

From Counting to Connecting

Exploring academia as a complex socio-technical
system of information transformation



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Overview

Background

- Intro
- Why this might be relevant for you

Application projects

- Knowledge landscape (“A data-driven, interactive and visual exploration of networked knowledge landscapes”)
- Net-Sights (only a glance)

Q&A and potential collaborations

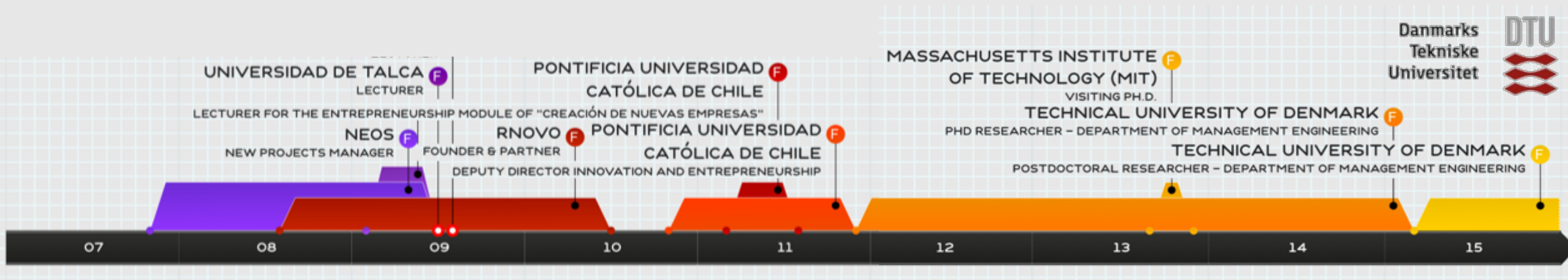
About me

Pedro Parraguez

Postdoc – DTU Management Engineering

PhD Thesis

A Networked Perspective on the Engineering Design Process:
At the Intersection of Process and Organisation Architectures





Anja Maier (Division Head), Josef Oehmen, Ole Broberg, Sten Bonke, Christian Thuesen, Joana Geraldi, Igor Kozine, Melanie Kreye, Pedro Parraguez, Carolina Souza da Conceição, Anna-Rose Vagn Jensen, Simone Nyholm, Baris Bekdik, Julia Thorpe, Miroslava Tegeltija, Nina Koch-Ørvad, Verena Stingl, Sebastiano Piccolo, Emil Andersen, Christian Schou Jensen, Lisbeth Bjerre Damgaard, Jakob Wulff.

**Socio-technical, data-driven approach to
understanding & supporting the design and management of complex systems**

www.es.man.dtu.dk

YouTube: [Designing Engineering Systems](#)

1. INTRODUCTION

1. INTRODUCTION
The engineering design process with three interdependent domains (activities), the organizational network of whom all correspondents
ppru@du.ac; anja.maier@cantab.net; e
Systems Engineering Vol. 19, No. 2, 20
© 2016 Wiley Periodicals, Inc.

The engineering design
ties and their informal
of interfaces on process
characterizes process
performing interfacing
of those characteristic
aspects of the organiza
to better manage cor
development of a pow
the structure and con
of this approach indu
systematic identifica
support for engineeri
© 2016 Wiley Periodi

ABSTRACT

INTERNATIONAL DESIGN CONFERENCE - DESIGN 2016
Dubrovnik - Croatia, May 16 - 19, 2016.

Keywords: new product development, innovation, collaborative design process, collaboration, networks.

[illegible][illegible]

Abstract—The pattern of information flow through the network of interdependent design activities is thought to be an important determinant of engineering design process results. A previously unexplored aspect of such patterns is the nature of the relationships between the tasks of information transfer between activities as those activities are implemented through the network of people executing the project. To address this gap, we develop a dynamic modeling method that integrates both the network of people and the network of activities in the project. We then employ a large data set from an industrial setting, consisting of project-related e-mails and activity records from the design and development of a renewable energy plant over the course of more than three years. Using network analysis and clustering, we make three important contributions: a novel method for identifying the network of activities in complex engineering design; the network of information flows in a project as it evolved over time and how network structure changes over time; and insights; and 3) we provide a useful tool for analyzing the evolution of information flows. Implications include guidance for the design of information flows as well as better understanding of engineering design projects and the activity characteristics that influence them.

