USB Nets: from message ferrying to leisure

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ABSTRACT

Offering a USB flash drive filled with personalized or generic content, with or without direct reciprocation is a low-cost alternative for content sharing, message ferrying and other interesting delay tolerant applications, which we call USB Nets. The success of a USB Net crucially depends on the motivation of a few influential people or a public authority to bootstrap this process and of the rest to play the game. In this position paper we bring forward this underutilized mode of communication and identify the most important building blocks of a USB Net and our under development USB Net setup application. Our long-term objective is to allow non-technical users to configure and bootstrap a wide variety of USB Nets, like the ones we describe in this paper and many others we have not thought of.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous; C.2.4 [**Computer-Communication Networks**]: Distributed Systems

General Terms

Design, Human Factors

Keywords

USB, delay-tolerant networks, message ferrying, group communication

1. INTRODUCTION

Small USB flash drives (called also sticks, chips, or keys) are a very efficient way for data exchange since they provide (i) high capacity, (ii) universal access, (iii) increased privacy (under certain assumptions), and (iv) high usability at least for less-technical users.

The DeadDrops[1] art project – tracing USB drives cemented in walls used for anonymous peer to peer file-sharing in public spaces – shows the potential for a wider adoption of this mode of data exchange: Handing a USB drive to a friend (risking it is getting lost or forgotten) is much easier than building one inside a wall and more safe than downloading content from a publicly open USB drive. However, in reality USB drives are not often handed over probably because of their non-negligible cost and the lack of a corresponding social norm or fashion. People are used to carry their personal USB drive and exchange data only when this could be done on the fly (e.g., by copying them from a friend computer when visiting) but not passing it on.

There are three main case studies in which this communication paradigm has (or could have) a technical merit:

1. When there is no alternative communication infrastructure (i.e., Internet or WiFi).

2. When there is a requirement for strictly private communications. For example, when there are legal threats (as in political movements) or censorship attacks.

3. When the content size is very large and/or its online availability poses privacy concerns; either due to the possibility to become publicly available by accident or because of its potential misuse by the hosting peer.

In the first scenario, in which adhoc communication between end devices is the only means for data exchange, the exchange of USB drives as a means for message ferrying [18] or for group communication could be seen as a cheap alternative and/or a complement to opportunistic networks relying on mobile devices [2, 12, 16].

A set of USB keys actually form a delay-tolerant network [9] (very tolerant indeed) but with a very high per contact capacity, absolute privacy and an interesting human dimension due to the required face-to-face contact and hand-in-hand exchange of the key. The PodNet [3] and Haggle [1] projects were initially thought as digitally enabling such data exchange by relying on smartphones instead of USB keys. Yet, many technical limitations such as the lack of support for ad hoc communications have prevented such opportunistic networks to be widely used.

In this paper, we propose *USB Net*, where users rely on a set of non-personal USB keys to exchange any kind of data or build a social network. These keys could be filled with useful content and handed to friends or peers whenever they meet or even in organized "USB exchange parties". The more people engaged in this form of content exchange, the more interesting applications could arise and the less prob-

[1] http://deaddrops.com/

ExtremeCom '12, March 10-14, 2012, Zürich, Switzerland.

Figure 1: Offering a USB drive to a friend

able that one would need to invest a lot of money in purchasing USB keys since the chances of becoming a receiver of a key would increase significantly.

These USB keys will form a huge collective mobile memory to which everybody contributes by donating a certain number of them and passing them on. Of course, as in all P2P applications one would expect some people to be more altruistic than others to that respect, as the numerous seeders in BitTorrent [6]. To motivate "USB seeders" to help bootstrap the system one needs to provide the appropriate vision and stimulate carefully intrinsic motivations [15].

An important functionality that could be developed to this end is the online tracking of the evolution of USB drives as they are being passed from person to person. Such tracking could take place in dedicated web sites (as in the case of BookCrossing[2] or Where's George?[3]), in generic online social networks such as Facebook, Twitter, and Flickr, or even in hard format (e.g., a paper accompanying the USB driver, depending on the envisioned application). The use of sophisticated mapping tools (such as Google maps) and the ability to add comments and rating of the shared content as in popular online social networks (e.g., a Facebook-like application that reads and writes on a USB drive) might also increase the usability and attractiveness of a USB Net.

