Boundary Infrastructures for Conversational Knowledge Federation

Jack Park
Knowledge Media Institute
The Open University, UK

Abstract. One of the primary tools of collective intelligence is conversation. Conversation takes many forms, from interactive storytelling, to an emerging *lingua franca* of structured conversation, Issue-based information systems (IBIS) and related forms of contested discourse. Conversation federation facilitates improved collective intelligence for sensemaking and for decision making. Federating conversations is performed through topic mapping processes where conversations are organized around the subjects they entail. While each conversation is, itself, a subject, each conversation is *about* one or more subjects. Structured conversations created in IBIS settings are typically rooted in a central topic or central question (issue). Where conversations are about the same topic or issue, they federate—that is, they are combined through a topic mapping *merge* process that maintains a well-organized map of the combined conversations. A goal that animates collective intelligence is collective wisdom; making wise decisions. We describe a platform aimed to serve such a goal.

Keywords: boundary infrastructures, topic maps, knowledge federation, structured conversation, IBIS, collective intelligence, collective wisdom

> "In every deliberation, we must consider the impact on the seventh generation..."
>
> —Great Law of the Iroquois[1]

1.0 Background

We use the global issue of *climate change* to set a context for the terms and concepts we describe. Climate change is a growing concern to humankind, since the dominant view argues for rapid, significant changes in human behavior to avert catastrophic consequences; seven generation sustainability becomes an urgent cause. Climate changes are proposed against a backdrop of lifestyle and economic change due to proposed and emerging mitigation plans. This is a complex problem, known as a wicked problem (Conklin, 2005). A productive way forward is through creative, critical dialogue. Such dialogue requires new kinds of socio-technical infrastructure. As part of a research and development program aimed at a prototype of a new kind of socio-technical infrastructure, we are developing an open source collective sensemaking platform we call *Bloomer*[2]. Bloomer serves two purposes in our research. One purpose is to support a thesis project that explores the ability to *federate* structured conversations (Park, 2010); the other purpose is to provide a socio-technical infrastructure, a boundary infrastructure (Bowker & Star, 1999) for collective intelligence, described as a *knowledge garden* (Park, 2008). From (Bowker & Star, 1999, p.313):

> "Any working infrastructure serves multiple communities of practice simultaneously be these within a single organization or distributed across multiple organizations….Boundary infrastructures by and large do the work that is required to keep things moving along. Because they deal in regimes and networks of boundary objects (and not of unitary, well-defined objects), boundary infrastructures have sufficient play to allow for location variation together with sufficient consistent structure to allow for the full array of bureaucratic tools (forms, statistics, and so forth) to be applied."

---

[1] Iroquois quote: (Lyons, 1980) and mentioned in (Briskin, et al., 2009), quoted at http://en.wikipedia.org/wiki/Seven_generation_sustainability

[2] Bloomer: http://code.google.com/p/bloomer/

Bloomer combines a variety of web-based portals, including MediaWiki[3], Cohere[4], and others, each communicating with a topic map platform we call TopicSpaces. See Figure 2 below. To MediaWiki, we added a new extension that enables IBIS conversations to be conducted in the wiki.

Our use of the term *federate* entails topic maps. We posit that subject-centric merging of topics captured in social sensemaking settings offers opportunities for collaboration based on participants' discovery of like-minded others. Federation, in our sense of the word, is both a noun and serves as an act. The federation act is that of topic maps merging processes; a federation, the noun, is a collection of people, information resources, and the boundary infrastructure together with its many related boundary objects (Star, 1989). Boundary objects are those objects, such as a chalkboard, that we use in collaborative settings. A topic in a topic map, like a concept drawn on a chalk board, is an instance of a boundary object; it is co-owned by all participants and serves as a place where resources are shared.

In the following section, we sketch a boundary infrastructure to provide context for the remainder of the paper. The remaining sections describe knowledge federation as providing a topology, an entity and a process, and detail the nature of structured conversation in the context of both knowledge federation and the boundary infrastructure that mediates all activities. We close with our thoughts about the opportunities for a society engaged in the structured conversations we present.