From a research and managerial perspective, quantifying, analyzing, and understanding the evolving information flows between activities in the design process is an essential tool to provide support to complex engineering design projects [2], [6]. The intended or expected evolution of information flows between activities (given activities' information dependencies) has been modeled and analyzed through activity network process models [7]. In turn, the overall evolution of the design process has been framed and guided through stage-based models of the design process [8], [9]. The combination of these two approaches is particularly relevant in the context of process planning, supporting key decisions related to the design resource allocation, and budgeting [7]. However, in order to quantify and analyze how information actually flows between activities and support process execution and control, we require a model that simultaneously integrates the dynamic architecture of the process as well as the dynamic architecture of the organization that implements the process. This integration allowing the actual sequence of activities in the process through their work, exchange and transform activities [4].

Experimental Design Research

Approaches, Perspectives, Applications

Stanković Editors

 Springer

A Networked Perspective on the Engineering Design Process:

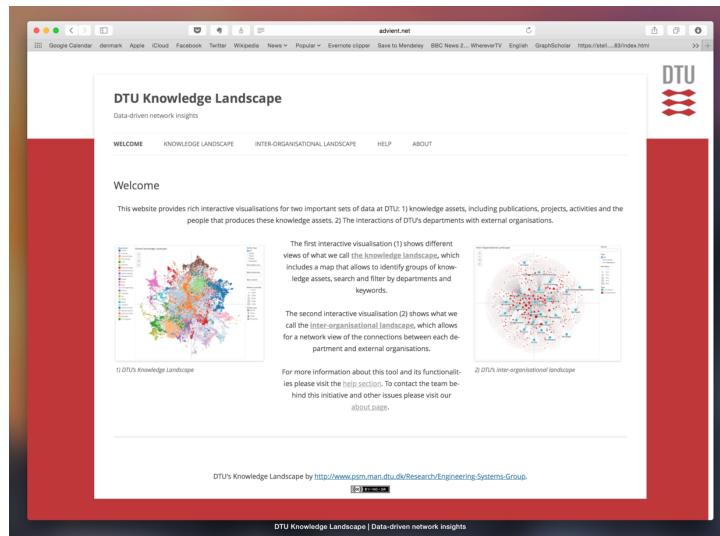
Pedro Parraguez and Anja Maier

Abstract

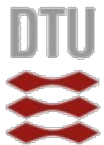
A network-based perspective on designing permits research on the complexity of product, process, and people interaction. Strengthened by the latest advances in information technologies and accessibility of data, a network-based perspective and use of appropriate research approaches in design. These tools allow us to explore new data-driven research approaches in design. This paper discusses pieces of data from existing literatures to answer the following research questions: how can we link disconnected pieces of data? How can we characterize research projects in design? How can we foster research projects in design? The paper contributes to the use of network science in design. It focuses on introducing a network-based perspective on the design process and practice. It makes contributions to the design process and practice. It focuses on introducing a network-based perspective on the design process and practice. It makes contributions to the design process and practice.

