KK-law for Group Forming Services

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Abstract

Communications services that facilitate or encourage the forming and bridging of social groups serve an important human need. Such services, therefore, should offer high value. The problem for service planners, however, is to predict the value of these services before they are offered, and to ensure pricing that will actually achieve the desired group forming. In this paper we derive a new formula for evaluating the usefulness and value of communication services, called KK-law and compare it with Reed's law. The major finding is that the service penetration is of utmost importance for group forming. Moreover, it is almost impossible to design a group forming service; rather group forming emerges freely when certain conditions are met. Thus the only reasonable approach, both from society and service provider viewpoints, is to offer an inexpensive, highly available and easy to use platform for group forming services.

1 BACKGROUND AND HISTORY

There has been a long evolution of group forming from rock-art to email and SMS (Short Message Service). Because group forming is a primarily a social phenomenon rather than a technical matter, it is important to look at it from a social viewpoint. For this purpose we give a brief account of the history of communications by applying the concepts of bonding, bridging, and linking. Those readers that are merely interested in the mathematical formulation of group forming may directly proceed to chapter 2. Yet, the conclusions we draw in the end of paper are based both on the mathematical model and on the discussion about group forming as a fundamental human need.

There are various approaches to evaluate the mechanisms of culture. Frank Webster [11] separates five elements in the society evolution: technology, economy, occupations, geography and culture. Obviously, our culture is deeply affected by the evolution of our mental capacity. However, there is a significant other side of cultural evolution because the ideas generated by the brain were first realized through hands and later on by means of technology. Historically, rock-art was a form and medium for information delivery before the invention of writing and all other amazing inventions in the area of communications. With its creative expressions, economical and social activities, ideas, beliefs and practices, rock-art are considered principal evidence of the earliest stages of human cultural history [3]. It reveals aspects of the imaginative and emotional life of man that no other available evidence of early civilization is able to do, and at the same time possesses all five elements of society evolution mentioned above. But what does rock-art have to do with group forming? Rock-art reveals the utmost importance of forming larger groups than family units in order to survive in an extreme environment. Group forming is, hence, a fundamental need for every one of us.

OECD has defined the social capital as networks together with shared norms, values and understandings that facilitate co-operation within or among groups [4]. This definition is clearly based on the concept of group. We may even argue that the most fundamental expression of communication is not the transmission of information but the structuring of common understanding and experience within a society–something that rock-art distinctly represents. Group forming has always been a crucial part of social evolution: group selection rewards small collaborating coalitions, and radical changes in every society tend to happen behind the scenes carried by a small group [8]. Thus it is imperative for the whole society to recognize and comprehend the effects of group forming.

Communications technologies can and do encourage group forming. To analyse the effects of communication technologies on group forming we can distinguish three types of social capital [7]:

- *bonding* social capital is characterised by strong bonds, e.g., among family members,
- *bridging* social capital is characterised by weaker but more cross-cutting ties, e.g., with business associates, or friends, and
- *linking* social capital is characterised by connections between those within a hierarchy, where there are differing levels of power.

While rock-art worked mainly in the area of bridging, the development of all later communication technologies is almost always started in the area of linking. Moreover, the technical aspect of transmitting information has been excessively stressed at the expense of other aspects like building social capital. Finally, the reason and first use of most communication technologies has been in military needs. We can easily find numerous examples that justify this model of three foundations of communication technologies.

Optical telegraph is an extreme example in which military use was often the sole reason for building the network, and linking by providing faster transmission medium was the primary application of the technology. For instance, in Finland optical telegraph has been applied twice [5]. In the first occasion, in 1796, the major function of the optical telegraph was to speed up the transmission of official bulletins from Finland to Sweden. The last message transmitted by this telegraph line was the order that the inhabitants of Åland Islands should not deliver any supplies to the Russian army. Finland belonged to Sweden until 1809 when Finland became a part of the Russian empire. The second optical telegraph in Finland was built during the Crimean War of 1854-55 for the purpose of providing the fastest possible communications of enemy naval activities. When the war was over in 1856, the optical telegraph had served its purpose, and the equipment was dismantled and sold off. Obviously, there was no bonding or bridging type of use for optical telegraph.

