Process for Measuring and Visualizing an Open Innovation Platform: Case Demola

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ABSTRACT
Open innovation breaks the traditional pattern for developing new innovation leading to new business and the activities toward it. Consequently, new requirements are posed to innovation measurement. Demola is an open innovation platform that takes real-life problems from companies and other organizations and puts together and facilitates projects where students from different universities come together to solve the problems. This paper describes a set of network visualizations and animations that were developed in co-creation with the Demola operators to make visible the activity that Demola has initiated. Moreover, the development process used to design the visualizations and the technical process that was applied are described and discussed. We claim that static network visualizations and animations of an open innovation platform development are useful in presenting, describing, marketing and selling the platform for existing and new stakeholders. Our experience shows that in order to develop visualizations and animations that meet the requirements set by the different stakeholders, an iterative and incremental development process is needed. Moreover, we claim that taking a data-driven approach to visualization development is a key enabler in supporting the development.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentations**]: Multimedia Information Systems – *animations.*

General Terms
Management, Measurement, Documentation, Performance, Design, Economics, Experimentation, Human Factors.

Keywords
Innovation ecosystems, co-creation, open innovation, information visualization, dynamic network analysis, animation, data-driven analytics.

1. INTRODUCTION
Carlson and Wilmot, among others, underline the critical nature of innovation: "Nothing is more important to business success than innovation" [6]. New approaches to innovation break the traditional patterns of in-house R&D. Innovation is nowadays seen to focus around customers, services and business models rather than solely around technology, in combining existing technologies and solutions with human knowledge resources from multiple sources, oftentimes outside of the boundaries of established companies. The multitude of theoretical approaches to innovation and the consequent paradigm shift place new demands for measuring innovation activities and their impact [14]. However, little research addresses the practical implications of creating and using these novel measures.

This paper describes the process of creating novel means of measuring open innovation developed for the context of an innovation ecosystem called Demola[1], an open innovation platform in Tampere, Finland. A Network Analysis and Visualization (NAV) process model [7] was applied and evaluated in a co-creative manner with the Demola team, resulting in network visualizations and animations that demonstrate the innovation activities and their impact.

1.1 Case Demola
Demola is an open innovation platform established in 2008 in Tampere, Finland. It puts together and facilitates innovation projects in which students from different universities, with backgrounds in different fields and cultures, come together with company representatives to solve company-initiated real-life

[1] Demola Tampere: http://tampere.demola.fi/

problems, challenges and new openings for the company portfolio [9][13]. By the beginning of 2013, 86 companies and 3 universities, with a total of about 1200 students, have participated in more than 250 projects. These projects are seen to energize the surrounding, larger ecosystem as they encourage the stakeholders to take alternative approaches to innovation work.

Nowadays, Demola is a part of Uusi Tehdas/New Factory[2], a platform for several initiatives supporting startups, innovation and business creation in different phases. Recently, new Demola sites have been opened in Oulu, Finland; Budapest, Hungary; Vilnius, Lithuania as well as in East and South Sweden. This study concentrates on Demola activities in Tampere, Finland. Demola projects from the other sites are excluded here as are all other connections Uusi Tehdas/New Factor has had a role in facilitating that are not directly related to Demola projects.

In Demola many of the traditional innovation metrics (changes in company turnover, the number of patents, companies or scientific publications created, or the amount of new product launches) cannot be easily tracked down to individual projects or even to the organizational level. In fact, many Demola stakeholders see these to be less relevant to the core activity. Still, Demola needs to communicate about its activities and impact internally as well as externally.

1.2 Network visualization process

As network visualization and animation tools have developed, interest in visual analysis of dynamic networks has increased [3][10]. More recently, the developers of an open source network visualization and exploration platform Gephi [2] have implemented functionalities that support dynamic network analysis and animation of network evolution over time. One of the more recent examples of visualizing network evolution, more specifically network construction, is the retweeter network of the Egyptian revolution that a developer was able to capture by incident [11]. The video has raised interest certainly among network analysis enthusiasts.