2.0 A Boundary Infrastructure—From Issues to Decisions

In this section, we sketch a boundary infrastructure intended to facilitate the flow of information from issues to decisions. In Figure 1, we illustrate interactions with an element labeled *Federated Knowledge*, a collection of resources information resources. We label this framework a *knowledge garden*, a term we did not coin, but have used many times (Park, 2007; 2008).

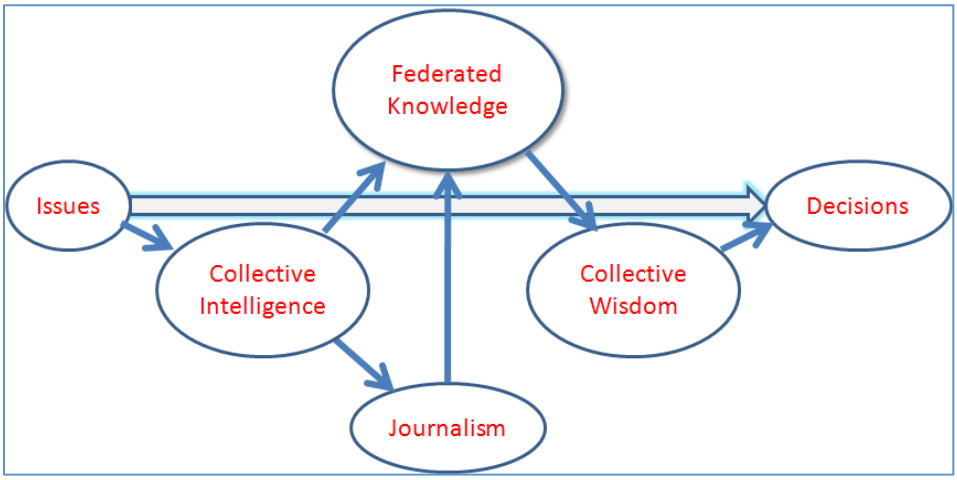

Figure 1: A Knowledge Garden Framework

Our focus in Figure 1 is presently on the flows of user activity that range, left to right, from *issues* to *decisions*. In the next section, we encounter the *Federated Knowledge* component. A good example of a boundary

[3] MediaWiki: http://www.mediawiki.org/

[4] Cohere: http://cohere.open.ac.uk/

infrastructure is the Climate Collaboratorium[5], which combines not only the server and database platform, but also a variety of boundary objects useful for conducting structured conversations, maintaining plans of action, and exercising climate models.

We deliberately, perhaps controversially, separate two processes from one another. Sensemaking processes, labeled *Collective Intelligence*, correspond with those acts of both humans and software agents that collect information resources in the context of well-posed issues, organize the resources into a framework of understanding that later will be used for decision making, and finally deal with the ambiguities, misunderstandings, and disagreements that are entailed in any complex issue that seeks resolution. Decision making processes, labeled *Collective Wisdom*, are those acts of humans and software agents that result, ultimately, in made decisions. Decision processes follow those of sensemaking, relying on the best efforts of the sensemakers.

Situated between the sensemakers and decision makers, we include *journalists*. Journalists tell stories; they interpret and lend context to the frameworks of understanding created by the sensemakers. Ideally, journalism would follow the decision makers as well; that's left off for clarity in the illustration.

A technological boundary infrastructure, envisioned in Figure 1, entails software and hardware commitments that are to be shared, indeed, *owned* by the stakeholders that use them. A boundary infrastructure, as mentioned above, includes *boundary objects* of many kinds. They range in variety from the Compendium platform that sits on a desktop and allows users to create conversation maps that can be shared, to complex Web-based widgets such as Webbles (Kuwahara & Tanaka, 2010) that resides in browsers, allowing users to create complex information objects out of resources found on the Web.