Of course, depending on the level of trust between the people engaged in a USB Net application, there might be more or less important security concerns, such as virus spreading, or privacy threats. For example, for a USB drive that is meant to be passed amongst trusted people (e.g., the members of a lab) very strict security measures might introduce unnecessary complexity. But for USB drives that are meant to be exchanged between strangers (e.g., in a "message in a bottle" type of application) we need to ensure the highest possible security level.

Our main objective and core design choice is to provide a bootstrap service with different configuration options for creating different variations of a USB Net. The tracking mode, the pre-installed software, documentation and help files, security measures, and online support are some of such options that one could define in a "Start your USB Net project" web page or desktop application.

[2]http://www.bookcrossing.com
[3]http://www.wheresgeorge.com

In the following, we elaborate further on different case studies for which USB Nets can contribute both as an efficient and ludic means of communication. We identify the most important building blocks of a USB Net and the corresponding trade-offs that arise. The paper concludes with discussion on perspectives and interesting research questions that arise in this context.

2. APPLICATION CLASSES

2.1 Message ferrying

In areas with very limited Internet connectivity, a USB Net could be seen as a collective USB memory, used to transfer data to an Internet gateway, like the shared bicycles in big cities (e.g., Velib in Paris) serve as a common mobile transport infrastructure shared by all citizens. Delay-Tolerant Networks (DTNs) are another viable alternative but they do require the widespread adoption of sophisticated mobile devices like smartphones, which for the moment are not widely available in poor disconnected areas.

So, one could imagine remote villages investing in buying a certain number of USB keys that could be used to transfer data to the single Internet gateway from where people would take the "empty" ones and redistribute them for future use. How many USB drives would be enough and which is the optimal capacity per USB drive as a function of the population, its communication needs and the mobility patterns? How the investment is compared with a technology based on smartphones and DTNs for the same result? These are some interesting research questions that appear in this context and which we wish to pursue in our future work.

2.2 Group communication

Of course, in addition to message ferrying USB Nets could be used for private group communication as an alternative or complement to DTN networks [2, 18] when connectivity is limited or when there are legal threats and/or censorship practices. But the value of USB Nets goes beyond such extreme communication scenarios since today's popular social networking and content sharing solutions over the Internet, such as YouTube, Facebook, and Flickr are subject to various privacy and information control issues:

- **Unintended sharing**: Personal content is often exposed to wider social circles than intended.
- **Exposure risks**: There have been many incidents in which private information was exposed through mistakes or intended attacks.
- **Unauthorized use**: Huge amount of private information is available today to large corporations and is used for targeted advertisement, social studies, etc.
- **Hidden activity**: In order to increase their stickiness online social networks hide or manipulate activity information (e.g., the source and number of visits to one's page).

Of course, there are existing platforms that do try to address those above concerns. From Google+'s circles, to BitTorrent and Diaspora, anonymizers, and numerous other P2P systems. Each of these solutions has its own pros and cons which in general express the trade-off between privacy

protection and attractiveness in terms of usability, efficiency, and critical mass among others.

The same holds for USB Nets, which are not meant to replace the existing solutions but act instead as an interesting complement that occupies a different, extreme, spot in the trade-off matrix. That is, they offer the potential for absolute privacy and very high capacity per contact, but suffers from limited usability and need for critical mass. Our "USB Net setup application" described below aims to highlight the benefits of this mode of communication and address its limitations.

2.3 Leisure

Ludic USB Net projects, like DeadDrops, can contribute significantly in the adoption of the habit to fill and pass on USB drives to friends. Similar to the excitement of using walkie talkies as an independent user owned means of communication instead of conventional mobile phones, the romanticism of a message in a bottle, and the personal connection of a mix tape, a USB Net can build on the required physical contact for data exchange and its gift semantics to create interesting and fun communication games.

The lack of control over the next hops of communication, the randomness of the content that could lie in a USB drive, and the rather slow time scales from limitations could be transformed to attractive properties with clever application design, suitable USB management tools, and some marketing.

3. WHAT CAN WE DO?

It is trivial to create a USB Net today without the need of any sophisticated software. Passing a few USB drives together with some guidelines for the expected behavior should be enough. However, what is challenging is to really engage users in the project and reach the required critical mass that would make the required investment in time and USB drives worth it for an end user.