Whereas we draw from existing work on visual analytics and component-based data processing pipelines for visualization [11], we found the Network Analysis and Visualization (NAV) process model [7] to be a suitable framework to structure the process of this exploration. We see the NAV process model includes the steps of general information visualization reference model [5] that provides a framework for the technical process needed to make the process data-driven and reproducible in an automated manner.

According to the NAV model, the network analysis process starts from defining the goals of the analysis, after which data can be collected and structured. Next, an interpretation of the collected data is done by defining rules to transform the data into a network format. Producing an insightful network representation requires iterating over the steps of 1) laying out the nodes of the network, 2) possibly filtering the data and 3) adjusting the visual properties of the nodes and edges of the network. Different SNA metrics such as node degree can, for example, be used to define node size or color. Importantly, reaching a result that meets the requirements set by the different stakeholders of the visualization process insists on following iterative and incremental development process.

[2] Uusi Tehdas/New Factory: http://newfactory.fi/

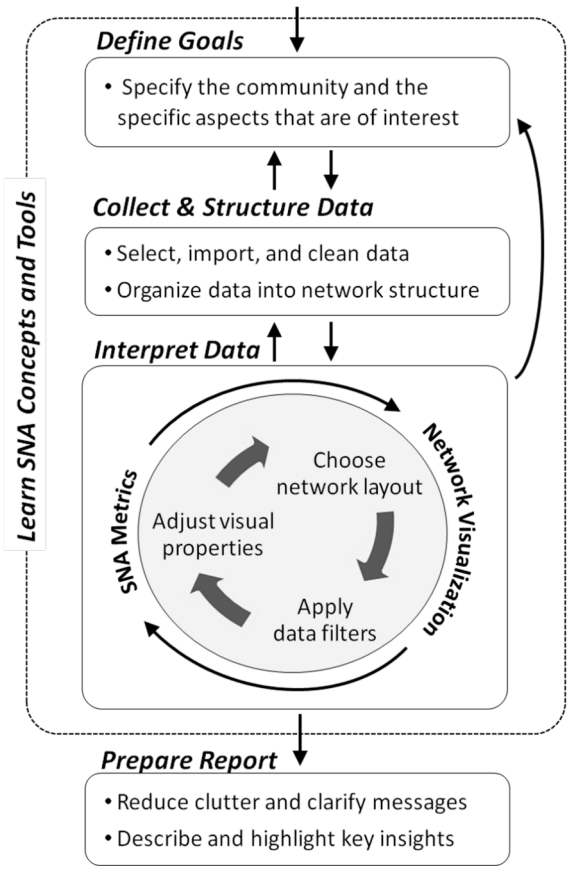

Figure 1. Network Analysis and Visualization Process Model [7].

2. Research method

As we have applied the visual network analytics paradigm for providing insights on innovation ecosystems in national [8] and European level [15][16] as well as within e.g. mobile domain [1], the network approach allowed us to reuse and refine our existing processes to the context of an individual open innovation platform.

In this research, an action research approach was followed to make an inventory of the key challenges that the members of the Demola team face in measuring and communicating about their innovation activities and the impact of those. The most part of visualization and animation development was conducted by a team of three including 1) a person with deep knowledge on Demola vision, mission and strategy, 2) a person with specific knowledge of the existing system used to manage project data, and, 3) a person with knowledge on applying visual network analytics for innovation ecosystem analysis and visualization.

2.1 Defining goals

Due to the interconnected nature of the Demola platform as a co-creation space between companies and teams students from different universities, taking a network approach for visualizing Demola activities was found to resonate with the operators and decision makers at Demola. Hence, in this study, we used NAV to develop new instruments for making the activities and impact more tangible and transparent to its different stakeholders, existing and new in the context of Demola.

Whereas the approach taken was seen promising also in providing value for operative tasks within the team running Demola, this study focuses in measurements and related visualizations that are targeted for stakeholders external to Demola. The target audience includes students, company representatives, university representatives, policy makers, without excluding general public.

