Chapter 9

STRATEGIES FOR RE-ENGINEERING GLOBAL KNOWLEDGE e-NETWORKS

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Introduction

The purpose of this chapter is to take stock of the performance of the Global System for Sustainable Development (GSSD) for the purposes of identifying central tendencies and providing some insights into directions for re-engineering. In this chapter, we provide an analysis at one point in time. Our purpose here is contextual, that is, to remind ourselves of the fundamentals of knowledge and of knowledge networking designed for this particular system as well as its targeted domain, namely sustainable development. We also provide a review of the current design of GSSD and its implementation, as well as its implications for the next generation of distributed knowledge e-networking

Put succinctly, the purpose of this chapter is to review and assess GSSD performance to date, to determine if the record is consistent with the intended objectives, and to highlight ways of improving or enhancing the overall undertaking. We begin this chapter with a discussion of methodology: how we shall measure the successes and shortcomings of GSSD. GSSD needs to be measured across two dimensions: its knowledge content and its user-traffic. In the second part of this chapter, we provide some initial results, closing with several recommendations for improving GSSD.

It is important to note that interactive knowledge e-networking in the context of distributed systems is of rather recent vintage. As a result, no robust track record has been generated against which we can examine the GSSD case. In addition, multi-lingual distributed e-systems are of even more recent vintage, thereby complicating the situation. The rules are not yet formally codified, nor are the methodology norms generally agreed upon. However, there are some common practices that we draw upon over the course of our inquiry.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 151–175.

9.1 Some Fundamentals

By way of placing the issues in context, we begin this chapter with some brief observations on the nature of knowledge and of knowledge-networking. Other chapters in this book have also dealt with knowledge and with networking – in many ways and with greater depth. Here, however, we highlight only those features that are directly relevant to the review.

9.1.1 Perspectives on Knowledge

Three perspectives of the ways in which *knowledge* has been viewed are especially relevant in this discussion. The first perspective treats *knowledge as an object* and assumes that knowledge can exist independent of human action and perception. Knowledge is conceived as some truth that can be codified and separated from the people that possess it. By adopting this perspective, the goal of knowledge management is then to convert the knowledge residing in the minds of people into structural assets owned by the firm and store it in the firm's knowledge management system (KMS).

The second perspective assumes that knowledge is *embedded in individuals*. Knowledge is inseparable from people, and knowledge resides only in the minds of individuals. Only people can know and only they can convert knowing into action. It is the act of thinking that can transform information into knowledge and create new knowledge. In addition, people seem to know a great deal more than they can articulate and this tacit component of knowledge has a personal quality which makes it hard to formalize and communicate. Thus this perspective focuses on the management of human resources. Since knowledge is viewed as difficult to codify, and loses its value once codified, the goal of a KMS in the second perspective should be to connect experts with knowledge seekers.

The third perspective considers *knowledge embedded in a community*, where knowledge is the social practice of knowing. In this perspective, learning, knowing, and innovating are closely related forms of human activity and knowledge is inexorably connected to practice. Each community develops its own language, its own shared narratives, and its own codes, making knowledge best understood within the context of its community. This view attempts to locate organizational knowledge and knowledge creation within distributed, multi-actor routines, rather than in the minds of individuals. The resulting focus in this third perspective is on processes that are geared towards enabling discussion, mutual engagement, and exchange between members of a community.

In the first two perspectives ('knowledge as object' and 'knowledge embedded in individuals'), knowledge is treated as a *private good*, where an individual owns the knowledge. Private goods are goods with high excludability and high rivalry. With private goods, it is clear who benefits and that person/organization can easily be charged for those benefits. In such cases, people exchange their knowledge through market mechanisms and receive commensurate benefits. Motivated by self-interest, they are less likely to exchange knowledge in the absence of returns.[1]

The 'knowledge embedded in community' perspective assumes knowledge is a *public good*. A public good is one where users collectively consume benefits and no one can be excluded from consuming the good or of reducing its essence. When confronted with a public good and no regulation, the economically rational action for the individual is to free-ride, or to consume the public good without contributing to its creation, maintenance, or development. We reconcile these perspectives by taking as assumptions the following: (i) knowledge is a public good that is privately produced, (ii) institutional and collaborative relations are the mechanisms through which individual generation of knowledge is embedded in *social interactions*, and (iii) knowledge outcomes assume the characteristics of public goods. We shall discuss the implications of treating knowledge as a public good and the theories of self-interest and collective action in the next section.

9.1.2 Knowledge Networks

At the most general level of analysis, knowledge networks can be characterized as comprising of actors, with relationships between actors categorized by their form, by their content, by their intensity, by the resources which may be used, and by their institutional properties, including structural, technological, and cultural dimensions.[2] It is useful to consider an overall context within which to place all key aspects of an e-networking initiative. Here we draw attention to the fact that some analysts consider a knowledge network as a unique hybrid form of organization between market and hierarchy because they contain elements of both forms (Thorelli, 1983). Please see Figure 9.1 for how we consider each element in turn using von Kragh's framework for characterizing knowledge networks as landscapes (Seufert et al., 1999).

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[1] These returns need not be tangible; reputation and status-directed obligation from the knowledge seeker may be garnered by sharing knowledge.

[2] Recall that the GSSD knowledge network is more formally designated to specify specific features pertains to the above, as noted in Chapter 2, and in other chapters of this book namely: (a) computer-assisted organized system of discrete actors, with knowledge producing capacity, (b) combined through the use of common organizing principles, (c) retaining their individual autonomy, such that (d) networking enhances the value of knowledge to the actors, and, accordingly, (e) knowledge is further expanded.

