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.

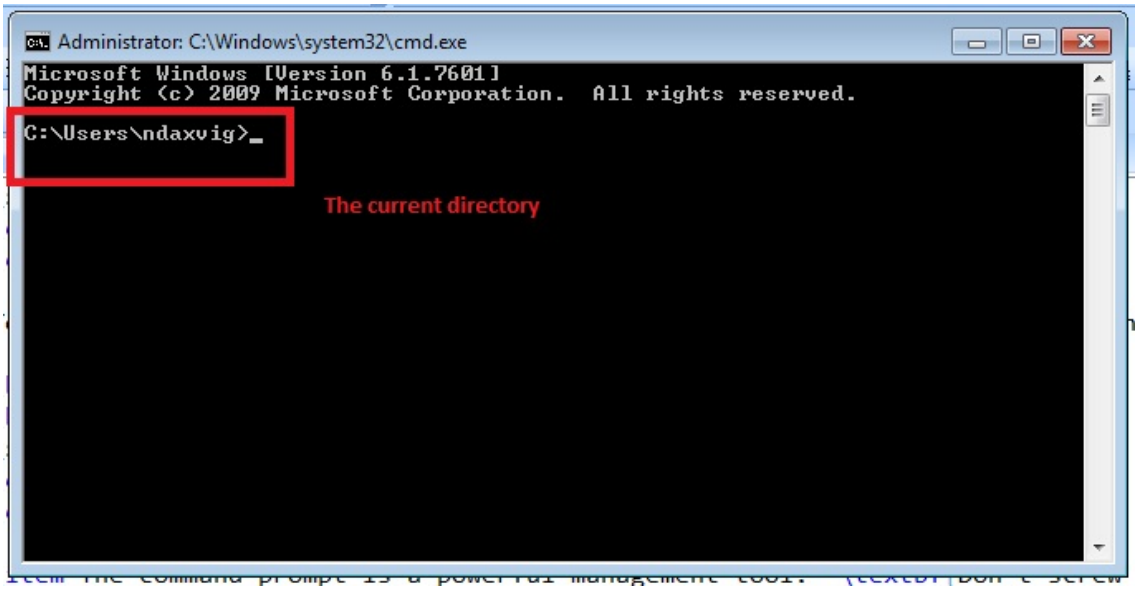
2. Unzip/decompress the file, and note the folder in which the uncompressed/unzipped file is located. For me, I have it in

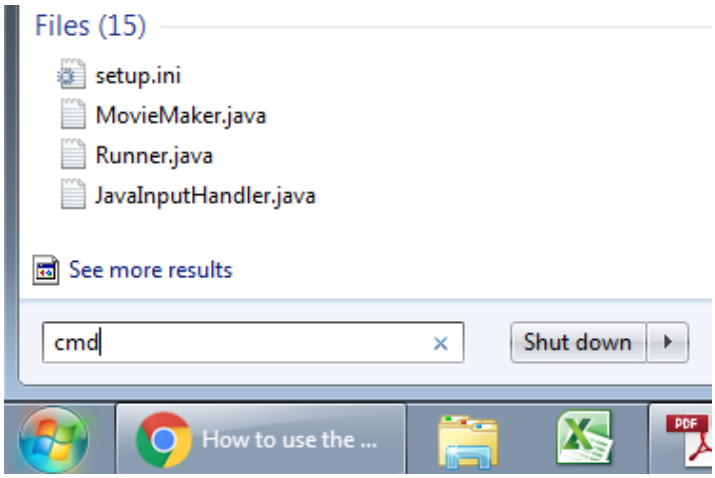
   ```
   C:\Users\ndaxvig
   ```

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.

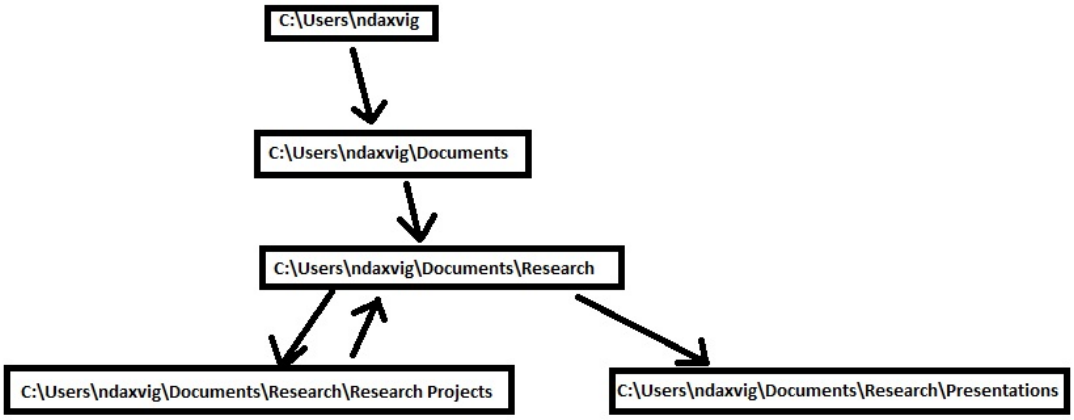
2. The command prompt is a powerful management tool. **Don't screw around in the command prompt, because if you delete something in this environment, it's GONE.**

   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.

