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TITLE: The Augmented Social Network: Building identity and trust into the next-generation Internet; (the need for a civil-society, not just commercial, solution)

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Could the next generation of online communications strengthen civil society by better connecting people to others with whom they share affinities, so they can more effectively exchange information and self-organize? Could such a system help to revitalize democracy in the 21st century? When networked personal computing was first developed, engineers concentrated on extending creativity among individuals and enhancing collaboration between a few. They did not much consider what social interaction among millions of Internet users would actually entail. It was thought that the Net's technical architecture need not address the issues of "personal identity" and "trust," since those matters tended to take care of themselves. This paper proposes the creation of an Augmented Social Network (ASN) that would build identity and trust into the architecture of the Internet, in the public interest, in order to facilitate introductions between people who share affinities or complementary capabilities across social networks.

OBJECTIVES AND ELEMENTS

The ASN has three main **objectives**.

1. To create an Internet-wide system that enables more efficient and effective knowledge sharing between people across institutional, geographic, and social boundaries.
2. To establish a form of persistent online identity that supports the public commons and the values of civil society.
3. To enhance the ability of citizens to form relationships and self-organize around shared interests in communities of practice in order to better engage in the process of democratic governance.

In this paper we present a model for a next generation online community that can achieve these goals. In effect, the ASN proposes a form of "online citizenship" for the Information Age.

The ASN weaves together four distinct technical areas into components of an interdependent system. The four main elements of the ASN are: Persistent online identity; interoperability between communities; brokered relationships; and, public interest matching technologies. Each of these is discussed in a separate section in detail.

The four main **elements** of the ASN are:

1. Enabling individuals online to maintain a persistent identity as they move between different Internet communities, and to have personal control over that identity. This identity should be multifarious and ambiguous (as identity is in life itself), capable of reflecting an endless variety of interests, needs, desires, and relationships. It should not be reduced to a recitation of our purchase preferences, since who we are can not be reduced to what we buy.

2. Interoperability Between Online Communities. People should be able to cross easily between online communities under narrowly defined circumstances, just as in life we can move from one social network to another.
3. Brokered Relationships. Using databased information, online brokers (both automated and "live") should be able to facilitate the introduction between people who share affinities and/or complementary capabilities and are seeking to make connections . . . Such a system of brokered relationships should also enable people to find information or media that is of interest to them, through the recommendations of trusted third parties.
4. Matching technologies need to be broad and robust enough to include the full range of political discussion about issues of public interest. They should not be confined to commercial or narrowly academic topics; NGOs and other public interest entities need to be represented in the process that determines these matching technologies.

The ASN calls for a public interest approach to online identity that enables individuals to express their interests outside contexts determined by commerce. This approach would include a digital profile that has an "affinity reference" that would facilitate connections to trusted third parties.

Aspects of the implementation could be undertaken by for-profit companies that respect these open standards, just as companies today profit from providing e-mail or Web pages. But to insure that the ASN meets its public interest objectives, participating organizations would have to agree to abide by the ASN's principles of implementation.

The "next generation" of online community should be a manifestation of flourishing, innovative democracy that encourages the active participation of its citizenry. Asking for any less would be a betrayal of our highest ideals.

In this new world, you will have an online identity that remains constant, allowing for continuity between your experiences in separate online environments. Well conceived, and done in the public interest, persistent identity could enhance interpersonal relationships and social organizing just as powerfully as the PC has extended personal creativity.

THE CONSUMER / BUSINESS INITIATIVES AND NEED FOR CIVIL SOCIETY TOOLS

Two business-based initiatives — the Passport initiative that is part of Microsoft's .Net architecture and the Liberty Alliance — are deliberate efforts to create de-facto standards for personal identity online. Unfortunately, these are primarily focused on how you behave as a consumer, rather than as an independent citizen apart from the commercial arena; their intent is to privatize this information, and then manage it in a way that gives them a share of every financial transaction you make. Current trends are pushing the Internet to become a closed, controlled, commercial space that most resembles a shopping mall. Certainly these initiatives show good business sense, but are they sound public policy?

But as the online social network grew from a few hundred to the many millions — becoming, effectively, many different, overlapping social networks — the ability to identify affinities and establish trust through the Net withered. And perhaps most importantly, a myriad of online communities — both commercial and not-for-profit — have emerged with little to no interoperability with one another. They exist as separate, isolated islands of discourse, unable to exchange meaningful information, leverage their accumulated knowledge, or connect with other communities that share their concerns.

