Problem: Find the least-cost way for routing V-Mobile's forecasted customer call-minutes to destinations through the various carriers for given price intervals and penalties over the given monthly planning horizon

Solution: Build a linear integer programming model that meets the forecasted demand while **minimizing the total routing cost** of call-minutes across carriers, destinations, price intervals, penalties for given months planning horizon, within the upper and lower bound constraints

Inputs: In blue in spreadsheet,

- The price per call-minute for destination d from carrier c in price interval i in month t
- The (forecasted) number of call-minutes for destination d in month t
- The lower and upper limits for carrier c in price interval i
- The lower and upper limits on capacity (number of call-minutes) for carrier c in month t
- The penalty per call-minute (to discourage poor-quality options) for carrier c to destination d in month t

Objective function: Min (**Total call routing cost**) **=**

$$\min_{c,d,i,t}\left(\sum(\boldsymbol{Xcdit} * \boldsymbol{Pcdit}) + \sum(\boldsymbol{Xcdit} * \boldsymbol{Qcdt})\right)$$

- $\mathbf{X_{cdit}}$ – No of call-minutes made by customers through carrier c to destination d in price interval i for month t
- $\mathbf{P_{cdit}}$ – Price per call-minute through carrier c to destination d in price interval i for month t
- $\mathbf{Q_{cdt}}$ – Penalty per call-minute for using carrier c to destination d in month t
- **c** ∈ **(1…3)** for the 3 carriers
- **d** ∈ **(1…5)** for the 5 destinations
- **i** ∈ **(1…3)** for the 3 price intervals
- **t** ∈ **(1…2)** for the 2 month planning horizon

Decision variables:

- $\mathbf{X_{cdit}}$ – No of call-minutes made by customers through carrier c to destination d in the price interval i for month t
- $\mathbf{Y_{ci}}$ – Binary variable for each carrier c and price interval i, which
  - = 1, if total call-minutes for carrier cover all destinations d and months t falls in price interval i
  - = 0, otherwise

Constraints:

1. $\sum_{c,i}$ **Xcdit >= $\mathbf{FD_{dt}}$ for all (d,t),**
   - $\mathbf{FD_{dt}}$ - Forecasted Demand of call-minutes for destination d in month t
2. $\sum_{d,i}$ **Xcdit >= $\mathbf{LCB_{ct}}$ for all (c,t),**
   - $\mathbf{LCB_{ct}}$ – Lower Capacity Bound of total no of call-minutes for carrier c in month t

3. $\sum_{d,i} \mathbf{Xcdit}$ **<= UCB_{ct} for all (c,t),**
    - **UCB_{ct}** – Upper Capacity Bound of total no of call-minutes for carrier c in month t
4. $\sum_{d,t} \mathbf{Xcdit}$ **>= (ILL_{ci} * Y_{ci}) for all (c,i),**
    - **ILL_{ci}** – Lower Limit for total call-minutes for carrier c in price Interval i
5. $\sum_{d,t} \mathbf{Xcdit}$ **<= (IUL_{ci} * Y_{ci}) for all (c,i),**
    - **IUL_{ci}** – Upper Limit for total call-minutes for carrier c in price Interval i
6. **X_{cdit}** ∈ **int,** only integer call-minutes are allowed
7. **X_{cdit} >= 0,** non-negativity constraint
8. **Y_{ci}** ∈ **(0,1),** as it is a binary decision variable

Result:

- V-Mobile's minimum **total routing cost** of **call-minutes** is **$ 68,400**

Recommendation:

1. For the given optimized model, we can see that V-Mobile should assign customer call-minutes to those carriers that will allow it to meet forecasted customer demand by
    a. Avoiding carrier-destination combinations that get charged a penalty for poor quality
    b. Using the lowest call-minute option from the carrier, destination, price interval combination for each month
    c. However, this is subject to lower and upper capacity limits on the total call-minutes allowed in each interval for each carrier
    d. And it is also subject to lower and upper bound constraints on carrier capacity for each month
    e. So, it might not always use the lowest price call-minute option, but the overall cost for V-Mobile will be minimized by this model
2. Potential problem parameters that would require update to model
    a. The monthly capacity upper and lower bound for each carrier could be updated to each destination separately
        i. That would require an update to the sigma function for constraints 2 and 3
        ii. Updated inputs must also be provided at destination level
    b. They could charge customers extra on the call-minutes for using good quality carrier in each destination
        i. That would increase their revenue, so will require change to the objective function by reducing the extra revenue from the total cost (minimize)
        ii. New inputs for the bonus revenue for carrier, destination combination
    c. Data charges for mobile internet included into total routing cost
        i. They are generally based on total data used and across different time frames
        ii. Customers get different options based on data amount and time frame
        iii. Different international destinations have different charges based on carrier
        iv. That would require new decision variables and update to the objective function to handle new input prices with data size limits to handle this combination of data amounts, time frames, destinations and carriers