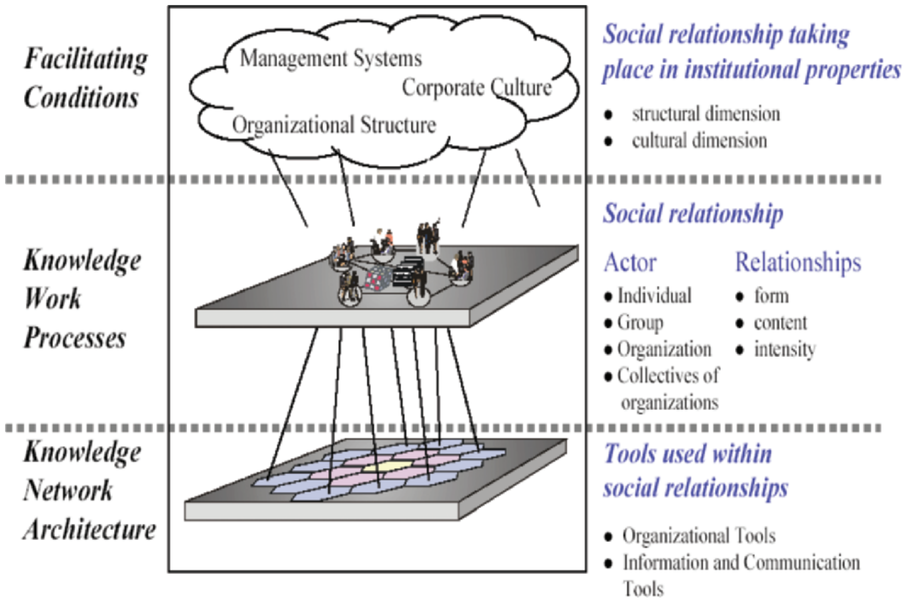

Figure 9.1 **Analysis framework for knowledge network. Source: Seufert et al. 1999.**

Across the left-hand side of Figure 9.1 are three layers: *Facilitating Conditions, Knowledge Work Processes,* and *Knowledge Network Architecture.* The first, *Facilitating Conditions*, refers to the network's internal structural and cultural dimensions in which knowledge work processes take place, thereby defining the environment for knowledge creation and transfer. This includes the organizational structure, the management systems, and the network culture. The structural dimension also includes the nature of relationships with various participants.

Knowledge Work Processes comprise social interaction and communication processes on an individual and at the group level. These processes can be conceptualized as an adaptation of Nonaka's (1991) four-stage knowledge spiral since the processes in the network act as a transformation process between explicit and tacit knowledge from *socialization* (the exchange of tacit knowledge between individuals in order to convey personal knowledge and experience) to *joint experience* (resulting in new shared implicit knowledge) to *externalization* (the actual exchange of knowledge between individuals and a group) to *combination* (where different fields of explicit knowledge are combined with each other to make new knowledge available on a network wide basis).

The third and final layer, the *Knowledge Network Architecture* refers to the tool-set used within social relationships. These tools include organizational tools, the roles of the knowledge actors, and the informational tools used to enable and improve knowledge work processes. This layer is also where the knowledge medium is set, how the network is configured to best supply knowledge, how the moderation mechanisms and quality control procedures are defined, and how the ontology is determined. Against this background, we now summarize some key elements of the GSSD e-network in order to yield some basic information to contextualize our analysis of system performance.

9.1.3 GSSD e-Network

The GSSD system is a large e-network which supplies knowledge pertaining to sustainability and sustainable development. A knowledge e-network is a *computer-assisted organized system of actors with knowledge producing capacity*. Common organizing principles define both the relationships of actors to one another as well as knowledge topics to one another, but the individual actors retain a high level of autonomy, such that networking enhances the value of knowledge to the actors and, accordingly, knowledge is further expanded.

As an intelligent document repository, the GSSD knowledge-base consists of thousands of *abstracts* which link to resources (websites) on sustainable development. Abstracts can be submitted by any user (without registration), and the submitted abstracts are reviewed, translated and published by the institutional partners GSSD works with.

Document repositories are usually unidirectional, impersonal, and often with little feedback.[3] Furthermore, the materials are treated as published books would be treated: with full respect of copyrights and complete acknowledgement of the authors' ownership. Document repositories have also been characterized as altruistic networks in the sociological literature as the motivations and incentives for people to contribute are not readily apparent (Desouza, 2002).

As discussed in Part I of this book, at the core of GSSD is its knowledge-base, consisting of a body of quality-controlled Internet resources on sustainability accompanied by abstracts of their content. These abstracts are organized within a consistent conceptual framework and translated into all supported GSSD languages (currently supported languages are English, Chinese and Arabic with soon to be included mirror sites for Japanese and French translations). The tags used for cross-referencing in the GSSD

[3] Note that the term document refers to any item that is entered into the knowledge-base, which may or may not be a document in traditional terms.

knowledge-base allow efficient retrieval of these abstracts by user specifications and facilitate an understanding of the linkages among issues and problems, strategies, and solutions. In this manner, GSSD serves to enhance integration of alternative views of sustainability.

Adopting a meta-networking strategy, GSSD provides networking facilities across stakeholder communities in order to help identify innovative approaches, enabling technologies, as well as new institutional, financial and regulatory mechanisms for meeting sustainability challenges that confront all countries. The GSSD collaborators are located in various institutions, including universities (The American University in Beirut), or in government agencies (Ministry of Science and Technology, Government of China). Collaborators assume the responsibility for abstract review and translation. The challenge within GSSD is to selectively aggregate content while maintaining a balance in the quality control process. This is very important because a lax selection process may lead to user searches yielding irrelevant results, and a strict quality control process may result in under-populated repositories that yield too few results.

Surrounding the core knowledge-base of GSSD and interactions with the institutional patterns is a set of processes and a preset workflow. The translation process deserves special mention here. Any abstract submitted within GSSD is automatically routed through an inbuilt workflow to a translation partner, who translates the abstract into his own language. Over time, this process results in a system where the content is available in all GSSD-supported languages. This process – along with the fact that GSSD is distributed over the Internet through a system of servers, or mirror sites allowing users worldwide to select both the server location that provides them with the fastest access (bandwidth) and the language they most prefer – greatly reduces some of the most difficult barriers to knowledge, especially in developing countries.

