Managing the size and growth of a social network: Exclusivity and habit formation

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Many social networks start out humbly, and deliberately so. Facebook rolled out slowly by initially restricting access to users with email addresses from universities and gradually relaxed restrictions over a period of years. Pinterest was as an invitation-only service from its launch in March 2010 until August 2012 when it finally opened its doors. These examples, and others we could note, raise the following questions. When is it optimal for a social network to *restrict* access? When and at what rate to relax restrictions as the social network grows in size?

There are several oft-discussed reasons why a network manager might restrict access. Limiting access can create "buzz" for the service and attract users. On the other hand, "buzz" can be short-lived and may not explain why access is restricted long after launch (as in the case of Facebook and Pinterest). Another consideration is limited capacity for growth – users are added slowly to ramp up network architecture for hosting content. However, with increasingly cheap access to scaleable cloud services capacity expansion seems less of a concern with time. Separate from capacity, there is the stability of the product itself. Social networks may launch in private "beta" to a limited audience for debugging purposes. However, in practice, periods of restricted access far outstretch major changes in successive iterations of the service. A telling example is the release of Dota 2 by Valve, which appeared as an invitation-only private beta for two whole years. There have been as many or more significant changes *since* public launch than during the beta period.[1]

Our model highlights an important strategic reason to restrict access, even when the above considerations no longer apply. This is the fact that the average *quality* of the existing users and the content they produce can be increased by limiting access. A social network like Facebook with highly connected users with ties to business or government is more attractive than one whose users are predominantly of lower socioeconomic status. A sharing site like Pinterest hopes to attract users who create refined and fresh content, not to have a service dominated by users who only repost and rehash tired ideas. Highly-skilled users of an online multiplayer game like Dota 2 attract similarly skilled players looking to challenge themselves. Unlimited access admits unskilled players who diminish the standard of competition. Furthermore, a higher average level of quality attracts future users to the service. Free access to the network at the outset may lead to poorer average quality that dampens the long term growth prospects of a network due to worsening perceptions of user experience. In particular, early adopters and champions of the product may leave if the service becomes flooded with less dedicated or otherwise undesirable users. This tradeoff between quality and access is largely unaffected by advances in technology and software development practice.

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[1] http://dota2.gamepedia.com/Patches

Our model considers a profit-maximizing network manager tasked with managing the inflow of potential users into a social network service (where they become "users"). In particular, we study what determines the optimal growth rate of new users. Clearly, a growth rate that is too slow limits profits through missed opportunities. A high growth rate also has drawbacks due to quality considerations, for reasons discussed above. In particular, under the assumption that user utility depends on the average quality of all users, and some additional technical assumptions, we show that unrestricted access attracts only the least desirable users in rational expectations, a conclusion that is reminiscent of the well-known "market for lemons" Akerlof (1970).

An optimal growth rate policy thus typically follows a path of intermediate growth, balancing expansion with maintenance of quality. The growth rate of users depends on two factors: the rate of growth in potential users via word-of-mouth and restrictions on access to the service, as we saw in the case of Pinterest and Facebook. Word-of-mouth itself is a function of the underlying network structure and the effectiveness of efforts to spreading awareness of the service. The network manager has two operational levers: promotion to intensify word-of-mouth and and setting restrictions on access. When natural growth in the potential user pool exceeds the optimal rate of growth for users, restrictions are enforced to maintain quality. Conversely, when natural growth in the potential user pool lags behind the optimal growth rate for users, promotions are adopted to intensify growth in the potential user pool. This model provides economic justification for the practice of restricting access to a service, and provides insight into when such restrictions are required.

However, there is an additional consideration that is crucial to understanding the dynamics of growth in social networks. Both Pinterest and Facebook gradually relaxed restrictions and opened their service to the public. Given the deleterious effects described above of free access on the size and quality of the user base, why would Pinterest and Facebook follow this strategy? This highlights an additional factor: habit formation of existing users. Users do not leave, despite deteriorating quality, because of usage habits and growing attachment to the service. Indeed, hip early adopters of Facebook continue to use the product even when their own mothers (or even grandmothers) start "polluting" the user-base. This is incorporated into our model by allowing for nonstationary utility functions for users that depend on the cumulative time spent using the service. Habituation allows the network manager to relax restrictions to attract newcomers and not alienate existing users. It may be optimal to have slow growth, in order for habituation to advance and secure participation of high quality users.

Our analysis provides policy suggestions for promotion and restriction that depend on the strength of word-of-mouth, the underlying network structure, the strength of habit formation, the cost of promotion and the distribution of potential users in terms of quality. We show the following results. When word-of-mouth is very effective and quality considerations dominate, we discuss an

optimal policy for dynamically reducing quality restrictions. Conversely, when growth concerns dominate we describe an optimal promotion policy. We also explore the qualitative properties of intermediate cases. Assuming a line network structure and monotonically increasing strength of habit formation, we show an optimal policy initially restricts entry and eventually goes public. When there is obvious clustering in the underlying network, the network manager tends to restrict entry when the app is expanding within a cluster and promotes when the network is expanding across a bridge between clusters. Such cases exhibit a cycling strategy between restricting entry and promoting. Restriction strategies seen in practice are not always successful. While industry observers attribute part of Facebook's success to its exclusivity strategy, others point to exclusivity as a reason for the failure of Google Wave. Careful consideration of the network setting and user characteristics is required to design a successful restriction policy.

Research on social networks in the operations management literature has focused on issues of pricing (Candogan et al. (2012)), learning (Lobel and Sadler (2014)), and brand awareness (Bimpikis et al. (2013)) with a fixed underlying social network. Existing studies on dynamic network formation in the economics and computer science literature typically focuses on global properties, such as how measures of centrality or clustering, depend on the mechanics of how newly born nodes connect to the existing network (see, for instance, Jackson (2008), Blume et al. (2013)). Networks in this literature are thought to evolve dynamically without any form of central authority who impacts evolution. To the author's knowledge, our study is the first to consider the strategic value for a central authority to restrict access to a social network. This initiates investigation into the operational decision of deciding the degree of restriction and the sensitivity of this choice to the overall network structure. We believe this is an important contribution, since many social networks are managed for membership and exclusivity, in additional to generating revenue through acquiring information and marketing products.

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