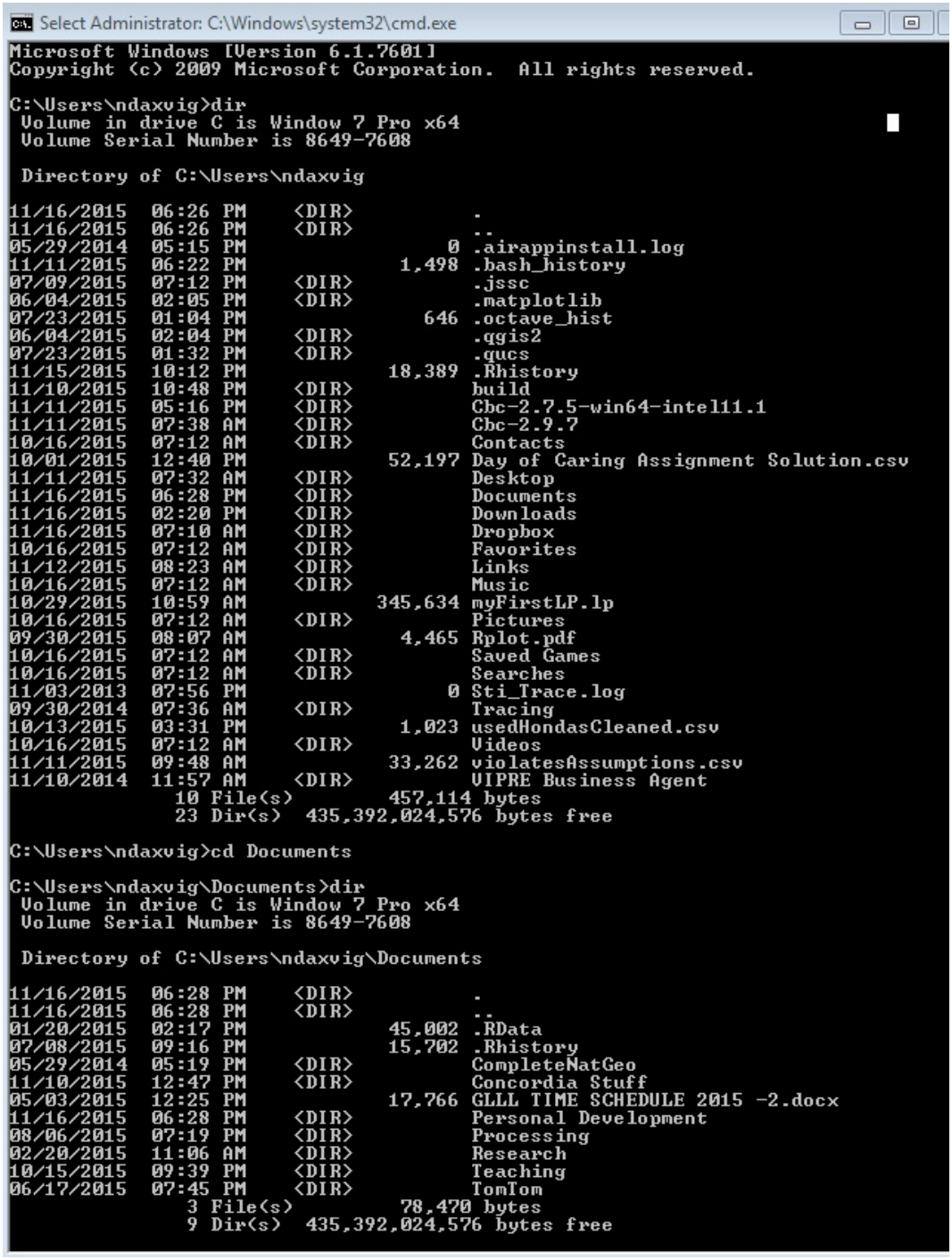


Here's what I will actually type into the command prompt window to do this, with an implied "Enter" at the end of each line:

