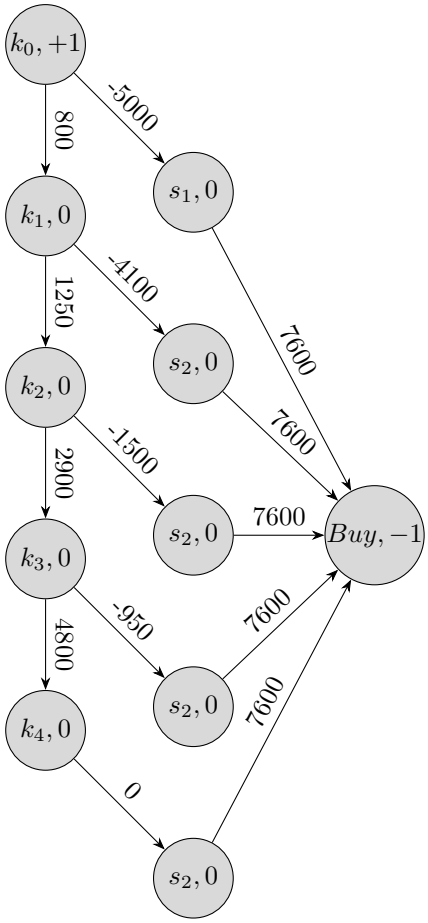
Homework 3 Advanced Analytics and Metaheuristics

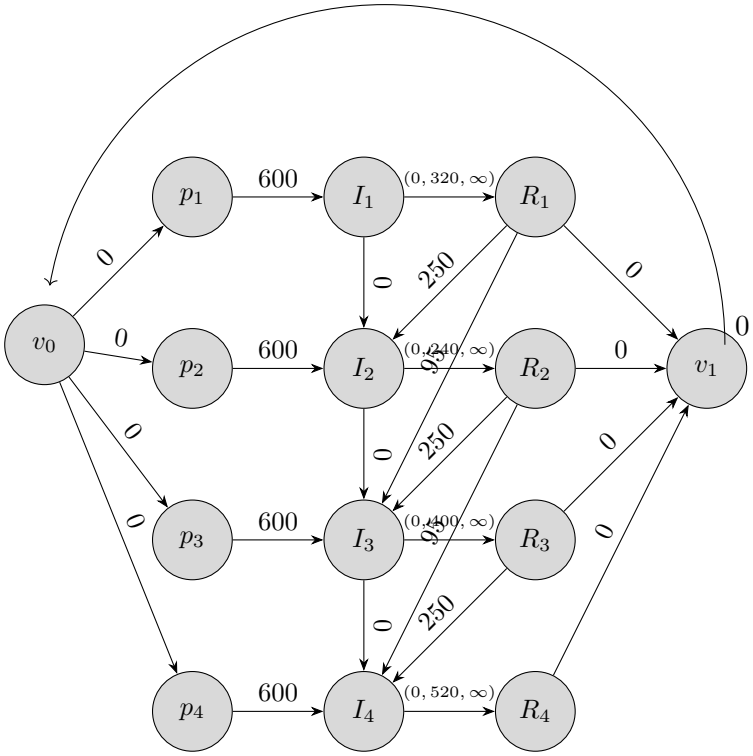
Group 1: Nicholas Jacob

February 15, 2024

1. Team Building
   (a)
   (b)
2. Outdoor Grilling



3. Here is my flow model:



Here is my model file:

```
# AMPL model for the Minimum Cost Network Flow Problem
#
# By default, this model assumes that b[i] = 0, c[i,j] = 0,
# l[i,j] = 0 and u[i,j] = Infinity.
#
# Parameters not specified in the data file will get their default values.
reset;

options solver cplex;

set NODES;                          # nodes in the network
set ARCS within {NODES, NODES};     # arcs in the network

param b {NODES} default 0;          # supply/demand for node i
param c {ARCS}  default 0;          # cost of one of flow on arc(i,j)
param l {ARCS}  default 0;          # lower bound on flow on arc(i,j)
param u {ARCS}  default Infinity; # upper bound on flow on arc(i,j)

var x {ARCS};                       # flow on arc (i,j)
```