3.0 Knowledge Federation—A Topology, a Memory System, and a Process

The Federated Knowledge element of Figure 1 is comprised of a topic map (Park & Hunting, 2003), first described as a tool for knowledge federation in collaboration with Adam Cheyer (Park & Cheyer, 2005) and later in a conference call in collaboration with Patrick Durusau (Park & Durusau, 2006), coupled with Web interface features that enable webservices communication with various portals that satisfy the user experience (UX) needs of different user communities. Information resources are available in a large variety of formats, from the relatively unstructured texts of stories, emails, and so forth, to the highly structured formats of ontologies. Topic maps reside at a place on the continuum between unstructured and highly structured, imposing just enough structure to represent individual subjects by collections of attribute/value pairs that reveal properties of the subject according to specific needs. Some properties represent specific topic attributes, such as birth date, name strings, and so forth, while others link subjects into roles they play in relationships with other topics.

How does the abstract notion of a federation illustrated in Figure 1 reify as a knowledge garden? What's inside a knowledge federation and how does it work? We provide some answers to those questions in the following sections.

3.1 Federation as Topology

[5] Climate Collaboratorium: http://climatecollaboratorium.org/

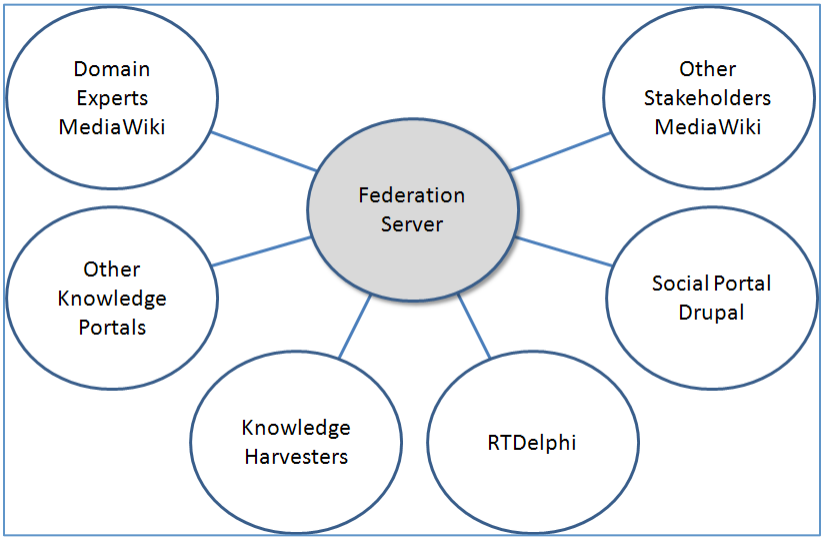

Figure 2. A Federation of Knowledge Portals

We illustrate a federation as a collection of knowledge portals, including wikis, social platforms, specialized knowledge portals, and knowledge harvesters, all *federated* with an instance of a federation server, a topic map as we describe in §3.2. Figure 2 illustrates a particular instance of a federation being installed as an instance of the Bloomer project described above. The Federation Server illustrated is classed as a *local* server. It has the ability to share its knowledge with one or more *global* federation servers, to form a knowledge garden that engages and federates stakeholder activities everywhere.

The Federation Server serves the dual purposes of performing federation acts, and serving as the federation's *memory*. We describe the memory functions, and federation behaviors next.

3.2 Federation as Memory

We believe that processes of evolutionary epistemology (Campbell, 1974) are in play in any knowledge garden. The *evolutionary* term implies that *selection* and *reproduction* among *populations* of competing ideas and concepts are active processes. For that to happen, a memory is in play as illustrated in Figure 3.

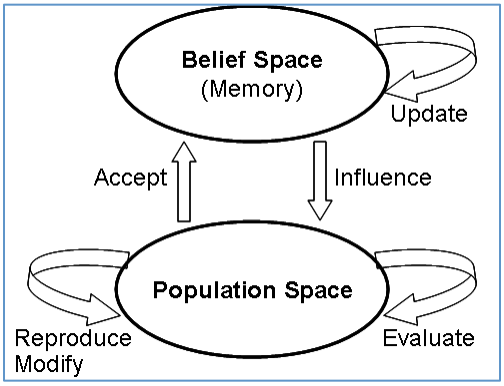

Figure 3: Memory in an Evolutionary Idea Space[6]

[6] Figure 2 after (Reynolds & Stefan, 2003)

Geoffrey Bowker (2005) suggests that, in general, we are not good at remembering complete stories from the past. Rather, we are good at breaking out facts from the past and organizing them into usable artifacts. Belief space in Figure 3 represents a kind of *map* of those artifacts. We thus implement that space as a topic map. A topic map is a container of usable artifacts—boundary objects, in this case—which represent individual subjects. An entire story, this paper, say, is a subject. But a story is *about* many other subjects; the topic map is a kind of road map that locates individual subjects in relation to all other related subjects, showing, equivalently, the *roads that connect them*.

