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Networks of innovation relationships: multiscopic views on Finland

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Abstract: In this study, we present a solution for describing and visualizing networks of innovation relationships in the context of a single nation, in this case Finland. We resolve the limitations of separate datasets by building multiscopic views into networks of innovation relationships, using separate datasets as well as an aggregated dataset that federates them. We proceed to support the interpretation of these visualizations explaining context with network metrics as well as other descriptions. Our approach allows examining the relationships needed for value co-creation at various levels of the ecosystem as well as between those levels, providing novel possibilities for network orchestration and innovation management. Our practical suggestions include active communication and data sharing using a wide variety of media, and utilizing network views for targeted actions as well as for creating shared understanding and vision.

Keywords: Innovation; networks; relationships; multiscopic; Finland; metrics; data-driven; visualization; transformation; orchestration

1 Background

This research addresses the challenge of managing innovation in an increasingly global business environment. While there is a growing recognition that networks, relationships, and ecosystems are essential in understanding innovation today, very little is known about the character, role and impact of multilevel relationships (i.e. relationships between organizations, between organizations and individuals, and between individuals) on accelerating company growth and enabling a local to global context transformation.

Our research aims to fill this important scholarly gap by providing a "multiscopic" view of innovation ecosystems that allows for actionable insights into the complex, evolving relationship structure within and across multiple levels. These views are accomplished using separate, though complementary data about the various actors of the ecosystem, and especially with aggregating data representing them to explore the ecosystem. Through resulting network analytics and visualizations, we support the different stakeholders of the innovation ecosystem with their innovation management and network orchestration activities.

1.1 Networks of innovation relationships

The shift of innovation from a single firm toward an increasingly network-centric activity (Chesbrough 2003) has added significant complexities to innovation management. The importance of collaboration and value co-creation (Ramaswamy and Goullart 2010) and resulting networks of relationships (Kogut and Zander 1996, Vargo 2009) between individual and organizational entities (i.e. policy makers; educational institutions; venture capitalists, business angels and other investors; serial entrepreneurs; employees, managers and board-members of start-ups, growth companies and in established companies as well as the entities surrounding them) have consequently led to the study of innovation ecosystems (Iansiti and Levien 2004, Russell et al. 2011, Basole et al. 2012, Hwang and Horowitt 2012, Mars et al. 2012).

It is generally acknowledged that (networks of) relationships are at the core of innovation ecosystems shaping the behaviour and outcome of all stakeholders as well as the system-level effects (Hwang and Horowitt 2012). This perspective is further corroborated by Burke (2011) who argued that "Innovation is about people. Once you remove the obstacles to entrepreneurship, the most important ingredient is the network." The ability to connect and manage competencies across a broad network of relationships is considered as one of the most important meta-capabilities for a networked world (Wind et al. 2008) and is commonly referred to as network orchestration (Russell et al. 2011, Nambisan and Sawhney 2011).

1.2 Toward multiscopic views

The introduction of the network perspective, and especially that of social structures (Wasserman and Faust, 1994) as the defining characteristic of innovation ecosystems, allows for utilizing visual analysis of social networks for exploring innovation ecosystems and their clusters of unique actors and unique reciprocal links among them (Chandler and Vargo 2011). Visualizations enable researchers and other stakeholders to 'see' the structural context and the scalable influence of the context within market structures (Freeman 2009, Chandler and Vargo 2011), showing the connections of individual nodes, organizations or the network at large (Basole et al. 2011). Furthermore, ‘seeing’ with multiple layers of views, outlooks or perspectives offers advantages in addressing the inherent complexities of innovation.

There is very little theoretical understanding on how ecosystems emerge and evolve, or how to address innovation in multiple levels (Ahuja et al. 2011). Methodological approaches to quantitatively study these transformation phenomena have focused on event sequences at single levels in the biotechnology sector (Owen-Smith and Powell 2004), local innovation ecosystems (Hwang and Horowitt 2012), national innovation ecosystem (Huhtamäki et al. 2011), and knowledge-intensive industries (Iansiti and Richards 2006). Still, theoretical concepts of addressing multiple levels of innovation and their structures are available. For example Nahapiet and Ghosnal (1998) when talking about the dimensions of social capital, have introduced three distinctive levels, micro-meso-macro, addressing first individual contacts and personal relations, then social networks, and finally institutions. A similar naming convention can be found in research addressing resource integration and structurization of service ecosystems, in which levels are contexts that influence each other (Chandler and Vargo 2011), hence adding dimensionality to the networks and their visualizations. The micro-context is seen to frame exchanges among actors as dyads; the meso-context as triads (which are based on the dyad of micro-context); and the macro-context as complex networks (based on triads of the meso-context); with service ecosystems as meta-layers of context.

