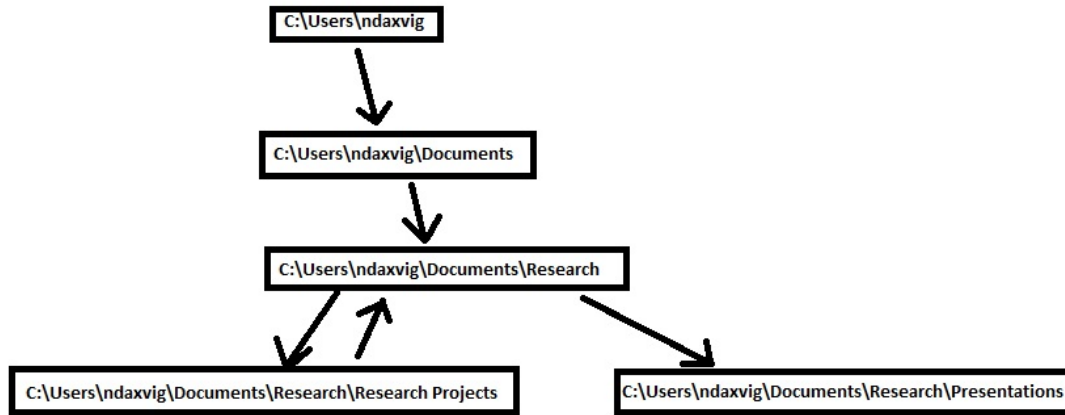
2. The command prompt is a powerful management tool. **Don’t screw around in the command prompt, because if you delete something in this environment, it’s GONE.**

The only commands you need to know now are

- dir - Gives you a list of files in the current directory (always indicated in the current line - see red box in Figure 1.)
- cd - stands for “change directory”
- cd .. - okay, almost the same as the last one, but “..” refers to the parent directory of the current one.

There is a better tutorial at <http://www.computerhope.com/issues/chusedos.htm>. For now, though, an example.

In this example I'll use the command prompt to navigate to my Research Projects, then realize that I really wanted to go find an old conference Presentation. Here's a schematic of how we'll travel through the nested folders.



Here's what I will actually type into the command prompt window to do this, with an implied "Enter" at the end of each line:

```
dir
cd Documents
dir
cd Research
dir
cd "Research Projects"
dir
cd ..
dir
cd Presentations
```

Now, let's see what it really looks like!