3.3 Federation as Process

From (Park, 2010):

> "Federation, in our context, is simply based on a root dictionary definition: a process that *brings together without filters*. As a knowledge organizing process, federation organizes information resources by the subjects described in those resources, much as the index in the back of a book collects subjects and provides links to where those subjects are found in that book. A goal of the federation process is to help all stakeholders better understand the complexity of policy issues and to navigate the arguments, in the long run, without traversing redundant arguments."

Consider the *Collective Intelligence—Sensemaking* phase illustrated in Figure 1. Federation starts with the fabrication of information resources, some simple, and some complex. Federation in that phase has the intermediate step that aggregates those resources in memory. In the case that those aggregated resources are never used again, federation, the process, for those would end at that point. In most cases, the aggregated resources may be brought out of memory as grist for further sensemaking acts.

What, precisely, occurs in that aggregation process? This is a *memory process*, not unlike processes typically associated with, say, dream states of human memory, where information is organized. In topic maps, each entering resource is considered *as a topic*—it is, indeed, imported as a topic structure. As a topic, the resource exhibits subject identity properties which allow it to be compared with other topics already in the map. When two topics are found to be of the same identity, that is, *about the same subject*, they are merged. (Garshol & Moore, 2008, §6) say that merging is "a process applied to a topic map in order to eliminate redundant topic map constructs in that topic map". Like any map, the objective is to *co-locate* all resources about and associated with a given subject. (Garshol & Moore, 2008) then proceed to outline steps typically taken to perform merge operations.

In recent literature, (Park, 2010a; Kivela, 2010), a different form of merge operation is described. To contrast previous and emerging techniques, consider that the previous (c.f. (Garshol & Moore, 2008)) system performed the equivalent of a *set-union* aggregation of two resources into one. One topic serves as a base, and anything that is different in the other topic is copied into the base; the other proxy is then discarded. Methodologies described in (Park, 2010a) and (Kivela, 2010), posit a new proxy for the subject, called a *virtual proxy* (Park, 2010a) which serves as a place holder for the subject itself, while the two proxies to be merged remain intact, linked to the virtual proxy by way of associations (subjects) which describe the reasons for the merge.

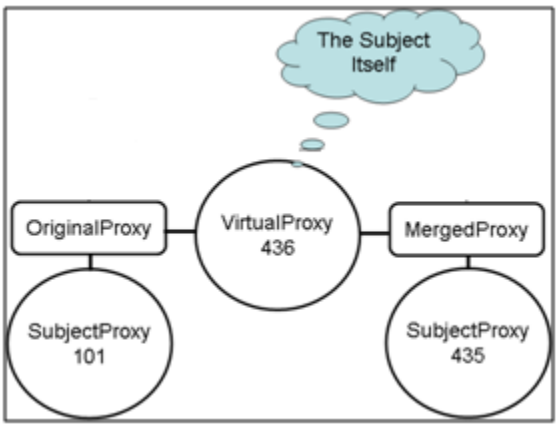

Figure 4: A Virtual Merge Scenario

Figure 4, adapted from (Park, 2010a), illustrates a virtual merge of two proxies. `SubjectProxy #101` is linked to `VirtualProxy#436` by way of a merge association identified as `OriginalProxy`. The merge is then performed on `SubjectProxy #435` through its `MergedProxy` association.

Advantages associated with virtual merging follow two key issues: merges should be contestable, and merges that succumb to a successful contest must be restored to the individual state before merge. In the case of the framework described in Figure 4, a merge association, itself a subject in the topic map, can serve as an actor in a relationship which contests its validity. Indeed, it is possible to use the same structured issue-based conversation processes described here on the topic map itself. If a merge action between an original and another proxy is contested and shown to be invalid, un-merging becomes a matter of recording the reasons for invalidating the association, then marking it invalid; the merge is then not treated as valid by the topic map, but all the facts surrounding the merge remain recorded in the topic map.