However, we may argue that optical telegraph has been the last significant communication technology that has been used solely for linking purposes. In contrast, all the later technologies are sooner or later adapted to bridging and bonding purposes. Telephone is a good example of technology that has a strong bonding effect as stated by Claude Fischer in [6, p. 262-3]: "..., Americans apparently used home telephones to widen and deepen existing social patterns rather than to alter them. ... As well as using it to make practical life easier, Americans–notably women–used the telephone to chat more with neighbors, friends, and relatives, ...".

Another, even more illustrating case is the development of radio technology. As discussed in [2] the First World War accelerated the development of transmission via electromagnetic waves. It became very important that the different units could communicate with each other. Even ships and aircraft were equipped with transmitters and receivers when these devices became small enough. This application of radio technology belongs clearly to the linking category, while a large-scale bridging service did not emerge until 70 years later (radio amateurs have, of course, used radios for bridging, but without any public service). Although there are some obvious technical reasons for this amazingly long delay, particularly the requirement of advanced semiconductor technology for realizing small radio terminals, there obviously have been cultural reasons as well. Authorities have often preferred well-controlled linking services instead of free bridging services. Even now wide frequency bands are reserved for special linking purposes, while public frequency bands and the services offered through them are under heavy licence fees and taxation.

Now when the Internet is the dominant platform for bridging services, it is important to remember that even its roots are in the military side, that is, in ARPANET. However, in addition to linking, a quite strong bridging motive was present during the development of the Internet (although the terms are used here in social context rather than in technical context, we would also argue that technically bridging is the essence of the Internet). This rare combination of military funding and bridging type of service might partly explain the special role that Internet nowadays has; it will be very difficult to imitate this development because the sponsors of the endeavour did not aim at creating a technology for bridging the whole world. Then there is one more technical invention that has greatly affected the social bridging in modern societies, that is, television. For instance, according to a Finnish social study [9] the time spent for watching TV increased from 27% to 35% of free time between 1988 and 2000 while the time spent for social life decreased from 23% to 17%. This trend has created a huge hole in the area of social bridging. It seems that the hole is particularly problematic in older age groups where the lack of effective bridging seems to be very difficult to compensate. In contrast, younger persons are much more active to seek and adopt new ways to satisfy the deep need of bridging with others. This phenomenon has also been found in social studies: If we classify people in groups based on how active they are in bridging type of social contacts, young people are six times more likely to belong to the most active group than older people [1].

As a summary, bridging, or in other words group forming, is a fundamental need for all members of any society. Therefore, it is important for the society to ensure that all applicable technical means for efficient bridging are available for all members of the society. Further, the importance of bridging also implies a significant business potential for service providers. However, both from society and form business viewpoint the availability of the group forming service is a highly critical matter. We are profoundly assessing this issue in the following two chapters.

2 DERIVATION OF KK-LAW

Some theoretical formulas have been presented to model the behaviour of group forming. The most popular of these models is Reed's law [10]. Reed basically states that the value of N member net is proportional to 2^N, because the total number of possible groups is of order of 2^N. This can be compared to Metcalfe's Law stating that when the service is about connecting pair of persons the value of the service is proportional to N^2. Then by adding a linear component, Reed obtains the following formula for the total value of N member net:

$$V_{\mathrm{Reed}}(N) = c_1 N + c_2 N^2 + c_3 2^N \qquad (1)$$

Although Reed's reasoning seems to be quite convincing, our paper shows that the group forming phenomenon can be modelled more realistically. The fundamental problem with Reed's law is the assumption that factor c_3 remains constant even when N grows large. That hardly could be a realistic assumption. For instance, let us assume that the total population were 1 000 000 persons and the total value of all possible groups for each person were 1000 €. Now if we remove 20 persons from the population, while 999980 remains, the value of remaining groups would diminish down to 0.001 €/person. Although the example clearly reveals the problematic behaviour of Reed's law as such, there still is certain wisdom in the Reed's basic idea. While group forming is a significant phenomenon and should not be ignored, the formal model has to be more realistic.

Now let us approach the issue of group forming from somewhat different viewpoint than Reed. Let us still assume that the value of a networking service has three components related to

1. Services that do not require any other persons, like remote access
2. Services connecting two persons, like telephone call
3. Services connecting a group of persons, like mailing lists

Note also the correspondence between these service components and the types of social capital: linking belongs mainly to the first service category, bonding to the second category, and bridging to the third category.

Let us first consider the value of all services for one individual person in a fixed size, large population of *K* persons. We may assume that there is a limit for the value of each service component for the person:

m_1 = total value of connecting the person to different sites,
m_2 = total value of connecting the person to other persons and,
m_3 = total value of making connections among a group of persons.

