

Social media supported innovation indicators

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<p>Summary</p> <p>Sindi stands for Social media supported indicators for monitoring and evaluating user driven innovation. Sindi was a two-year, Tekes funded project and a collaboration between VTT, Tampere University of Technology (TUT) and Stanford-led Innovation Ecosystems Network (IEN). Through a spectrum of cases from end-user level to city, regional, national, European and global level, the project worked to develop data-driven indicators for timely, actionable insights on user-driven innovation as well as the network structure and dynamics of different innovation ecosystems. A major part of the project was the development of data-driven methods for visual network analysis as well as the integration of the methods with the research paradigms of innovation, innovation policy and user driven innovation.</p> <p>As a result of the project, it was shown that social media provides data that can be used toward exploring innovation activities in various levels. Using social network analysis, novel types of indicators that can be called “blue sky indicators” were introduced for measuring broad-based innovation — in forms of network visualizations including network analytics; also other forms of visualizations, such as time lines, were seen to bring insights and support the network views. The project results have been communicated and validated through scientific articles, workshops arranged as well as formal and informal discussions with various stakeholders of the research.</p>		
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Preface

Sindi (Social Media Supported Indicators for User Driven Service Innovation) was a 2-year research project from Oct 2010 and to Dec 2012. It responded to spring 2010 Tekes call and funding with theme “from demand and user-driven innovation policy to action”. It was a collaboration project between VTT, the Intelligent Information System Laboratory (IISLab) at Tampere University of Technology (TUT) and Innovation Ecosystems Network (IEN) group at mediaX at Stanford University. The goal of the project was to develop and validate indicators for measuring the process and impact of user driven ICT supported service innovation. The project concentrated in exploiting the increasingly diverse digital *socially constructed* databases, and data collected from *social media* in indicator measuring, visualizing and meaning making. A major focus of the project was the development of methods and toolchains for the data-driven visual analysis of the network structure and network dynamics of selected innovation ecosystems.

As a result of the project, it was shown that social media provides data that can be used toward exploring innovation activities in various levels. Using social network analysis, novel types of indicators that can be called “blue sky indicators” were introduced for measuring broad-based innovation — in forms of network visualizations including network analytics; also other forms of visualizations, such as time lines, were seen to bring insights and support the network views. The results as well as processes towards them are described in the number of conference papers and other scientific papers produced during the project.

The Sindi team was strongly supported by the steering group consisting of the following members: Petteri Alahuhta (chair), VTT; Antti Eskola, TEM; Christopher Palmberg, Tekes; Outi Rouru-Kuivala, City of Oulu; Ilkka Ketola, Videra; Seppo Pohjolainen, TUT; Martha G. Russell, mediaX at Stanford; and Minna Isomursu, VTT. The team wants to thank all of them for their great advice and valuable support. Also, we want to express our thanks to: Case EIT ICT Labs, Prof. Marko Turpeinen; Case MEL at Metsokangas, with Otto Leskinen, Pekka Nivala; Case Erimenu with Terhi Hurme, Tarja Heimolehto, Kirsi Silius and Anne-Maritta Tervakari; Case Owela with Pirjo Friedrich and Kaarina Karppinen; Case Tekes Young Innovative Companies and Kari Herlevi, Soile Ollila and Risto Setälä as well to Finnvera’s Petri Laine. In addition, we want to express our deepest thanks for prof. Stephen Vargo for his insights; for Neil Rubens and Camilla Yu from IEN for their contributions; for Dr. Rahul Basole for his support and data; and for everyone else who we had the privilege to meet during the Sindi project.

In Oulu, 15.12.2012

Authors

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1. Introduction

The benefits and necessity of user driven innovation is already widely acknowledged. However, there is no or very little indicators to measure and follow the actual efficiency and impact of user driven innovation, or even innovation in general. Innovation indicators are intended to help us to better understand innovation and its relation to economic growth as well as provide for benchmarking (Oslo Manual), but problems with innovation measurement are widely acknowledged: Milbergs (2007) has concluded that “currently available indicators and measurement methods do not adequately describe in a timely manner the dynamics of innovation today”; OECD has called for “blue-sky indicators” (2006), and Nesta for reliable data for evidence-based policy (2008) etc.

Most of the prevailing methods for analysing innovation diffusion and impact are very much based on *ex post/retrospective* analysis which means they analyse the situation “after the fact” and cannot be used for monitoring and steering innovation work. Current indicators are based on statistically representative samples, often collected with dedicated surveys, as well as official financial corporate reports—and they rely on what companies already track, since many firms do not yet monitor their own innovation activities in a consistent manner (NESTA, 2008). In addition, current innovation indicators are oftentimes seen as incomplete, not addressing the intangibility of innovation, and too concentrated on organizational and national levels, with team levels and regional levels receiving little attention (Beck et al., 2008; Nilsson et al., 2010); they are seen to be lacking in detail and timeliness (Perani et al., 2006) and, perhaps most importantly, aggregate indicators, mean values and many other statistical indicators are not able to show the ecosystemic side of things, the networked structure of the ecosystem and the networks of relationships around and between the innovation actors.

Lack of indicators also makes the comparison of different methods of innovation and approaches for innovation policy development challenging. Thus, policy makers and other high-level innovation stakeholders insist timely, actionable innovation indicators that, at the same time, sometimes paradoxically, are consistent, repeatable, enable comparisons over time and between nations and regions. Consequently, companies are finding it difficult to choose the method(s) that would best fit their situation.

The goal of the SINDI project is to explore, define and validate social media supported indicators measuring the efficiency and impact of user driven innovation methods when developing ICT supported service innovations. Figure 1 illustrates the scope of the project.