9.1.4 Evaluation of Knowledge Networks

At the most general level, the effectiveness of the network is defined as the ultimate value of a knowledge network to its users in terms of: (i) joint value creation, (ii) building capacity, and (iii) providing the information tools to influence policy processes. Effectiveness means doing the right thing as gauged by the constituency in question. Measuring the *effectiveness of the network* involves defining the overarching goals and the ultimate purpose of the knowledge network. Although most knowledge networks state their goals upfront, it is important that these goals are well defined, that they are clear, and that they are endorsed by its members.

As noted at the onset, in this chapter we use two different modes of operational analysis for gauging a network's success. The first is a *content analysis* approach, concerned with the relevance, usefulness, and the accessibility of the content within the network. The value of content is based upon the combination of its primary useable form, along with its application, accessibility, usage, usefulness, and uniqueness. Content analysis is targeted at understanding and matching content to user needs with the aim of facilitating collaboration and knowledge-sharing through greater content accessibility. In this approach, we inventory the knowledge resources available within the network, we identify the characteristics of content provision, and we seek to improve upon the organization of this content in the network by refining the set of rules and processes for contributing, collaborating on, and controlling content. One of the aims of the content approach is in refining the ontology for displaying content. Of course, in the GSSD case the detailed composition of the content may change, as new documents are submitted and old ones are deleted, but the overall framework is rendered consistent due to the ontology that has been developed to represent sustainable development as a knowledge domain.

The second approach focuses on the record of system usage and traffic of the network itself. One of the advantages of electronic knowledge networks is the ease with which data can be gathered about their usage. All websites generate log files that can be analyzed by a wide variety of software tools or outsourced services. The difficulty lies in deciding precisely what to analyze, and in determining the real significance of the data. Are *page impressions* a more accurate metric than *hits*, for example, or should we forget them both and concentrate on *conversion rates* or *repeat visits*? When applied to networks in any context, traffic analysis is used to examine the following features:

- *Size* of the online community using the knowledge system, and the size of the message base.
- *Growth* of the online community. This includes the number of new members voluntarily adding subscriptions versus the number of members who are defecting.
- *Activeness* of the online community, as determined by the percentage of contributors to subscribers.[4]
- *Relative activeness* of the online community, as measured by the number of total postings, the number of postings per contributor, the growth in postings, and increases in the thread length.

[4] This rate is always low. It is not uncommon to find that the bulk of the messages in successful networks come from a very small percentage of the members.

- *Relative number of sanction messages,* required keeping contributions on topic.[5]

Neither content nor traffic analysis yield any inferences regarding impacts on the constituency nor implications for actual behavior. At the same time, however, both content and traffic analysis provide useful tools to gauge the vitality and robustness of the network and need planned data collection mechanisms and organizational processes to make sure they are carried out on a periodic basis. These analysis tools provide an empirical view of the performance of the knowledge network. To assess the extent to which people's opinions, attitudes, and behaviors are changing these studies could be complemented by user surveys. Although surveys measure people's perceptions, these may or may not reflect empirical reality. However, people's perceptions will determine their behaviors with respect to knowledge collaboration and sharing.

9.2 The Analysis of GSSD Content

9.2.1 The Knowledge-Base Defined

What is the effectiveness of the ontology of the GSSD knowledge system? Effectiveness is defined here as the ability of the ontology to help the user find the content he or she desires. Our approach could also be viewed as a generalized method towards analyzing other similar knowledge or information classification systems such as the World Bank's Development Gateway's Topic Pages and the UNEP's Grid System on Sustainable Development. This approach also aids in developing dynamic ontologies or, more specifically, ontologies that continuously adapt based on the content that flows through them.[6]

9.2.2 Methodology and Results

In order to extract systematic observations on content, we exported the GSSD Lotus Notes Database and processed it to yield a text file. Each row of the file represented one abstract. Each abstract could reference one or more *slices* and one or more *rings*. Recall from the chapters in Part I that slices refer to the domains of sustainable development (such as Agriculture

[5] No sanctioning messages might indicate a dead community (no one cares any longer), while too many sanctioning messages might indicate a community having difficulty establishing the proper norms and expectations.

[6] The knowledge-base does not include news items, conferences, or any information that is time bound or whose value is not generic in some form.

or Industry) and the rings refer to the key dimensions (such as Activities and Conditions or Scientific and Technical Solutions).

For each pair wise combination of slices and rings, the number of abstracts referencing *both* was calculated. The results, illustrated in Table 9.1, and help us visualize the extent of interrelationships in the knowledge-base content. Table 9.1 should be read vertically (by columns). For example, the entry in Row C, Column D (6%), should be interpreted as follows: of all the 764 abstracts in the database that contain the slice Energy Use and Sources, 6% of them are also contained the in the slice Consumption. This example shows that the table is asymmetric – the entries for Row C, Column D are different from those of Row D, Column C. This difference is due to the fact that the figure of 13% represents the percentage of abstracts that contain Energy Use and Sources as a percentage of abstracts that contain the Consumption slice; and this figure is greater than the 6% figure noted above.

This asymmetry is a function of the composition of the knowledge-base during the period of this analysis. It shows the results of the knowledge provision practices. However, it is not possible to determine empirically whether this asymmetry is a function *only* of knowledge provision or, alternatively, it represents some underlying pattern or trend in the materials available on cyber venues. The purpose of Table 9.1 is only to highlight the composition of the knowledge-base during this specific period of investigation.

9.3 Implications for Re-Engineering the Ontology

For researchers trying to map a new domain, one measure of the effectiveness of their ontology could be the distribution of results in Table 9.1. A more equalized distribution would indicate a more effective classification, whereas one with *lumps* would indicate a high dependency across two slices.

Lumpiness could be due to a natural convergence between two domains (such as say energy and environment), but it sometimes requires that the slices be made more granular (divide ‘energy’ into ‘power generation’ and ‘energy sources’). Also, as the above example illustrating the difference between (C, D) and (D, C) indicates, one could gain insight into the directionality of the slices, with one slice being more important to another in a pair-wise relationship. Both granularity and directionality have important implications towards topic rationalization and therefore the users’ navigation experience.

