Growing model for the supply network in a tourism destination

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Objective

To explain the formation of the supply network (lodgings and tourist attractions/services) in a tourist destination according the visitors' behavior.

Introduction

The supply of a tourist destination (coastal resorts, towns, rural areas, etc.) is composed by lodgings and services. A tourist who stays in a destination for some days requires a room and enjoys of some services. The movement of tourists in the destination conform a complex network. To know the network topology would allow identifying the key nodes and components of the supply network. In this poster, we present a growing network model which explains how this network is formed. The analytical results are tested with empirical data extracted from opinions made by tourists of Maspalomas (Gran Canaria) in Tripadvisor.com.

Figure 1. Tourist area in Maspalomas (Gran Canaria). Lodgings are composed by hotels, apartments and bungalows. Services include beaches, thematic parks, restaurants, etc.

The model

We build an evolving bipartite network with two categories of nodes, hotels (H) and services (S). In every hotel, we assume a representative tourist. A link between a hotel and service appears if the representative tourist visits/enjoys the service during his/her staying in the destination.

The bipartite network grows similarly to previous models for collaboration networks [1]. We start at time t_0 with H_0 hotels and S_0 services. At any time $t > t_0$, 1 new lodging and ***m* new services** are created in the destination. **The representative tourist of all new hotels visit *c* different services**, including the old and *m* new ones, following the rule:

- A percentage $\phi \in [0,1]$ at random.
- A percentage $1-\phi$ by linear preferential attachment according to service's degree *s*.

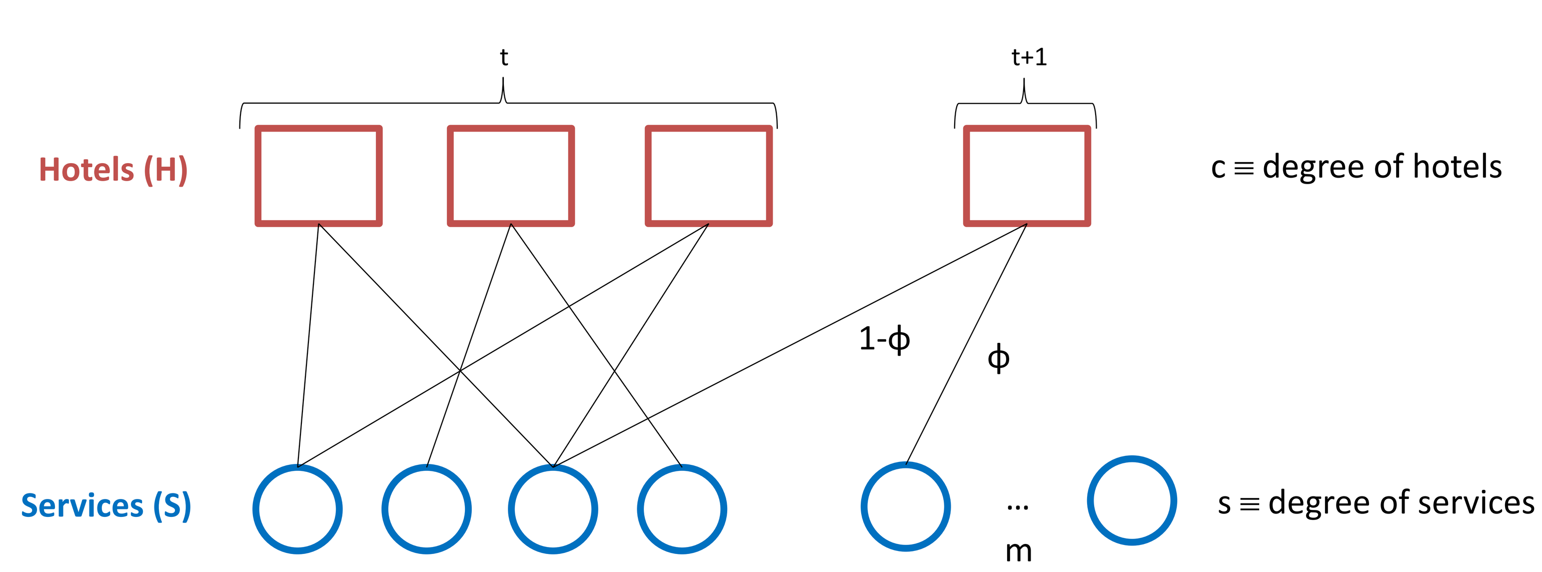


Figure 2. Representation of the growing rule of the supply network of a tourist destination.