To get a first idea of how a USB Net could look like and what could go wrong, we have bootstrapped two very small-scale experiments with non-technical users. The first involved a handful of USB drives handed to a small close circle of friends in Zurich with personalized multimedia content (a modern version of a Mix Tape [14]). The USB drives had a sticker with their unique ID and a short URL leading to a Google form[4] with a few simple questions. The replies are then casted to a private Google spreadsheet, which allows the USB Net administrator (only) to trace the evolution of the keys and receive feedback from the users.

Another toy example of a USB Net was setup in the context of meetups between Flickr users. The idea is that in each meetup a new USB stick is created or an existing one is passed on, with photos taken during the meetup. Some of these photos are added to a dedicated Flickr group[5] in separate threads making easy to trace the evolution of each USB drive and adding a visual element to each hop.

Our toy examples have demonstrated what we expected in the first place. Engaging people in this unconventional form of communication is not trivial. Although feedback is in general rather positive (i.e., people appreciate receiving for free a USB drive with interesting for them content and they find

[4]http://tinyurl.com/USBnet4U/

[5]http://www.flickr.com/groups/1872620@N22/

Figure 2: A Flickr group for tracking the path of different USB sticks exchanged during meetups between Flickr users

the idea of a USB Net exciting), the reaction times in terms of further passing the USB drives are not satisfactory. In addition to the inherently slow time scales, especially when compared with existing online social networks, the requirement for a face-to-face communication and the absence of an established social norm for USB key offering seem to pose a significant challenge for the proliferation of a USB Net.

The main objective of our project is to facilitate the implementation and deployment of a wide variety of USB Nets, from simple to more sophisticated, according to the vision of their creators and the constraints of the environment. In other words, we wish to help individuals and authorities that wish to bootstrap a specific type of USB Net to define the rules of the game and put in place the corresponding functionality. If needed, this functionality could be implemented by different specialized software modules residing in different possible locations: the USB drive itself, on the users' desktop or online servers.

Notice that such a functionality should be generic enough to allow exactly different types of people to target their own vision by bootstrapping a USB Net with a certain number of keys linked to a certain web site. So, different solutions with incremental complexity will be provided based on the requirements of the users who should have the freedom to create the USB Net of their choice.

4. SETTING UP A USB NET

In the following we identify the core functionality that that our envisioned USB Net setup application will support.

4.1 Vision and guidelines

The first step for creating a USB Net is to define the vision and the rules of the game. Although trivial technically it is perhaps the most critical ingredient of a successful USB Net and any collaborative system relying on the participation of end users [17].

Clearly, the simplest way to define a USB Net is through free text. However, we expect in later stages of our project to provide predefined templates based on the type of the envisioned network optimized through the experience by more or less successful USB Nets.

Then the selected description will be copied to all USB drives in a typical README file and can also be part of the project's web page, if available. The existence of a public web page is very important when one wants to ensure the integrity of the created USB Net and the corresponding brand

name.

For this, we wish to provide additional tools for creating simple web sites that can be easily hosted in any web hosting provider or help the creation of space in existing platforms like Facebook, Twitter, and Flickr (as we did for our second toy example described above).

Interesting decisions to be made concerning the rules of a USB Net and should allow for configuration options during the setup of a project include the following:

- The definition of a specific group of people that should be offered a USB drive (e.g., the citizens of a certain city, travelers, colleagues, funs of a music group, etc.)
- The restriction to an initial set of USB drives or the permission to add new USB drives along the way by independent users.
- The type of content expected to be shared and other content management options (e.g., the ability to comment or rate, the option to delete existing content if needed, etc.)
- The participation rules in terms of expected investments in USB drives and/or content such as direct/indirect reciprocity [10], minimum required contributions [5], or social incentives [4].

Of course, none of the above, and many other possible rules, can be strictly enforced. However, defining them could contribute significantly in the success of a project even if this comes out of breaching its rules. Indeed, it will be often the case that USB Net creators will lose control over their project, which could be appropriated by its users, as it has happened in the past with popular online social networks like Friendster [7].

Finally, the implementation of dedicated desktop software for content management could help the enforcement of the defined rules and address various security issues discussed below.