As the methods to explore ecosystems have developed, so have the computational capabilities that allow for managing vast amounts of data continuously generated by actors and their activities in innovation ecosystems (McKinsey 2011, Kohlhammer et al. 2012). This data can be accessible through company reports and other company filings (such as patent filings) contributing to official government data about companies, as well as in data shared or contributed to social media—all providing data that can link the entities of ecosystems together (for example by the alliances or other deals signed by companies, by linking individuals to companies where they are employed, etc.), and allowing for network and data-driven approaches.

2 Research methodology and findings: case Finland

Our earlier data-driven studies have revealed insights about ecosystemic innovation and its actors on multiple levels, for example about EIT ICT Labs at local and European level (Still et al. 2011, Still et al. 2012) and about the converging mobile ecosystem at the firm and individual level (Basole et al. 2012, 2013). However, showing the interactions between the different levels or perspectives has been historically constrained by the limitations of separate datasets.

In this study, we proceed to bridge the limitations of separate datasets by building multiscopic views into networks of innovation relationships, using separate datasets as well as an aggregated dataset that federates them. Hence, we are addressing validity, which is one of the key challenges of data-driven research (Barnes and Vidgen 2006). It can be managed with data-triangulation for building a richer, more complete picture of the phenomena under investigation and for validating and cross-checking findings, in particular when data from different sources point to congruent insights (Kaplan and Duchon 1988).

We apply a four-stage process for analysing a business ecosystem (Basole et al. 2013). It consists of (1) boundary specification for determining the primitives (nodes, relationships) of the networks as well as the analysis timeframe (2) metrics identification for selecting the appropriate social network and graph theoretic metrics for understanding the dynamics of an ecosystem, (3) computation, analysis and visualization toward analysing and visualizing temporal, relational ecosystem data, and (4) sense-making and storytelling, describing the processes from data to understanding and visual narratives for telling the story.

2.1 Boundary specification

This study concentrates on Finland. Though small, Finland is generally considered a vibrant innovation ecosystem which has been achieving high results in global rankings such as the Global Innovation Index (#4 in 2012) and the Global Competiveness Index (#3 in 2012-2013), with some very successful start-ups and growth companies (such as Supercell and Rovio) and some established companies with global presence (Nokia and Nokia Siemens Networks). In addition, in our previous research (Huhtamäki et al. 2011, Huhtamäki et al 2012) we have explored the Finnish ecosystem, and are familiar with it. Hence, we used Finnish companies and the ecosystem around them as our case for exploring data-driven network analytics at multiple levels between organizations and individuals. In this study, we focused on the recent five years of data (from Jan 1, 2008 to Dec 31, 2012) to provide timely insights and possibilities for comparisons of temporal changes.

Traditional company data sources tend to have data about the established, larger companies; start-ups and growth companies are oftentimes missing from that data. Therefore, we complemented Thomson Reuters' SDC dataset—one of the most prominent sources of inter-firm relationships (Schilling 2009)—with two datasets that reveal the relationships of start-ups and growth companies, IEN Startup and IEN Growth. These two data sources provide socially curated (or crowd-sourced) rich data about companies at the meso- and micro-levels, as well as individuals and investors related to them in almost real-time, though with "public bias".

For bringing out the variety of actors of the Finnish ecosystem and showing the specific types of relationship highlighted in each of the datasets, we use the micro-meso-macro naming convention. Founders and angels and their relationships with start-ups drive the microscopic view; executives and financing relationships with growth companies drive the mesoscopic view; and the macroscopic view is generated by the deals and alliances at the enterprise level.