Without trusted relationships, civil society comes undone. In effect, the ASN promises new tools that will support citizen involvement in governance. Already *de facto* standards for online identity and trust are being established. But where is the voice of civil society in these discussions? The intention is for the ASN to become the de facto standard for Internet-wide online community interactions — the functionality described in the scenarios above should be the norm. But it is important to understand that the ASN can be effective if used by only a fraction of the Internet's community members. The ASN can be launched as a sub-set of all online community activity. Then, over time, as it proves itself to be valuable, the ASN's applications, protocols, and standards can be adopted by a growing number of Internet communities.

TECHNICAL DESCRIPTION

The essential technical elements of the ASN are as follows:

1. **Persistent Identity.** As federated network identity becomes ubiquitous on the Internet, spearheaded by industry initiatives such as the Liberty Alliance and Passport, civil society organizations will need to articulate a public interest approach to persistent online identity that supports the public commons. As one aspect of a public interest vision of persistent identity, we propose (a) a civil society digital profile that represents an individual's interests and concerns that relate to his or her role as a citizen engaged in forms of democratic governance. One aspect of this civil society approach would be to provide a working model for persistent identity that gives individuals a high level of control over how their profile is used. In particular, the digital profile should include the ability for each individual to (b) express affinities and capabilities, and to list or assist in the discovery of other trusted individuals who share these interests. The purpose of this functionality is to enable automated agents or third party brokers to access this data in a digital profile, through a series of (c) introduction protocols, in order to provide connections between individuals who share affinities or have complementary capabilities. In this way, the ASN is able to introduce those who have shared affinities or complementary capabilities, including those who are members of wholly distinct online communities, based on the recommendations of trusted third parties. These recommendations might either be fully automated, in the case of less valuable or less sensitive relationships, or take place through a brokering service, when privacy, trust, and stakeholderism is of the highest concern.
2. **Enhancements to Online Community Infrastructure.** Some "walled garden" online communities have begun to implement ASN-type functionality within the confines of a single community infrastructure. With the implementation of the ASN, automated ASN interactions will take place across existing online community environments. In order to support this activity, modularized enhancements to the technical infrastructures of separate online communities will need to be developed and adopted. These enhancements are essentially of two types. The first is the writing and adoption of (a) interoperability protocols that will enable communication between the membership management databases of distinct online community infrastructures, so that ASN-related data can flow between separate online communities. The second is the development of modularized applications that enable (b) the pre-processing and post-processing of e-mail communications on online community infrastructures, as well as the ability to compose, address, and tag ASN messages appropriately. These applications would facilitate three types of activity. First, they would enable ASN users to (c) receive specially tagged automated introductions to others with whom they share affinities or have complementary capabilities.
3. **Matching Technologies.** For the ASN to be effective, the civil society issues addressed within the system have to be easily identified by searches, with matches made even when exact use of language does not correspond. To facilitate high quality searching which supports online discourse and networking in the public interest, there is a need for an initiative to develop (a) matching technologies for topics relevant to civil society, including public interest ontologies and taxonomies. Focused efforts must be established to insure that ontologies and taxonomies developed with standards such as XML, RDF and topic maps include consideration of those issues relevant to civil society. In addition, the ASN would develop (b) protocols for the interoperability of online ontological frameworks, so that the same set of data could be encountered through multiple perspectives, enabling comparisons of diverse viewpoints, which in itself would lead to new connections between disparate social networks.
4. **Brokering Services.** In instances when personal relationships are highly prized and carefully guarded, though still available through the ASN, an automated introduction system would not be advisable. In these cases, ASN users would engage a third party brokering service to carefully analyze potential affinity or complementary capability matches, and to provide (a) a brokered introduction. These interactions would not necessarily take place only within existing online community infrastructures, but also through the auspices of a brokering service that exists as a separate entity, designed to facilitate these more sensitive introductions. In these special cases, (b) context specific introduction protocols would be developed, allowing each social network to establish the terms through which introductions are made at a highly granular level, perhaps including intermediaries in the process in order to facilitate the initial person-to-person interactions.

