Date:12/10/2021

Still working on the paper ***Resource and Power Allocation in SWIPT-Enabled Device-to-Device Communications Based on a Nonlinear Energy Harvesting Model***. Record some notes for the piecewise linear EH model mentioned in this paper, and methods for transforming the linear programming model into nonlinear programming model.

Technical term

- **Piecewise linear functions**

  It is a function whose graph consists of straight line segments. it is a function of which the each piecewise is linear.

  $$f(x) = \begin{cases} 2x & x <= 2 \\ -x + 3 & x > 2 \end{cases}$$

  For the linear EH model mentioned in this paper:

  $$EH_i^D = \begin{cases} 0 & P_i^R \in [P_{tn}^0, P_{th}^1] \\ k_j P^R + b_j, & P_i^R \in [P_{th}^j, P_{th}^{j+1}], j \in 1, \ldots, L-1 \\ P_{max}^{EH} & P_i^R \in [P_{th}^L, P_{th}^{L+1}] \end{cases}$$

  Where the EH_i^D is the power harvested by D2D receiver i , and P_i^R is the received power for EH at D2D receiver i when sharing the RB with CUE k, which can be expressed as:

  $$P_i^R = \lambda_i^e (P_i^D + P_k^C h_{k,i} + N_0)$$

  Note that $P_{th} = \{P_{th} | 1 \leq j \leq L+1\}$ is the set of thresholds on P_i^R for $L+1$ linear segments. The k_j and b_j are the coefficients and the intercept of the linear function in the j_{th} segment. P_{th}^1 denotes the minimum received power requirement for activating the **RF EH** circuit, which is also the circuit sensitivity of the EH circuit, and te P_{max}^{EH} is the maximum power the **RF EH** circuit can harvest.

  So the above piecewise linear EH model shows the different amount of energy that the system can harvest at different segment.

- **Maximization of energy efficiency(EE)for SWIPT-enabled D2D links**

  The final equation of **Energy Efficiency(EE)** for D2D links can be expressed by

  $$EE_i^D = \frac{T_i^D}{EC_i^D} = \frac{log_2(1 + \frac{P_i^D h_i^D}{(P_k^C h_{k,i} + N_0) + \frac{N_1}{1-\lambda_i^e}})}{P_i^D + 2P_{cir} - EH_i^D}$$

  As shown in the equation, if i want to find the maximum value of the Energy Efficiency, it is all about finding a optimal value for the transmission power at D2D link i (P_i^D), the harvest energy from the system(EH_i^D), the power splitting ratio(λ_i^e).

  And in this paper, the transmission power for **CUE link is constant for simulation**

- **non-linear programming**

  In mathematics, **nonlinear programming** (**NLP**) is the process of solving an optimization problem where some of the constraints or the objective function are nonlinear

- **linear programming:**

  Linear programming is a simple technique where we **depict** complex relationships through linear functions and then find the optimum points. The important word in the previous sentence is depicted. The real relationships might be much more complex – but we can simplify them to linear relationships.

  As shown in the figure 1, it is a very classic example for people to use LP to save on fuel and time and find the shortest route.

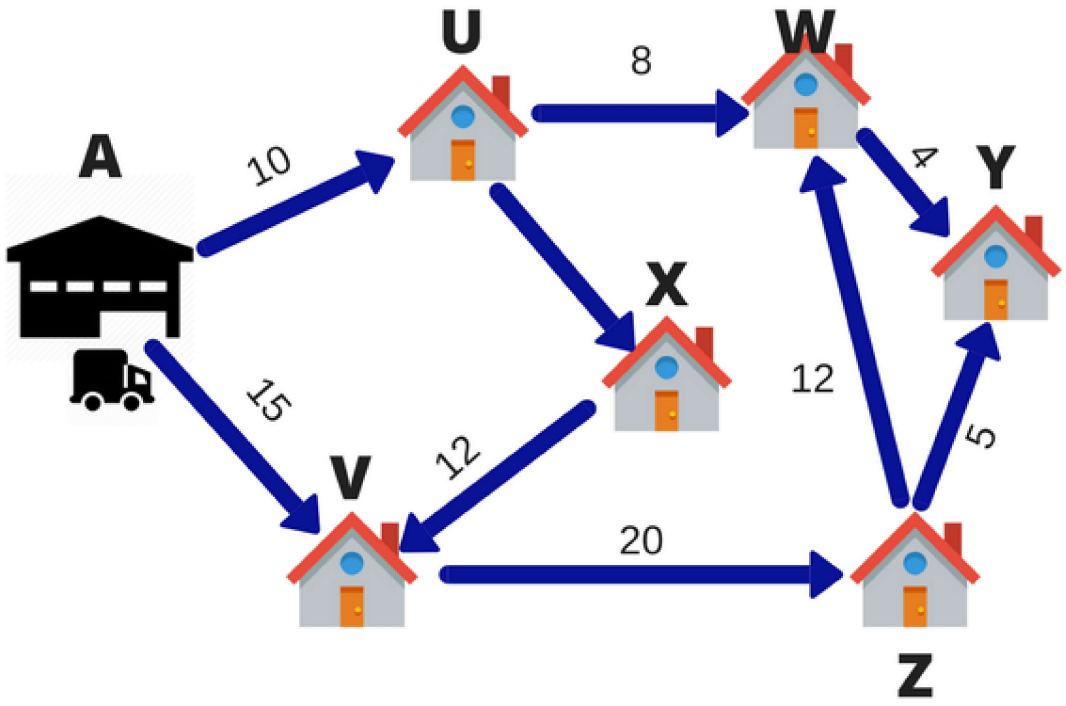

Figure 1: A simple example for linear programming