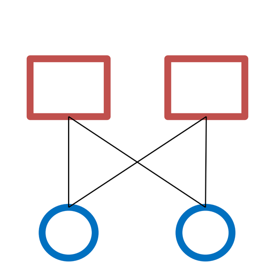
We prove that, in the long term, the service's degree *s* follows a shifted power-law distribution

$$p_s(s) \sim (c\phi + m(1-\phi)s)^{-\frac{1}{1-\phi}-1}. \qquad (1)$$

Given k_j the degree of service *j* in the one-mode projection, we have the following relation

$$k_j = (c-1)s_j - q_j, \forall j \in S,$$

where q_j represents the number of X-motifs which include service *j*.



X-motif

We prove that (F.O.D.=First Order Dominates):

$$p_q(q) \ \text{F.O.D.} \ O(t^{-1})q^{-1-\frac{1}{2(1-\phi)}}, \ \phi > \frac{1}{2},$$

$$p_q(q) \ \text{F.O.D.} \ O(t^{-\frac{\phi}{1-\phi}})q^{-1-\frac{1}{2(1-\phi)}}, \ \phi < \frac{1}{2}$$

Therefore, we have that the degree of services in the projection follows a shifted power-law distribution:

$$p_k(k) = \frac{1}{c-1} p_s\left(\frac{k}{c-1}\right) \sim (c(c-1)\phi + m(1-\phi)k)^{-\frac{1}{1-\phi}-1}.$$

Comparison with real data

We have collected the opinions of lodgings and services in the destination of Maspalomas (Gran Canaria) published by users in tripadvisor.com during the period 2005-2016.

Table 1. Basic statistics of the lodging-services network in Maspalomas. H ≡ Lodgings; S ≡ Services; L ≡ Links; <c> ≡ mean degree of lodgings; <s> ≡ mean degree of services; ρ ≡ density.