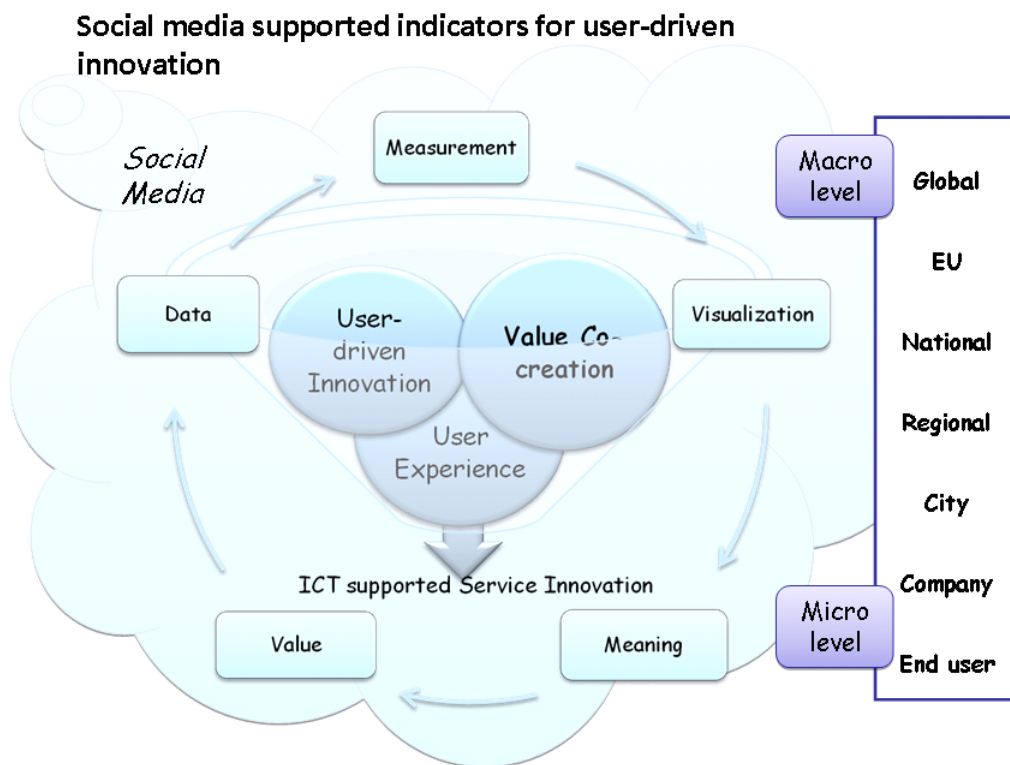


Figure. 1. Initial scope of Sindi project

If previously shortage of real-time innovation data was a challenge, this is no longer the key issue; the vast sea of data being generated through social media and other sources putting out openly available data is oftentimes addressed as information overload or big data “as the next frontier for innovation, competition and productivity” (McKinsey, 2011). In this project we argued that social media tools and platforms can provide faster and more flexible tools for monitoring the diffusion and impact of user driven innovation in both micro- and macro levels. Hence, the focus and the novelty of the research was in deriving indicators through extensive use of socially constructed data sources and measurement processes enacted with social media based solutions. Furthermore, methods of information visualization and social network analysis were used for analysing the diffusion of innovation and the structure, dynamics and evolution of value networks in the context of user driven innovation. As an end result, real-time and socially constructed indicators and social-media inspired user driven innovation measurement and visual analysis tools were developed.

2. Goal

The overall goal of this project was the design, implementation and evaluation of novel innovation indicators. Optimizing the impact of investments made by stimulus programs and public and private stakeholders is a quest shared by developers and decision makers around the world. Therefore, the objective of the project was to derive practical social media supported indicators, processes and tools for measuring, monitoring and follow-up of the impacts of user driven innovation in the context of ICT supported service innovations.

The project was structured into 4 work packages, each with their specific tasks. The expected results, as stated in the project plan, are also presented in table 1.

Table 1. Structuring of this project

WP	Task	Time	Expected results
1: Social media supported indicators for measuring the impact of user driven innovation (leader: VTT)	<i>1.1. Needs and requirements for indicators</i>	3 months/ VTT	Indicator needs and requirements
	<i>1.2. Indicator framework</i>	3 months(VTT)	Generic indicator and measurement framework Domain specific indicator and measurement frameworks
2: Impact analysis and meaning making support process and tools (leader: TUT)	<i>2.1 Measurement and impact analysis process</i>	2 months/VTT	Description of use of innovation indicators in selected contexts
	<i>2.2. Analysis and measurement instruments</i>	1 month/VTT 5 month/TUT	Analysis and measurement instruments and tools
	<i>2.3. Visualization, meaning making and value co-creation support tools</i>	2 months/VTT 9 months/TUT	Visualization, meaning making and value co-creation support tools
3:Evaluation (leader: VTT)	<i>3.1. Evaluation framework</i>	2 months/VTT 2 months/TUT	Evaluation framework
	<i>3.2. Evaluation at the field</i>	7 months/VTT 2 months/TUT	Revised deliverables, evaluation reports
4: Dissemination and communication (leader: VTT)	4.1. Dissemination	3 months/VTT 3 months/TUT	Web-based dissemination, workshops, roundtable discussions, scientific and other publications
	4.2 Management	1 month/VTT	project status reports, steering group meetings

The project results were first used by participating case organizations for analyzing the impact of selected innovation examples. Already during or immediately after the project, the goal is that the results of the project will be widely adopted in participating organizations and to be used outside the context of case examples used in the project.

3. Description

Earlier perception of innovation was limited to new products or technologies that were a result of in-firm R&D activities. Now, innovation is seen as a wider concept including service and process innovation and goes well beyond R&D units and even beyond the borders of individual companies (Crossan and Apaydin, 2010). New theoretical approaches have emerged, including: (a) user- and demand driven innovation as well as user innovation (Karat, 1997; Holmqvist, 2004; von Hippel, 1976; Franke et al., 2006), (b) open innovation (Chesbrough, 2003) and co-creation (Ramaswamy and Gouillart, 2010) (c) innovation networks and emphasis on multiple, independent actors (Kogut and Zander, 1996), as well as innovation ecosystems (Russell et al., 2011), and (d) service dominant logic for resource integration of actors (Vargo and Lusch, 2004; Vargo, 2009). Hence, the locus of innovation activities has changed, and many actors, most significantly users and consumers, are seen to be involved in it. Also the process of innovation is seen less linear, less waterfall-like, and approaches of agile methods and lean startup (Ries, 2011) are oftentimes applied. All this calls for changes in innovation measurement and management!

3.1 Toward ecosystemic thinking

Our systemic thinking recognizes the interactions among the many actors and other “determinants of innovation processes . . . that influence the development and diffusion of innovations” (Russell and Still, 1999). The ecosystem metaphor enriches the systems model with value and culture. Therefore, we use the term “innovation ecosystem” to refer to the inter-organizational, political, economic, environmental and technological systems of innovation through which a milieu conducive to business growth is catalyzed, sustained and supported. An innovation ecosystem is a network of relationships through which information, talent and knowledge flow through systems of sustained value co-creation. We use “social networks” to characterize networked individuals as sources of innovation in ecosystems. Networks are described by connections, or social links (Krackhardt and Hanson, 1993). Furthermore, we see that relationships are the channels through which resources flow, which has also been described in the flat-world economy (Friedman, 2005).

3.1.1 Through co-creation and shared vision

In our framework (figure 2), we have divided determinants, or elements of innovation ecosystem, into the categories of events, coalitions, impact, which all require shared understanding:

- We see that change-making events take place within the innovation ecosystem. Independently and individually, decisions are made and actions are taken in the context of existing relationships, practices, finances, policies and culture.
- Coalitions, or combinations, of various resources are key to innovation. According to Fung, Fung and Wind (2007), this ability to connect and manage competencies across a broad network of relationships is one of the most important meta-capabilities for a networked world.
- Over time changes are observed; these are important impact milestones

A shared vision develops among the coalitions and networks of people who perceive a synergistic future. It is this shared vision that enables people who are making individual and independent decisions to co-create value and accomplish transformation. Through these

relationships, shared meaning and dynamic trust develop into performance expectations about a shared future (Hagel and Seely Brown, 2005).

