Modeling Opportunistic Application Spreading

Extended Abstract

Ádám Horváth
University of West Hungary
Institute of Informatics and Economics
Bajcsy-Zsilinszky u. 9.
Sopron, Hungary
horvath@inf.nyme.hu

ABSTRACT

Investigating information spreading via opportunistic connections between mobile devices is a popular research topic today. However, studying the characteristics of application spreading via such a way has not got too much attention so far. In this extended abstract, we propose the use of Closed Queuing Networks to model application spreading which tries to capture not only the opportunistic connection possibilities but also the users' behavior. In the future, we want to examine how to set the parameters of our model, and run simulations to evaluate it.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Wireless communication*

General Terms

Design

1. INTRODUCTION

Knowing the characteristics of application spreading is important not only from technical but also from economical point of view. The application provider has to know or at least should be able to assess how many pieces of a given application can be sold in a given population; how much time is needed to reach the state in which there is no more interest to purchase the application; which factors influence the spreading mechanism and how.

The traditional way of distributing applications is using a central entity, like an Internet webshop, from where the users can purchase and download the selected application software. However, modern communication paradigms, such as ad hoc or opportunistic communication between mobile devices, can and will influence the way how the users get the applications. Hence, the desired application software can be downloaded directly from a mobile node during a spontaneous communication session or at least the user, depending on his attitude, can get the incentives to purchase it later via a traditional way.

Studying the characteristics of this, opportunistic way of application spreading has not got too much attention so far but its importance is increasing with the proliferation of modern communication paradigms. In [1], the authors define a dynamic model for the spreading of infections in scale-free networks. The authors in [2] examine information propagation in a hierarchical network using the susceptible-infected-resistant (SIR) model. However, none of these papers deals with application spreading and does touch user behavior and economical aspects.

In this paper, we propose the use of Closed Queuing Networks (CQNs) [3] to model opportunistic application spreading. With CQN stochastic models appearing and disappearing nodes in spontaneous communication within a given population can be described. Moreover, a CQN allows us to order intensities to state transitions, by which the time behavior of the spreading process can be described.

The rest of this contribution is organized as follows. First we describe the opportunistic way of spreading applications what we use in our model, than we give a short overview about our proposed spreading model and finally we give a brief summary.

2. OPPORTUNISTIC WAY OF APPLICATION DISTRIBUTION

For the application spreading process we are using the following communication model. Each application is a multiuser application having two versions, a trial and the full version. The nodes are mobile and are categorized into different classes depending on whether they have got the application or not. Using the terminology of epidemics, because application spreading shows similarities to infection spreading in epidemiology, we call these classes as *infected* if the node has the full version of the application, *susceptible* if the node has a trial version and *resistant* if the node does not have the application or already lost the interest of using it.

The nodes form ad hoc networks from time to time where spontaneous communication takes place. In such networks, a node can appear, connect to the other nodes, download and try out the trial version of the application if at least one node in the given ad hoc cloud has already got the full version. The trial can be used only by connecting to a node with the full version. If the node's user likes the application, he can buy the full version via some traditional purchasing

MobiOpp '10, February 22-23, 2010, Pisa, Italy.

way (this phase is necessary unless a secure and reliable payment and licensing method is implemented in the ad hoc network). Later, when the user connects to another ad hoc network he can use the application or even spread the trial version further in that network cloud.
Moreover, in a given ad hoc network cloud there is a limit (leech limit) that constrains how many nodes (leeches) with the trial can connect to a node having the full version (seed). In this sense, the seed nodes can be considered as servers which can serve only a limited number of clients or leeches. Furthermore, we distinguish three different user behavior. $Type_A$ users are interested in using the application and if they can try it out and liked it they will purchase it. $Type_B$ users are also interested in using the application, but if they can find a seed to which they can connect to with a given probability they will not purchase the application. These users do not want to spend money only in the case if they cannot use the trial version frequently. $Type_C$ users never purchase the application, however, their presence influences the spreading mechanism.

3. MODELING APPLICATION SPREADING

In this section, we present our application spreading model and point out to the use of this model.

3.1 Spreading model

We use CQNs to model application spreading, because appearing and disappearing nodes in spontaneous communication within a given population can be described with stochastic models. Moreover, a CQN allows us to order intensities to state transitions, by which the time characteristics of the spreading process can be described.

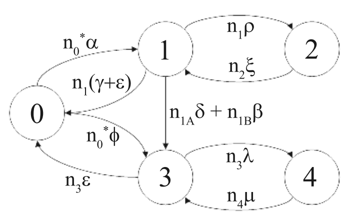

Figure 1: The proposed CQN model for application spreading

Figure 1 shows our CQN model. In this model, the whole user population is represented by different states. Each node is in one of the states depending on the actual class of the node. The resistant nodes are in state 0. Initially most of the nodes are in this state. The passive susceptibles which are currently not using the application are in state 1. The active susceptibles which are currently using the application are in state 2. Similarly, the passive and active infected nodes are in state 3 and 4. n_i denotes the number of nodes in state i. The nodes from time to time form ad hoc networks and depending on getting the different versions of the application or not can change their state. This is represented by the state transitions with different intensities in the model. These transitions are described in Table 1.

Table 1: State transitions in our CQN model

Transition	Description
$1 \rightarrow 2$ $3 \rightarrow 4$	A node starts to run the application. The Greek letters in Figure 1 mean the transition intensities of one node.
$2 \rightarrow 1$ $4 \rightarrow 3$	A node stops running the application.
$0 \rightarrow 1$	A node got the trial version of the application. n_0^* means the minimum of the number of nodes in the network and the number of nodes in state 0 which has not become susceptible or infected yet.
$3 \rightarrow 0$	An infected node lost his interest in using the application.
$1 \rightarrow 0$	Similar to $3 \rightarrow 0$, but it has γ additional intensity representing a waiting probability.
$0 \rightarrow 3$	A user purchased the application.
$1 \rightarrow 3$	A susceptible user bought the application. n_{1A} and n_{1B} mean the number of $type_A$ and $type_B$ users, respectively.

3.2 Usage of the spreading model

By determining the parameters (α, β, γ, δ, ϵ, ϕ, ρ, ξ, λ and μ) of our model we can calculate the holding time before every state transition and generate the next state by the ratio of transition intensities. The intensities change after every transition, because the node distribution also changes. If a node returns to state 0 the process terminates for it. The whole process will terminate if every node returns to state 0. Summing the holding time we can get the application usage time, while the number of $1 \rightarrow 3$ and $0 \rightarrow 3$ transitions determine that how many pieces of the examined application can be sold.

4. SUMMARY

In this extended abstract, we investigated opportunistic application spreading. We proposed a model based on CQNs for describing application spreading, in which we assumed that users support the spreading process by distributing the trial version of the application. Our model is able to capture user behavior, too. As the setting of the model parameters is a complex issue, it requires further investigations what we plan to do as future work.

5. ACKNOWLEDGMENTS

I would like to thank the help to my PhD advisor, Dr. Károly Farkas. This work has been partially supported by the Hungarian Scientific Research Fund (OTKA, PD 72984).

6. REFERENCES

[1] A Vespignani R. Pastor-Satorras. Epidemic spreading in scale-free networks. *Phys. Rev. Lett.*, 86:3200, 2001.

[2] L. Wang F. Fu, L. Liu. Information propagation in a novel hierarchical network. *arXiv:math/0605293v1 [math.DS]*, May 2006.

[3] Thomas G. Robertazzi. *Computer Networks and Systems: Queuing Theory and Performance Evaluation.* 1990 Springer-Verlag New York, Inc., New York, USA, 1994.