Keywords: Network Analysis • Complexity • Design Process

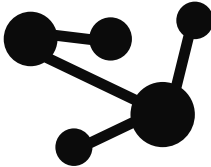
Keywords: Network Analysis • Complexity • Design Process



Danmarks
Tekniske
Universitet



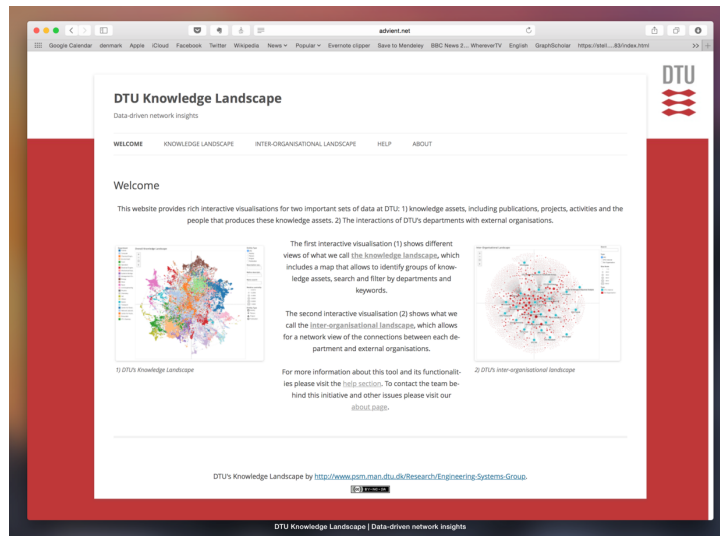
Knowledge Landscape



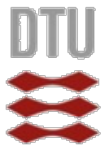
Net-Sights

Network Insights for Collaborative Sustainable Production





Danmarks
Tekniske
Universitet



Knowledge Landscape

Net-Sights

Network Insights for Collaborative Sustainable Production

INDUSTRIENS
FOND
The Danish Industry Foundation

State of Green
Join the Future. Think Smart.

CLEAN
Clean Energy for All





DTU as a Complex Engineering System

A socio-technical process of information transformation

Education



Innovation

Scientific advice

Research

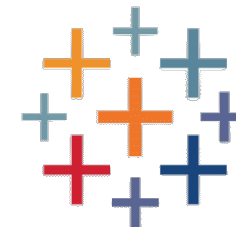
Engineering system: 'A class of systems characterized by a high degree of technical complexity, social intricacy, and elaborate processes, aimed at fulfilling important functions in society' (de Weck et al., 2011, p. 31).

Why and how this might be relevant for you

1)  
Descriptive and Predictive

New possibilities, expectations and goals
e.g. new levels of analysis and questions

2)