Translate, measure and transform an innovation ecosystem

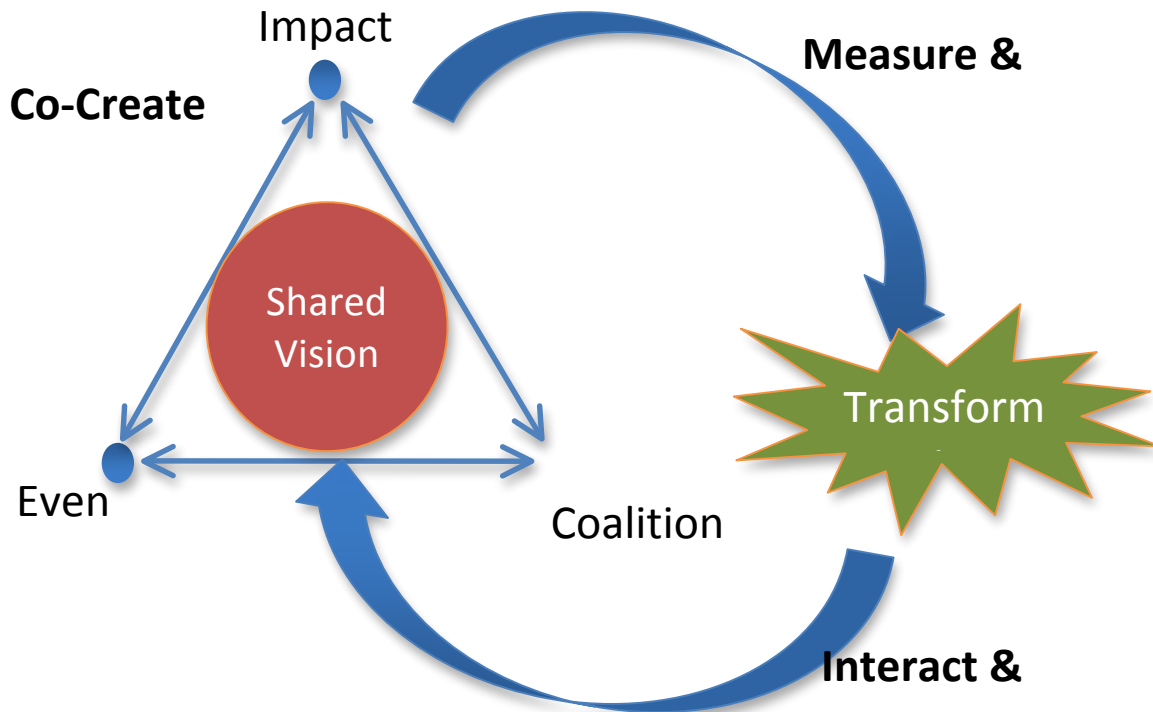


Figure. 2. Innovation ecosystems transformation framework (Russell et al., 2011)

Organisations receiving investment resources from the same financial resource may share complementary visions of the futures, complementary benefits from new technologies, and synergistic market development (Huhtamäki et al., 2011). In a like manner, organizations collaborating at board, task force and project team levels across government, academia and business sectors build and share complementary visions of the futures, complementary benefits from new technologies, and synergistic market development. The participation of executives and board members in two or more organizations with related missions, markets, products or social responsibility is a potentially powerful force for value co-creation.

3.1.2 Quest for transformation and visualizations

Transformation takes place over a period of time as synergistic relationships of people, knowledge and resources evolve in response to changing internal and external forces. Changes take place through the innovation ecosystem, which can be defined at many different levels of an organization, a community, a region or country. The capacity to continually co-create and maintain value is essential for radical adjustments to disruptive forces (Christensen, 1997) as well as for the harmonious evolution of incremental growth.

The transformative potential of the shared vision for an innovation ecosystem arises from new coalitions and network connections and the relationships on which they are based. Their shared vision is collectively realized and continually updated by the co-creation of events and their impact. The transformative potential of an innovation ecosystem lies in its capacity for continual realignment of synergistic relationships of people, knowledge and resources that promote harmonious growth of the system in agile responsiveness to changing internal and external forces.

Our data-driven approach is a vital element of our framework, and a key tool in understanding the transformation. This means that we believe it is important to gather data about the innovation ecosystem (events, coalitions and impact) and its shared vision so that the processes of measuring and tracking as well as of interacting and feedback can take place:

- **Measuring and tracking:** Indicators used to measure and track change in innovation ecosystems have been described by Milberg et al. (2007) in the white paper prepared for the US National Academy of Sciences. Additional refinements and prioritization of the impact of transformations in innovation ecosystems have been proposed by Still et al. (2011). As organizational and social structures in the innovation ecosystems have been represented as networks (Wellman & Berkowitz, 1988), with nodes (social system members) and links (relationships) connecting the members, measuring and tracking those with methods of social network analytics (SNA) becomes possible.
- **Interact and feedback:** Presenting and communicating about the results of measuring and tracking is a requirement for understanding the transformation. Through these visualizations (for example, network visualizations from SNA), the unknown becomes visible, and it can be used to refine the shared vision, simultaneously stimulating the next round of events.

Transformation can be activated and accelerated through the orchestration of these networks. The concept of network orchestration refers to a kind of “discrete influence” that addresses the interdependencies and flexibility of actors in the network (Rizova, 2006), enabling coordination of the innovation network and bringing out the innovation output (Dhanaraj & Parkhe, 2006). Whereas network orchestration is not at the center of this research, we see that catalyzing and optimizing networks of relationships relies on network orchestration through an action model of events, impacts, and coalitions that build a shared vision that empowers the transformation. The shared vision can be seen to contribute to the issue of innovation appropriability as well as network stability, therefore enabling better network orchestration.

3.2 With social network analysis

Addressing complex systems, here complex innovation systems or, in fact, innovation ecosystems including value and culture, as networks, allows us to study them as such. Therefore, if innovation networks need to be measured to be managed, then networks need to be measured, analysed and understood as networks.

Social network analysis is a research field studying the structure of networks as social actors. The basic idea of network analysis perspective is that social structures can be represented as networks, that is, as sets of nodes (social system members) and sets of ties connecting the members (Wellman & Berkowitz, 1988). It has been used for several decades to study the sociological relationship of people and organization, and its key statistics include centrality (indicating relative importance of a node within the network), number of components in the networks (indicating how fragmented the network is (Wasserman and Faust, 1994; Welser et al., 2007) and others. With the rise of consumer-generated content, social network analysis has been deployed to analyze communication structures, content and virality in social media (Welser et al., 2007).

