Dynamic matching models

Sujet de stage M2

Context

We consider a dynamic matching model with random arrivals – a dynamic version of the bipartite matching model. As in the static setting, it is based on a bipartite graph. In the discrete-time dynamic model there are arrivals of units of 'supply' and 'demand' that can wait in queues located at the nodes in the network. A control policy determines which items are matched at each time.

The theory of matching has a long history in economics, mathematics, and graph theory [5, 7], with applications found in many other areas such as chemistry and information theory. Most of the work is in a static setting. The dynamic model has received recent attention in [4, 3, 6]. The most compelling application is organ donation: United Network for Organ Sharing (UNOS) offers kidney paired donation (KPD). This is a transplant option for candidates who have a living donor who is medically able, but cannot donate a kidney to their intended candidate because they are incompatible (i.e., poorly matched) [1]. In this application, or application to resource allocation (such as in scheduling in a power grid) [2, 8], data arrives sequentially and randomly, so that matching decisions must be made in real-time, taking into account the uncertainty of future requirements for supply or demand, or the uncertainty of the sequence of classification tasks to be undertaken. The choice of matching decisions can be cast as an optimal control problem for a dynamic matching model.

Objetives

The objective of this internship is to study the performance (the number of unmatched customers/servers in the system) of this model under various matching policies including: ML (Match the Longest), MS (Match the Shortest), FIFO (match the oldest), priorities. There are several possible directions for the internship: comparing different policies (numerically and/or analytically); searching for heuristics to minimize the total number of unmatched customers/servers in the system; extending the model to include impatience (unmatched items disapear after some delay), or the matching preferences of the customers.

Prerequisites: Basic knowledge of random structures and algorithms. Some prior experience with programming (C, C++ or Matlab) is strongly recommended.

Contact: Ana Busic (ana.busic@ens.fr)
Inria Paris and
Département d'Informatique de l'École normale supérieure (DIENS)
Équipe Dyogene

References

[1] United Network for Organ Sharing. Online, `https://www.unos.org/docs/Living_Donation_KidneyPaired.pdf`.

[2] Y. Berstein and S. Onn. Nonlinear bipartite matching. *Discrete Optimization*, 5(1):53–65, 2008.

[3] A. Bušić, V. Gupta, and J. Mairesse. Stability of the bipartite matching model. *Adv. in Appl. Probab.*, 45(2):351–378, 2013.

[4] R. Caldentey, E.H. Kaplan, and G. Weiss. FCFS infinite bipartite matching of servers and customers. Adv. Appl. Probab, 41(3):695-730, 2009.

[5] L. E. Dubins and D. A. Freedman. Machiavelli and the gale-shapley algorithm. *American mathematical monthly*, pages 485–494, 1981.

[6] I. Gurvich and A. Ward. On the dynamic control of matching queues. *Stochastic Systems*, 4:1–45, 2014.

[7] L. Lovász and M. Plummer. *Matching theory*, volume 367. American Mathematical Society, 2009.

[8] L. Zdeborová, A. Decelle, and M. Chertkov. Message passing for optimization and control of a power grid: Model of a distribution system with redundancy. *Phys. Rev. E*, 80:046112, Oct 2009.