THE PROBLEM OF SITE-BASED IDENTITY

... [W]hile the Web has developed a sophisticated system for the creation of "sites," there has yet to appear a good means to represent each of us as individuals in cyberspace. Every time we visit a new Web site, we enter as an anonymous person. Then, with our own labor, we create an identity within that specific site, following the rules as they are presented to us (For example: "Please click here to register ..."). Once we establish our identity on that Web site, it effectively becomes the property of the Web site owner. For this reason, URL-based communities are like walled castles with one-way doors; once you have created an identity on that Web site, it is only of use on that same Web site; it can never escape.

Shouldn't we ask: in an ideal world, what kind of online identity would we want?

Many will protest that they do not want any form of online identity to be put in place. But the commercial sector is already creating the infrastructure that will support it, and there is nothing illegal about aggregating the information about what you buy that the system is being based upon. The challenge is not to stop this process, but rather to engage with it and influence it in order to insure that personal identity is implemented in the public interest, so that the system enhances, rather than detracts from, the public commons.

See: <http://www.xns.org>

Also: <http://www.identitycommons.net>

THE CONCEPT OF FEDERATED IDENTITY

In recent years, online businesses began to see the advantages of a persistent identity that could be maintained by an individual as she surfs from site to site. A persistent identity would combine the aggregated information about a person that sophisticated Web sites currently collect with the verification feature enabled by digital certificates — so that a user's digital profile could be shared by websites who choose to federate with one another. One of the major initiatives to establish such a form of federated network identity is the Liberty Alliance. In the introduction to the Liberty Alliance specifications document, the objective is succinctly expressed:

"Today, one's identity on the Internet is fragmented across various identity providers — employers, Internet portals, various communities, and business services. This fragmentation yields isolated, high-friction, one-to-one customer-to-business relationships and experiences.

"Federated network identity is the key to reducing this friction and realizing new business taxonomies and opportunities, coupled with new economies of scale. In this new world of federated commerce, a user's online identity, personal profile, personalized online configurations, buying habits and history, and shopping preferences will be administered by the user and securely shared with the organizations of the user's choosing."

The challenge is to establish a form of federated network identity that is an appropriate representation of the self, one that is flexible enough to provide a range of "public faces," depending on context. Certainly, information that facilitates commercial transactions should be a part of this identity — but only part. Defining the full potential of online identity, and pushing for the actualization of that vision as part of the development of the "next generation" Internet, deserves to be a public interest priority.

While there are several independent initiatives focusing on persistent identity, the field is being paced by two large scale efforts that, because of their access to resources and their position in the market, dominate discussion of the issue — and will likely determine the system everyone else will ultimately use to implement federated network identity. These are the Liberty Alliance, which was mentioned above, Microsoft's .Net identity system, named Passport.

Liberty's architecture calls for a variety of identity providers from whom consumers could choose, depending on personal needs and proclivities. Their intent is to create a market for online identity, just there is a market today for Web services (like online auction houses, stores, games, specialized information services, and newspapers). It is conceivable that the public interest sector could collaborate with one or several identity providers to develop digital profiles that reflect the needs of civil society, and not only those of business.

The not-for-profit initiative XNS.org has completed the first iteration of a civil society approach to building identity into the Internet's architecture. This work show great promise. In 2002, XNS.org worked with members of the standards body OASIS [6] to form a technical committee so they could agree on, discuss, and publish a standard for persistent identity and related data exchange. A specification for the persistent identity standard was published in 2002, and is now making its way through the OASIS approval system. A related specification for data-exchange, using the Security Assertion Markup Language, or SAML, is being developed following the same procedures, with an eye toward ultimate ratification by OASIS.

Underlying this report is the assumption that every individual ought to have the right to control his or her own online identity. You should be able to decide what information about yourself is collected as part of your digital profile, and of that information, who has access to different aspects of it. Certainly, you should be able to read the complete contents of your own digital profile at any time. An online identity should be maintained as a capability that gives the user many forms of control. Without flexible access and control, trust in the system of federated network identity will be minimal.

BEHAVIOR AS CITIZEN, NOT CONSUMER

As Liberty Alliance and Passport documentation suggest, most of their resources will go toward the capture and distribution of information about you that relates to your behavior as a consumer. They give little regard to information that could enhance your behavior as a citizen.

Once digital profiles include expressed affinities, the potential for networking through the Internet around common interests becomes significant, because it is a simple technical matter to connect individuals to others based on their shared affinity with a third party.