The benefits of network analysis is in enabling investigators of networks to gain insight in the social configurations of the networks and helping them in communicating their findings to others (Freeman, 2009). Recently, Liu, Slotine and Barabási (2011) have showed that understanding the structure of a network is a key factor in the controllability of both engineered and real complex networks.

Oftentimes visualizations, such as investigations of the patterning of the network, are used for sharing the findings of the investigations with others. They can reveal insights of

individual nodes, organizations or the network in the whole, and can contribute toward decision making about innovation, therefore supporting innovation management in the networked level.

The existence and emergence of strategic value creation networks can be observed through network analysis of small, medium and large enterprises. Network analysis has been used to study the interdependence of industries and nations (Yim and Kang, 2008), as well as the dependence of innovation networks on knowledge flows (Owen-Smith and Powell, 2004).

4. Limitations

We recognize the fact that innovation indicators, social media, user-driven innovation, service innovation and innovation ecosystems (all themes mentioned in our research title) are all very general and varied topics. Our research has uniquely combined their research towards the goals of this study and the needs of the specific cases—and therefore our exploration into those themes is not intended to be considered comprehensive at each of the mentioned themes. For example, our ecosystemic approach and focus of networks has meant that we see individuals not only as users but as actors in the complex innovation networks.

Further, the scope that the project addressed is very broad, ranging from the analysis of the development process and usage of a mobile learning application in an individual school in Oulu, Finland to the European innovation ecosystem and, eventually, its connections to Silicon Valley, Israel and the rest of the world. At the same time, the scale is representative of the power of the approach taken: with effectively equal resources, one can study phenomena from small to large and from local to global.

Finally, it is evident that not all the data is available in social media and other openly available sources (naturally, our counterpoint is that not all data is available or used for current innovation indicators). Social media data is not “official data”, which has been first checked by the respective organizations and then officially released; it includes the opinions and emphasis of the individuals sharing it. Combined with the pace of sharing being fast, we acknowledge that there is a “social and public bias” in social media data.

5. Methods

We have taken an explorative research approach in the project, i.e. we have taken steps to describe the potential that digital data in general and social media data in particular provides for the new innovation landscape. This exploration into innovation indicators was conducted with methods of literature reviews and multiple case studies. These methodologies were used side-by-side in an iterative manner.

Literature reviews were conducted toward getting an in-depth understanding about the transitions related to concepts of innovation, innovation activities, innovation processes, innovation indicators as well as into addressing the data available on innovation activities. Also tools and methods, or “instruments” and their applicability to context of innovation were investigated during the study.

During our project, we explored needs and requirements for innovation indicators within 5 case environments (see below). Within these, our methods were action research oriented, as we aimed to support them and work with them in their innovation activities and in searching for relevant innovation indicators. According to our research theme, we concentrated on digital data related to our case environments, though we supplemented our understanding

with more traditional innovation research data data collected through interviews, surveys and videos as well as discussions with the members of our case environments.

5.1 Case Owela—*addressing end-user level*

Owela is an online innovation space that helps companies to co-design new and improve existing products and services based on consumer needs and ideas. It supports active user involvement in the innovation process from the the first ideas to piloting and actual use. It is developed and run by VTT.

Supporting end-users in their activities to create value for the client is the key aspect of Owela. As end-users are organized as a community, the Owela facilitator needs to manage the community toward project success.

Level:	End-users
Social media:	Content created by users using Owela as well as log data collected from the user activities
Need:	Supporting the community of users through better facilitation and communicating about the innovation process

5.2 Case MEL—*addressing city level*

MEL (Media Enhanced Learning) is an educational technology service developed by VTT that is intended to support learning by introducing media components to studies in various subjects, allowing learning in and outside the classroom using mobile phones and computers. It is being developed and used at Metsokangas School in Oulu. The city of Oulu being an important stakeholder as it is actively supporting the development of new technologies by creating new services, and towards this goal wants to understand the potential of MEL.

Level:	City-level
Social media:	Very limited presence on social media, some log data on the service is available
Need:	To address value of innovation process and its impacts for various stakeholders

5.3 Case Erimenu—*addressing regional level*

Erimenu.fi (translation “a special menu”) is a free web-based service for people with food allergies and other specialty dietary requirements. It is a hub of information on food products with more detailed ingredient lists than required by the European food legislation, and recipes specifically developed for specific diets. In addition, erimenu.fi automates the process of finding products and recipes for people that have specified their diet into the service. The service is also a simple social networking service that allows the users to construct public or semi-public profiles and share information of their favourite products and recipes with other users. Therefore, the content of the service is a mixture of content generated by end users and companies. Erimenu.fi has been active since 2008 and in May 2011 had over 5,000 registered users, and on average 7,000 monthly visitors (registered and non-registered users.)

Level:	Started on regional level, also impacting national level
Social media:	Its actors present in this website (log data available for web analytics) and its facebook page
Need:	To address measurability of collaboration with different partners, user statistics

5.4 Case Tekes Young Innovative Companies—*addressing national level*

The Finnish Funding Agency for technology and development, Tekes, has a major role in building and sustaining the Finnish innovation ecosystem, through funding and other services that it provides for individual companies as well as clusters of organizations. One example of its strategy giving priority to growth-seeking innovative SMES is “funding for young innovative companies” (YIC), supporting young companies for international growth. Through this program, Tekes not only provides funding resources, but also expertise and experience of its personnel, access to accelerator services, as well as its connections.

YIC was initiated in 2011, and is intended for a company that (1) has a capacity and willingness to strive for fast international growth, (2) has products or services that can generate considerable business, (3) has a credible growth plan, and a committed and skilled management team, (4) has been in operation for less than 6 years and is small, and (5) invests strongly in innovation activities.

The list of companies that are included in YIC program is provided publicly on Tekes website.

Level:	National level
Social media:	YIC- program companies present in social media
Need:	Collaboration of YIC companies, their linkages to others and to resources

5.5 Case EIT ICT Labs—*addressing European level*

EIT ICT Labs (<http://eit.ictlabs.eu>) is a major initiative intended to turn Europe into a global leader in ICT innovation, by establishing new types of partnerships between leading companies, research centres and universities in Europe. It started its activities in 2010 with creating the operational as well as judicial infrastructure; the year 2011 can be viewed as its first year in operation.

EIT ICT Labs initially built upon nodes representing five world class ICT innovation centres located in Berlin, Eindhoven, Helsinki, Paris and Stockholm; in 2012 Trento was added as a node, and London and Budapest are associated partners. The role of the nodes is to execute the strategy, by focusing on excellence in education, research and innovation, and based on the co-location of the best academic and industry researchers, turning already excellent regional clusters into world-class innovation hotspots.