4.2 Drive ID and tracking

Tracking the path of a USB drive in terms of geography, holders, or any conceivable definition of a "step" towards a user-defined objective can be a very strong motivation for participation if properly implemented. For this, one needs to define a unique ID for each drive belonging to a certain USB Net. This ID could be just stored in text on the drive, printed on a sticker as in our first toy example, or even carved. Optionally, users could have their own IDs based on existing identities of popular online social networks or proprietary ones.

For tracking the evolution of drives the contribution of the people involved is obviously indispensable. To encourage them to do so one can employ a wide variety of user interface tools, from Google maps to social translucence [8], and other creative design options.

There are two places that could host the corresponding information: the USB drive itself or a dedicated web site. The former option, could increase the value and excitement of receiving a USB drive but could fail to hold the interest due to lack of public exposure. On the other hand, dedicated web sites can give a global view of the project and enable interesting social interactions, commenting and rating. Proprietary solutions should be preferred when there is a requirement for privacy and information control while popular sites like Facebook, Flickr, etc. could be exploited when the priority is on simplicity and reach.

4.3 Security issues

4.3.1 Viruses and malicious files

Any file sharing service has to confront the threats from viruses. As there are many USB-related viruses existing which would most possibly utilize the auto-run features to load the viruses into operating systems, the USB Net could be indeed used to spread viruses.

Unfortunately, the only way to prevent this threat in the general case is to use anti-virus software. For example, one could embed a virus scanning engine into pre-installed software on the USB stick to guarantee the safety of its contents. However, in this case the virus scanning service might take a significant amount of memory space and will need to get updated often. A simpler approach is just to warn the users to scan the USB sticks before opening them which is a good habit in any case.

Similar to the viruses, malicious files like deliberately conceived PDFs or Microsoft Word documents would take advantages of software exploits to compromise a user's computer. Likewise, anti-virus software or warnings are the only possible ways to reduce such threats.

4.3.2 Privacy leaks

As USB Net may take the responsibilities of ferrying private content, there is a possibility that this may be exposed to unwanted recipients. Note that even if a file is simply deleted, many systems only delete the file's index for performance concerns and the file content may still remain in the USB stick, which might be restored using software available in the Internet. So, malicious users could read other users' private data by restoring deleted files.

A possible approach to solve this problem is to provide a file-erasing service in the USB Net content management application. Another approach is to facilitate encryption capabilities for users to encrypt the sensitive data and sharing the keys only with the intended recipients, preventing other users reading them.

4.3.3 Illegal or unrated content

The files contained in the USB sticks possibly violate local laws to spread themselves in this anonymous P2P network. Moreover based on common sense, some contents should be rated to users on different ages, such as violent and pornographic content.

However, such issues are not specific to USB Nets, and they are notably more than present in existing popular content sharing systems such as YouTube, Flickr and BitTorrent. What makes USB Nets special is its inherently private communication channel during a single bilateral exchange, and the possible fully anonymous content sharing during future exchanges.

This property of USB Nets makes them part of the apparent trade-off and on-going debate between the potential inappropriate, or even illegal, uses of P2P software and the right to private digital communications. This is clearly a political issue that falls outside the scope of this work.

5. DISCUSSION AND FUTURE WORK

We believe that offering USB drives to friends and strangers requires a "tipping point" [11] to be transformed from a rare event to an everyday habit, which can generate a collaborative private P2P network for multiple uses.

Note also that the existence of such networks can become critical in places where Internet connectivity is non-existent. We believe that the development of tools that increase the usability of a USB Net and address its limitations will encourage the development of specialized hardware (e.g., massive USB readers for Internet gateways) and local authorities to invest in this solution for offering connectivity to remote areas. In areas where there is a non-negligible percentage of people who own smartphones, one could also imagine a *hybrid* solution with "interoperable" USB and standard opportunistic DTN networks, whose coexistence can increase the capacity and delay of the ad hoc part of the network.

Moreover, having developed this functionality and starting a few USB key sharing games one can collect interesting traces of "contacts" in a group of users, etc. This data could be then used to estimate the capacity of a USB network compared to one which supports a similar application, but depends on ad hoc content exchanges between smartphones. Under which assumptions should one or another mode of content exchange be preferred?