Table 9.1 Pair wise comparison of slices.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total Abstracts
A	7%	5%	9%	6%	11%	6%	7%	8%	5%	6%	7%	8%	7%	10%	904
B	3%	26%	3%	2%	3%	4%	1%	9%	2%	4%	3%	5%	3%	3%	453
C	7%	5%	5%	6%	7%	8%	6%	6%	5%	5%	5%	6%	8%	8%	764
D	11%	6%	13%	13%	11%	10%	24%	7%	25%	6%	10%	9%	8%	10%	1701
E	11%	6%	8%	6%	11%	7%	7%	8%	6%	6%	6%	8%	7%	11%	934
F	5%	6%	6%	4%	5%	4%	4%	7%	3%	6%	6%	8%	8%	6%	650
G	13%	6%	13%	23%	12%	11%	9%	7%	26%	6%	11%	8%	8%	12%	1689
H	3%	6%	2%	1%	3%	4%	1%	5%	1%	4%	3%	4%	4%	3%	341
I	8%	5%	9%	20%	8%	7%	20%	6%	7%	5%	8%	6%	6%	8%	1347
J	5%	6%	5%	3%	5%	7%	3%	8%	3%	26%	5%	9%	8%	4%	747
K	5%	5%	5%	4%	5%	7%	5%	6%	4%	4%	17%	7%	6%	5%	726
L	7%	7%	6%	4%	6%	9%	3%	9%	3%	9%	7%	6%	9%	6%	720
M	6%	5%	7%	3%	5%	8%	3%	8%	3%	7%	6%	8%	11%	6%	705
N	10%	6%	8%	5%	10%	8%	6%	7%	5%	5%	6%	7%	7%	7%	839

Agriculture	A	Migration and Dislocation	H
Conflicts and War	B	Mobility	I
Consumption	C	Population	J
Energy Uses and Sources	D	Trade and Finance	K
Forest and Land use	E	Urbanization	L
Governance and Institutions	F	Unmet Basic Needs	M
Industry	G	Water Use and Sources	N

The competitive advantage of GSSD relative to other peer meta-networks on sustainable development is its powerful ontology and classification system. Continuously updating the results of such an analysis into revisions of the ontology is needed if GSSD expects to maintain this advantage. The results of the content analysis are the first step in this direction. Examples of further content analysis could include:

- Formal cluster analysis to determine size of optimal clusters to characterize data. Cluster analysis is done on pair-wise comparisons of abstracts. The content analysis will have to consider more dimensions in its comparisons – as each abstract can reference more than one slice. Sophisticated graphical analysis tools for content affinity analysis need to be used for this purpose.
- Examining content characteristics across other features, like location/ time etc. The content analysis described above ignores the characteristics of the user submitting the data. It would be useful to know whether developing countries' members of GSSD are contributing more than developed nations' members to certain domains, which countries lead in providing technical solutions/policy solutions, etc.

9.3.1 Traffic Analysis and Network Mapping

Turning now to the second method of system evaluation, we examine the web traffic patterns as well as user profile to the GSSD website, and we then undertake a very preliminary analysis of the relative position of GSSD with respect to other knowledge sources on sustainable development on the Internet.

9.3.2 Traffic Analysis

The empirical database that we used for these purposes consisted of the server log file data for a 410 day period from 1st Jan 2002 to 15th Feb 2003. These files were obtained and analyzed using a commercial log file analysis tool. The summary of results in Table 9.2, indicate that on an average day, GSSD received around 160 visitors a day. This figure could be viewed as large or as small depending on one's perspective. Given that GSSD avoids advertisement and it does not engage in any promotion, and given that the content is *intellectually heavy*, we consider this pattern to be healthy. In this regard it can be described as largely passive, relying on pull (through branding, reputation and a satisfying experience) rather marketing for its visitor base. Toward the end of this chapter, we shall refer to more recent traffic statistics in order to provide some balance of judgment.

Table 9.2 **GSSD traffic summary, 2002.**

Figure	**Value**	**Description**
First hit	12/31/2001 12:00:46 AM	Time of first hit
Last hit	02/15/2003 05:27:41 PM	Time of last hit
Hits	421032	Total number of objects accessed on web site
Page views	279209	Total number of page views
Visits	64659	Total number of visits (continuous page views)
Page views per visit	4.32	Average number of pages viewed per visit
Time per visit	0:02:51	Average duration of a visit
Visitors	13382	Total number of visitors
Visits per visitor	4.83	Average number of visits per visitor
One-time visitors	11040 (82%)	Visitors visiting only once
Time spent per repeat visitor	0:13:48	Average total visiting time per repeat visitor
Visits per day	156.94	Average number of visits per day

At the same time, however, Table 9.2 also points to a troubling finding: the number of one-time visitors is a very high (at 82%), which means that six out of seven visitors who visit GSSD never come back. What is interesting is that the number of visits per visitor is 4.8, which means that even with an 82% one-time visitor percentage, the number of visits by repeat visitors is so large that the average comes out to almost five visits per visitor. This proves the existence of two very different classes of users – browsing members who are usually one-time visitors, and repeat members – constituting 1/7 of the GSSD visitor base, who use the website heavily. An even more encouraging statistic is the amount of time repeat visitors spend on the site: a whopping 13 minutes, an impressive amount of time for any knowledge-base, particularly one that mainly provides links to other web pages.

A knowledge network needs a high percentage of repeat visitors whose sustained participation is necessary for a critical mass of members and resources to cumulate. A knowledge network also requires a steady participation of new members to compensate for natural attrition. The high browsing or repeat visitor ratio is worrying in terms of recruiting new members into the network, and GSSD as an organization has to recognize why this is happening. The reasons for this phenomenon could be marketing factors (attracting the wrong kind of audience in the first place), bad user experiences (not providing what the visitors are looking for or cumbersome navigation methods), or technological factors (a slow website).

It is possible to find some partial answers to the reasons why this is happening. An analysis of the most frequent exit pages (the pages last seen by the visitor before exiting the site) yields Figure 9.2.

