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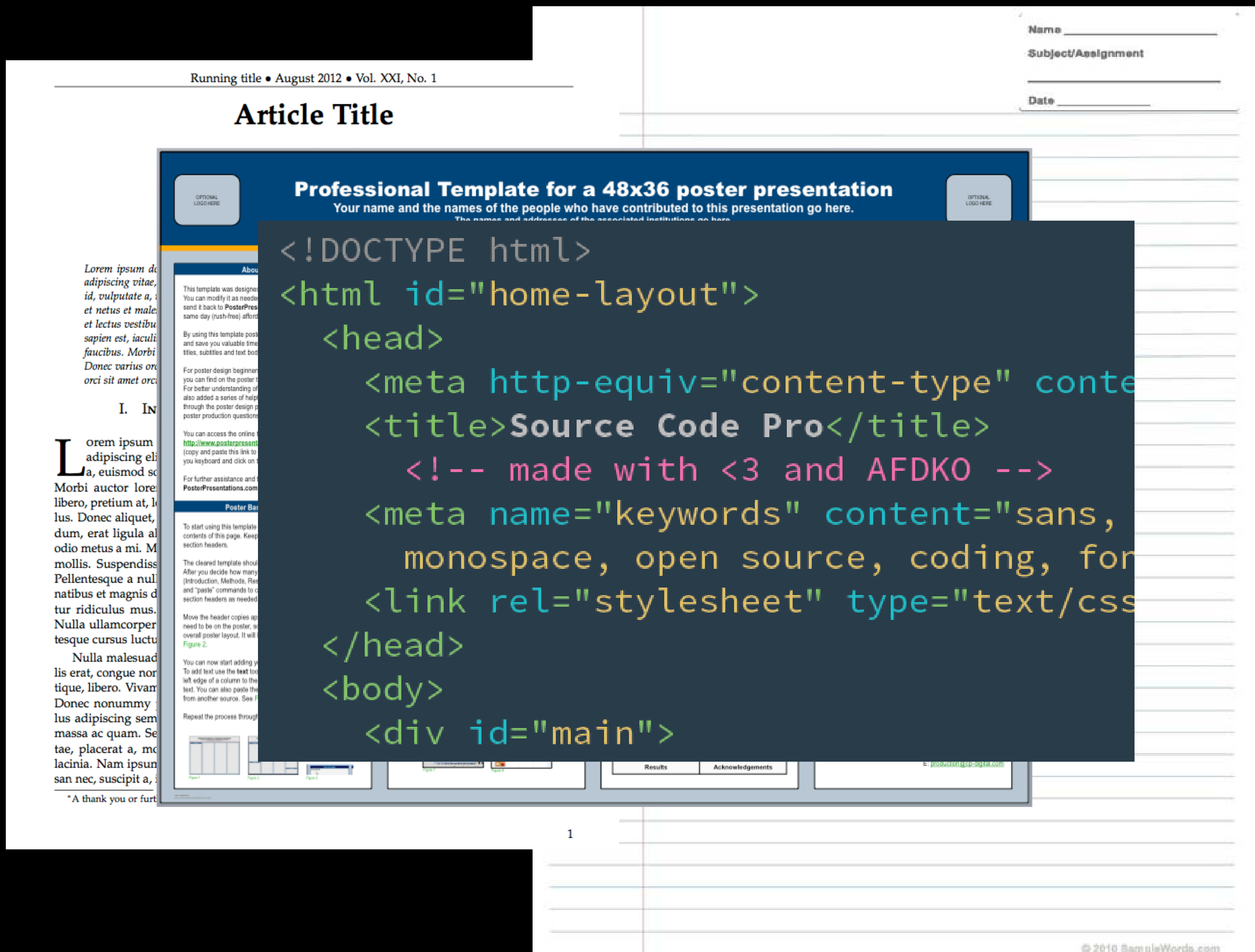

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Let’s Try Some!

On Modeling Product Advertisement in Large-Scale Online Social Networks

Yongkun Li, Bridge Qiao Zhao, and John C. S. Lui, *Fellow, IEEE, ACM*

***Abstract*—We consider the following advertisement problem in online social networks (OSNs). Given a fixed advertisement investment, e.g., a number of free samples that can be given away to a small number of users, a company needs to determine the probability that users in the OSN will eventually purchase the product. In this paper, we model OSNs as scale-free graphs (either with or without high clustering coefficient). We employ various influence mechanisms that govern the influence spreading in such large-scale OSNs and use the local mean field (LMF) technique to analyze these online social networks wherein states of nodes can be changed by various influence mechanisms. We extend our model for advertising with multiple rating levels. Extensive simulations are carried out to validate our models, which can provide insight on designing efficient advertising strategies in online social networks.**