Use cases for the visualizations include:

- Demola team member giving a presentation on Demola demonstrating existing Demola partners and processes. Audiences are heterogeneous and the specific needs vary accordingly. General introduction, marketing, sales. Requires "tailored storytelling" at best, for example pulling up and focusing into specific actors in the overall network, thus e.g. a fixed video is not an optimal solution.
- A student wishing to know more about Demola visits Demola website and plays a video showing the Demola process with real data on projects.
- A company representative is planning the first engagement with Demola. Browsing through the website, the person is interested in knowing more about the previous projects, the companies involved, the types of students participated and about the topics tackled.
- A policy maker is interested in the impact that Demola has had to the surrounding ecosystem. He or she visits the website, plays a video and makes an appointment with a Demola representative to discuss the specifics of the insights of the dynamics that the video provides. During the meeting, the dynamics are investigated in detail.

As the use cases demonstrate, several requirements are posed to the visualizations and animations going beyond individual static snapshots of the actor networks and even ready-made animations available in video format.

2.2 Collect & Structure Data: Demola Projects

Demola runs a dedicated Drupal-based web-based platform for setting up new projects as well as for running existing ones. During the first planning sessions, it became evident that Demola already collects and produces a useful data trail on projects.

Table 1 shows the structure of the data. As is often the case, new usage scenario for any set of data poses additional requirements. The data schema remained in practice the same from the beginning of the process but particularly the enumerated values for project key areas had to be harmonized over the course of the development project.

Table 1. Project data example

Project Detail	Example
Project Id	Project 115
Name	Koukkuniemi 2020
Started	2010-05-04
Ended	2010-10-31
Status	Completed
Collaboration Partner	City of Tampere
Type of Partner	Public
Project Domain	Non-profit
Location	Tampere
Key Areas	well-being, knowledge management, regional studies
Project Team Members	uta, uta, tut, tut

The start and end times of the project enable temporal analysis. Project status allows filtering in only project that are completed without loosing information on projects that e.g. were proposed but never started. Key areas field includes a comma-separated list of the areas that Demola operators have assigned for a project. The areas are selected from a curated list of domains for more specific semantics. Project team members are anonymized but their university affiliations are kept through listing the each university as many times as there are team members affiliated with a given university.

In this case, project data was the sole raw data used. The data was exported from the Drupal-based Demola platform with a tailored batch script and serialized in CSV (Comma Separated Values) format for further processing in a harmonization process. While less error-prone and more expressive formats for representing the data exist, CSV allows the use of general spreadsheet processors and other analysis software for managing and refining the data. A team of two Demola operators that were familiar with the origins of Demola as well as its evolution over the years conducted the harmonization process with simply using their collective recall and a spreadsheet processor as the refinement tool. Missing timestamps as well as some other inconsistencies were also fixed.

2.3 Interpret Data: Project Networks

While we realize that the project data available allows various kinds of analysis, the network approach was selected as the sole approach for this particular study. Projects, collaboration partners, project team members and their universities are all intuitive candidates to be used as network nodes. In addition, we decided to use nodes for representing the project key areas.

Whereas the NAV process model leads to the creation of a report of the network analysis results, our aim was set to developing static, interactive and animated network visualizations for a set of audiences with particular requirements. More specifically, our main objective was to develop views that allow insights on the immediate impact that Demola has had through its projects.

The technical implementation of the visualizations is an interplay between tailored code and the use of pre-existing tools. Whereas the technical process for creating the visualizations and animations is simplified, it does follow the logical steps of the information visualization reference model [5]. The model defines four steps for information process: First, Raw Data is collected. Second, Raw Data is refined into Data Tables that allow straighforward processing. Third, Data Tables are transformed into Visual Structures from which, finally, Views are created for representing the data. Importantly, the model states that at best, a visualization user should be able to interact with all the four steps of the process.