Table 1 Data sources enabling multiscopic views

For	*Microscopic view*	*Mesoscopic view*	*Macroscopic view*
Source of data	IEN Start-up dataset: socially curated English language data from news, press releases, and social media; data on more than 100,000 companies and individuals; updated quarterly.	IEN Growth dataset: socially curated English language data from news, press releases, and social media; data on more than 100,00 companies and individuals; updated quarterly	SDC Platinum 4.0: proprietary (Thomson Reuters Financial) based on U.S. SEC data; more than 1.9 million financial transactions, updated monthly.
Ecosystem entities	Firms, investors, individuals: Time stamps on individuals; strong emphasis on datadated from 2010	Firms, investors, individuals	Firms
Types of relationships	Founders and angels: *prominent individuals and companies and their relationships with location "Finland"*	Executives and financing: *Finnish companies and their relationships*	Deals and alliances: *Finnish companies and their relationships to any company*

Going beyond the snapshots of relationship networks for innovation, provided by the lenses of these datasets, we then combined the three datasets toward an aggregate dataset. In the aggregated dataset, the three datasets in use are complementary but, at the same time, partly overlapping, necessitating a refinement and curation process similar to what is being applied e.g. in data journalism (Gray, Bounegru and Chambers 2012).

2.2 Metrics identification

The metrics for understanding the dynamics of an ecosystem are categorized based on the distinct but related levels of analysis: the network as the whole (ecosystem) and the node level (firm/individual) (Basole et al. 2013). As these metrics reveal insights about the types of links in the ecosystem as well as the structure of the ecosystem, we use standard metrics (density, diameter, components) to describe the whole network and network clusters of the Finnish ecosystem.

For understanding the roles of individual nodes (actors in the ecosystem), we use node degree and betweenness centrality. Node degree values show the number of connections for a given node, indicating its immediate connectivity and importance in the networks. The betweenness centrality value equals the number of times a given node appears in the shortest path from all nodes in the network to all others. Hence, betweenness centrality shows the importance of a node in bridging the different parts or components of the network together.

2.3 Computation, analysis & visualization

First, a projection was created for each dataset including the Finnish companies, their directly connected actors and interconnections between the actors, using time-span of 5 years. The result is a cumulative 1-step networks include all of the relationships formed during the timeframe. Next, an aggregate dataset was created from the three different datasets and duplicate entities for companies, individuals and other actors were merged.

As can be seen from the descriptions of the multiscopes (Table 2) with different views, the datasets included significant numbers of Finnish companies and their relationships with other companies, individuals and financing organizations. Using the metric of betweenness and degree as defining factors, the top 10 actors from each dataset were identified (note: following the practices and guidelines related to privacy, in this research we do not provide the names of individuals). Some actors were found to have positions as key connecting nodes in more than one view, suggesting interlocking relationships between the different levels. However, their roles were different.

Table 2 Descriptions of the multiscope of cumulative networks of case Finland

View	*Microscopic*	*Mesoscopic*	*Macroscopic*	*Multiscope*
Nodes	844	821	231	1698
Connections	883	824	186	1664
Network description	Directed relationships, multimode network	Directed relationships, multimode network	Undirected relationships, 1-mode network	Directed and undirected relationships, multimode network
Network metrics	density: 0.002 diameter: 15	density: 0.002 diameter: 18	density: 0.007 diameter: 4	density: 0.001 diameter: 16
Top 10 actors based on betweenness centrality	Startup Sauna Nokia Ind-PK SunyRide Ind-KB Ind-TT Transfluent Ind-JE Ind-AK Ind-VM	Nokia Ind-PK Ind-TT Ind-JE Applifier Mendor Finnish Industry Investment WOT Services XIHA Tinkercad	Nokia Nokia Siemens Networks Wartsila Metso Kemira Finnair Microsoft Outokumpu Stora Enso Ilmarinen	Nokia Ind-PK Startup Sauna Ind-TT WOT Services SunyRide Ind-JE Mendor Ind-AK Ind-KB
Top 10 actors based on degree	Nokia Startup Sauna Ind-AK Ind-TL Ind-TT Holvi Ind-PK Ind-JE Ind-KL Ind-VM	Nokia Blyk Fruugo Grand Cru Rovio Entertainment XIHA Flowdock Finnish Industry Investment Sofanatics Sulake	Nokia Nokia Siemens Networks Wartsila Finnair Tabuk Cement Alcatel Lucent Telefonaktie–bolaget LM NEC NTT Docomo Zecon Bhd Elematic Fujitsu	Nokia Startup Sauna Ind-TL Nokia Siemens Networks Ind-AK Ind-TT Grand Cru Holvi Blyk Rovio Entertainment