First, find out what's in the current directory, then go to Documents and then find out what's there:

```

C:\Windows\system32\cmd.exe
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

C:\Users\ndaxvig>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig

11/16/2015 06:26 PM <DIR> .
11/16/2015 06:26 PM <DIR> ..
05/29/2014 05:15 PM 0 .airappinstall.log
11/11/2015 06:22 PM 1,498 .bash_history
07/09/2015 07:12 PM <DIR> .jssc
06/04/2015 02:05 PM <DIR> .matplotlib
07/23/2015 01:04 PM 646 .octave_hist
06/04/2015 02:04 PM <DIR> .qgis2
07/23/2015 01:32 PM <DIR> .qucs
11/15/2015 10:12 PM 18,389 .Rhistory
11/10/2015 10:48 PM build
11/11/2015 05:16 PM <DIR> Chc-2.7.5-win64-intel11.1
11/11/2015 07:38 AM <DIR> Chc-2.9.7
10/16/2015 07:12 AM <DIR> Contacts
10/01/2015 12:40 PM 52,197 Day of Caring Assignment Solution.csv
11/11/2015 07:32 AM <DIR> Desktop
11/16/2015 06:28 PM <DIR> Documents
11/16/2015 02:20 PM <DIR> Downloads
11/16/2015 07:10 AM <DIR> Dropbox
10/16/2015 07:12 AM <DIR> Favorites
11/12/2015 08:23 AM <DIR> Links
10/16/2015 07:12 AM <DIR> Music
10/29/2015 10:59 AM 345,634 myFirstLP.lp
10/16/2015 07:12 AM <DIR> Pictures
09/30/2015 08:07 AM 4,465 Rplot.pdf
10/16/2015 07:12 AM <DIR> Saved Games
10/16/2015 07:12 AM <DIR> Searches
11/03/2013 07:56 PM 0 Sti_Trace.log
09/30/2014 07:36 AM <DIR> Tracing
10/13/2015 03:31 PM 1,023 usedHondasCleaned.csv
10/16/2015 07:12 AM <DIR> Videos
11/11/2015 09:48 AM 33,262 violatesAssumptions.csv
11/10/2014 11:57 AM <DIR> UIPRE Business Agent
10 File(s) 457,114 bytes
23 Dir(s) 435,392,024,576 bytes free

C:\Users\ndaxvig>cd Documents

C:\Users\ndaxvig\Documents>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig\Documents

11/16/2015 06:28 PM <DIR> .
11/16/2015 06:28 PM <DIR> ..
01/20/2015 02:17 PM 45,002 .RData
07/08/2015 09:16 PM 15,702 .Rhitory
05/29/2014 05:19 PM <DIR> CompleteNatGeo
11/10/2015 12:47 PM <DIR> Concordia Stuff
05/03/2015 12:25 PM 17,766 GLLL TIME SCHEDULE 2015 -2.docx
11/16/2015 06:28 PM <DIR> Personal Development
08/06/2015 07:19 PM <DIR> Processing
02/20/2015 11:06 AM <DIR> Research
10/15/2015 09:39 PM <DIR> Teaching
06/17/2015 07:45 PM <DIR> TomTom
3 File(s) 78,470 bytes
9 Dir(s) 435,392,024,576 bytes free

```

Go to Research, then Research Projects (when there are spaces in the file names, you have to put double quotes around the file name), then see what we have:

```

Administrator: C:\Windows\system32\cmd.exe

C:\Users\ndaxvig\Documents>cd Research
C:\Users\ndaxvig\Documents\Research>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig\Documents\Research

02/20/2015  11:06 AM  <DIR>          .
02/20/2015  11:06 AM  <DIR>          ..
10/16/2015  04:01 PM  <DIR>          Consulting Projects
02/19/2015  01:06 PM  <DIR>          Grants
04/29/2015  09:01 AM  <DIR>          INFORMS
08/12/2014  02:20 PM  <DIR>          Literature Searches
09/17/2014  08:18 AM  <DIR>          My Papers
12/15/2014  08:20 AM  <DIR>          Papers
06/26/2015  06:54 AM  <DIR>          Papers to Referee
11/16/2015  06:35 PM  <DIR>          Presentations
09/17/2014  08:41 AM  <DIR>          Research from grad school
09/17/2014  08:34 AM  <DIR>          Research Projects
08/20/2014  08:32 AM  <DIR>          Software
               0 File(s)              0 bytes
               13 Dir(s)  435,391,500,288 bytes free

C:\Users\ndaxvig\Documents\Research>cd "Research Projects"
C:\Users\ndaxvig\Documents\Research\Research Projects>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig\Documents\Research\Research Projects

09/17/2014  08:34 AM  <DIR>          .
09/17/2014  08:34 AM  <DIR>          ..
12/11/2014  12:18 PM  <DIR>          FL13_LP_Pseudocodeword_Incorporation_Proj
ect
03/22/2014  02:51 PM  <DIR>          Generalized_Omura_2012
03/24/2015  03:56 PM  <DIR>          LP_Pseudocodeword_Incorporation_Project
09/17/2014  08:48 AM  <DIR>          Meals on Wheels
09/17/2014  08:19 AM  <DIR>          Polar Codes
07/16/2013  04:03 PM  <DIR>          SP12_Omura
               0 File(s)              0 bytes
               8 Dir(s)  435,391,496,192 bytes free