The unit of each component could be €/month. If the penetration of the networking service is $p = N/K$, the average value of the whole service for an individual is

$$V_{ind}(p) = m_1 + f_2(p)m_2 + f_3(p)m_3 . \qquad (2)$$

In Reed's law $f_2(p) = p$ and $f_3(p) = 2^{-(1-p)K}$.

The key question in our paper is what is the most realistic form of function $f_3(p)$? If the size of population is large, as it usually is, Reed's choice essentially means that $f_3(p) = 1$ if p=1; otherwise $f_3(p) = 0$. The key problem of this reasoning is the assumption that every possible group, regardless of the size of the group, is equally valuable. Note that, if *K* were 1 million, the number of groups consisting of 567123 persons is about 10^{297074} times larger than the number of possible groups of size 5.

Thus it is better to consider the total value of all groups of a certain size than the number of possible groups of certain size. The total value of all groups for a person is

$$\sum_{i=3}^{K} w(i) = m_3 \qquad (3)$$

where $w(i)$ denotes the total value of all groups of size *i* for a person.

By making appropriate independency assumptions, we can calculate the probability that all other members of a group of size *i* are using the service:

$$q(i, p) = p^{i-1} . \qquad (4)$$

Note that because the person to be considered belongs to the active persons by definition, the question is whether all other persons in a group are also using the service. Here we also assume that the service is useful only if all members of the group are using the service. Although this clearly is a strict requirement, it seems to be valid in many cases. For instance, if a sport team wants to arrange daily information transfer by SMS (Short Message Service), even one missing person from the distribution list decreases the usefulness of the SMS-service significantly.

In addition to these kinds of group, there are more flexible groups, like free Internet discussion groups. Apparently, our model is not suitable for those groups because there are not any pre-defined members that are strictly required to make the group functional. Rather, the more there are active members, the more useful the list is for the members. However, the dependency between group size and usefulness hardly is linear; it might even be that if there are too many active members the usefulness begins to decrease. Thus these kinds of groups require different models. In this paper we are not addressing this issue further, but limit the discussion to groups with somehow pre-determined members.

As a result we obtain the following general form for $f_3(p)$:

$$f_3(p) = \frac{\sum_{i=3}^{K} w(i) \cdot p^{i-1}}{\sum_{i=3}^{K} w(i)} . \qquad (5)$$

The practical problem of this formulation is the assessment of the value of different group sizes. Although it is possible to assess separately the importance of all possible groups, in practice we need a simpler and more practical approach. In this paper we assume that the total value of groups of size *i* obeys the following geometrical distribution:

$$w(i) = \begin{cases} c \cdot \alpha^{i-3} & \text{if } i \geq 3 \\ 0 & \phantom{\text{if }} i < 3 \end{cases} . \qquad (6)$$

Using this geometrical distribution we get

$$f_3(p) = \sum_{i=3}^{K} (1-\alpha)\alpha^{i-3} p^{i-1} . \qquad (7)$$

When *K* is large we obtain

$$f_3(p) = (1-\alpha)p^2 \sum_{i=0}^{\infty} (\alpha p)^i = \frac{(1-\alpha)p^2}{1-\alpha p} . \qquad (8)$$

A small value for α means that small groups represents majority of the total importance for the users of the service. When α approaches one, large groups become more and more important. Now if we calculate the average size of groups weighted by the importance of the group we get for large *K*:

$$r = \frac{\sum_{i=3}^{K} i \cdot w(i)}{\sum_{i=3}^{K} w(i)} \approx \frac{3-2\alpha}{1-\alpha}. \qquad (9)$$

By combining equations (8) and (9), we obtain

$$f_3(p) = \frac{p^2}{r-2-(r-3)p}. \qquad (10)$$

Thus from the viewpoint of an individual user, the value of the service as a function of penetration is:

$$V_{ind}(p) = m_1 + pm_2 + \frac{p^2}{r-2-(r-3)p} m_3. \qquad (11)$$

The total value of networking can be obtained simply by multiplying $V_{ind}(p)$ by the total number of persons using the service ($N = pK$). Thus our alternative for Reed's law, Kilkki-Kalervo-law or KK-law, can be presented in the following form:

$$V = \left(pm_1 + p^2 m_2 + \frac{p^3}{r-2-(r-3)p} m_3 \right) K \qquad (12)$$

where V = total value of a service,
p = service penetration,
r = the average size of groups weighted by the importance of the group,
m_1 = total value of connecting a person to different sites per person,
m_2 = total value of connecting a person to other persons per person,
m_3 = total value of making connections among a group of persons per person, and
K = size of population.