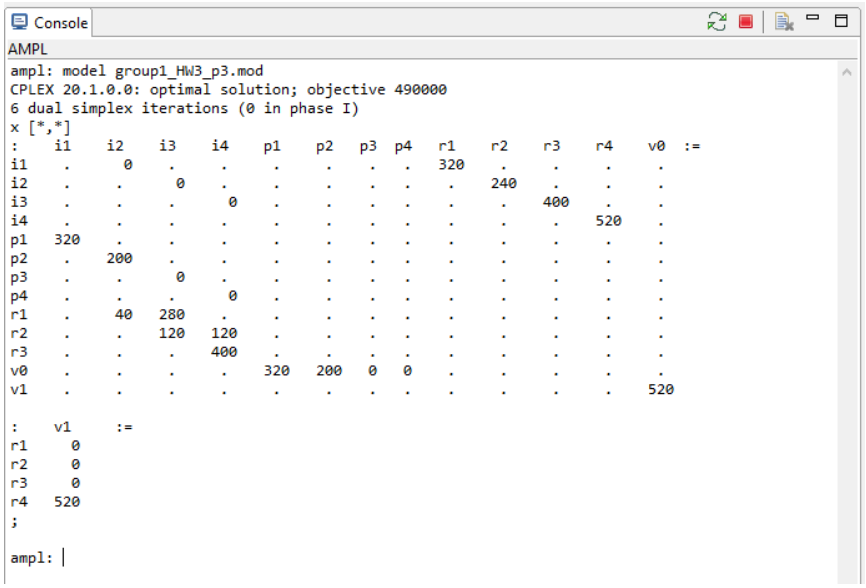
```
minimize cost: sum{(i,j) in ARCS} c[i,j] * x[i,j];  #objective: minimize arc flow cost

# Flow Out(i) - Flow In(i) = b(i)

subject to flow_balance {i in NODES}:
sum{j in NODES: (i,j) in ARCS} x[i,j] - sum{j in NODES: (j,i) in ARCS} x[j,i] = b[i];

subject to capacity {(i,j) in ARCS}: l[i,j] <= x[i,j] <= u[i,j];

data group1_HW3_p3.dat;

solve;

display x;
```

Here is my data file:

```
#MCNFP Problem - data file for problem instance
#Charles Nicholson, ISE 5113, 2015

#use with MCNFP.txt model
#note: default arc costs and lower bounds are 0
#      default arc upper bounds are infinity
#      default node requirements are 0


set NODES :=          v0, p1, p2,p3,p4, i1,i2,i3,i4,r1,r2,r3,r4,v1 ;

set ARCS := (v0,p1),(v0,p2),(v0,p3),(v0,p4), #start the flow
                        (p1,i1),(p2,i2),(p3,i3),(p4,i4), #purchase new tires each race
                        (i1,r1),(i2,r2),(i3,r3),(i4,r4), #move inventory to race
                        (r1,v1),(r2,v1),(r3,v1),(r4,v1), #move spent tires not fixed to
                        (i1,i2),(i2,i3),(i3,i4), #move unused inventory
                        (r1,i2),(r1,i3), #race 1 quick and slow fix
                        (r2,i3),(r2,i4), #race 2 quick and slow fix
                        (r3,i4), #race 3 quick fix
                        (v1,v0) #move from virtual to virtual to complete flow
                        ;



param:        c  l u :=
                [p1,i1] 600  . . #purchase new tires each race
                [p2,i2] 600  . .
```