H	S	L	<c>	<s>	ρ
182	1 496	13 359	73.4	8.9	$9.5 \, 10^{-3}$

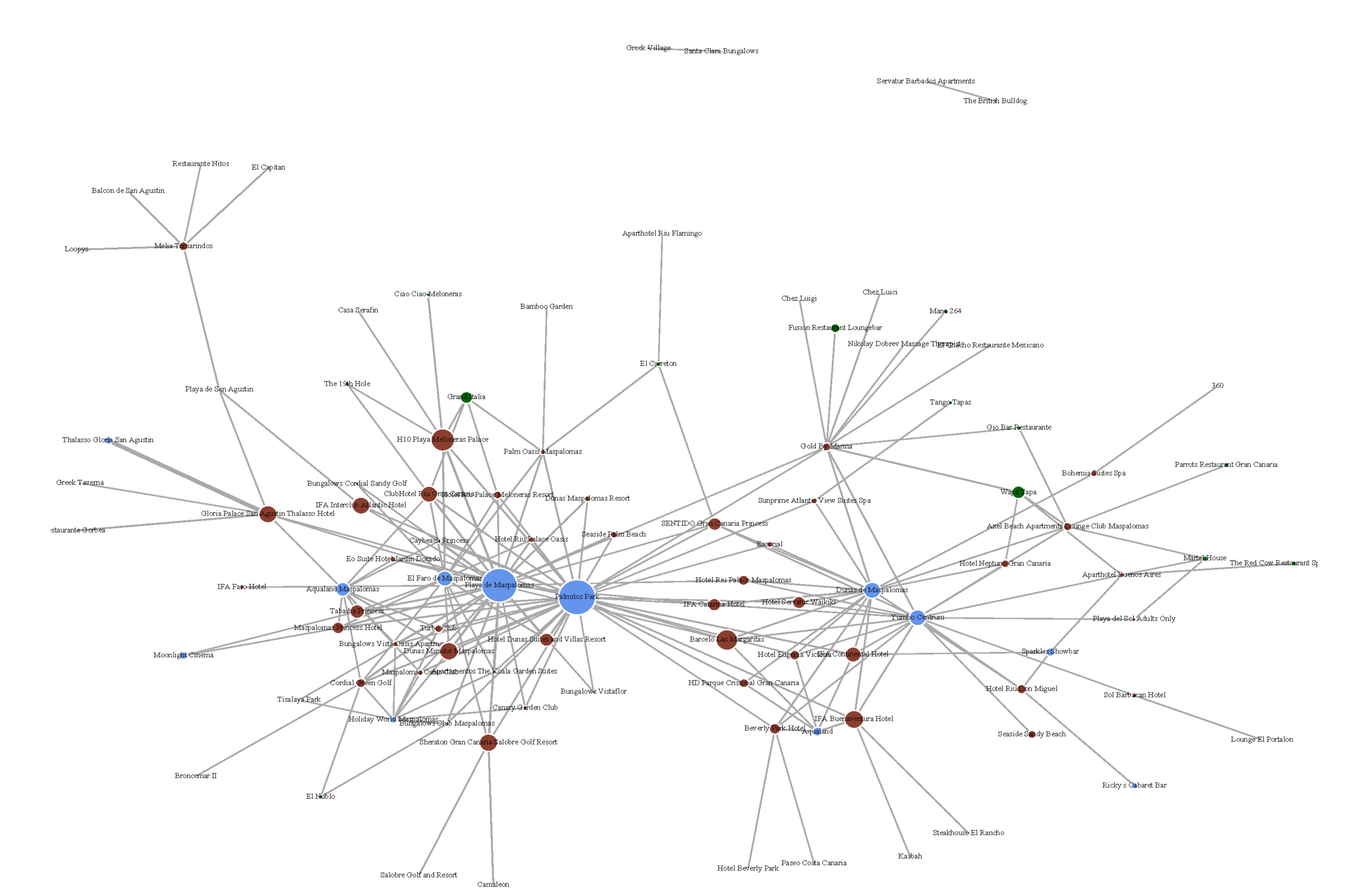
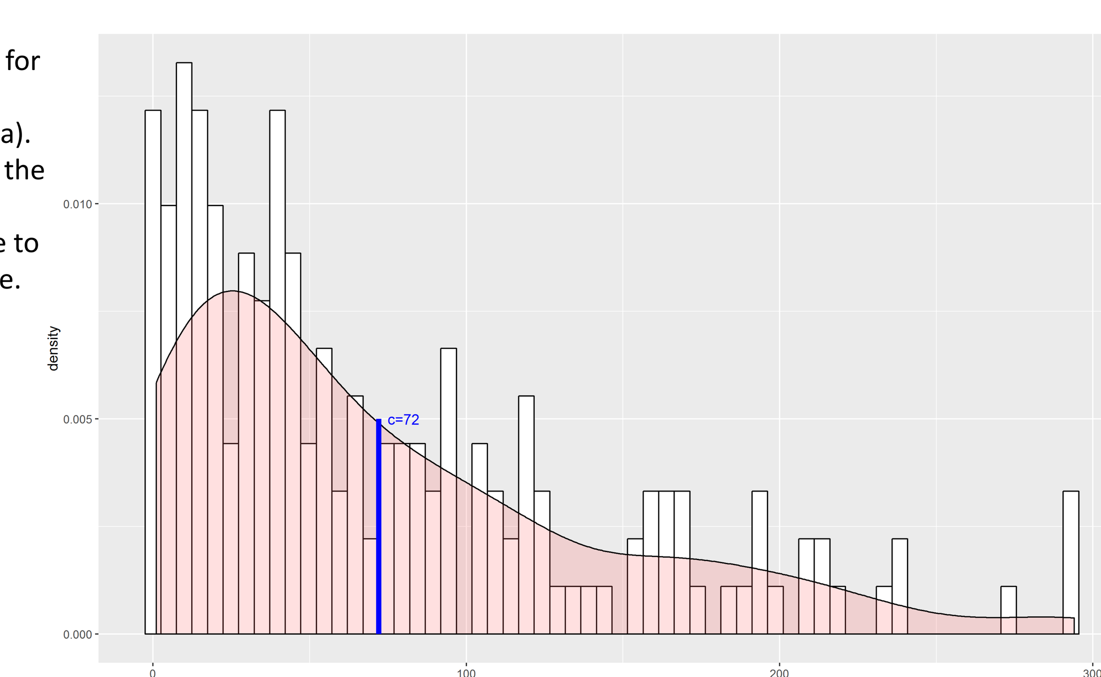


Figure 4. Representation of the lodging-services network in Maspalomas (Gran Canaria). Lodgings are colored in brown and services in blue and green. The link lodging-service indicates that at least 15 opinions of the service was made by tourists hosted in the lodging. Node's degree is represented by the ball size. Edges' thickness illustrate the number of opinions. The spatial disposition of the networks was made using the Fruchterman-Reingold layout algorithm implemented in the R package igraph.

Figure 5. Degree of hotels for the empirical sample of Maspalomas (Gran Canaria). We have selected c=72 as the constant degree in the simulations, which is close to the empirical mean degree.