The wheels are already in motion to digitize some of the most sensitive personal information imaginable — including your finances, work history, and health care records. . . . Certainly, everyone needs to maintain a vigilance regarding the security of their personal data. This will be one of the touchstone civil rights issues of the digital era — who gets to know what about you, and how is it protected . . . The greatest danger to civil society is not that the data associated with digital profiles is open to theft and illegal activity, but rather the real possibility that a system of federated network identity that erodes civil liberties and the public commons comes into being — while following the letter of the law.

The ASN should be embraced by existing online communities, because its intent is not to replace them, but rather to offer additional functionality that enhances their value. Just as commercial content sites came to appreciate the additional traffic that targeted links to "competitors" brought them, online communities will be glad to see the added traffic that comes with tactical interconnection between social networks . . . Most importantly, the ASN will not "break down the walls" between online social networks to create a single, global online community. Rather, the ASN calls for strategically placed doors that allow people and information to pass from one distinct online social network to another under certain, limited circumstances.

Persistent identity will enable people to present a consistent set of personal data as they go from one Web site to another. The technical infrastructures of online communities may well adapt to the emerging environment, and add functionality that can leverage persistent identity data into new services. For instance, once this new functionality is in place, after you review a Grateful Dead album on Amazon.com, you may find yourself greeted with a link to a Grateful Dead discussion page when you enter AOL.

COMMERCIAL RELATIONSHIPS WILL DRIVE GROWTH OF ASN

Given the current state of software development and the way new functionality is now being added to the Internet, the interoperability likely to emerge between communities — if it comes about at all — will be limited, and driven by commerce.

Of course, there is nothing wrong with commerce-driven interoperability between communities. But a great opportunity to strengthen the public commons could be lost without a deliberate effort to develop community interoperability for non-commercial purposes.

We believe it to be of the utmost importance that ASN interoperability protocols give individuals the broadest possible range of options regarding how they represent themselves in online environments.

In the preparation of this paper, while looking for potential partners in the development of the ASN, we identified 11 community-ware efforts that provide well-considered suites of tools to support communities of practice. We deliberately did not include the efforts of the software Goliaths, like IBM or Microsoft. Rather, these efforts are being spearheaded by smaller, independent companies, in some cases by not-for-profits. Several of them have a strong commitment to serving the public interest. They are:

- Real Communities/Mongoose
- Communispace
- Community Zero
- Tomoye
- Plumtree
- Living Directory
- Friendster
- Plaxo
- Spoke
- LinkedIn
- Ryze

NEW APPLICATIONS AND FUNCTIONS

Bringing ASN activity to online community infrastructures will require additional applications beyond those online community systems provide today. New applications that enable enhanced search features, as well as the pre-processing and post-processing of e-mail communications, need to be available to users of the ASN in order for the system to work. These applications would be developed as free-standing modules that can be "plugged-in" to existing online community infrastructures. They will need to allow ASN users to identify their messages properly when they are written, address messages in the appropriate manner (so that they are sorted and distributed by the ASN system), and send and receive messages in a way that distinguishes them from other e-mail (so they are recognized as ASN messages when they arrive in an "in box").

Among the functionality that these applications would provide are the following:

- **ASN Search Interface.** Users of the ASN need to be able to access its distributed database of affinity and compatibility profiles through their online community tools. An ASN search feature is essential, in order for users to find others with whom they share affinities or have complementary capabilities.
- **ASN Composition and Addressing.** When creating an ASN message, users will need to designate the message as an "introduction," "forwarded media," or an "ad hoc social network." Properly designated and addressed, the message can be sorted by the ASN system, and sent to the appropriate recipients.
- **Tag Incoming ASN Messages.** When ASN messages appear in an "in box," they should be tagged in a manner that distinguishes them from other e-mail.
- **Filter Incoming ASN Messages.** When an incoming ASN message arrives, it should be checked to make sure that it has a header that identifies its subject as a relevant affinity, and that it indeed came through a trusted third party. A filtering mechanism is necessary to eliminate spam within the system.

The "next generation" of online communities now being developed have begun to add elements from the list above to their infrastructures. But by no means has a standard community "tool kit" to support matching technologies emerged. Moreover, little attention has been paid to how the knowledge created inside each "walled castle" community could be exchanged with those outside its walls. The exponential benefits of connectivity (remember the discussion of Reed's Law) will be realized when the matching technologies allow focused interconnectivity between community groups. One of the purposes of the ASN

is to make this kind of interoperability commonplace on the Internet — and to raise the bar of expectations for what online communities serving the public interest ought to deliver.