```

Blast! I went too far... Back up with “cd ..” and look again, then go to Presentations to see what’s there:

```

C:\Users\ndaxvig\Documents\Research\Research Projects>cd ..

C:\Users\ndaxvig\Documents\Research>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig\Documents\Research

02/20/2015  11:06 AM    <DIR>          .
02/20/2015  11:06 AM    <DIR>          ..
10/16/2015  04:01 PM    <DIR>          Consulting Projects
02/19/2015  01:06 PM    <DIR>          Grants
04/29/2015  09:01 AM    <DIR>          INFORMS
08/12/2014  02:20 PM    <DIR>          Literature Searches
09/17/2014  08:18 AM    <DIR>          My Papers
12/15/2014  08:20 AM    <DIR>          Papers
06/26/2015  06:54 AM    <DIR>          Papers to Referee
11/16/2015  06:35 PM    <DIR>          Presentations
09/17/2014  08:41 AM    <DIR>          Research from grad school
09/17/2014  08:34 AM    <DIR>          Research Projects
08/20/2014  08:32 AM    <DIR>          Software
               0 File(s)              0 bytes
             13 Dir(s)  435,391,496,192 bytes free

C:\Users\ndaxvig\Documents\Research>cd Presentations

C:\Users\ndaxvig\Documents\Research\Presentations>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig\Documents\Research\Presentations

11/16/2015  06:35 PM    <DIR>          .
11/16/2015  06:35 PM    <DIR>          ..
11/16/2015  06:35 PM             0 0
11/16/2015  06:35 PM             0 cd
08/27/2013  11:32 AM    <DIR>          FL11_AMS_Research_Presentation
09/24/2015  07:38 PM    <DIR>          FL14_MAA_North_Central_Section_Meeting
08/27/2013  11:32 AM    <DIR>          JMM_2012_Research_Talk
09/17/2014  08:31 AM    <DIR>          Longwood Colloquium
               2 File(s)              0 bytes
               6 Dir(s)  435,391,496,192 bytes free

C:\Users\ndaxvig\Documents\Research\Presentations>_

```

- 
3. Now you're a pro at command prompt! Open a command prompt and practice navigating around with `cd`, `cd ..`, and `dir`.
  4. Now use your skills with command prompt to find the unzipped/decompressed folder with all the CBC stuff. Go into it, and then go into the folder entitled "bin". In this folder are two executable files, `cbc.exe` and `clp.exe`. The first is what you'll be using, the second is an auxiliary LP solver used by `cbc.exe`.

### 3 Using CBC

1. First, you need to save your `.lp` file you write with the "write.lp" command. This can be done by opening the file `myFirstLP.lp` (or whatever you named it) in LPSolve, Viewing it as a mps file, then saving it as an mps file. Save it in the same folder where `cbc.exe` is, namely "bin".

*Alternate way:* If you're doing this repetitively, you can make `write.lp` put things into mps format straight away - simply say:

```
#make sure your working directory is set to the 'bin' folder
write.lp(myFirstLP,'myFirstLP.lp',type='mps')
```

2. Navigate to the "bin" folder with `cbc.exe` and `myFirstLP.mps`.
3. Type "cbc" (without the quotes) to open cbc. You'll get a menu.
4. Type "import myFirst.mps" to load the LP into `cbc.exe`.
5. Type "solve". You'll see a lot of messages, and then usually it solves pretty fast.
6. Once it's solved, type "solution myFirstLPSolution.txt". This creates a `.txt` file in the "bin" folder that contains your optimal solution.
7. Type "exit" to leave `cbc.exe`. If you type "exit" a second time, the command prompt window will close.
8. Since your original variable names get destroyed with `write.lp`, you'll have to write a bit of code to interpret `myFirstSolution.txt` in RStudio.