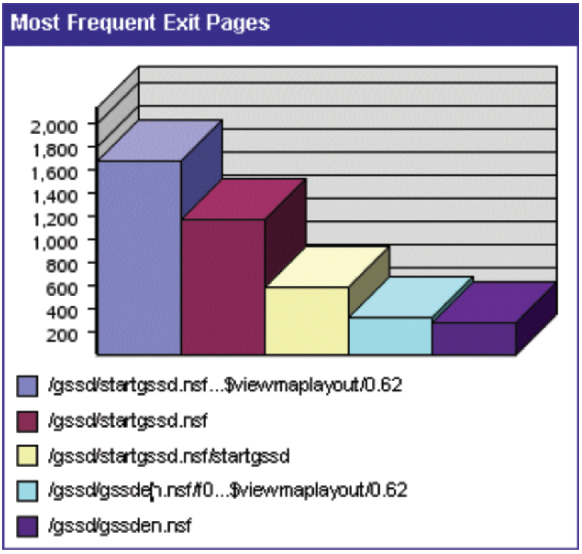

Figure 9.2 **Most frequent exit pages.**

The most frequent exit pages are all within the first two navigation levels of GSSD. This means that most visitors leave within the introduction page (where the visitor has to choose from amongst a list of languages and mirror site locations) or within the start page. The fact that most visitors exit from these pages indicates that the typical user who visits the GSSD website either faces confusion (over the choices), or frustration (over the multiple levels) to get access to the desired knowledge.

This problem is not serious for repeat visitors who are used to the interface, but this might be a significant deterrent to attracting new visitors to come back again. Clearly, GSSD will have to look at alternative design choices in its first two web pages to improve new user experience.

9.3.3 Network Mapping Analysis

Network Mapping Analysis may also shed more light on the types of people who are using GSSD. Hypothetically, the large incidence of one-time users could be the result of users who are looking for something non-GSSD related. The aim of this exercise is to find the relative position of GSSD vis-à-vis existing content domains on sustainable development existing on the Internet during the time of this analysis. This approach maps out the domain of knowledge on this topic on the web, providing a topology of similar content which could form the basis of collaboration and reverse linking, competitive analysis and benchmarking.

Specifically, we seek to find out the possible approach paths to the GSSD website (either by directly typing http://gssd.mit.edu, or by redirection from another website, or through a search engine). The log file data for redirection and direct entry into GSSD is not available, but a look at the search engine keywords used to come to the GSSD website gives us some insights. Table 9.3 and Figure 9.3 show the analysis on the keyword data for a period of two months (September–October 2003).

Table 9.3 **Most frequently used keywords to find GSSD – two month period.**

	Keywords	Visits
1	sustainable development	280 (4.9%)
2	MIT	118 (2.0%)
3	global system	94 (1.6%)
4	GSSD	94 (1.6%)
5	Substainable development	46 (0.8%)
6	global sustainable development	19 (0.3%)
7	Sustainable	19 (0.3%)
8	What is sustainable development	14 (0.2%)
9	global system for sustainable development	12 (0.2%)
10	GSSD MIT	11 (0.2%)

We see that during this two month period in 2000, users who came to GSSD do so by using either a combination of general keywords (sustainable development, sustainable, etc.), or very specific keywords (GSSD, MIT, etc.) Curiously, none of the popular keywords reference any of the content within GSSD. This is usually the largest and most important source of traffic for most knowledge networks as most knowledge network resources are indexed and made available to search engine robots. GSSD has only recently opened its database for public indexing. We expect to experience a substantial rise in user traffic.

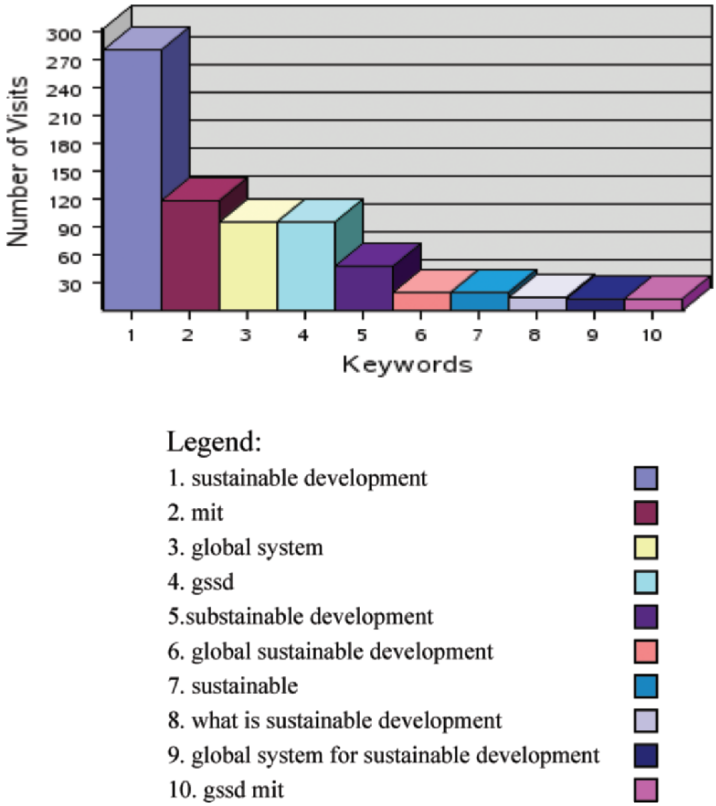

Figure 9.3 **Most frequently used keywords to find GSSD, two month period in 2000.**

In Figure 9.4, network mapping analysis is conducted by using a cartographic tool. The results delineate where GSSD stands with respect to other e-systems focused on providing sustainability resources over the Internet. The figure indicates where GSSD stands with respect to others on the search phrase 'global sustainable development.' Based on this map, one can see that while GSSD is geared towards users seeking 'resources' on sustainable development, the UNDP and the UN websites are for networking and for describing the challenges respectively. Amazon and Questia provide information on books related to sustainable development.