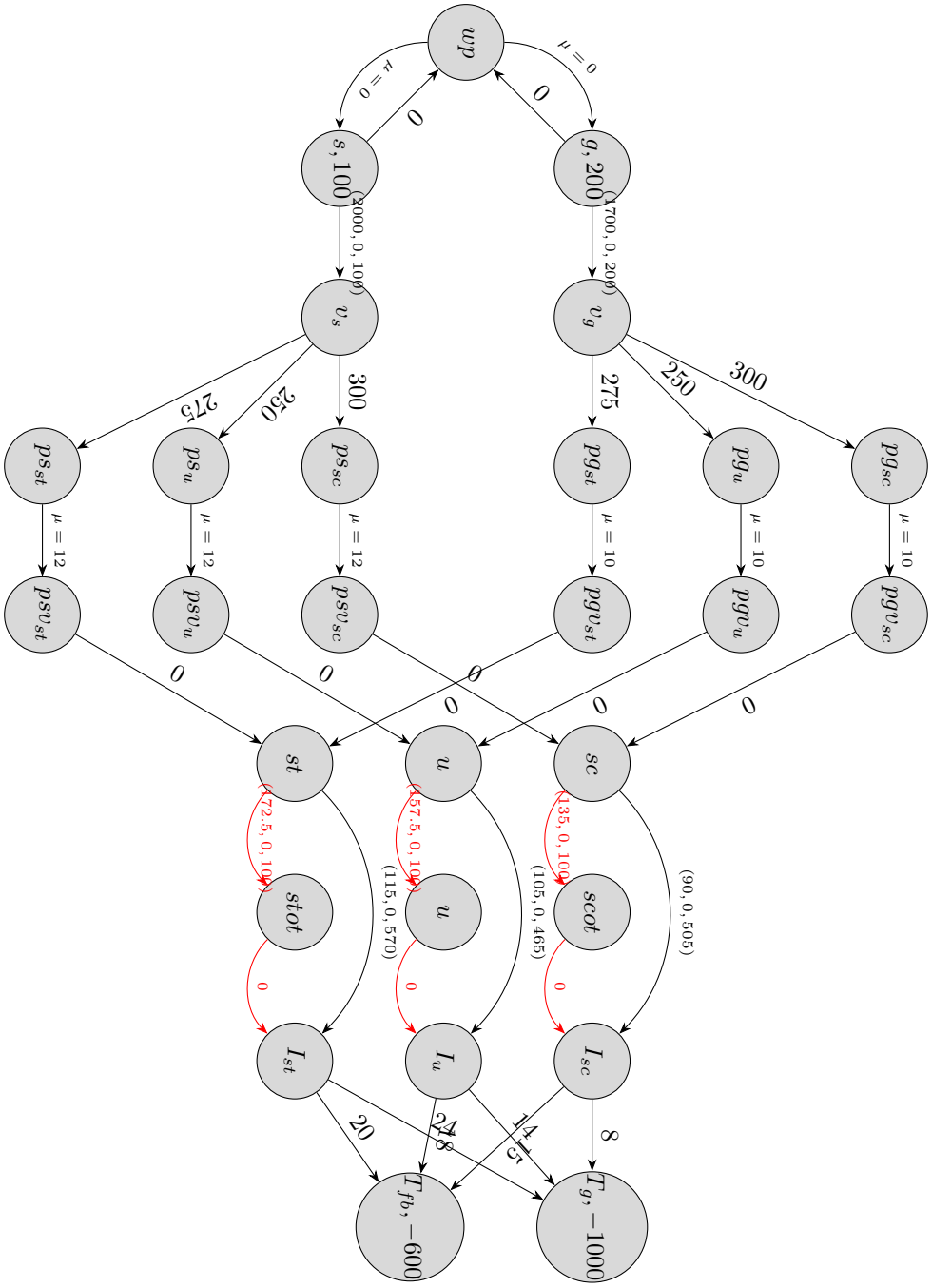
```
[p3,i3] 600   . .
[p4,i4] 600   . .
[i1,r1] .         320 . #minimum tires needed each race
[i2,r2] .         240 .
[i3,r3] .         400 .
[i4,r4] .         520 .
[r1,i2] 250 .          . #quick fix
[r2,i3] 250 .         .
[r3,i4] 250 .         .
[r1,i3] 95  .         .#slowfix
[r2,i4] 95         .         .
;
```