To create the Data Tables, data was exported from the spreadsheet processor used to refine the data in CSV format and a simple Python script was implemented to parse the data for further processing. After the refinement process, data was ready for the creation of Visual Structures, here networks. The interpretation rules were implemented in Python and NetworkX[3], an expressive Python library for analysis of complex networks, was used to help in constructing the network representations. The Python script is set to serialize the constructed network into files following Graph Exchange XML Format, in short GEXF, allowing e.g. the representation of dynamic networks.

For network visualization, i.e. the final part of the information visualization process, View Creation, we used Gephi. Gephi is an open source platform for explorative network analysis and visualization [2]. Gephi developers' original object to develop "the Photoshop for networks" has extended to include dynamic network analysis as one of its key features. Network visualization is an interactive process in which, as the NAV process model suggests, network layout, data filtering and the adjustment of visual properties are applied iteratively to create insightful views into the network. As its rapidly increasing popularity[4] indicates, Gephi provides all of the key functionalities required for network visualization.

2.4 Preparing Report: Static and Dynamic Visualizations

As result of the iterative and incremental co-creation process, a set of static network visualizations and a dynamic animation of network evolution were created.

2.4.1 Static Network Visualizations

Instead of creating one network including all the possible combinations between different types of nodes, two separate networks were constructed.

Firstly, the Project Network (Figure 2) is composed of companies, project and universities. It includes the three universities at its core. Each project is represented as a node and connected to all the universities from where project team members are from. Companies are connected to each project that they are involved in.

Network metrics are used to highlight features of the network. Node sizes indicates its connecting role for the whole network: the size is defined on basis of node betweenness value, i.e. the number of times a shortest path from all network nodes to all others goes through a particular node. Edge width shows the weight of the connection, i.e. the number of students that participated in a project from a given university.

A force-driven layout algorithm is used to define the position of each node in the network. The basic principle of force-driven layout is simple: nodes are programmed to repel each other and connections between nodes act as springs pulling them towards each other. In the resulting view, nodes that have the most interconnections are often placed close each other, thus revealing the overall structure of the network. The overall structure of the network is further highlighted through node colors showing the cluster of nodes in the network that particular node is included in with the exception that company nodes are always light green. Gephi's implementation of the modularity algorithm [4] is used for cluster analysis.

Secondly, the Domain Network (Figure 3) also starts from the three universities. Again, universities are connected to project nodes through project team member affiliations. Key areas are represented as nodes and connected to each project that has mentioned them. Finally, collaboration partners are connected to projects that they have been affiliated with.

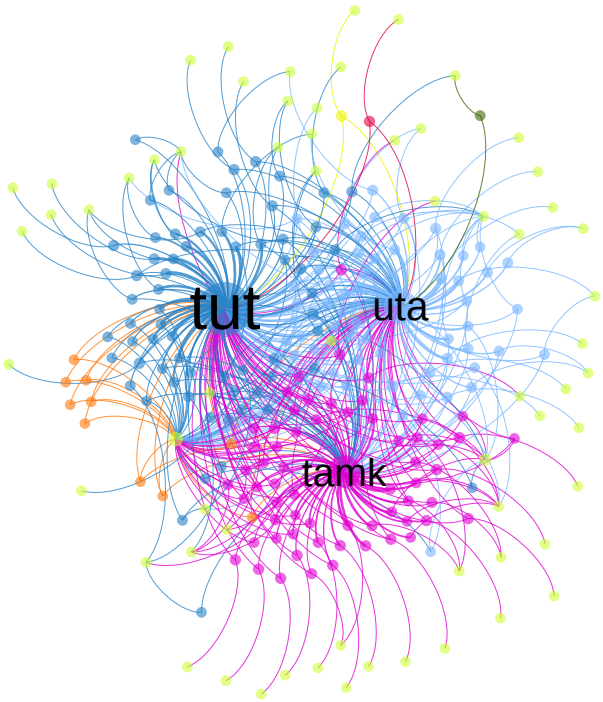

Figure 2. Demola Project Network.