Level:	Eu-level
Social media:	Its actors present in social media and in socially constructed data
Need:	To address measurability on its impact on the the European level and global level, for example: mobility, which is one key dimension

6. Results

The co-creation throughout Sindi brought results in many levels. New framework for thinking about innovation indicators was created (addressed as “paradigm shift”); the process toward indicators for innovation ecosystems presented (addressed as “data-driven innovation ecosystem visualization model”), and the novel social media based indicators were introduced. Throughout the project, the co-creation took place through writing of the papers for conferences and journals, which are also listed as results of the project.

6.1 Paradigm shift in innovation indicators

	Analog	Digital
Innovation	Companies R&D, closed innovation Few innovation actors New technology Tangibles Waterfall-model of innovation Patents, scientific publications, Number of new products	Networks of companies, (eco)systems Open innovation, co-creation Many innovation actors, including users New technology, new services, new processes, new products Intangibles Agile innovation, lean start-ups Time-to-market, scalability
Data	Surveys, company reporting Lack of data Structured data Statistically representative samples	Digital footprints of innovation actors Information overload Unstructured, unorganized, incomplete data Biased data
Indicators	Lagging behind Manual processes Table format, some graphs	Possibilities for real-time Economical computer-powered processes, though challenging Interactive, data-driven visualizations, network visualizations, timelines, geospatial representations, (eco)systemic level

6.2 Data-driven innovation ecosystem visualization model, emphasis on social network analytics

Previously, large amounts of data have presented challenges for data handling, data analysis and data representation as well as the related organizational processes. Even with computers in use, much of the data processing has been conducted by people: collecting data from different sources with surveys or even from secondary, already digital sources, cleaning, aggregating and analyzing data with spreadsheet processors and tools alike is laborious, thus making the work cycles long, from weeks to months to years. Now, the advancements of computing capabilities have made storing, analysing, presenting and even interacting with large amounts of data possible, fast, almost real-time and economical. Data-driven information visualization (Nykänen et al., 2007) is based on automating the visualization process with pipelines through which the data flows from raw data to multivariate, interactive dynamic representations at best in real time.

Traditionally, innovation information is presented in tabular formats, with some excel-supported graphs, with few dynamic and interactive features. The process of turning data into a dynamic graph or visual model has been seen as expensive, technically tricky and regarded as more of an experiment's end product than an every-day tool (Hadnazy, 2011). The increased computing power available inexpensively coupled with immense amounts of data, or big data, now affords new possibilities for the development of innovation indicators and their representation as visualizations.

Visualizations can help us “see through the forest of data”: they are more than pretty pictures as they allow for exploration of complexly interacting variables in real-time, as well as can reveal when instruments are not performing as intended (Hadnazy, 2011). Hence, for in-depth understanding, the power of visualizations comes from combining human strengths to the computational capabilities. Visual analytics addresses this, with the definition of “the formation of abstract visual metaphors in combination with a human information discourse

(interaction) that enables detection of the expected and discovery of the unexpected within massive, dynamically changing information spaces.” (Wong and Thomas, 2004, p. 20).

Figure 3 depicts the data-driven innovation ecosystem visualization model developed in the project. The collected raw data is managed locally to speed up the further steps of the analysis. Case- and question-specific projections of the data are created on basis of case-specific filtering options, e.g. the home office of a company, and the projections are transformed to different visual representations such as networks, timelines, and value distribution diagrams. Finally, the visualizations are operationalized with the help of tools and widgets, in our case e.g. with Gephi, NodeXL, Gexf-js, and Highcharts.

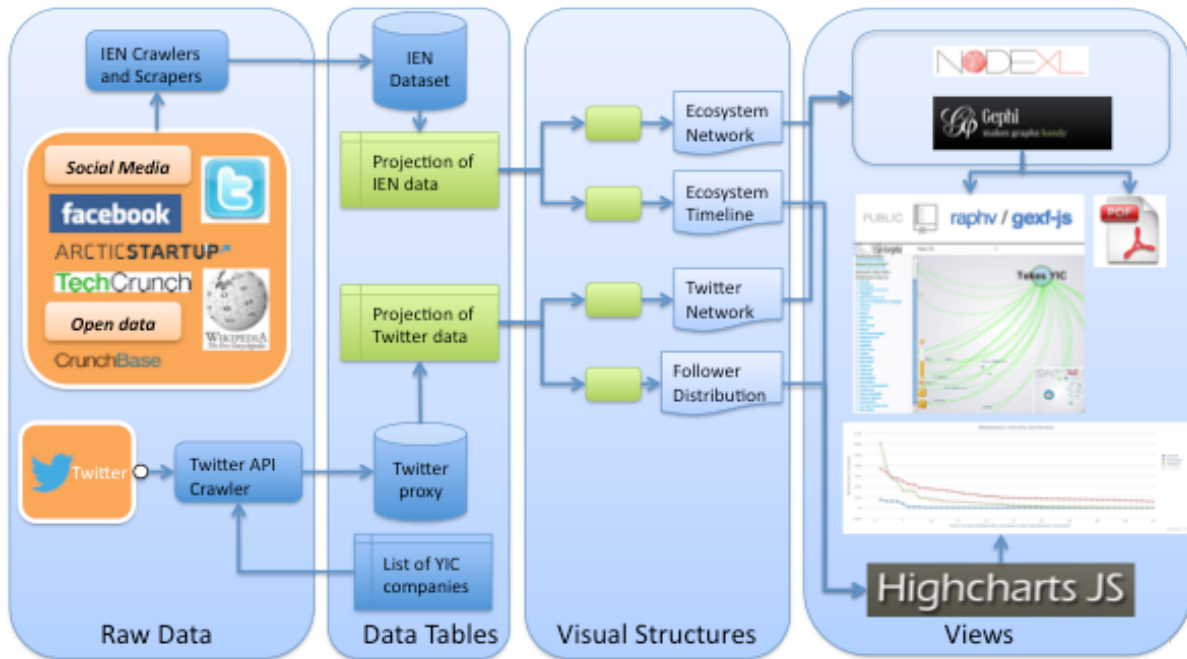


Figure 3. Our data-driven innovation ecosystem visualization model

IEN dataset, a key resource used in the project, is based on socially constructed data that people have chosen to openly communicate about, share and modify related to businesses and start-ups (Rubens et al., 2010). In summer of 2012, the set contained data about over 100,000 people, over 80,000 companies and 7,000 financing event.

Figure 4 shows the basic principles of network analysis process applied as part of the overall ecosystem analysis. After a network is constructed, it is laid out to reveal its structure. The different roles of network nodes are highlighted with the help of network metrics. Node betweenness, for example, shows nodes that act as bridges between different sections of the network.