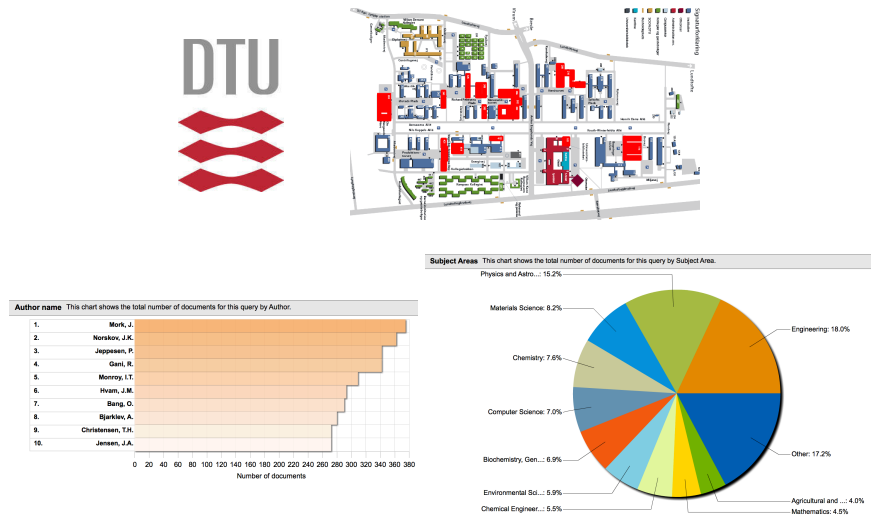
From Counting



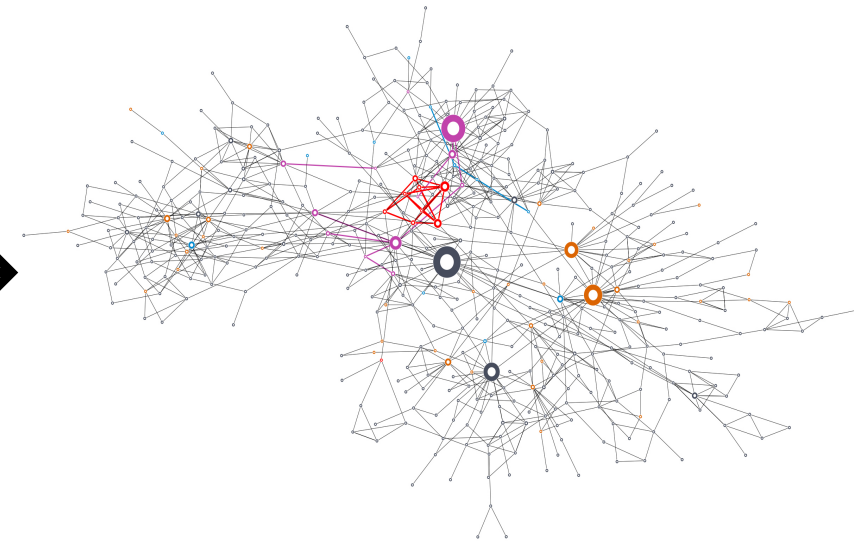
to Connecting



From counting to connecting



Knowledge census



Knowledge landscape