The results of the visibility analysis and the network mapping exercise can aid the network managers in planning corrective actions to draw more users to the website. Moreover, by examining the link to (the list of sites which link to the network the most), the network manager could identify co-promotional opportunities that could provide a steady source of traffic in a more sustainable way.

Figure 9.4 **GSSD's position in the sustainable development domain, two month period in 2000.**

9.4 Implications of Re-Engineering the GSSD e-Networks

9.4.1 Select Performance Issues

GSSD faces a problem of under-provision of knowledge resources due to a paucity of large-scale community participation. At the same time, however, GSSD does not actively encourage participation. Its partners and mirror sites are the major knowledge providers. In addition, the kind of resources submitted into GSSD are highly selective, the process of approval is even more rigorous, and the repeat GSSD user is much more discerning than users looking at other e-systems on sustainable development. The knowledge within GSSD is more akin to basic research and is augmented with selective and focused materials from policy sources. By contrast, other e-systems which focus on matters of sustainable development are more in the nature of managing applied research.

To explain, GSSD's core competence is the value added to the content through its powerful ontology. The users of GSSD draw upon the ontology to navigate and search for content, appreciating the multiple languages.

Moreover, GSSD is selective about the articles it includes into its knowledge-base. News reports and press releases – acceptable to the Development Gateway – are not allowed within the GSSD knowledge-base.

GSSD targets quality over quantity and moving to a community model of resource provision raises fears that the quality might be affected. However, we are still faced with the problem of continually populating the knowledge in a scalable manner. However, attracting a larger audience will not necessarily lead to a deterioration of the quality of content as the rigorous multistage approval process will still be used to weed out unworthy submissions. It must be recognized that GSSD only stands to gain irrespective of the quality of the users it attracts (as long as it does not turn off serious users). GSSD should clearly bait its users by attracting as large an audience as possible and hook them with its features – a comprehensive, intelligent, quality controlled knowledge-base.

Thus the key challenge for GSSD is to attract more visitors and to retain them. Attracting new visitors can be done by continuing to market the knowledge-base on search engines, by implementing link exchange programs, and by e-mail marketing. However, retaining visitors and making them visit again is a much harder task.

9.4.2 Strategies for Improving Performance

In order to improve performance, we need to increase the total number of members and we need to increase the total number of return users. We propose three potential strategic solutions, namely: (i) to build a feeling of community, (ii) to re-engineer the work process, and (iii) to re-engineer the partner incentives.

9.4.2.1 Community-Building

The lack of persistent identity in GSSD is striking. To combat this, community-building needs to be utilized. Communities are created when individuals build and maintain relationships within networks. Researchers have identified that interpersonal trust is a central characteristic of relationships that promotes effective knowledge creation and sharing in networks (Tsai and Ghoshal, 1998). However to create a feeling of trust, one needs to have a unique identity within the network. Currently GSSD does not recognize unique identities externally – it is not possible to find out who submitted a resource, nor is there a way to log on to the network and be recognized by the system. The first step towards building a community would involve a registration mechanism where users register their preferences and profile with the network with an option to disclose their profile to all other registered users.

The absence of mechanisms for social connections within GSSD is also a problem. Interactions are one way: between the user and the knowledge-base. New connections could be formed by allowing for comments on submitted resources or by launching new discussion groups. As currently conceived, the function of a discussion group is not incorporated within the GSSD mission.

Currently, the GSSD knowledge-base also does not systematically provide information on what has changed since the last visit. There should be a provision for displaying the most recent resources added, the number of resources in each of the domains and the number of new members added since last log on, in a prominent location. Such a development would make GSSD appear dynamic rather than static.

9.4.2.2 Re-Engineering the Work Process

The second set of solutions involves changing the organizational processes for improving participation. *Work processes* refer to the content submission policy, the content review process, and the process for translation and publishing. To a certain extent, it also refers to the user search and navigation process.

In order to improve the work process, the layout must be redesigned. The current layout of GSSD requires six mouse clicks before the user can get to the "Search GSSD" page, the principle navigation page of the site. This presents six opportunities for the user to leave the site. An analysis of the top exit pages have shown that most people leave the website after the first two pages. To combat early exit, the search feature should be made available in the first or second page. However, since these early clicks route users to theoretical and design related issues, bypassing these may hide some of the intellectual elements central to the overall mission.

Another way of changing the work process rests in changing the content-submission process. The current content submission process involves filling a form that has over 15 fields: a burdensome process for any but the most dedicated user. This form should be simplified by decreasing the number of fields. This would increase the burden on the internal reviewer.

9.4.2.3 Re-Engineering Partner Incentives

The third category of solutions involves re-engineering the incentives and motivations of the network's institutional partners and their representatives. Partners are motivated to collaborate with GSSD for a variety of reasons ranging from a genuine desire to participate in an initiative that provides a holistic view of knowledge on sustainable development, to a desire for peer recognition, to a desire to promote their own language or region (digital inclusion) to a desire to be affiliated to the GSSD-MIT brand name.

Of all the motivating factors, the most important ones are those where the actors genuinely believe in GSSD as a way of providing a new way for representing sustainable development and where the actors have internalized the values that GSSD stands for: an integrated perspective that cuts across domains, geography, and languages. As we have seen before, commitment by internalization is the preferred way of cultivating commitment behavior. In the context of GSSD, this ensures that the knowledge worker will try to maximize one's value added contributions and will not artificially inflate the quantity of contributions or skimp on the quality.

It is important to recognize that all of these are *soft* incentives and the temporal lag between the motivation and the actual deliverance of results could pose problems for ensuring sustained participation in the network. Soft incentives take time to deliver and need to be continuously reinforced to take effect. GSSD has been effective in rewarding genuinely committed partners by inviting partners to conferences within and outside MIT. However, more needs to be done. Other ways of engaging committed partners could be by initiating institutional joint projects on similar topics, providing access to sources of funding, offering increased networking options for partners where they interact with other MIT faculty/researchers, and by providing access to other scarce resources.