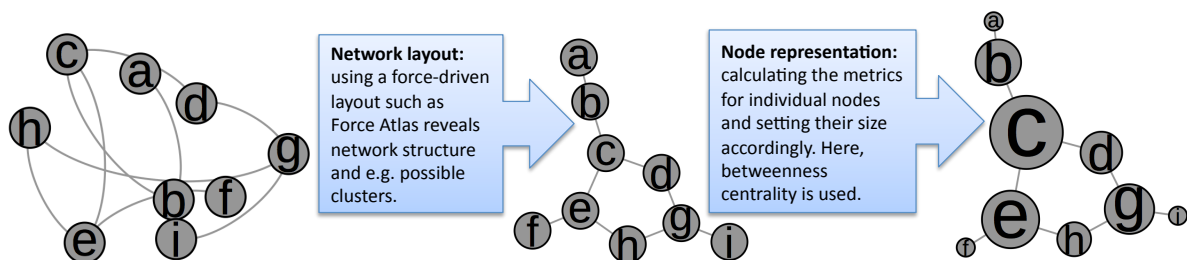


Figure 4. The two key stages of the network analysis process

6.3 Social media supported innovation indicators

The resulting innovation indicators are constructed using on social network analysis metrics (of which we concentrated on betweenness centrality) presented in forms of visualization, representing multimode networks, i.e. networks including multiple types of actors.

6.3.1 Examples of our novel, contextual innovation indicators

Figure 5 is a compilation a set of examples of visual innovation indicators developed in the project:

- **Top left:** Network of Tekes Young Innovative Companies and their Twitter followers (Huhtamäki et al., 2012).
- **Top right:** A sample of hashtags from tweets sent during CeBIT 2012 tradefare (not published).
- **Middle left:** The interconnections between innovation actors related to the six EIT ICT Labs nodes (Still et al., 2012; Still et al., 2011).
- **Middle right:** The interconnections between innovation actors related to Tekes YIC program on basis of IEN data (Huhtamäki et al., 2012).
- **Bottom:** Timeline analytics of the development process of the Multimedia Enhanced Learning (MEL) service (Still et al., 2012).

To read the network visualizations, the following helps:

- Nodes of different color represent different actors of the innovation ecosystem: investors are green, companies blue, individuals red, and universities are orange.
- The lines connecting the nodes represent relationships of nodes: individuals working for or having worked for companies, individuals affiliated with universities, investors investing in companies, companies buying companies.

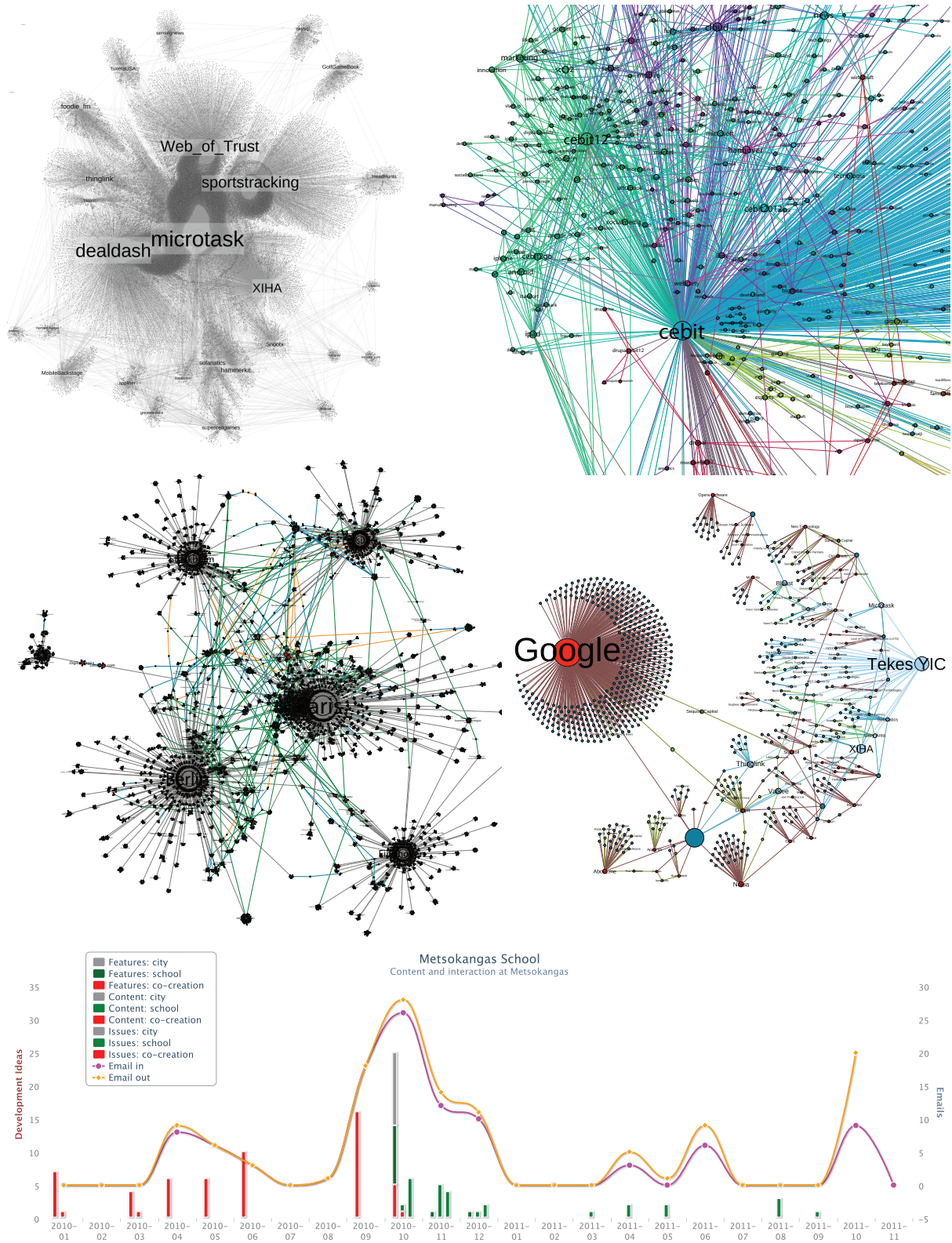


Figure 5. Examples of visual innovation indicators developed in the project

6.3.2 Value of our innovation indicators

Indeed, we have used network analysis more as a qualitative than quantitative means of showing and describing the different aspects of ecosystemic innovation, toward supporting human decision-making:

- More generally, visual network analytics provide means to model the skeleton of an ecosystem, bringing transparency to something that might be tacit (McKinsey 2011).
- It is important to keep in mind the fact that the person looking at visualization is able to observe many of the other metrics: the number of connections per node, the size, diameter, and density of the network and so on.
- Additional information can be inferred from the actors in the network such as the financial results of companies, the volume of the possible liquidity events, the size of venture capital fund, change in the number of people working for a company and so on can be projected on top of the network through node size, color or other visual properties.