Here are screen shots of the action above:

```

Administrator: C:\Windows\system32\cmd.exe

C:\Users\ndaxvig>cd Cbc-2.7.5-win64-intel11.1
C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1>cd bin
C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1\bin>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1\bin

11/17/2015  09:41 AM    <DIR>          .
11/17/2015  09:41 AM    <DIR>          ..
11/11/2015  05:16 PM             10,265,600 cbc.exe
11/11/2015  05:16 PM              6,765,568 clp.exe
11/12/2015  08:24 AM              22,266 myFirstLP.mps
               3 File(s)          17,053,434 bytes
               2 Dir(s)  435,832,463,360 bytes free

C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1\bin>cbc
Welcome to the CBC MILP Solver
Version: 2.7.5
Build Date: Nov 10 2011
Revision Number: 1759

CoinSolver takes input from arguments ( - switches to stdin)
Enter ? for list of commands or help
Coin:import myFirstLP.mps
               LPSolver
At line 8 NAME
At line 9 ROWS
At line 92 COLUMNS
At line 429 RHS
At line 438 BOUNDS
At line 559 ENDDATA
Problem LPSolver has 81 rows, 121 columns and 546 elements
Coin0008I LPSolver read with 0 errors
Coin:solve
Continuous objective value is -4.5 - 0.00 seconds
Cgl0004I processed model has 81 rows, 121 columns (120 integer) and 546 elements

Cbc0038I Pass 1: suminf. 0.00000 (<0>) obj. -4 iterations 38
Cbc0038I Solution found of -4
Cbc0038I Before mini branch and bound, 81 integers at bound fixed and 0 continuous
Cbc0038I Full problem 81 rows 121 columns, reduced to 40 rows 28 columns
Cbc0038I Mini branch and bound did not improve solution (0.04 seconds)
Cbc0038I Round again with cutoff of -4.05001
Cbc0038I Pass 2: suminf. 0.75013 (15) obj. -4.05001 iterations 20
Cbc0038I Pass 3: suminf. 0.70013 (23) obj. -4.05001 iterations 14
Cbc0038I Pass 4: suminf. 6.51670 (22) obj. -4.05001 iterations 30
Cbc0038I Pass 5: suminf. 4.86252 (28) obj. -4.05001 iterations 13
Cbc0038I Pass 6: suminf. 0.95017 (21) obj. -4.05001 iterations 15
Cbc0038I Pass 7: suminf. 0.80014 (14) obj. -4.05001 iterations 10
Cbc0038I Pass 8: suminf. 3.55010 (21) obj. -4.05001 iterations 49
Cbc0038I Pass 9: suminf. 0.75013 (20) obj. -4.05001 iterations 6
Cbc0038I Pass 10: suminf. 0.60011 (12) obj. -4.05001 iterations 9
Cbc0038I Pass 11: suminf. 3.30005 (11) obj. -4.05001 iterations 25
Cbc0038I Pass 12: suminf. 0.70013 (11) obj. -4.05001 iterations 4
Cbc0038I Pass 13: suminf. 0.65012 (10) obj. -4.05001 iterations 10
Cbc0038I Pass 14: suminf. 3.30005 (11) obj. -4.05001 iterations 18
Cbc0038I Pass 15: suminf. 3.30005 (11) obj. -4.05001 iterations 9
Cbc0038I Pass 16: suminf. 3.30005 (11) obj. -4.05001 iterations 18
Cbc0038I Pass 17: suminf. 3.30005 (11) obj. -4.05001 iterations 9
Cbc0038I Pass 18: suminf. 3.30005 (11) obj. -4.05001 iterations 18
Cbc0038I Pass 19: suminf. 6.38766 (30) obj. -4.05001 iterations 51
Cbc0038I Pass 20: suminf. 1.96322 (23) obj. -4.05001 iterations 29
Cbc0038I Pass 21: suminf. 1.28139 (28) obj. -4.05001 iterations 26
Cbc0038I Pass 22: suminf. 3.95017 (19) obj. -4.05001 iterations 43