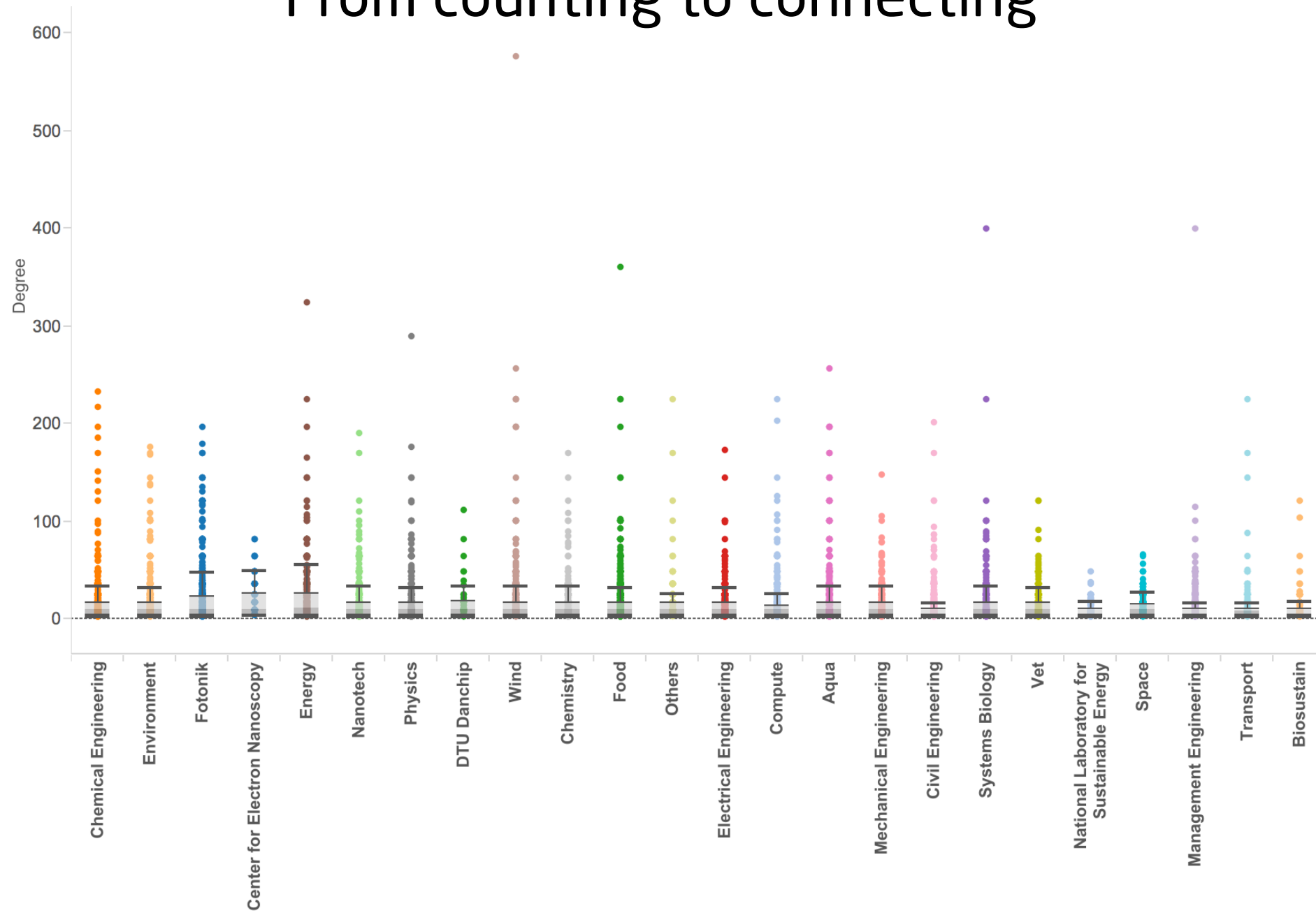
From counting to connecting

Publication types - 2015 - DTU Orbit (13/02/2016)

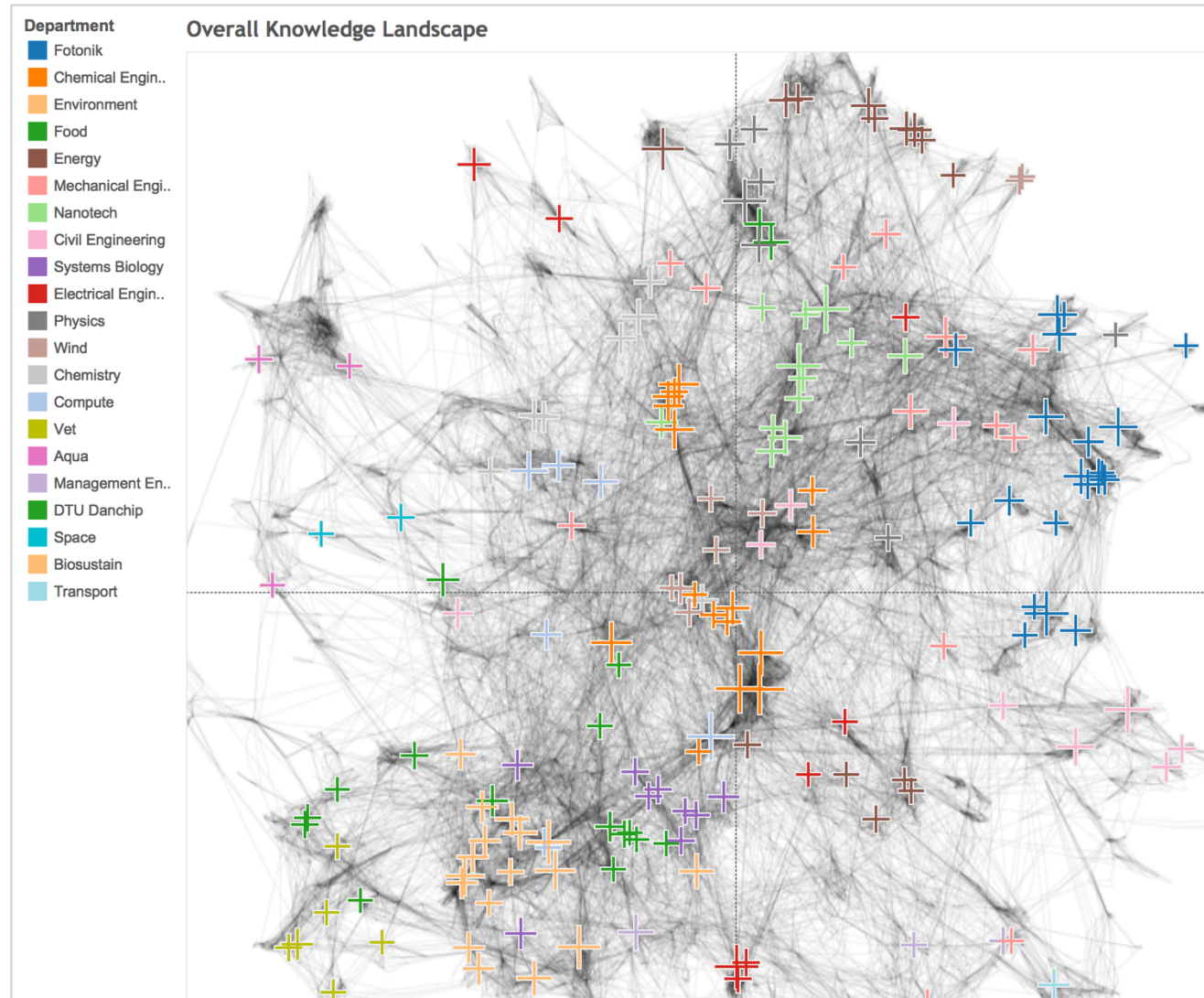
1. Publication types (DTU records)