To see a federation act, a merge in action, consider a trivial example. In the following figures, we first show screen captures of two tiny conversations conducted with the Compendium[7] platform. We then show them federated into a single conversation. Figure 5 is two conversations. Visual inspection by humans reveals that both conversations open with the same question, even though each question is different in choice of names for the same thing.

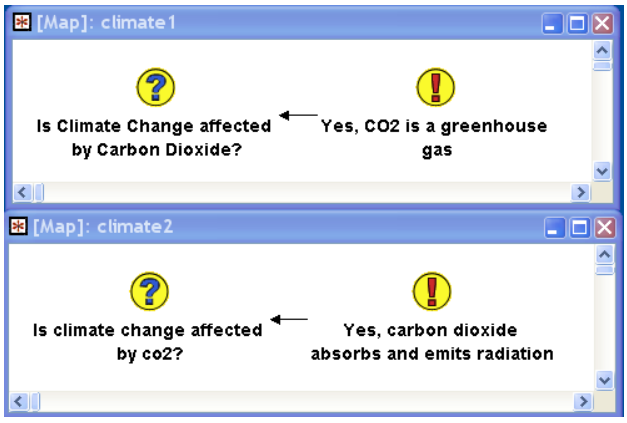

Figure 5: Two IBIS Conversations

Figure 6 represents the lone view one would receive when looking for a conversation that asks the opening question.

---

[7] Compendium: http://compendium.open.ac.uk/

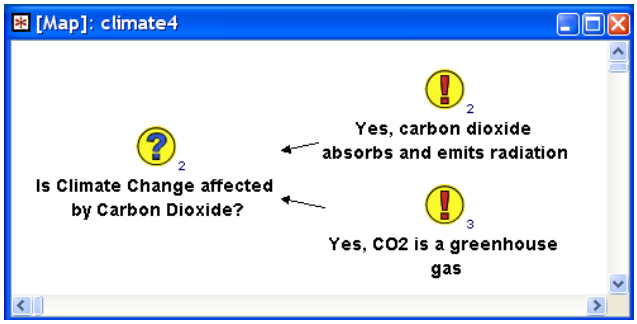

Figure 6: Federated IBIS Conversations

We illustrate a simple federation act that only required synonym detection to make a merge decision. The situation is not as simple as that; we must be prepared to deal with statements with different structures, statements decorated with adverbial or adjectival phrases that cloud the subject, and statements riddled with typographical error or errors of omission or commission. Federation processes are, indeed, non trivial; they are the subjects of interesting research.

4.0 Structured Conversation—Speaking and Listening

According to the *conversation theory* of Gordon Pask (Scott, 2001), two entities are required: a speaker and a listener. The theory entails *mental models*[8], several of them. Both the speaker and listener have models at some level of sophistication about the *domain of discourse*—the subjects of the conversation. The speaker is expected to have a model of the listener's domain model. To illustrate, a teacher of third grade subjects maintains a mental model that drives expectations of what each child, each listener, can understand, which, to some extent, determines what is uttered by the teacher.

We draw structured conversations from many possible approaches to collective sensemaking (Weik, 1995). Simon Buckingham Shum (2006) says that "in sensemaking there is an important role for discourse-oriented tools to help capture, comprehend, integrate and manage competing interpretations and arguments". In (Park, 2010), we made a distinction between *conversations that matter* (Brown & Isaacs, 2005), and social conversations. Our focus is on conversations that matter. Structured conversation is a term we use synonymously with *dialogue map* (Conklin, 2005) and *issue map* (Conklin, 2008) and which can be thought to include the term *argument map* (Twardy, 2004). Structured conversations appear in varieties of forms. Figure 7 shows an issue related to climate change created with Compendium.