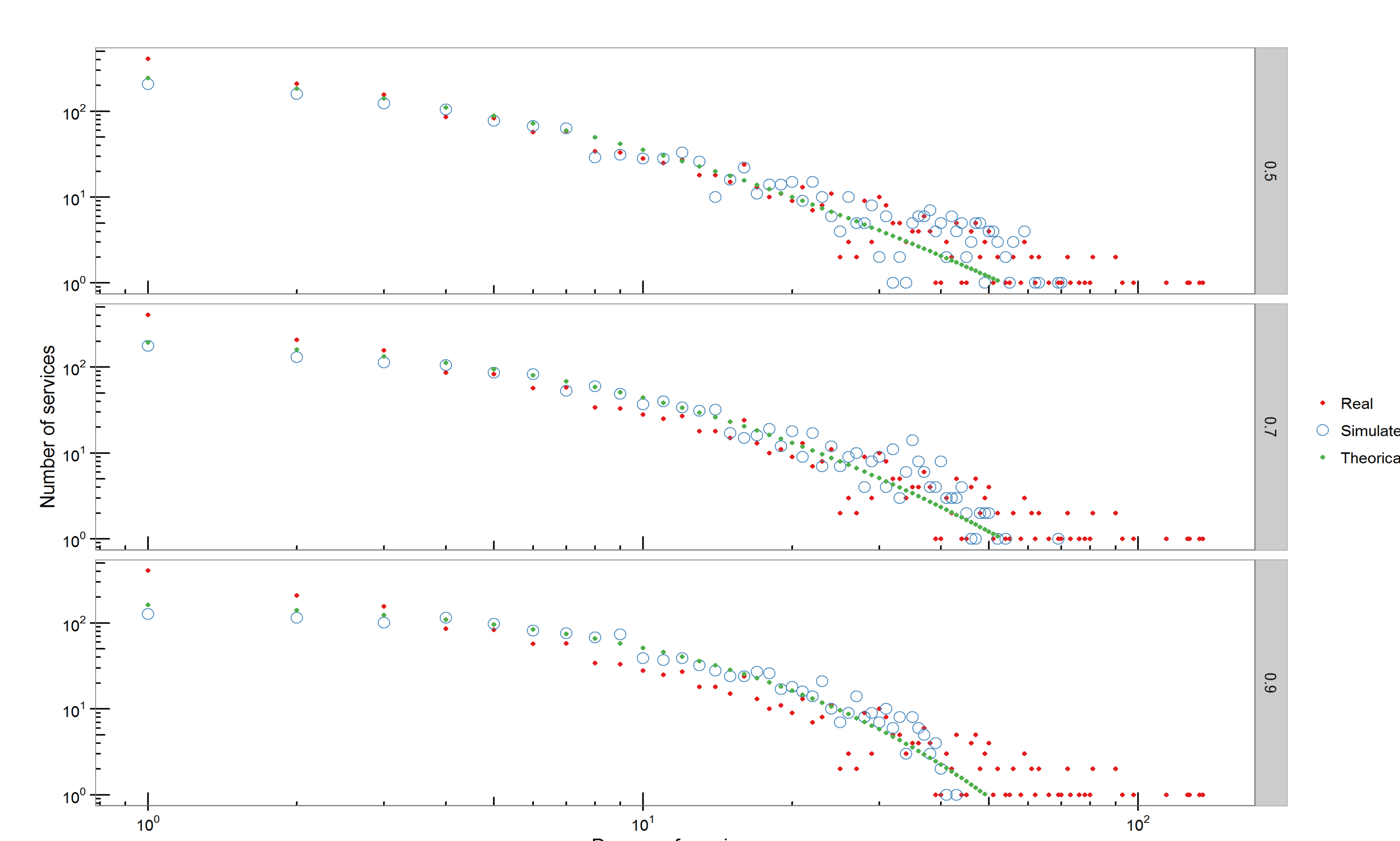


Figure 6. Comparison among the services degree distribution for the empirical sample of recommendations in Maspalomas (red points), the simulations of the model (blue circles) and the theoretical predictions in Equation 1 (green points). Every graph assumes a different value of the percentage of services chosen at random: ϕ=0.5 (up), ϕ=0.7 (middle), ϕ=0.9 (down). The other parameters are determined according the real data (c=72, m=8, H_0=2, S_0=56). The time horizon is T=180. A rather good agreement of the model with data is presented for ϕ=0.5.

Conclusions

- We have built an evolving bipartite network model that represents the supply network formed by the tourist visits to services, which follow a combination of random and preferential attachment rule.
- The model presents a rather good agreement with data. Nevertheless, new tests with data from larger destinations are necessary.

References

[1] Ramasco, J.J., Dorogovtsev, S.N., Pastor-Satorras, R. *Phys. Rev E*, 70, 036106, 2004.