```



```

Administrator: C:\Windows\system32\cmd.exe
ok 0.22 seconds
Cbc0012I Integer solution of -4 found by feasibility pump after 0 iterations and
0 nodes (0.24 seconds)
Cbc0038I Full problem 81 rows 121 columns, reduced to 40 rows 28 columns
Cbc0038I Full problem 81 rows 121 columns, reduced to 0 rows 0 columns
Cbc0006I The LP relaxation is infeasible or too expensive
Cbc0013I At root node, 0 cuts changed objective from -4.5 to -2 in 1 passes
Cbc0014I Cut generator 0 (Probing) - 2 row cuts average 2.0 elements, 6 column c
uts (6 active) in 0.000 seconds - new frequency is 1
Cbc0014I Cut generator 1 (Gomory) - 0 row cuts average 0.0 elements, 0 column cu
ts (0 active) in 0.000 seconds - new frequency is -100
Cbc0014I Cut generator 2 (Knapsack) - 0 row cuts average 0.0 elements, 0 column
cuts (0 active) in 0.000 seconds - new frequency is -100
Cbc0014I Cut generator 3 (Clique) - 0 row cuts average 0.0 elements, 0 column cu
ts (0 active) in 0.000 seconds - new frequency is -100
Cbc0014I Cut generator 4 (MixedIntegerRounding2) - 0 row cuts average 0.0 elemen
ts, 0 column cuts (0 active) in 0.000 seconds - new frequency is -100
Cbc0014I Cut generator 5 (FlowCover) - 0 row cuts average 0.0 elements, 0 column
cuts (0 active) in 0.000 seconds - new frequency is -100
Cbc0001I Search completed - best objective -4, took 16 iterations and 0 nodes (0
.28 seconds)
Cbc0035I Maximum depth 0, 0 variables fixed on reduced cost
Cuts at root node changed objective from -4.5 to -2
Probing was tried 1 times and created 8 cuts of which 0 were active after adding
rounds of cuts (0.000 seconds)
Gomory was tried 0 times and created 0 cuts of which 0 were active after adding
rounds of cuts (0.000 seconds)
Knapsack was tried 0 times and created 0 cuts of which 0 were active after addin
g rounds of cuts (0.000 seconds)
Clique was tried 0 times and created 0 cuts of which 0 were active after adding
rounds of cuts (0.000 seconds)
MixedIntegerRounding2 was tried 0 times and created 0 cuts of which 0 were activ
e after adding rounds of cuts (0.000 seconds)
FlowCover was tried 0 times and created 0 cuts of which 0 were active after addi
ng rounds of cuts (0.000 seconds)
TwoMirCuts was tried 0 times and created 0 cuts of which 0 were active after add
ing rounds of cuts (0.000 seconds)

Result - Optimal solution found
Objective value:           -4.00000000
Enumerated nodes:          0
Total iterations:          16
Time (CPU seconds):        0.29
Time (Wallclock seconds):  0.29

Coin:solution myFirstLPsolution.txt
Coin:exit
Total time (CPU seconds):      25.97   (Wallclock seconds):      25.97

C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1\bin>dir
Volume in drive C is Window 7 Pro x64
Volume Serial Number is 8649-7608

Directory of C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1\bin
11/17/2015  09:43 AM    <DIR>          .
11/17/2015  09:43 AM    <DIR>          ..
11/11/2015  05:16 PM           10,265,600 cbc.exe
11/11/2015  05:16 PM           6,765,568 clp.exe
11/12/2015  08:24 AM           22,266 myFirstLP.mps
11/17/2015  09:43 AM           2,496 myFirstLPsolution.txt
               4 File(s)          17,055,924 bytes
               2 Dir(s)          435,832,455,168 bytes free

C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1\bin>_

```

Summary of results,  
and time it took to get  
them.

The solution file

The exact commands I typed into the command prompt here were:

```
cd Cbc-2.5.7.-win64-intel11.1
cd bin
dir
cbc
import myFirstLP.mps
solve
solution myFirstLPsolution.txt
exit
dir
```

Open up myFirstLPsolution.txt to see your solution!