Here is my output:



We look to be purchasing new tires for both the needs of the first two races, 320 and 200 respectively. This is the maximum number of tires needed. We use the normal service on 280 tires from the first race and quick on the other 40. In second race we use the normal service on 120 but quick fix 120. For the third race we quick fix all 400 tires used. We end up with exactly the number of tires needed in the fourth race. Total cost is $490 000.

4. Dunder Mifflin



Here is my model file:

```
# AMPL model for the Minimum Cost Network Flow Problem
```

```
#
# By default, this model assumes that b[i] = 0, c[i,j] = 0,
# l[i,j] = 0 and u[i,j] = Infinity.
#
# Parameters not specified in the data file will get their default values.
reset;

options solver cplex;

set NODES;                          # nodes in the network
set ARCS within {NODES, NODES};     # arcs in the network

param b {NODES} default 0;          # supply/demand for node i
param c {ARCS}  default 0;          # cost of one of flow on arc(i,j)
param l {ARCS}  default 0;          # lower bound on flow on arc(i,j)
param u {ARCS}  default Infinity; # upper bound on flow on arc(i,j)
param mu {ARCS} default 1;        # multiplier on arc(i,j) -- if one unit leaves i, mu[i,

var x {ARCS};                       # flow on arc (i,j)

minimize cost: sum{(i,j) in ARCS} c[i,j] * x[i,j];  #objective: minimize arc flow cost

# Flow Out(i) - Flow In(i) = b(i)

subject to flow_balance {i in NODES}:
sum{j in NODES: (i,j) in ARCS} x[i,j] - sum{j in NODES: (j,i) in ARCS} mu[j,i] * x[j,i]

subject to capacity {(i,j) in ARCS}: l[i,j] <= x[i,j] <= u[i,j];

data group1_HW3_p4.dat;

solve;

display x;
```

Here is my data file:

```
#MCNFP Problem - data file for problem instance
#Charles Nicholson, ISE 5113, 2015

#use with MCNFP.txt model
#note: default arc costs and lower bounds are 0
#      default arc upper bounds are infinity
#      default node requirements are 0
```

```
set NODES :=          #v0, v1, #virtual nodes at begining and end to get the flow going
                           g, s, #general and specialist
                           vg, vs, #virtual to get the cost of general and speciali
                           pgsc, pgu, pgst, pssc, psu, psst, #shipping cost of each
                           pgvsc, pgvu, pgvst, psvsc, psvu, psvst, #convert each em
                           sc, u, st, #workers (as items) now at the plants
                           scot, uot, stot # overtime possible
                           isc, iu, ist, #inventory at each plant
                           tg, tfb, #transport goods to location
                           wp; #unhired worker pool

set ARCS := (s,vs),(g,vg), #hire the workers
                      (s,wp), (g,wp), #unhired workers
                      (wp,s), (wp,g), #flow the unhired workers back to keep the balan
                      (vg,pgsc),(vg,pgu),(vg,pgst),(vs,pssc),(vs,psu),(vs,psst), #move
                      (pgsc,pgvsc),(pgu,pgvu),(pgst,pgvst),(pssc,psvsc),(psu,psvu),(ps
                      (pgvsc,sc),(psvsc,sc),(pgvu,u),(psvu,u),(pgvst,st),(psvst,st), #
                      (sc,isc),(u,iu),(st,ist), #create the products
                      (sc, scot), (u, uot), (st,stot), #overtime hours making products
                      (scot, isc), (uot,iu), (stot, ist), #overtime products created g
                      (isc,tg), (isc,tfb), (iu, tg), (iu,tfb), (ist,tg), (ist,tfb), #m
                      ;

param: b:=
        g 200
        s 100
        tg -1000
        tfb -600;

param:        c  l u mu:=
                [s,vs]                      2000          .         100         . #re
                [g,vg]                      1700          .         200         .
                [vg,pgsc]                    300          .         .           . #mo
                [vg,pgu]                     250          .         .           .
                [vg,pgst]                    275          .         .           .
                [vs,pssc]                    300          .         .           .
                [vs,psu]                     250          .         .           .
                [vs,psst]                    275          .         .           .
                [pgsc,pgvsc]          .              .         .              10 #c
                [pgu,pgvu]                 .              .         .
                [pgst,pgvst]          .              .         .              10
                [pssc,psvsc]          .              .         .              12
                [psu,psvu]                 .              .         .
                [psst,psvst]          .              .         .              12
```

```
[sc,isc]                90                .          505          . #cre
[u,iu]                       105          .          465          .
[st, ist]                115          .          570          .
[sc, scot]               135          .          100          . #overtime
[u,uot]                  157.5        .          100          .
[st,stot]                172.5        .          100          .
[isc, tg]                8                 .          .
[isc, tfb]               15                .          .
[iu, tg]                 14                .          .
[iu, tfb]                18                .          .
[ist, tg]                24                .          .
[ist,tfb]                20                .          .
[wp,s]                        .                .          .
[wp,g]                        .                .          .
;
```