Figure 1 illustrates the behaviour of our formula in a case where $Km_1 = 0.1$, $Km_2 = 0.25$, $Km_3 = 0.65$, and $r = 15$.

The first two terms in (3) are essentially the same as those in the Reed's formula with $c_1 = m_1$ and $c_2 = m_2/K$, whereas the last term is clearly different. Note that regardless of p^3 in the third component, on the interesting region of high penetration the nominator r-2-(r-3)p dominates the actual behaviour of the function. Moreover, we get similar behaviour as in Reed's law merely by using very large value for group size.

It should be noted that Figure 1 closely resembles Figure 3 in Reed's article [10]. Actually an almost perfect fit can be achieved by choosing $Km_1 = 0.26$, $Km_2 = 0$, $Km_3 = 0.98$, and $r = 31$ when the scale in both dimensions is 1. Thus, our formula catches very well Reed's fundamental idea and general insight on the phenomenon itself, even better than his own mathematical formulation.

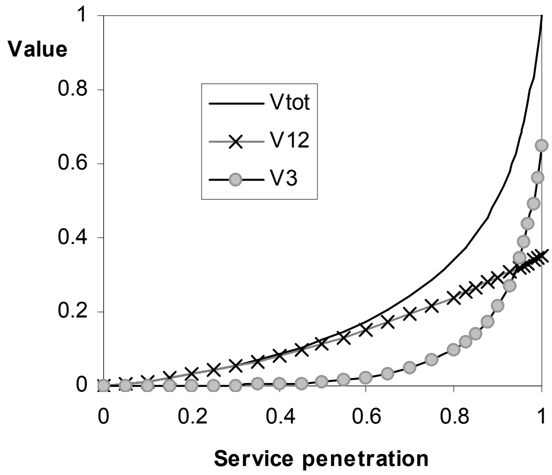

Figure 1. Total value of a networking service (V_{tot}) as function of service penetration; V_3 = value generated by group forming, V_{12} = value generated by other two components

3 APPLYING KK-LAW

When does the group forming really take off when penetration increases?

Evidently the threshold depends on the average group size in a way that with smaller groups, lower penetration is sufficient while with very large groups almost 100% penetration is required. One way to examine the issue is to use KK-law only group forming ($m_1 = m_2 = 0$ and $m_3 = 1$) and determine the turning point as the penetration with which the derivative of is 1. The results are illustrated in Figure 2.

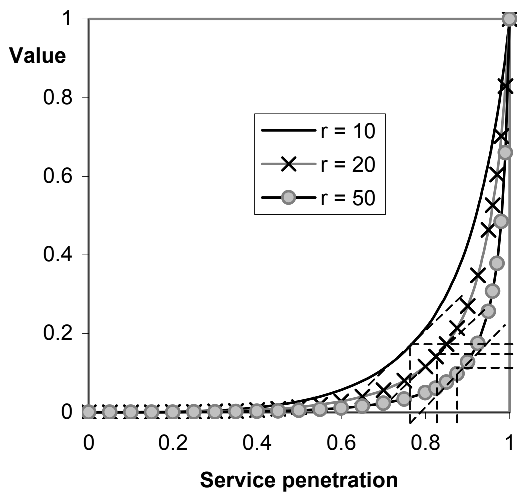

Figure 2. Effect of average group size on the efficiency of group forming

A rough estimation for the turning point is:

$$p_{gf} = 1 - \frac{1}{1+\sqrt{r}} \qquad (13)$$

With moderate sizes for r, the turning point is typically at a penetration of 80% although only 15% of the potential value of group forming is attained at this point. Furthermore, a high penetration of 95% is usually required to achieve the majority of the possible benefits of group forming.