Our experience shows that a straightforward way to allow interactive network exploration is to use network visualization widgets based on Web technologies, exposing variability and enabling experimentation (McKinsey 2011). Gexf-JS¹ presents an example of a useful tool allowing users to browse the nodes and links of a network that has been prepared with a chain of expert tools. An interactive version of the Tekes YIC network is available online: <http://bit.ly/browse-tekes-yic-network>.

Also, from a more narrow, quantitative perspective, network analysis introduces useful means for indicator development: diameter, density, cluster analysis, node count and other network-level metrics can be used to trace the changes in the ecosystem in the whole. To quantitatively evaluate the role of individual nodes, metrics such as degree, in-degree, outdegree, betweenness, clustering coefficient and other become useful.

Showing a rough sketch of a phenomenon is the important first step toward its modeling. The eventual objective in modeling is to enable simulation and prediction. To create a model of this level of detail, however, we need to first make sure that the different stakeholders see the model as valid. Here, policy makers, entrepreneurs, serial entrepreneurs, business angels, venture capital investors and e.g. education developers have a very different viewpoint, yet at best, they all should accept the created models.

6.4 Dissemination and publications

Much of the shared content about Sindi is available from “Sosiaalisen median tukemat käyttäjälähtöisen innovation indikaattorit” at Tekes Hankegalleria: http://www.hankegalleria.fi/tekes/?so_id=29507. In addition, the Tekes Policy Brief “Sosiaalisesta mediasta data innovaatiotoiminnan ymmärtämiseen ja mittaamiseen” communicates about the results from the policy perspective (also available from Hankegalleria).

List of publications (all of the conference papers were presented at their respective conferences; *the list is presented in chronological order*):

Huhtamäki, J., Russell, M. G., Still, K. & Rubens, N. 2011. A Network-Centric Snapshot of Value Co-creation in Finnish Innovation Financing. Open Source Business Resource, March 2011: Co-creation. Available: <http://osbr.ca/ojs/index.php/osbr/article/view/1288/1234>

Still, K., Russell, M. G., Huhtamäki, J., Yu, C. & Rubens, N. 2011. Gender and Innovation: Networks of Executive Women in Technology-Based Companies. Proceedings of Triple Helix IX Conference, July 2011, Stanford University. Available: http://www.leydesdorff.net/th9/THIX_Women_final.pdf

Still, K., Tervakari, A-M., Huhtamäki, J., Isomursu, M., Koskela, K. & Silius, K. 2011. User driven social innovation: roles and knowledge of university, business, government and the

¹ Gexf-js at GitHub: <https://github.com/raphv/gexf-js>

community of users in the case of a web based service. Proceedings of Triple Helix IX Conference, July 2011, Stanford University. Available: <http://www.leydesdorff.net/th9/TH-Erimenu-final-1.0.pdf>

Still, K., Russell, M. G., Huhtamäki, J. & Turpeinen, M. 2011. Explaining innovation with indicators of mobility and networks: insights into central innovation nodes in Europe. Proceedings of Triple Helix IX Conference, July 2011, Stanford University. Available: <http://www.leydesdorff.net/th9/THIX-InnovationEcosystemMobility-final.pdf>

Russell, M. G., Still, K., Huhtamäki, J., Yu, C. & Rubens, N. 2011. Transforming Innovation Ecosystems through Shared Vision and Network Orchestration. Proceedings of Triple Helix IX Conference, July 2011, Stanford University. Available: http://www.leydesdorff.net/th9/3NWAFYZH9_Russell.pdf

Yu, C., Russell, M. G., Still, K., Rubens, N., Huhtamäki, J. & Pöchko, J. 2011. Social Media, Reputation and Branding of Innovation Hubs: A Periscope Using Content Analysis of Twitter. Proceedings of Triple Helix IX Conference, July 2011, Stanford. Available: <http://www.leydesdorff.net/th9/Social%20media,%20reputation%20and%20branding%20of%20innovation%20hubs.pdf>

Huhtamäki, J., Russell, M. G., Still, K. & Rubens, N. 2011. Business Angels and Investment Organizations as Networked Co-creators in the Finnish Innovation Ecosystem. Proceedings of Triple Helix IX Conference, July 2011, Stanford. Available: <http://www.leydesdorff.net/th9/THIX-FinnishInnovationEcosystemCo-creation-final.pdf>

Still, K., Isomursu, M., Koskela-Huotari, K., & Huhtamäki, J. (2011). Social media-supported indicators for user-driven service innovation. Proceedings of VTT Symposium on Service Innovation, August, 2011, Espoo, Finland (pp. 208–217). Kopijyvä Oy, Kuopio 2011. Available: <http://www.vtt.fi/inf/pdf/symposiums/2011/S271.pdf>

Rubens, N., Russell, M.G., Perez, R., Huhtamäki, J., Still, K., Kaplan, D. & Okamoto, T. 2011. Alumni Network Analysis. In Global engineering education conference (EDUCON), 2011, IEEE, Amman, Jordan, 2011, 606-611. Available: <http://www.innovation-ecosystems.org/wp-content/uploads/2010/12/2011.educon.pdf>

Still, K., Huhtamäki, J., Isomursu, M., Lahti, J., & Koskela-Huotari, K. (2012). Analytics of the impact of user involvement in the innovation process and its outcomes. Case study: Media-Enhanced Learning (MEL) service. Presented at the 4th World Conference on Educational Sciences, February 02-05, 2012, Barcelona, Spain. Accepted for publication in Procedia Social and Behavioral Sciences, 2012. Available: <https://dl.dropbox.com/u/4026049/sindi/article/WCES-case-MEL-final.pdf>

Still, K., Huhtamäki, J., Russell, M. G. & Rubens, N. 2012. Transforming Innovation Ecosystems Through Network Orchestration: Case EIT ICT Labs. Proceedings of the XXIII ISPIM Conference – Action for Innovation: Innovating from Experience, June 17-20, 2012, Barcelona, Spain. Available: https://dl.dropbox.com/u/4026049/sindi/article/ISPIM-transforming-eit-ict-labs_v10.pdf

Basole, R. C., Russell, M. G., Huhtamäki, J., & Rubens, N. (2012). Understanding Mobile Ecosystem Dynamics: a Data-Driven Approach. Proceedings of the 11th International Conference on Mobile Business, June 21-22, 2012, Delft, Netherlands. Available: <http://dl.dropbox.com/u/4026049/sindi/article/ICMB-ecosystemdynamics-cameraready.pdf>

Huhtamäki, J., Still, K., Isomursu, M., Russell, M. G. & Rubens, N. 2012. Networks of Growth: Case Young Innovative Companies in Finland. Proceedings of the 7th European Conference on Innovation and Entrepreneurship, September 20-21, 2012, Santarém,

Portugal. Restricted access:

https://dl.dropbox.com/u/4026049/sindi/article/ECIE_Networks%20of%20growth_v10.pdf

Friedrich, P., Huhtamäki, J., Koskela-Huotari, K., Karppinen, K., & Still, K. (2012). Facilitating active participation in webbased co-development. Proceedings of Innovation through Social Media (ISM), December 3, 2012, Oslo, Norway. Available:

<http://www.tapironline.no/fil/vis/1086>

Still, K., Huhtamäki, J., Russell, M. G., & Rubens, N. (2012). Paradigm shift in innovation indicators—from analog to digital. Proceedings of the 5th ISPIM Innovation Forum, 9-12 December, 2012, Seoul, Korea.