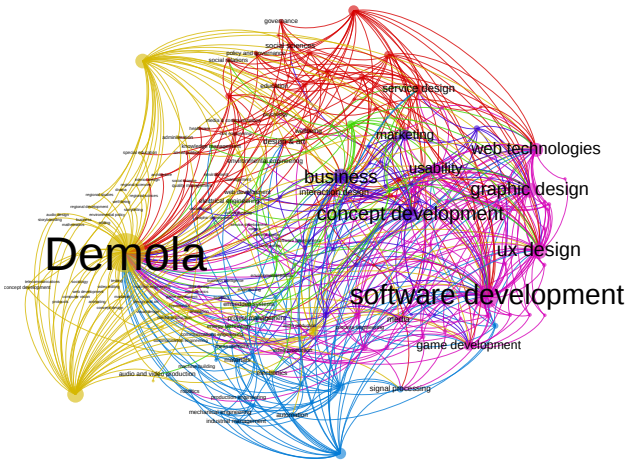

Figure 3. Demola project Domain Network.

2.4.2 Animation

An animation showing the current situation of the project network was also created. The project network is partly cumulative, partly showing a situation view. Connections between projects and universities only include the time when the project starts, thus projects are cumulated around the universities over time. The

[3] NetworkX is available at http://networkx.github.io/

[4] Google Trends for Gephi: http://www.google.com/trends/explore#q=gephi

connections between companies and projects use both the start and end dates. This means that, together with force driven layout algorithm, company nodes are pulled towards the center of the ecosystem during the project and start drifting away once a project engagement is finished.

A snapshot of the resulting animation is shown in Figure 4. Gephi allows network animation through two key features: First, it implements a timeline component with play functionality. Second, it allows graph layout algorithms to be run simultaneously while playing the timeline. Capturing the video was done with screen recording software. Post-production was required to include a timeline component into the video in an elegant manner.

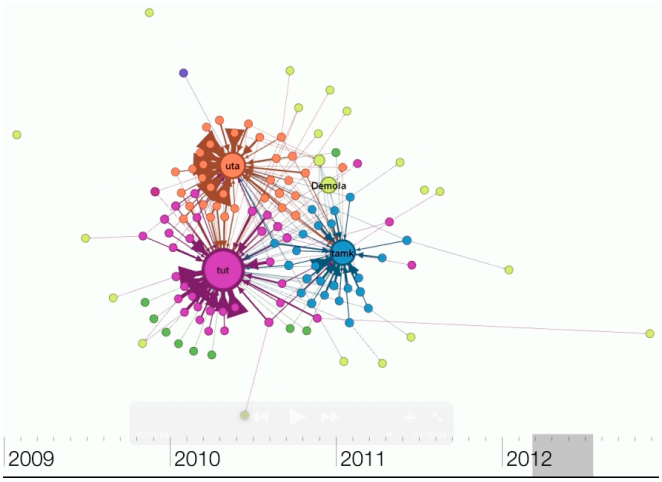

Figure 4. Snapshot of the animated project network.

3. DISCUSSION

In this paper, we used the Network Analysis and Visualization (NAV) process model for supporting the measurement of an innovation ecosystem. The resulting artifacts, i.e. the static visualizations as well as the animation, were all created in a co-creative manner with members of the case context, Demola.

Based on the feedback received during the co-creation process, we claim that static network visualizations and dynamic animations of an open innovation platform structure and evolution are useful in presenting, describing, marketing and selling the platform for existing and new stakeholders. As evidence, we offer the fact that a decision has already being made to start using the animated project network as a tool for communicating Demola activities and their evolution over time. Also the international collaborators of Demola have indicated their interest in using the tool to facilitate the discussions with their stakeholders.