Thus far we have suggested that a community-oriented participation model, coupled with a strong institutional network backbone of partners can provide GSSD with a strong model. For this to happen, there needs to be a strong top management commitment, a long-term vision for the network where objectives are clearly stated, a clear list of timelines and resources needed, and a funding/sponsorship plan in place.

9.5 Key Features of GSSD-MIT

MIT's GSSD is viewed as a network mainly for researchers and policy analysts in the sustainable development community. GSSD is particularly focused on efficiently representing content and has differentiated itself through its ontology and its unique way of mapping the complex domain of sustainability. GSSD also has a well-defined workflow for routing of abstracts to content reviewers who approve all content submitted to GSSD. Content reviewers review respective language submissions and classify websites using the GSSD ontology. Content reviewers are pre-specified, and are not subject matter experts in any one domain. They are typically faculty, student research assistants, or temporary staff members.

Two distinctive features of the GSSD editorial policy bear mention in this context. One is that GSSD exercises a strict control of abstract submissions to the system as it was originally conceived as a knowledge-based system, not simply an information access device. To this end, GSSD does not allow submissions into its website that are: daily news items, popular magazines, etc.; statements of opinion or papers of opinion, *per se;* or unidentifiable institutional or individual sources.

The other unique feature of GSSD is that it is a system geared to replicating all content in all languages in all mirror sites. This high redundancy strategy (the idea being to let users access the mirror site closest to them, in any language) imposes a constraint on the architecture, and the system has to be geared for high redundancy without inconsistency.

Topic pages on the site are managed by guides (individuals and institutions) with demonstrated experience and expertise in the topic area, and are supported by advisors that help evaluate the page, and make contributions. Content suggested by users, like all content on GSSD, is reviewed prior to acceptance on the site. Like GSSD multiple languages are supported, however the content is not always available in every language. This eases the burden on synchronization of data amongst the different partner websites, who can now function as more or less autonomous content creation entities.

GSSD mirror sites have an arrangement where the partnering institutions maintain a server live to the web and integrated into the GSSD system that contains a replica of the entire GSSD database. Although this affords for easy and fast creation of local content, there is very little that can be done in terms of localization of the delivery of content. This is a drawback of the architecture of the system, where once the core application is developed; the regional deployment consists of simply translating the terms used in the application to each of the languages. This is managed at present using the Lotus Domino Global Workbench.

The relative merits of a centralized architecture of GSSD over a relatively decentralized architecture is that it enables better control and is thus ideally suited to an organizational model where individual mirror sites share the task of translating content from all other languages into their own. However, as a matter of policy and strategy, the current architecture does not enable a mirror site to develop its own customized welcome page and additional functionality without impacting the design of the system as whole. Since the GSSD mission is one of 'exact replica' or cloning such that there remains no difference between the MIT and other site location, the customization is, by definition, not an issue. Also, if strict access control measures are not employed, it is easy for any particular mirror site to tamper with the material of other mirror sites.

9.5.1 Performance Issues

The Domino server is not built for high traffic access. Given the loads under which GSSD operates (120 sessions, 10 concurrent sessions), the server has proved adequate, but the Domino server has known vulnerabilities at higher loads.

9.5.2 Lack of Development Experience

Availability of skilled technical resources is a key requirement to manage any technological system. It is difficult to find developers and administrators with Lotus/Domino experience. For GSSD, the problem is even more difficult considering that the main workers on the site are students. There are few skilled Lotus Notes programmers amongst the student community.

However, to move away from a proprietary, hierarchical system, one needs a multi-site relational database/content management system alternative that will still provide the benefits of easy content management, multi-lingual mirror site replication, and synchronization. Although multi-lingual and multi-site clustering solutions for relational databases exist currently – Oracle and MS SQL both provide solutions – they are not linked to content management systems. The alternative is to build a system from scratch with content submission, translation, publishing processes and the process of replication and synchronization across multiple languages using various scripting tools.

9.5.3 Re-Engineering Implications

So far, we have utilized an engineering systems methodology in our approach towards characterizing, measuring, and evaluating knowledge networks. Engineering systems are diverse, complex systems that include components from several engineering disciplines, as well as economics, sociology, psychology, and other sciences. An engineering systems methodology requires an inter-disciplinary approach to design, develop, implement, and sustain complex engineering systems.

Knowledge networks are perfect examples of engineering systems, and re-engineering knowledge networks typically involve proactive, systematic (and systems-based) approaches toward planning and design, management, measurement and evaluation to cultivate the conditions for sustained sharing and dissemination of knowledge resources.

As described earlier, knowledge network components are the actors, the relationships between actors, the resources which may be used by actors within their relationships, and the institutional properties, including structural and cultural dimensions such as control mechanisms, standard operating-procedures, norms and rules, communication patterns, etc.

Each of these components and the relationships amongst them contribute towards the viability of a knowledge network. For instance, a successful knowledge network requires both a supportive social atmosphere and an appropriate technical infrastructure to support that atmosphere. The technical infrastructure must mesh with the control and communications mechanisms.

In this section, we introduce an integrated framework that helps a network designer or planner layout the objectives and goals of the network. This framework consists of several components, and jointly they are integrated into a multi-stage network. The network as a whole consists of the following phases:

- Network Planning
- Network Design
- Implementation
- Network Evaluation
- Monitoring

See Figure 9.5 for a representation of these phases. Since each of the phases is distinctive, a description of each phase as well as the entire framework is in order.