THE BROKER FUNCTION

The essential activity of the ASN is that it brokers introductions between people across social networks, based on expressed affinities and capabilities, through trusted third parties. In order for those introductions to take place, there have to be rules that guide when introductions can be made and how they are facilitated.

Clearly the ASN needs to provide a range of introduction options, so users can choose what is right for them. These options, and the rules they would follow, would be determined by a set of "introduction protocols" — explicit instructions about the sequence of actions that would automatically take place before an introduction is facilitated through a trusted third party.

What would this protocol do? It instructs an automated agent (or "broker-bot") to follow a sequence of actions that would lead to relevant introductions. It tells the broker-bot to read the "affinity reference" in a user's digital profile, and then match those expressed affinities or capabilities to others with complementary interests, based on links through trusted third parties. The broker-bot would be instructed to use ontological frameworks as a guide to determine meaningful matches. At the end of this sequence, the broker-bot would send a specially tagged ASN Introduction e-mail to the match that it found, without copying the person who made the original request. That "discovered match" can then decide whether to reply to the introduction, or not. If the "discovered match" does not reply, the person who made the initial inquiry would never know, and so would not feel slighted by the rejection.

These customized introduction services, among many others, would be offered by independent brokers, which would mix and match protocols, shaping them to meet the needs of their constituents. Brokering services could either be for-profit companies, or not-for-profit civil society initiatives. A brokering service could be hosted on a single destination Web site (like About.com, where you go to their online "front door" to use their services), or it might syndicate its services on many other sites (like Amazon.com's Affiliates program, which allows a multitude of Web sites to create their own e-bookstores by linking into Amazon's backend). Our interest is in allowing for the widest possible variety of these services to take shape — which means that the basic introduction protocol has to be written to facilitate this wide range of customization while maintaining interoperability.

IMPLEMENTATION CHALLENGES

Suffice it to say that the ASN is unlikely to become an industry priority. It does not offer immediate avenues to profitability.

The ASN could be achieved in an incremental manner, with software and protocols developed among a relatively small group of participants, and gradually adopted by larger online community systems as they see fit. The development of the software and standards would best take place as part of pilot projects that introduce ASN functionality to a small group of online communities that can participate in working kinks out of the system, preparing it for a broader launch. These online communities could be either not-for-profit initiatives or for-profit companies, or a combination of the two.

But once the ASN is in place, it offers a range of opportunity for companies that could generate revenue by providing features of the overall system. These include:

- Community sites that have incorporated ASN functionality;
- Personal identity companies that offer identity services that cater to specific communities;
- Boutique brokering services that charge for specialized introductions; and,
- Specialized search services that use customized ontological frameworks.

IMPLEMENTATION PRINCIPLES

The intent of the ASN is to increase interconnectivity between people by enabling them to more easily find and share relevant relationships and information. Clearly, engendering trust in the system is critical to its success. To that end, it is necessary for the implementation of the ASN to be guided by principles that support such an environment of trust. These principles include:

- **Open Standards.** For this system to be broadly adopted, it must be transparent so that all of the entities that participate in it are reasonably assured of its trustworthiness. This means that the software code that enables the system should be non-proprietary and freely available, and that the process by which the software is written and the standards enacted should be open to the highest levels of scrutiny.
- **Interoperability.** Our vision is of an Internet with more bridges and fewer walls, where the individual can travel easily between communities. To enact this vision, online communities need to consider ways of being open to one another. Interoperability between diverse environments and ontological frameworks is central to this effort.
- **Inclusivity.** For the system to successfully draw in the largest possible number of participants, and to enable free connection between potential correspondents, it must be designed to embrace every online community that agrees to its standards and principles. In this regard, the ASN must be value-neutral, open, and inclusive, not unlike the open connectivity of the underlying Internet protocols.
- **Respect for Privacy.** The ASN should be a galvanizing force for the strengthening of privacy protections online, in support of a thriving civil society. Every person online must be certain that private information remains private, and that neither governments nor commercial interests will use this information in any way without the individual's knowledge and expressed permission.
- **Decentralization.** The Internet works best when systems are not commanded from the top down, but rather emerge from the bottom up — and are then adopted on a voluntary basis, in a manner that best suits the specific needs of the distinct communities that together comprise the Net's totality. We are in favor of an "opt-in" system, rather than one commanded by a government or commercial authority. For that reason, our approach is to develop software and standards that can be added to existing community operating systems in a modular fashion — so they do not have to rewrite their software from scratch, but rather can "plug-in" these modules to their existing infrastructures. Similarly, the ASN would support decentralized structures for the maintenance of persistent identity and ontological frameworks.