From a technical viewpoint, the study allowed the following observations:

- Moving between tabular and structured format insists custom code development. Data-driven information visualization allows automation of the process but during the prototyping phase, we found interactive computing to be a more suitable paradigm to frame the development.
- The current implementation of dynamic network analysis in Gephi is rudimentary. To reach the level that e.g. software control management visualization tool Gource[5] allows for animation developers, additional work is required for developing Gephi further. Plans exist, already: https://gephi.org/2013/rebuilding-gephis-core-for-the-0-9-version/

We acknowledge the fact that more thorough user studies are required to evaluate the utility of the developed visualizations and to define specific steps to develop them further. More work is also needed to be able to show the change in the way that companies change their thinking over several Demola engagements, something that Demola operators have first-hand experience in. While the role of software development, for example, appears to be central in the Domain Network, the operators' experience shows that many companies start with software development (on prototype level) but continue to propose projects with a more cross-disciplinary framing. A way to take steps towards showing the shift in companies' thinking includes, for example, measuring and showing how the key areas of the projects change over time for a company. In addition, future possibilities include:

- Constructing steps from the Demola ecosystem through New Factory to national, European and global levels of the innovation ecosystem.
- Creating specific visualizations for different purposes / target groups: e.g. marketing, internal CRM, reporting of results.
- Creating visualizations from different perspectives, such as segments identified by industrial domains, university-oriented, expertise and skills –oriented.
- Interactive storytelling with data-driven, yet narrative-based views allowing real data driven, animated network view to the Demola ecosystem.
- Developing a real-time situation view implementing a fully automated, data-driven operation of the system to allow daily use of both the animatied and static cumulative views. For example, this requires solving the current requirement to create the layout through an interactive process manually with Gephi.

The NAV process model, coupled with the iterative and incremental approach taken in the process, was found to provide a useful task structure for the process of measuring and visualizing activities and the impact of an ecosystem through explicating the key steps required in the analysis. We found out that visualizations are useful in validating the source data. Disconnected or redundant nodes e.g. indicate errors in the data. Furthermore, the data-driven process and especially the flows of feedback built in the NAV process model did support the development of insightful visualizations and animations. In those discussions, we observed how the iterative detailed specification of visualizations and animations required the availability of the prototypes. From the first iteration, the visualizations that were used to validate the data catalyzed discussions on further requirements for the visualizations and animations.

More generally, the relationships identified with network connections allowed a preview of potential alliances for collaboration that could be created through participation in Demola. These relationship resources extended the value of the business ideas, talented employees and captured markets. They

[5] Gource homepage: https://code.google.com/p/gource/

described the character of the current Demola impact as well as the potential of the continuing impact, as individuals in these relationships collaborate on the current and future projects.

The selected set of tools was found to be fit for prototyping, creating versions of the animated network that are of high-quality and engaging. Appealing to the more hedonistic qualities of the observers that are attached to the concept of user experience (in an arcade-like mode) was found to be difficult task with Gephi. Thus, in the future, we seek to find an approach stemming from game development to develop an animation player allowing interactive storytelling with high user experience.

4. SUMMARY

In this study, static and dynamic visualizations of the network representation of Demola, an open innovation platform and an ecosystem engager, were developed in co-creation between Demola representatives and researchers developing new approaches to use visual network analysis as a tool for measuring innovation. Particularly, an animation representing the Demola key activities was found to be useful and of interest to many of the stakeholders. While this kind of an approach to measure innovation is very different from the more traditional approaches, we see that it has potential in allowing shared insights on the dynamics of innovation activities long before their impact surfaces as new product releases, patents filed, publications accepted, startups created or venture capital funding collected.

5. ACKNOWLEDGMENTS

This research is sponsored by Tekes – the Finnish Funding Agency for Technology and Innovation through project Reino (Relational Capital for Innovative Growth Companies) and is done in collaboration with the Innovation Ecosystems Network (http://www.innovation-ecosystems.org/). The authors wish to extend their gratitude to Ville Ilkkala from Meanfish Ltd for his insightful feedback and support in developing the animations.

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