[8] Mental Model: we use the term to describe knowledge artifacts held in human brains which can be expressed to the outside world as stories, ontologies, questions, answers, and arguments, and more. Further disambiguation of the term is found here: http://en.wikipedia.org/wiki/Mental_model

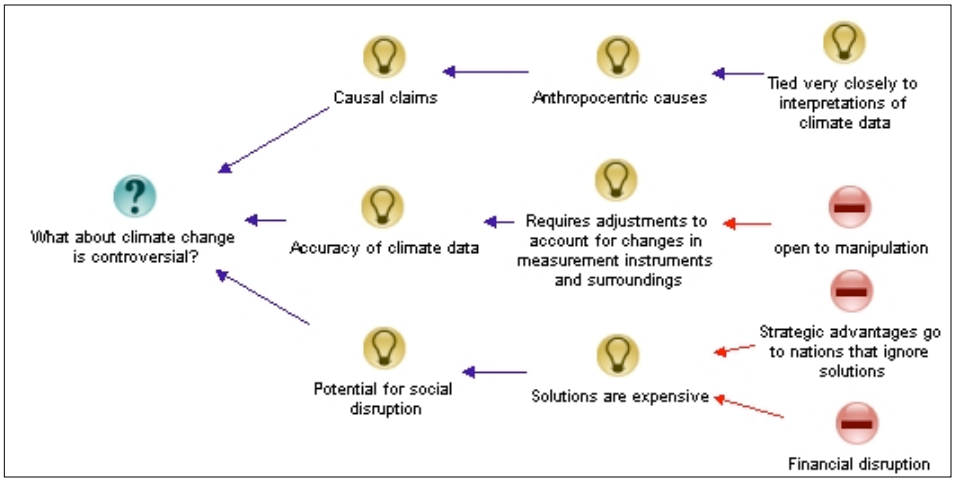

Figure 7: A Compendium Issue Map about Climate Change

A different view of a similar climate change conversation is Figure 8, which covers issues specific to the Copenhagen Summit.

