A Universal Lifetime-Distribution for Multi-Species Systems

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Abstract

Lifetime distributions of social entities, such as enterprises, products, and media contents, are one of the fundamental statistics characterizing the social dynamics. To investigate the lifetime distribution of mutually interacting systems, simple models having a rule for additions and deletions of entities are investigated. We found a quite universal lifetime distribution for various kinds of inter-entity interactions, and it is well fitted by a stretched-exponential function with an exponent close to 1/2. We propose a "modified Red-Queen" hypothesis to explain this distribution.

Keyword: Lifetime distribution

1 Introduction

Society is a system where diverse entities coexists showing a high turnover of its membership. Examples of such entities include enterprises, products, and media contents. Lifetime distributions of these entities is one of the most fundamental properties of such systems, thus understanding of these distributions will reveal the secret of underlying social dynamics. Although several models have been proposed to fit the lifetime distributions, such as a simple Poisson process, return-time distribution, or age-dependent mortality, most of these models do not explicitly take into account the interactions between entities. Here we investigate the lifetime distribution of mutually interacting systems since the interactions between entities often play a significant role in actual society.

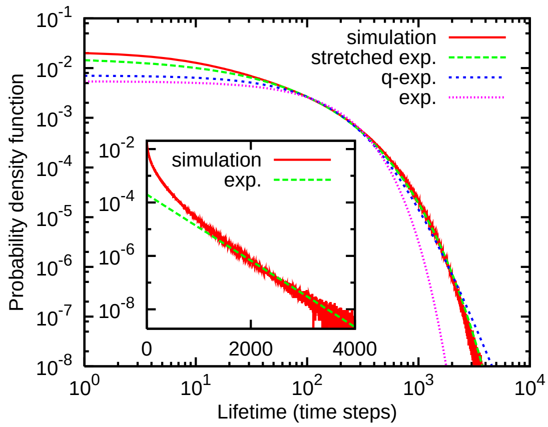

Figure1: A typical lifetime distribution obtained from the model [1].

2 Model and Main Results

In order to investigate the lifetime distribution of mutually interacting systems, we propose a simple dynamically evolving model which is originally introduced for biological community assembly [1]. A system is represented by a weighted and directed network, which self-organizes by successive migrations and extinctions of nodes. Each node has a state variable called "fitness", which is defined as the sum of the weights of incoming links. At each time step, a new node is added with links whose weights are randomly assigned from a certain distribution. If nodes with negative fitness exist, they are eliminated from the system.

With this simple model, a characteristic lifetime distribution is obtained. As shown in Fig. 1, the distribution is neither a simple exponential nor a simple power law distribution. It is well fitted by a stretched exponential function with an exponent close to 1/2. Interestingly, we found that this distribution is quite robustly observed for more complicated population dynamics models [2]. We also show that the distribution is well explained by the "modified Red-Queen" hypothesis, which assumes age-independent mortality with a varying extinction rate.

References

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