In the resulting visualizations (created using Gephi), the nodes (points) represent the various actors, with lines between them indicating relationships. The size of the node signals its role based on betweenness centrality. Node color shows its type: blue is for individuals, red for companies, green for investors, and light green for incubators. Finnish companies are highlighted in orange.

The macroscopic view highlighting enterprise level relationships (Figure 2) depicts a landscape of a rather loose network with many dyadic company relationships. However, its comparably higher density can be explained with its composition as a 1-mode network, where all nodes can be connected. Only a few Finnish companies are connected to more than one company. Both Nokia and Nokia Siemens Networks are shown as the most prominent nodes that have each collected a cluster of companies around them, emphasizing their role of connecting the Finnish ecosystem to the world. The cluster including players from more traditional industries – Wartsila, Metso and Kemira – indicates their connecting role both within Finland as well as globally. Interestingly, Rovio Entertainment, which by many is still regarded more of a growth company than an established company, is present in this view, due to its enterprise level relationships. Due to the nature of the data, all of the actors in the top 10 based on betweenness are companies, including Microsoft which is there due the its strategic alliance with Nokia.

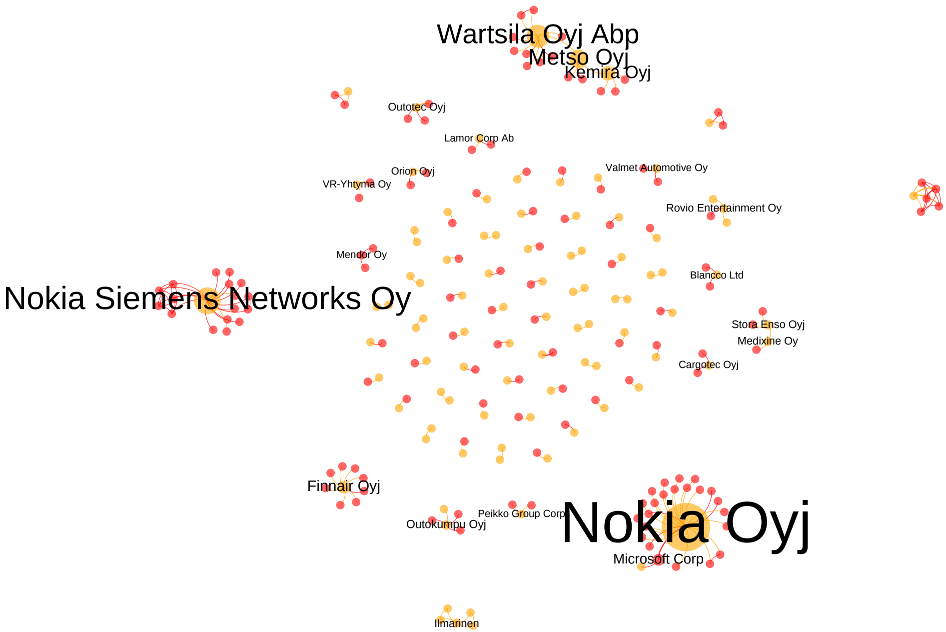

Figure 2 Macroscopic view highlighting enterprise level relationships

The mesoscopic view highlighting growth companies (Figure 3) shows many Finnish companies with relationships to 1-3 actors; it also introduces more complex, networked relationships, showing a chain of nodes connecting key nodes. The key nodes that act as bridges between various network actors are not only companies (such as Nokia and WOT Services), but include also prominent individuals—in their roles as company executives, advisors and investors—as well as financing organizations (Finnish Industry Investment).