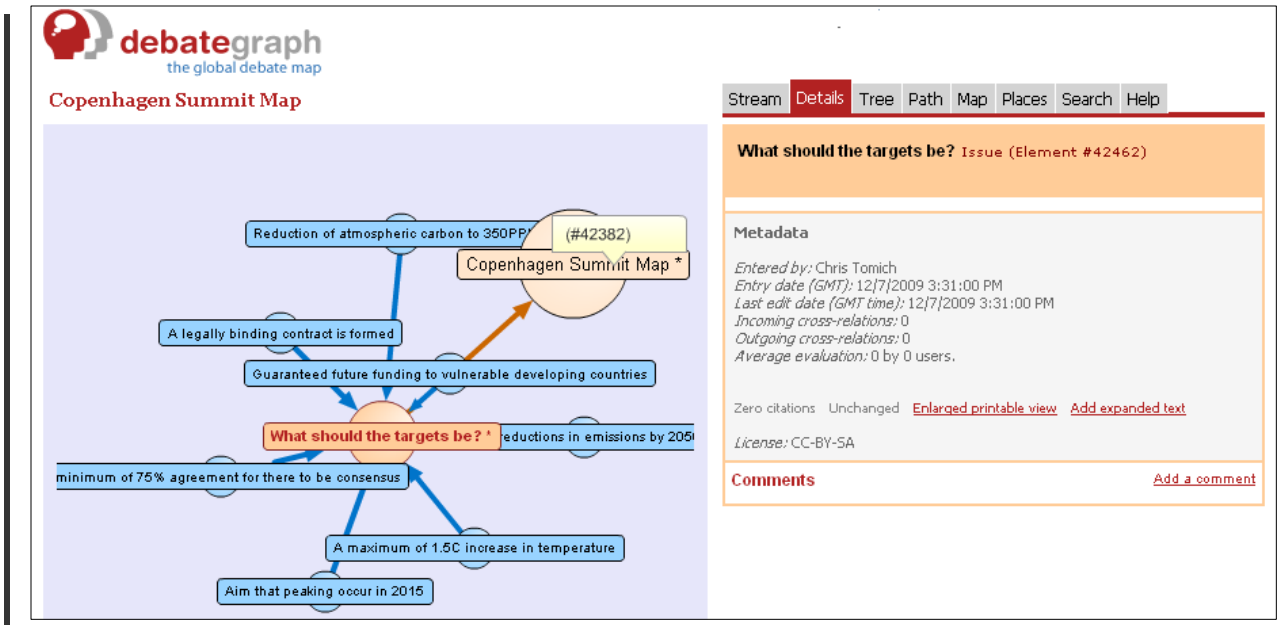

Figure 8: A Debategraph Conversation

While we speak of structured conversation, we recognize that, for the largest body of available resources for sensemaking, conversations exist, but they are not structured in the sense we describe such structures. Conversations exist in tweets, blog entries, emails, and various online fora, from simple linear chat rooms to indented comment fields at blogs. If we are able to construct the tools of structured conversation disambiguation, we believe we can extend those tools to recognize elements of conversation in *in-the-wild* text. For instance, with Twitter, we might spot incipient conversations through the aggregations associated with hash tags, then apply forms of temporal pattern recognition to sequence questions, answers, and arguments. Similar processes might apply to blog posts. Our thesis research is now exploring this opportunity.

5.0 Discussion

> "If we are going to succeed in this rapidly changing world, we face two challenges: making sense of the changes around us, and making progress in an increasingly unfamiliar world."
>
> — (Hagel, et al., 2010, p. 3)

It is our thesis that federation, as a process, is a circular flow, from collections of information resources, to human interactions with those resources resulting in changes to the collection of information resources. Human interactions occur both at the sensemaking and decision making stages. Results of human interactions are documented in varieties of journalistic ways, which increase the variety of information resources available.

Humans represent *knowledge stocks* and conversations represent *knowledge flows*. With that characterization, we are able to cast conversational knowledge federation into the arena of *pull architectures* (Hagel, et al., 2010). Those authors characterize pull architectures several ways, one of which is appropriate to this topic; they say "The edges of our social networks represent the weak ties that connect us to people who can provide us with access to new insights, experiences, and capabilities that provoke us to improve our own game." (Hagel, et al., 2010, p. 23). Conversations, in our view, create opportunities for those edges to form, to blossom, and, through collaboration, to solve complex and urgent issues.

Conversation federation supports a range of pedagogical practices, from learning conversations conducted in classrooms, to online portals that encourage global participation. The Dunbar number (Dunbar, 1993) suggests that humans are capable of engaging up to 150 people; World Cafés[9] suggest setting tables for four to five individuals in conversation at a time, and guilds in online role playing games such as Worlds of Warcraft engage a few dozen or less participants in any quest. Conversations can occur in *wildfire* situations (Engeström , 2009), where people join forces to rapidly deal with urgent situations,

6.0 References

Bowker, Geoffrey C. (2005), *Memory Practices in the Sciences*. Cambridge, MA: MIT Press.

Bowker, Geoffrey, and Susan Leigh Star. (1999). *Sorting things out: classification and its consequences*. Cambridge, MA: MIT Press.

Briskin, Alan, Sheryl Erickson, John Ott, and Tom Callanan (2009). *The Power of Collective Wisdom and the Trap of Collective folly*. San Francisco: Barret-Koehler Publishers, Inc.

Brown, Juanita, and David Isaacs. (2005). *The World Café: Shaping Our Futures Through Conversations That Matter*. San Francisco: Berrett-Koehler Publishers.

Buckingham Shum, S. (2006). "Sensemaking on the Pragmatic Web: A Hypermedia Discourse Perspective". Proc. PragWeb'06: 1st International Conference on the Pragmatic Web, Stuttgart, 21-23 Sept. Online at http://kmi.open.ac.uk/publications/pdf/kmi-06-16.pdf

Campbell, Donald T. 1974, "Evolutionary Epistemology." In P. A. Schilpp(Editor) *The philosophy of Karl R. Popper* , pp. 412-463. LaSalle, IL: Open Court

Conklin, Jeff (2005). *Dialogue Mapping: Building Shared Understanding of Wicked Problems*. Wiley.

Conklin, Jeff (2008). "Issue Mapping". Online at http://www.cognexus.org/issue_mapping.htm

Dunbar, R. I. M. (1993). "Coevolution of neocortical size, group size and language in humans". *Behavioral and Brain Sciences* 16 (4): 681-735

Engeström, Yrjö (2009). "Wildfire Activities: New Patterns of Mobility and Learning". International Journal of Mobile and Blended Learning. Volume 1, Issue 2. IGI Global.