List of workshops, seminars organized:

- “Innovation Ecosystems Summit”, Stanford, US, July 2011
- A thematic Workshop “Accelerating Trust through Telepresence: Relationship Resources and Triple Helix Dependencies for Co-creating Innovation”, organized at Cisco Headquarters in San Jose, for Triple Helix IX Conference in Stanford, US July 2011.
- Workshop “Visualizing Innovation Ecosystems” at MindTrek, Sept 28, 2011
- Seminar “Innovation Ecosystems in Learning Technologies and Education” at University of Electro-Communications, Tokyo, Japan on May 16, 2012

7. Validation of results

For our theoretical approach, validation meant tying our research to the research conducted by others. Especially valuable were discussions with prof. Stephen Vargo, who is a leading thinker in service innovation and a proponent of systemic understanding of exchanges between actors (service dominant logic). Also collaboration with visual ecosystem analysis scholar Dr. Rahul C. Basole allowed us to both broaden and validate our approach. In addition, with the progress of Sindi we noticed that our themes and approaches became more prominent in the publications. For example, in an article in Harvard Business Review October 2012 it is stated that: *“Data-driven decisions are better decisions—it’s as simple as that. Using big data enables managers to decide on the basis of evidence rather than intuition”*—corresponding very much to our data-driven approach that we developed and practiced throughout Sindi.

Within the specific cases and subsequent examples of social media indicators, we relied heavily on informal discussions and feedback from the stakeholders of those case environments as well as on workshops we arranged and the scientific conferences and other arenas throughout the project. Hence, about the validity and relevance of the results we heard comments like: “We are used to making decisions with data that is three years old”, “but can social media data be relied on”, “these are not real indicators”, “it is a nice picture but what does this mean?” and “we have never seen this before”, “this has really been eye-opening”. Generally, we noticed that network visualizations are not something that people are used to, and a lot of explaining was needed for people to understand what is included in the picture. Also, it seemed to be beneficial if people could see themselves, or their organizations, in the visualizations—corresponding to the visual network analysis strategy “start with what you know, then grow” formulated by an often cited information visualization researcher Jeffrey Heer (2005).

Due to the highly contextual and temporal nature of networks as well as the visualizations and indicators describing them, we did not utilize a formal evaluation framework in this initial exploratory study of innovation indicators. However, the overall feedback of the research project can be characterized as positive. For example, one of our papers got rewarded as “best paper” at ICMB2012, one paper was awarded as “best technology paper” at ISPIM

Seoul 2012; furthermore, at ISPIIM Seoul 2012 we heard from head of innovation at NSN that they are going to use our approaches at their work. We have been asked to present our ideas to various stakeholders, especially those of the Finnish innovation ecosystem, and to continue collaboration with them.

8. Conclusions

Sindi's quest for novel innovation indicators, specially in the context of including user (user-driven innovation) and widening the understanding of innovation to include service innovation, required thorough analysis of innovation activities and their measurement in general, as well as within case environments. Part of this understanding is captured in the paradigm shift presented above (addressing the need and possibilities of novel indicators) as well as in the process description, which highlights the use of various methods and tools, but also the need for human interpretation within the context.

The resulting novel indicators are visual indicators that exhibit the social network metrics (such as betweenness centrality and in-degree) in an intuitive, user-friendly way. Though we propose that these novel indicators can bring novel insights into innovation activities at ecosystem level as well as allow for zooming in to look at individual actors and their networked innovation activities, we recommend their complementary use together with other existing or emerging indicators. Furthermore, challenges remain in three different levels: (1) managing the data-driven process toward these new indicators insists seamless integration of its phases, requiring oftentimes special competences and tailored software components; (2) interpreting and comparing these new indicators required new kinds of processes as they might be context specific and in visual format; and (3) acknowledging the fact that even the novel big data based indicators tell us more about the history than about the future, which posits demands for even more advanced tools and methods to simulate or predict the future for support taking the what-if approach (Haas et al. 2011).

Overall, we agree with Kohlhammer et al. (2012) in that "visualization and visual analytics are vital for informed decision-making and policy modelling in a highly complex information environment overloaded with data and information". Hence, we propose that social media provides access to volumes of global, multipurpose, real-time digital data related to innovation activities in a cost-efficient manner. The visual representations based on these vast datasets are not intended to replace other traditional or emerging innovation indicators, but are seen to bring added value to understanding, managing and improving innovation activities, both on ecosystem-level as well as zooming to individual actors and their networked innovation activities. We see this adding to innovation management with possibilities of (adapted from McKinsey 2011):

- (1) Creating transparency, for example by making tacit information related to connections and relationships very explicit, or visible, through network visualizations;
- (2) Exposing variability and enabling experimentation and simulation;
- (3) Segmenting populations, or networked individuals, to tailored actions;
- (4) Supporting human decision-making with automated algorithms; toward innovating new business models, products and services.

9. Summary

Sindi stands for Social media supported indicators for monitoring and evaluating user driven innovation. Sindi was a two-year, Tekes funded project and a collaboration between VTT, Tampere University of Technology (TUT) and Stanford-led Innovation Ecosystems Network (IEN). Through a spectrum of cases from end-user level to city, regional, national, European and global level, the project worked to develop data-driven indicators for timely, actionable insights on user-driven innovation as well as the network structure and dynamics of different

innovation ecosystems. A major part of the project was the development of data-driven methods for visual network analysis as well as the integration of the methods with the research paradigms of innovation, innovation policy and user driven innovation.

As a result of the project, it was shown that social media provides data that can be used toward exploring innovation activities in various levels. Using social network analysis, novel types of indicators that can be called “blue sky indicators” were introduced — in forms of network visualizations including network analytics; also other forms of visualizations, such as time lines, were seen to bring insights. The project results have been communicated and validated through scientific articles, workshops arranged as well as formal and informal discussions with various stakeholders of the research.

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