For Rovio Entertainment, this view indicates the connected individuals as well as investors. Accordingly, three out of the top 10 actors based on betweenness are individuals. However, as degree measures the number of connections, all top 10 actors based on it are companies, including one financing organization.

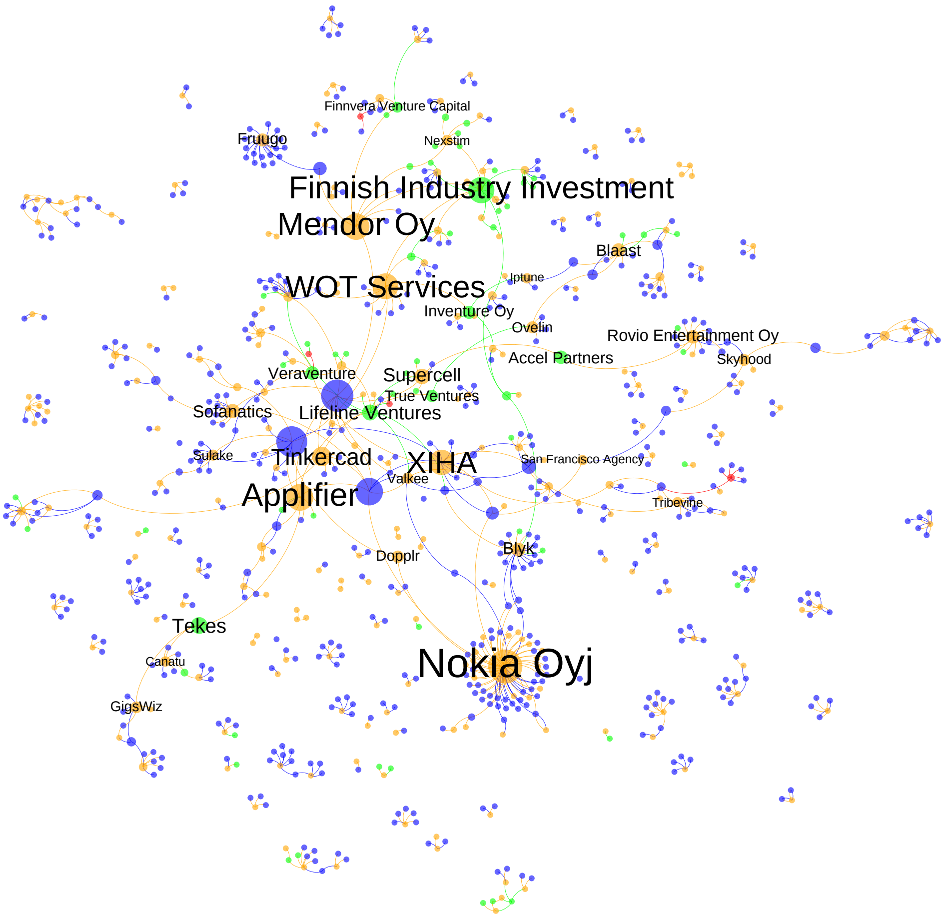

Figure 3 Mesoscopic view of growth companies

The microscopic view highlighting startup companies (Figure 4) illustrates an intricate web of connections within the Finnish ecosystem. In addition to start-ups, the key nodes now include prominent individuals (in roles of founders, advisors and angels) as well as a business incubator, Startup Sauna, reflecting this particular incubator's role as active advocate of start-up culture as well as home for start-ups, a place for building relationships. Six out of the top 10 actors based on betweenness are individuals. Highlighting the emphasis on individual connections, most of the top 10 actors based on degree are individuals. The role of Nokia is again important, as individuals with Nokia background are connected to other companies and thus interconnecting the Finnish ecosystem. As this view is drawn from data centered on individuals and their relationships to startups, a number of non-Finnish actors are introduced.