***Index Terms*—Local mean field (LMF), online social networks (OSNs), product advertisement, viral market.**

I. Introduction

In recent years, advertising has become a major commercial activity in the Internet. Traditionally, advertisements are broadcast oriented, e.g., via TV or radio stations so as to reach as many people as possible. With the development of the Internet, new advertisement models emerge and blossom. For example, Google provides the *targeted* advertisements: when a user searches for information, related advertisements, either products or services, are returned together with the search results. Such targeted advertisement can enhance the success rate for selling products. In recent years, online social networks (OSNs) offer another new way of performing advertisement. In OSNs, users are logically grouped together by one or more specific types of interdependency such as friendship, values, interests, ideas, etc. Since the dependency is quite strong, if one user decides to purchase a product, he/she may influence his/her friends and thereby increase the possibility of sales. With the success of OSNs such as Facebook and Myspace, advertising on OSNs is receiving more attention.

To advertise on OSNs, a company first applies advertising strategies, either traditional or Internet-based, targeted or non-targeted, so as to attract a small fraction of users to purchase the product. Based on this initial fraction of buyers, a cascade of word-of-mouth influence by users is triggered, and eventually a large fraction of users may decide to purchase the product. *The aim of our paper is to model advertisement in OSNs. In particular, given a small fraction of users who have purchased the product, what is the influence spread of such a cascade in OSNs, and at the steady state, what is the fraction of users in this OSN that will eventually purchase the product?* Predicting the final fraction of buyers is important for companies since one can use this result to design efficient advertising strategies so as to maximize their revenue. However, this is not an easy task since various factors make the analysis difficult. The first important factor is the topology of OSNs, which is very different from traditional random graphs. The second important factor is that the mechanism that determines whether a user will purchase a product is unknown. Several conventional models such as the independent cascade model and the linear threshold model [1] characterize such mechanisms, and we will employ them in our analysis later. Third, realistic OSNs are usually large in size (e.g., with over 10 million nodes), which makes the analysis complicated.

The contributions of this paper are the following.

- We use *local mean field* (LMF) to estimate the influence in large social networks. Using the LMF, one can concentrate on the correlation structure of local neighborhoods only, so that one can easily derive the statistical properties of the underlying graphs.
- We formally analyze various influence mechanisms and propose a framework to find the final fraction of buyers under a given mechanism for large social networks. We also validate our models via extensive simulations.
- We extend the analysis to scale-free graphs with high clustering coefficient and propose a framework to quantify the influence in such networks.
- We extend our framework to allow users to have multiple levels of ratings on a product and also show its effectiveness via simulation.

The outline of this paper is as follows. In Section II, we model the underlying OSN as an infinite scale-free random graph and introduce the LMF model, then we present several influence models and estimate the final fraction of buyers. We also validate our analysis via simulation and reveal various factors that affect the influence spreading. In Section III, we consider a more realistic social network that has high clustering coefficient and extend the local mean field model to analyze it. In Section IV, we generalize the three influence models to deterministic model and probabilistic model. In Section V, we extend our framework to allow multiple levels of rating on a given product. Related work is given in Section VI, and Section VII concludes the paper.

II. Basic Model

In this section, we study the influence spreading in OSNs. As stated before, users who have purchased a product can also

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CHAPTER 1

Introduction to Reinforcement and Systemic Machine Learning

1.1 INTRODUCTION

The expectations from intelligent systems are increasing day by day. What an intelligent system was supposed to do a decade ago is now expected from an ordinary system. Whether it is a washing machine or a health care system, we expect it to be more and more intelligent and demonstrate that behavior while solving complex as well as day-to-day problems. The applications are not limited to a particular domain and are literally distributed across all domains. Hence domain-specific intelligence is fine but the user has become demanding, and a true intelligent and problem-solving system irrespective of domains has become a necessary goal. We want the systems to drive cars, play games, train players, retrieve information, and help even in complex medical diagnosis. All these applications are beyond the scope of isolated systems and traditional preprogrammed learning. These activities need dynamic intelligence. Dynamic intelligence can be exhibited through learning not only based on available knowledge but also based on the exploration of knowledge through interactions with the environment. The use of existing knowledge, learning based on dynamic facts, and acting in the best way in complex scenarios are some of the expected features of intelligent systems.

The learning has many facets. Right from simple memorization of facts to complex inference are some examples of learning. But at any point of time, learning is a holistic activity and takes place around the objective of better decision-making. Learning results from data storing, sorting, mapping, and classification. Still one of the most important aspects of intelligence is learning. In most of the cases we expect learning to be a more goal-centric activity. Learning results from an inputs from an experienced person, one's own experience, and inference based on experiences or past learning. So there are three ways of learning:

- Learning based on expert inputs (supervised learning)

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Reinforcement and Systemic Machine Learning for Decision Making, First Edition. Parag Kulkarni.

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