		Count
No. 1	Contribution to Journal	3718
No. 2	Book/anthology/thesis/report	751
No. 3	Contribution to book/anthology/report	1838
No. 4	Contribution to conference	857
No. 5	Working paper	4
No. 6	Contribution to newspaper	46
No. 7	Memorandum/exposition	8
No. 8	Contribution to memorandum/exposition	2
No. 9	Net publication	73
No. 10	Patent	61
No. 11	Non-text contribution	206
No. 12	Other	1

From counting to connecting



From counting to connecting



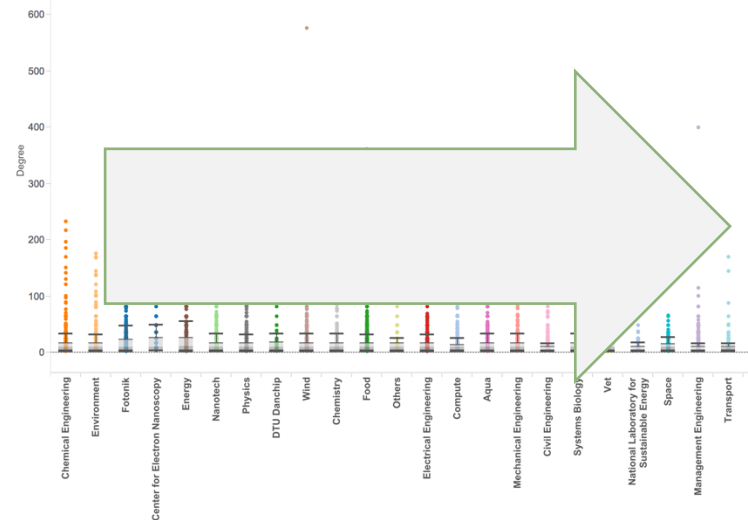
From counting to connecting

[From tables to networks]

Publication types - 2015 - DTU Orbit (13/02/2016)