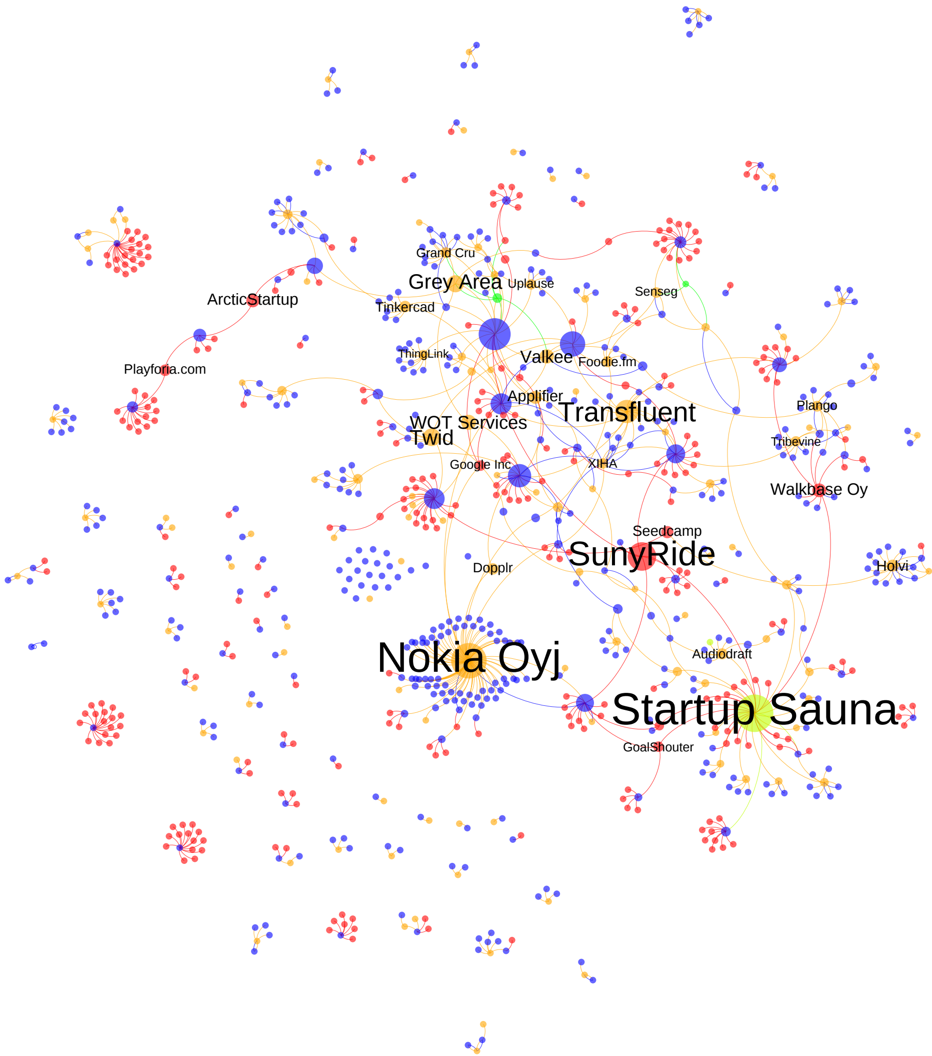

Figure 4 Microscopic view of start-up companies

The aggregated network depicts an ecosystemic view of Finland (Figure 5) as it combines the Finnish companies from the three separate datasets, and shows their direct connections. Hence, for the first time, we can see in a single visualization the founders and angels, executives and financing organizations, as well as companies from start-ups to established enterprises. Overall, key actor of the ecosystem with the highest betweenness centrality is not surprising: Nokia is the super-node underscoring its connective role in the Finnish ecosystem. Accordingly, the same companies, financing organizations and individuals that have been prominent in previous lists and visualizations are highly visible in this ecosystemic view. As the weight of data from the micro and meso levels is greater, the top 10 of actors in the ecosystem based on their betweenness as well as degree includes a significant number of individuals. There are 7 shared nodes between micro and macro views; 184 between micro and meso views; 10

between meso and macro views; four nodes appear in all three views: Rovio Entertainment, F-Secure, Mendor and Nokia.