A somewhat problematic assumption with KK-law, as well as with Metcalfe's and Reed's laws, is that the service penetration is assumed to be homogeneous over the whole population. In practice, the population would be fragmented in a way that groups of persons primarily communicate with each other. Further, if the service penetration varies between those groups, the probability that person A using the service is able to reach a desired person B, is higher than the overall penetration p. With small groups (including pairs of persons), this effect is most significant with low penetration ($p < 0.1$). Actually, this is one of the reasons why it is possible for the operator, in the first place, to cross the problematic area of low penetration and gradually attain higher penetration. However, this kind of use belongs more to social bonding than bridging, and thus does usually belong to the category of bridging or group forming.

With larger groups it is quite unlikely that all members of a group belong to the same cluster of active users when penetration is low. In the region of moderate penetration (50%...80%), the heterogeneous growth may somewhat improve the efficiency of group forming. The essential thing when assessing this matter is whether the potential groups using the service are somehow correlated with the clusters of active users. For instance, when a group wanting to use a service is directly related to the technology used to build the service, a positive correlation is obvious. In contrast, with a miscellaneous hobby there hardly is any significant correlation between the use of service (like SMS) and the probability of being an active hobbyist. As we may safely assume that for an average person the number and importance of miscellaneous uses of the service is much higher than the number and importance of uses related to the service and technology itself, the assumption about homogeneous penetration likely is sufficiently realistic.

Another issue affecting the usefulness of the service is that those who first select the service usually assess the value of the service higher than those who select the service later. Thus, although from the perspective of an individual person, parameters and can be independent of penetration, from the operator's perspective the parameters do likely depend on p in a statistical sense. Again, this phenomenon improves the business potential of connecting services when the penetration is low, because the readiness to pay is higher in certain clusters of users than on average in the whole population. If the readiness to pay is high enough, those special clusters may justify the service offering even with low penetration. However, in case of group forming the situation is more difficult, because high price apparently prevents the service provider from enticing the majority of consumers with low readiness to pay. Thus our main conclusions are as follows:

- High service penetration, let's say over 90%, is only possible when price level is low enough, which makes it very difficult for the service provider to exploit differences in readiness to pay.
- Because the differences in readiness to pay are difficult to exploit, the only viable approach is to offer an inexpensive and easy to use technical platform for efficient group forming.

The gains for the service provider, society, and individuals will emerge through a free development of applications and uses. It is in the interest of all parties to stimulate this evolution.

4 Conclusions

Because telephone service is primarily a bonding service, it strengthens the existing societies and is usually supported by authorities. However, since telephone service can also be used for bridging, though only in limited sense, authorities have tried to restrict or control long distance and international calls in many countries. The connection-oriented nature of telephone networks has made this control if not easy at least doable.

Real bridging is quite a different case. Bridging is something that has to happen freely without any significant control of any authority, even without the authority of developers of the technology. SMS is a typical example of this; we may even claim that any purposeful development of a bridging service for mobile terminals would end up with a worse result than the current SMS. Maybe we shall accept this as a general rule and only assess how services primarily designed for some other purposes can efficiently be applied for bridging purposes. The term efficiently is the key issue. In many cases the use of bridging service would escalate to an extent that does not anymore serve the original purpose; the situation with current email service is a notorious example of this phenomenon. Another important viewpoint is that bridging service cannot be effective unless it can be used by a great majority of the whole population. KK-law, i.e. equation (12) in this paper, offers a strong evidence for this statement.

There are numerous practical consequences to be drawn from KK-law.

- Any technology itself (e.g., email or SMS) must not be divided into separate regions without very efficient interworking, because a penetration below 50% is quite useless.
- A basic form of the service shall be available for everybody with as low fee as possible, because otherwise it is not possible to achieve a high enough penetration.
- If these conditions for efficient group forming are met and when the penetration reaches a certain limit, the use of the service will explode, because reachability via the service as a member of various groups becomes a social imperative.

When the use of the bridging service increases new applications and features will emerge, which further accelerates the rise of the penetration and the benefits of the service. If certain technology or service reaches the position of the dominant means for social bridging, there is almost nothing that could prevent people from using it even when some authority tries to do that.

The earliest use of a communication service is typically based on linking (the first term in KK-law), or bonding (the second term in KK-law), not on bridging. Because group forming is very inefficient with low penetration, it is very difficult to predict all the potential uses of the service just based on the early use of the service. The sure thing is that efficient tools for social bridging will be eagerly demanded as long there are human societies. Moreover, the success of any society will strongly depend on the available tools for bridging. Rock-art was the first expression of this and as it started the amazing development of human societies, while email and SMS are the latest but not the last stages in the evolution of group forming technologies.

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