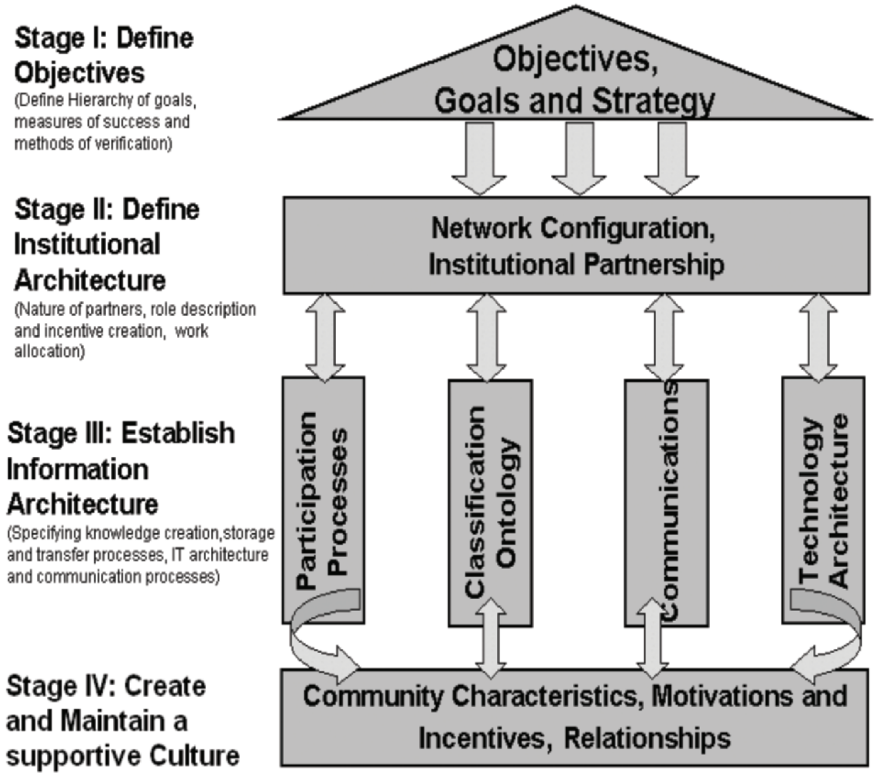

Figure 9.5 **An integrated framework for knowledge network assessment.**

The first phase in the framework consists of *Knowledge Network Planning* and involves establishing the goals and objectives of the network. In principle, it consists of identifying and prioritizing amongst various goals and creating a hierarchy of objectives that takes into account all stakeholder interests – including the needs and objectives of the sponsoring organization, the various institutional partners and the other individuals and groups that participate in the knowledge network. This stage also involves defining operational variables and the processes that reflect the network's ability to reach these goals. Once the hierarchy of goals is defined, the next phase is to choose an organizational and technological architecture most effective in realizing these goals.

The second phase consists of *Knowledge Network Design and Implementation* and incorporates Stages II, III and IV of the integrated assessment framework. Stage II involves laying out the organizational architecture that decides the number and type of partners, the level of control by the sponsoring organization, the degree of centralization, task assignment and alignment of incentives of partners, the amount of workload per partner and the network governance mechanism. Stage III is concerned with the planning of the information architecture and lays out the set of principles and standards that guide the high level design and selection, construction and implementation, support, and management of all processes of the organization and its communications infrastructure. Stage IV involves defining and maintaining a network culture (including amongst others the values, purposes, structural relationships, language, etiquette and history of the network) – and engineering trust, tolerance and rewards systems in place to reinforce the culture. This phase involves both planning and the actual implementation and often includes creating low-level designs, work schedules, performance targets and relevant incentives, rules of participation, moderation, and control.

The third phase focuses on *Knowledge Network Monitoring and Evaluation* and consists of an ongoing activity that involves setting up both the implementation of performance measurement processes and the decision rules to act on them. This phase specifies who has to monitor what and when, and what to do with the results. The organization develops and trains its personnel in the different methods of analysis (traffic analysis, content analysis and network mapping, surveys, etc.) and provides guidelines on how to interpret and act on the results.

It has to be noted here that knowledge networks as dynamics systems also exhibit features of adaptability and emergent behavior and do not always follow a plan–design–implement cycle. Very often processes, norms and relationships are created within a network that was not originally envisioned. The framework helps in deciding on which kind of emergent behavior needs to be encouraged and adopted and what needs to be censored or dropped.

The integrated structure outlined above uses an engineering systems approach to provide both a micro and a macroperspective that enables us to comprehend knowledge networks in its entirety. The multi-phase framework enables laying out the individual components while recognizing the interdependencies that exist among them. For example, the framework recognizes that networks are structural as well as cultural, and that the planning, design, and the evaluation phase will have to take into account the individual–organizational, the technological–institutional and the individual–technological interconnections that exist.

9.6 Next Generation Knowledge Networks

Knowledge e-networks are complex entities with many component systems and many inter-linkages between the systems. By looking at the various subsystems involved – individual, organizational, and technological – we take the knowledge network as an integrated whole. Although the approach adopted could be used for analyzing most configurations of knowledge networks and application domains, we are particularly interested in the characteristics of knowledge networks in the sustainable development domain. The interest in building and managing successful knowledge networks in development is particularly high among International Development Organizations (IDOs) who view these networks as an important part of their capacity development activities. Knowledge sharing at these IDOs has evolved over time, from an emphasis on capturing and organizing knowledge, to their current focus of adopting, adapting, and applying knowledge while connecting knowledge workers.

However, knowledge networks are continuously evolving and the next generation of knowledge networks is likely to be those that go beyond the sharing of knowledge to those that are able to translate knowledge into action. In the context of sustainable development, this would involve integrating knowledge principles and practices into the institutions and policy frameworks. Evidence of this phenomenon is already around us – from flourishing best practices networks to the shift towards Just in Time Knowledge – as knowledge-sharing practices are integrated into organizational work processes. The next generation knowledge network will be a more intelligent system, through the development of dynamic and adaptive ontologies for representing continuously changing knowledge domains, using data mining tools for analyzing linkages for improve cross-disciplinary understanding, and for other developments.

Technological improvements in the form of the next generation Internet, the semantic web and the growth of web services are likely to change the notion of knowledge storage and dissemination as we know of it today, allowing us to transform knowledge by combining, classifying, and analyzing it in new ways and with the emphasis shifting from connectivity to new levels of interactivity, would allow us to learn and create across disciplines, languages, and cultures. Essential in this regard is greater attention to the matter of language, to inter-cultural interpretation of common concepts and modes of communication, and to the overall science of the measurement of meaning.

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