Garshol, Lars Marius, and Graham Moore (Editors) (2008). "Topic Maps—Data Model." Online at http://www.isotopicmaps.org/sam/sam-model/

---

[9]World Café*s* : http://www.theworldcafe.com/ and (Brown & Isaacs, 2005)

Hagel, John III, John Seely Brown, and Lang Davison (2010). *The Power of Pull: How Small Moves, Smartly Made, Can Set Big Things in Motion*. New York: Basic Books.

Kivelä, Aki (2010). "Introduction to Layered Topic Maps". Online documentation for the open source Wandora topic map platform. Online at http://www.wandora.org/wandora/wiki/index.php?title=Introduction_to_Layered_Topic_Maps

Kuwahara, Micke N., and Yuzuru Tanaka (2010). "Webbles: Programmable and Customizable Meme Media Objects in a Knowledge Federation Framework Environment on the Web". This conference.

Lyons, Oren (1980) "An Iroquois Perspective." in *American Indian Environments: Ecological Issues in Native American History*. Vecsey C, Venables RW (Editors). New York : Syracuse University Press, Pp. 171-174

Park, Jack, and Adam Cheyer (2005). "Just for Me: Topic Maps and Ontologies". in Lutz Maicher and Jack Park (eds), *Charting the Topic Maps Research and Applications Landscape: First International Workshop on Topic Map Research and Applications, TMRA 2005*, Leipzig, Germany, 6-7 October 2005, Revised Selected Papers, Springer LNCS Volume 3873/2006, 145-159.

Park, Jack, and Sam Hunting (Eds) (2003), *XML Topic Maps: Creating and Using Topic Maps for the Web*, Boston, MA. Addison-Wesley.

Park, Jack, and Patrick Durusau (2006). "Avoiding Hobson's Choice In Choosing An Ontology". Invited teleconference talk to the Ontolog Community, 27 April, 2006. Slides and mp3 online at http://ontolog.cim3.net/cgi-bin/wiki.pl?ConferenceCall_2006_04_27

Park, Jack (2007). "Just-In-Time Learning: A Tool-builder's Perspective". Invited presentation to the *Global HR Forum*, Seoul, S. Korea, October 25, 2007.

Park, Jack (2008). "Knowledge Federation as Knowledge Gardening". In *Proceedings of the First International Workshop on Knowledge Federation*, Dubrovnik, Croatia, 20-22 October, 2008

Park, Jack (2010). "Boundary Infrastructures for IBIS Federation: Design Rationale, Implementation, and Evaluation". PhD Thesis Proposal kmi-10-01. Knowledge Media Institute, The Open University, Milton Keynes, UK. Online at http://kmi.open.ac.uk/publications/techreport/kmi-10-01

Park, Jack (2010a). "Topic Merge Scenarios for Knowledge Federation". In *Proceedings Topic Maps Research and Applications, 2010*. In press.

Reynolds, R.G.; Stefan, J.M. (2003) "Web services, Web searches, and cultural algorithms", IEEE International Conference on Systems, Man and Cybernetics. Volume 4, 5-8 Oct. 2003, pp 3982 - 3987

Scott, Bernard (2001). "Gordon Pask's Conversation Theory: A Domain Independent Constructivist Model of Human Knowing." *Foundations of Science, special issue on "The Impact of Radical Constructivism on Science"*, edited by A. Riegler, 2001, vol. 6, no.4: 343–360. Available online at http://citeseer.ist.psu.edu/597969.html

Star, Susan Leigh. (1989). "The Structure of Ill-Structured Solutions: Heterogeneous Problem-Solving, Boundary Objects and Distributed Artificial Intelligence". In M. Huhns and L. Gasser, eds. *Distributed Artificial Intelligence 2*. San Mateo, CA: Morgan Kaufmann Publishers. 37-54

Twardy, Charles R. (2004). "Argument Maps Improve Critical Thinking". *Teaching Philosophy*, 27:2, 95-116. June 2004

Weik, Karl, (1995), *Sensemaking in Organizations*, Sage Publications, Inc.