1. Publication types (DTU records)

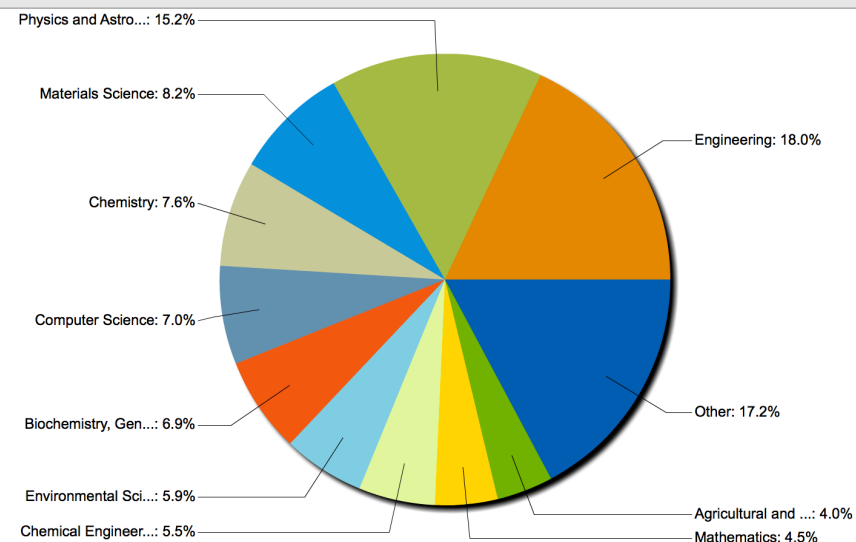
		Count
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No. 10	Patent	61
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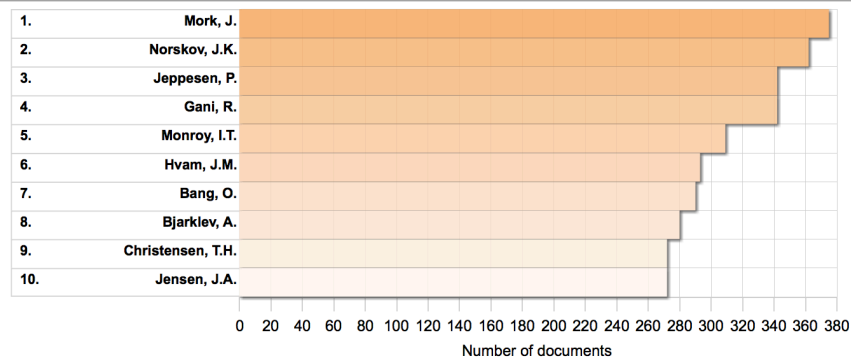
Holistic knowledge mapping VS counting



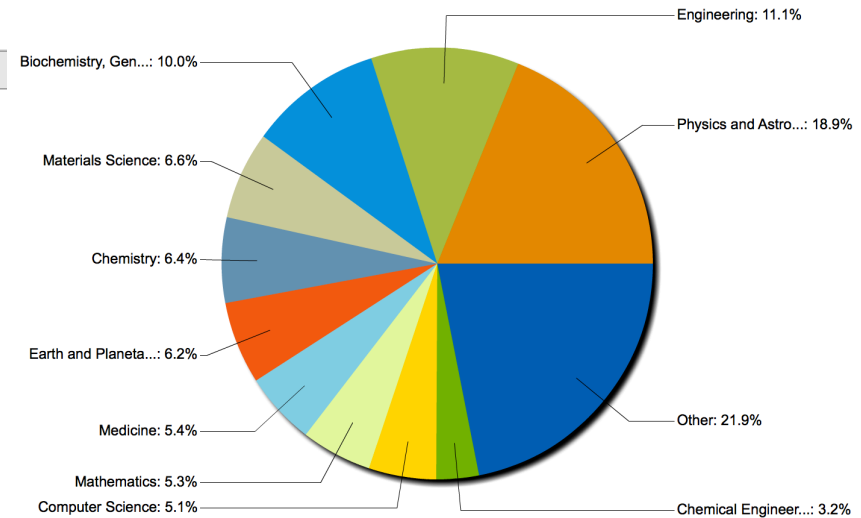
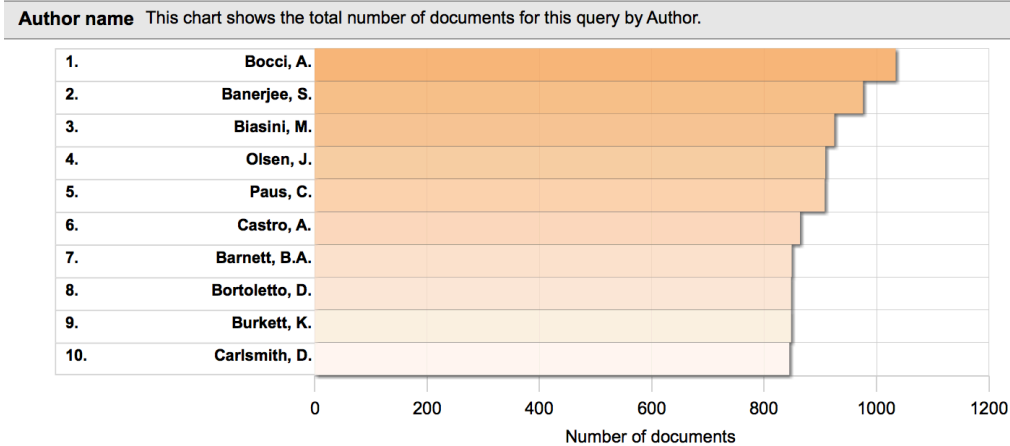
Subject Areas This chart shows the total number of documents for this query by Subject Area.