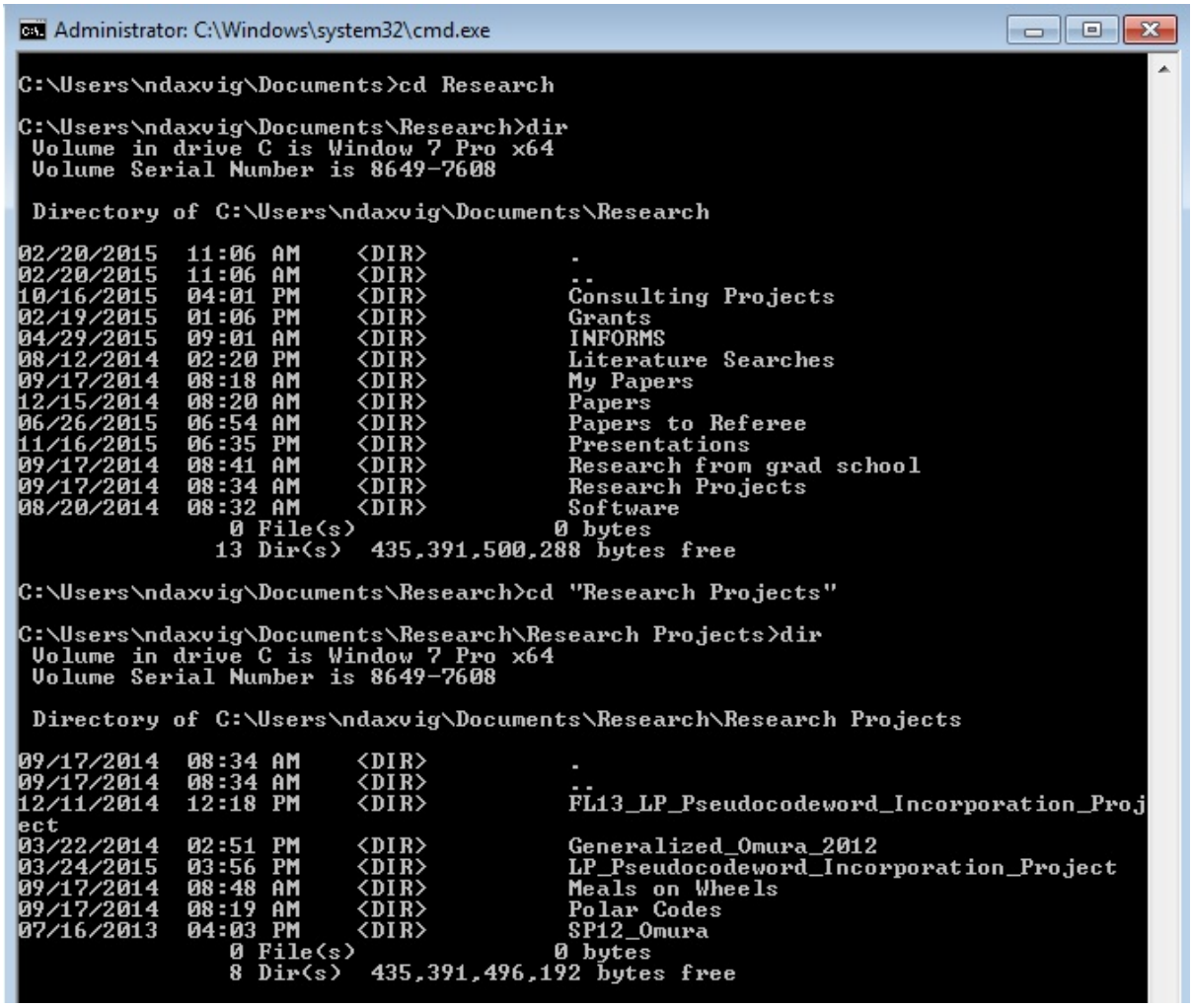
```
dir
cd Documents
dir
cd Research
dir
cd "Research Projects"
dir
cd ..
dir
cd Presentations
```

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:



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:



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
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 cuts (6 active) in 0.000 seconds - new frequency is 1
Cbc0014I Cut generator 1 (Gomory) - 0 row cuts average 0.0 elements, 0 column cuts (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 cuts (0 active) in 0.000 seconds - new frequency is -100
Cbc0014I Cut generator 4 (MixedIntegerRounding2) - 0 row cuts average 0.0 elements, 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 adding 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 active after adding rounds of cuts (0.000 seconds)
FlowCover was tried 0 times and created 0 cuts of which 0 were active after adding rounds of cuts (0.000 seconds)
TwoMirCuts was tried 0 times and created 0 cuts of which 0 were active after adding 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
Summary of results, and time it took to get them.
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
11/17/2015 09:43 AM 2,490 myFirstLPsolution.txt
The solution file
4 File(s) 17,055,92
2 Dir(s) 435,832,455,168 bytes free
C:\Users\ndaxvig\Cbc-2.7.5-win64-intel11.1\bin>

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!