Since the bottleneck of a USB Net in most cases will be the motivations of users to edit and pass the USB drives, collected data from small or large scale experiments can give us invaluable insights on the different types of users in terms of motivations and cooperative behavior. Which is the profile of an altruist contributing a number of USB drives? Which is the overall cooperation level required to sustain altruistic motivations? Interestingly, this type of behavioral analysis could be also performed based on cultural, social and other differences as in [13]. For example, has a specific USB Net project the same chances to succeed in rural or urban areas? In China or in Europe?

Finally, a more formal game theoretic approach could be developed to identify the conditions under which a USB Net can be successful (e.g., number and capacity of available USB drives, content characteristics and popularity, rate of physical interactions between members, etc) and compare the effectiveness of various explicit incentive schemes such as reciprocity rules and minimum contributions.

More advanced USB Nets that we plan to set up with simple solutions that will guide the implementation of our generic USB Net configuration application include the following:

- A local ETH content exchange application between colleagues
- An academic USB Net bootstrapped at ExtremeCom'12.
- A city-wide experiment with USB sticks that aim to reach a certain destination (e.g., a famous artist).

Our hope is that many more researchers and interested users will bootstrap their own USB Nets using our under development setup application or other existing platforms and tools. This process will eventually add one more option to our everyday communications with some interesting novel properties with their own advantages and disadvantages compared to existing alternatives such as cloud computing, P2P systems, and ad hoc networks.

6. ACKNOWLEDGEMENTS

We thank the anonymous reviewers for their encouraging comments and useful suggestions for future work.

7. REFERENCES

[1] FP6 Haggle project. http://www.haggleproject.org.

[2] N4C project. http://www.n4c.eu.

[3] PodNet project. http://www.podnet.ee.ethz.org.

[4] P. Antoniadis. Incentives for resource sharing in ad hoc networks: Going beyond rationality. In B.-C. Seet, editor, *Mobile Peer-to-Peer Computing for Next Generation Distributed Environments*. Information Science Reference, USA, 2009.

[5] P. Antoniadis, C. Courcoubetis, and R. Mason. Comparing Economic Incentives in Peer-to-Peer Networks. *Special Issue on Network Economics, Computer Networks, Elsevier*, 45(1):133–146, 2004.

[6] J. Bieber, M. Kenney, N. Torre, and L. Cox. An empirical study of seeders in BitTorrent. Duke University, Computer Science Dept, Technical Report No. CS-2006-08, 2006.

[7] d. boyd. Autistic Social Software. In J. Spolsky, editor, *The Best Software Writing I*. Apress, 2005.

[8] T. Erickson and W. Kellogg. Social translucence: Using minimalist visualizations of social activity to support collective interaction. *ACM Transactions on Computer-Human Interaction*, 2000.

[9] K. Fall. A delay-tolerant network architecture for challenged internets. In *Proceedings of ACM SIGCOMM*, 2003.

[10] M. Feldman and J. Chuang. Overcoming Free-Riding Behaviour in Peer-to-Peer Systems. *ACM SIGecom Exchanges*, 5(4):11–20, 2005.

[11] M. Gladwell. *The Tipping Point: How Little Things Can Make a Big Difference*. Little Brown, 2000.

[12] S. Guo, M. Falaki, E. Oliver, S. U. Rahman, A. Seth, M. Zaharia, and S. Keshav. Very Low-Cost Internet Access Using KioskNet. *ACM Computer Communication Review*, 2007.

[13] J. P. Henrich, editor. *Foundations of human sociality: Economic experiments and ethnographic evidence from fifteen small-scale societies*. Oxford University Press, 2004.

[14] T. Moore. *Mix Tape: The Art of Cassette Culturel*. Universe Publishing, 2005.

[15] R. M. Ryan and E. L. Deci. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary educational psychology*, 25:54–67, 2000.

[16] A. Seth, D. Kroeker, M. Zaharia, S. Guo, and S. Keshav. Low-cost Communication for Rural Internet Kiosks Using Mechanical Backhaul. In *Proceedings of ACM MOBICOM*, 2006.

[17] C. Shirky. *Here Comes Everybody: The Power of Organizing Without Organizations*. Penguine Press, 2008.

[18] W. Zhao, M. Ammar, and E. Zegura. A Message Ferrying Approach for Data Delivery in Sparse Mobile Ad Hoc Networks. In *Proceedings of ACM Mobihoc*, 2004.