Here is my output:

Console

AMPL

```
ampl: model group1_HW3_p4.mod
CPLEX 20.1.0.0: optimal solution; objective 497016.6667
10 dual simplex iterations (0 in phase I)
x [*,*] (tr)
:       g    isc   ist   iu  pgsc pgst  pgu pgvsc pgvst  pgvu    pssc     psst :=
pgvsc    .     .     .     .    0    .     .     .     .     .        .        .
pgvst    .     .     .     .    .    0     .     .     .     .        .        .
pgvu     .     .     .     .    .    .    40     .     .     .        .        .
psvsc    .     .     .     .    .    .     .     .     .     .  47.0833     .
psvst    .     .     .     .    .    .     .     .     .     .        .     47.5
sc       .     .     .     .    .    .     .     0     .     .        .        .
st       .     .     .     .    .    .     .     .     0     .        .        .
tfb      .     0   570    30    .    .     .     .     .     .        .        .
tg       .   565     0   435    .    .     .     .     .     .        .        .
u        .     .     .     .    .    .     .     .     .   400        .        .
vg      40     .     .     .    .    .     .     .     .     .        .        .
wp     160     .     .     .    .    .     .     .     .     .        .        .

:       psu   psvsc psvst psvu    s    sc  scot   st  stot    u  uot   vg   :=
isc     .         .     .     .     .   505   60    .    .     .    .    .
ist     .         .     .     .     .     .    .  570    0     .    .    .
iu      .         .     .     .     .     .    .    .    .   465    0    .
pgsc    .         .     .     .     .     .    .    .    .     .    .    0
pgst    .         .     .     .     .     .    .    .    .     .    .    0
pgu     .         .     .     .     .     .    .    .    .     .    .   40
psvu  5.41667     .     .     .     .     .    .    .    .     .    .    .
sc      .       565     .     .     .     .    .    .    .     .    .    .
scot    .         .     .     .     .    60    .    .    .     .    .    .
st      .         .   570     .     .     .    .    .    .     .    .    .
stot    .         .     .     .     .     .    .    .    0     .    .    .
u       .         .     .    65     .     .    .    .    .     .    .    .
uot     .         .     .     .     .     .    .    .    .     0    .    .
vs      .         .     .     .   100     .    .    .    .     .    .    .
wp      .         .     .     .     0     .    .    .    .     .    .    .

:        vs      wp     :=
g         .        0
pssc   47.0833     .
psst   47.5        .
psu     5.41667    .
s         .      160
;
```