RECOMMENDATIONS

In the near term, there are a number of practical steps that should be taken to bring the ASN into being. While some of this work could be pursued as for-profit/not-for-profit hybrids, our inclination is to support this work strictly through grants, and to make the fruits of these efforts (the software and protocols they lead to) freely available to the public through GPL (and other similar) licenses. These steps include:

- Establishing an ASN coordinating body.
- Convening a board of technical advisors.
- Providing a dedicated engineer to represent the public interest at standards bodies working on persistent identity.
- Co-develop basic ASN functionality with select online community companies.
- A dedicated team would coordinate implementation of matching technologies for the public interest sector. The ASN effort should act as a catalyst to bring attention and support to the development of ontologies and taxonomies for the public interest sector. A pilot project to begin this work should be initiated in collaboration with one or more NGOs.

About the Authors

Ken Jordan is one of the pioneers of Web-based multimedia. In 1995 he led the development and served as founding editorial director of SonicNet.com, the first multimedia music zine. SonicNet was named best Web site of 1995 by Entertainment Weekly and won the first Webby award for music site before becoming a property of MTV. In 1996 Mr. Jordan became creative director of Icon New Media, publisher of two seminal, award-winning online magazines: the general interest zine Word.com, and the action sports site Charged.com. In 1999, he co-founded the public interest portal MediaChannel.org, in partnership with Globalvision and the international civil society network OneWorld.net; it was OneWorld's first U.S. based project. He is currently a writer and digital media consultant based in New York, and Director of the Art and Culture Network.

*Ken is co-editor of *Multimedia: From Wagner to Virtual Reality* (New York: W.W. Norton, 2001), an anthology of seminal articles that trace the "secret" history of digital multimedia; the book is widely taught at colleges and universities around the world. Outside the digital realm, he collaborated with the playwright and director Richard Foreman on the book *Unbalancing Acts: Foundations for a Theater* (New York: Pantheon, 1992).*

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Jan Hauser (<http://www.janhauser.com>) is currently a Business Development Manager at Science Application International Corporation (SAIC) and is also a visiting professor at the Naval Postgraduate School, in Monterey California. At SAIC Jan focuses on business development of SAIC's Latent Symantec Indexing Product (LSI). This product is capable of discovering and matching "concepts" which it discovers in unstructured text. LSI functions independent of what native language these concepts are expressed in and also works independent of the various terminologies used by individuals to express their concepts.

*Jan was formerly principal architect at Sun Microsystems where he was responsible for Sun's membership in the Santa Fe Institute (SFI). Jan has been a catalyst for the application of Complexity Science to business, social, and environmental problems. In this pursuit he co-organized a workshop with the Institute For The Future (IFF) — *Growing At the Edge: The New Corporate Structures for Innovation and the Challenge of Governance.**

Jan has worked on the development of Sun's architecture for automated markets, Electronic Trade Exchanges, and principals that lead to the emergence of "communities" of trading partners. He currently spends much of his personal time working on problems of "Global Sustainability."

Jan has also worked with Dee Hock, founder of VISA International, in the development of new organizational models and implementations of so called "Chaordic," or self-organizing institutional forms, which were included in Sun's Jini community, design. This work led Jan to focus his energies on promoting the development and adoption of technologies that would support the emergence of "Chaord Light," a means of exploiting the internet in catalyzing latent "Social Networks" based on shared or complementary interests and capabilities combined with the transitive nature of trust amongst people who know each other indirectly through our "six degrees" of our personal knowledge and connectivity.

He can be reached through his Web site at <http://www.janhauser.com>.

Steven Foster was a pioneer in Internet resource discovery. His Veronica project, the first comprehensive Internet search engine, was the paradigmatic resource harvester which established many precedents for succeeding search engines. Veronica was the most active service on the Internet in 1994 and was awarded the American Library Association's award for "most valuable research tool." Steven has worked in development of software for taxonomic crosswalks and presently is focused on creating concept-based matching technologies for interpersonal brokering.

Steven also has a long term interest in problems of "global sustainability" and was an initiator of the first Planetnetwork conference.