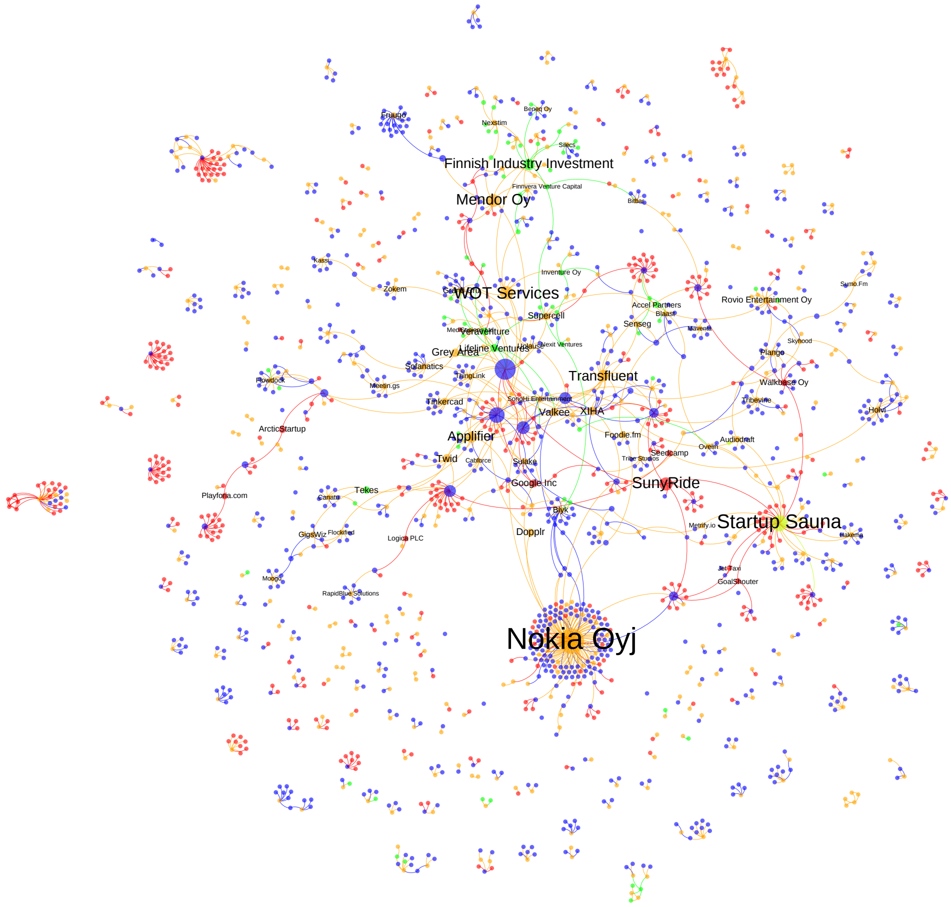

Figure 5 Aggregate view to the ecosystem

2.4 Sense-making & storytelling

Our visualizations of metrics and networks can be seen to model the skeleton of an ecosystem. However, they rely on human insights for emerging "sense-making" as well as for forming narratives and telling the stories that help stakeholders view and interpret the images. The visualizations are highly contextual and, for most stakeholders, are interpreted in the context of the user by the user's actions such as inspecting, ranking, comparing, categorizing, inferring, associating and correlating (Xu et al. 2009). They make knowledge about existing networks explicit, however, the interpretation and understanding of the visualizations is built on tacit knowledge and ground truths of individuals investigating them. Hence, providing information to support users in sense-making is essential. Additional multiscopic context with explanatory insights about the data sources as well as processes used for curation and visualization can be used for improving the sense making processes. For example:

- Understanding the different sources of data (Table 1)—official, curated data vs. socially constructed data with public bias—and their impact on richness as well as timeliness of the data can build insight for interpreting the multiscopic views drawn from the aggregate dataset. It is also important to point out that this data is based on English language sources.
- The metrics presented (Table 2) about the primitives of the network (number of nodes and connections) indicate that each of the three separate datasets provide only a limited view into the multitude of relationships of Finnish companies, both in Finland as well as globally. At the same time, by showing the numbers of shared nodes—entities that are present in more than one view—it makes visible the existing interconnections between the different views.

Overall, the visualizations highlight the small scale of the Finnish innovation ecosystem. Furthermore, the blue color dominating the overall ecosystem indicates that a small group of individuals form the interconnecting core of the ecosystem. Nokia continues to be the focal point of the network. With some exceptions, investment organizations and venture firms, shown in green, are scarce in the ecosystem. These insights are not new as such but our results show, for the first time, a complete structure of the Finnish innovation ecosystem with a federation of three different data sources.

3 Discussion

This study presents a solution for describing and visualizing an innovation network on multiple levels. The benefit of the visualization approach is that tacit knowledge about the intangible nature of networks becomes visible and shared. Our data-driven visualizations using separate and aggregated data provided multiscopic views on one country, in this study Finland. With additional contextual information, the analytical process was communicated to the observer for supporting the subsequent intepretations processes of sense making and storytelling. This allowed for understanding the scope and limitations of the explicit mapping of relationships, and tracking the changes with the context of Finland, based on this particular data using these particular processes toward data-driven visualizations.

We believe that the benefit of the multiscopic views approach lies in the dimensionality of the overall network that can be understood by considering various levels of the network but also by considering the holistic network. The combined results of the visualizations and interpretations can be used to examine the relationships on various levels with expanding network connections toward understanding the ways relationships have begun to converge. Hence, they provide competitive intelligence and insights into a coherent ecosystem. Using separate and aggregated data, the visualizations of micro, meso and macro levels span from startups to growth companies to established companies for perspectives on company maturity, and traverse toward systemic behavior and outcomes on the ecosystemic innovation.

3.1 Implications for data sharing and data management

We have entered the era of both big data and open data. The success of individual startups, incubators, investors and other innovation ecosystem stakeholders is increasingly dependent on their visibility. We encourage the different stakeholders to make sure that the data representing their key relationships is present in public sources, such as Wikipedia, Angel List, Crunchbase and services alike. Moreover, we harnessing these sources of data for ecosystem analysis in micro, meso and macro level to keep the knowledge of the surrounding ecosystem up to date. For example, our visualizations highlight the role of Startup Sauna in the Finnish innovation ecosystem—however, there are rather successful business incubators also in cities such as Tampere and Oulu that have been noted press-worthy both nationally and internationally but yet do not appear regularly in socially constructed data.

Theoretically, this study contributes to our understanding of how large, disconnected, potentially complementary structured and semi-structured datasets can be leveraged for insight, exploration, and discovery, and how ecosystem complexity can be analyzed and results visually communicated. For the scholar interested in innovation ecosystems, this approach to holistic multiscopic ecosystem analysis invites the exploration of dynamic multiple networks and forces of transposition and refunctionality (Padgett and Powell 2012), such as those elaborated by Padgett (2012) in his analysis of Renaissance Italy. It begs the fundamental questions of emergence and transformation.

For the practitioner, we emphasize that (a) the dataset, (b) the filters for creating the projections, (c) and the rules for creating the connections from the data and for including and excluding nodes, all have an impact on the network metric values and the resulting views. For this reason, we argue that the data acquisition and analytical process should be transparent so that the observer can not only react to the static snap-shot of the network, but can interact with the views created and also with the processes used to create them. With these insights, a social media savvy company can for example easily connect more individuals to their company by publicly sharing company information, and this may make the company more visible in network visualizations, with an impact on increasing the betweenness value of the company.

3.2 Implications for innovation management and policy-making

With the data-driven visualizations, descriptions of the current relationship-based links of the network are revealed, allowing observers to see visual indicators of the broad systems of value co-creation. As each of the resulting visualizations shows a different aspect of the ecosystem, according to the Finnish ecosystem stakeholders, the insights that come from visualizing the "invisible" provide concrete possibilities for improving network orchestration. These activities also provide an opportunity for various stakeholders to come together to discuss their interpretations of the visualizations. In addition to contributing to the understanding of elements and processes shaping the transformation of innovation ecosystems, the process can enhance the discussion about global relationships by company stage (startup, growth, establishment) as well as contribute to the national level discussion of the local-to-global relationships within the Finnish innovation ecosystem.

As influential and connecting actors of the ecosystem are revealed, they can be contacted and included in discussions and other tailored actions. Furthermore, they can be targeted: used for benchmarking activities or for learning about “best practices”, for regional as well as national levels of development. Hence, visualizations and supportive contextual information provide practical tools for innovation ecosystems stakeholders, as well as methods toward the controllability, manageability and orchestrability of the network.

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