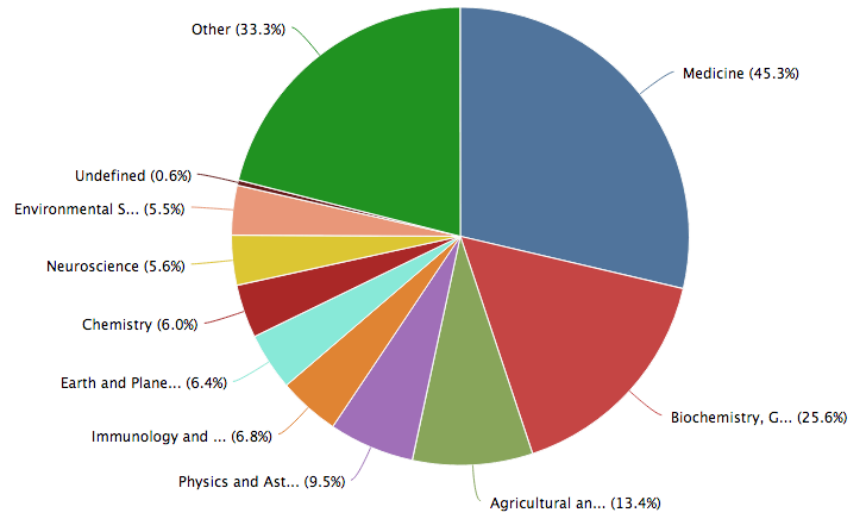
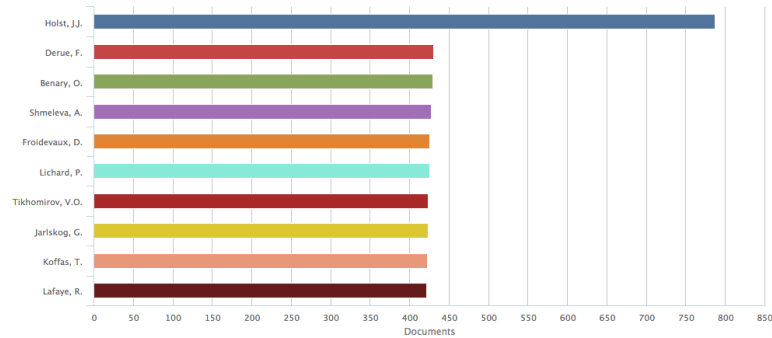
Author name This chart shows the total number of documents for this query by Author.



Holistic knowledge mapping VS counting



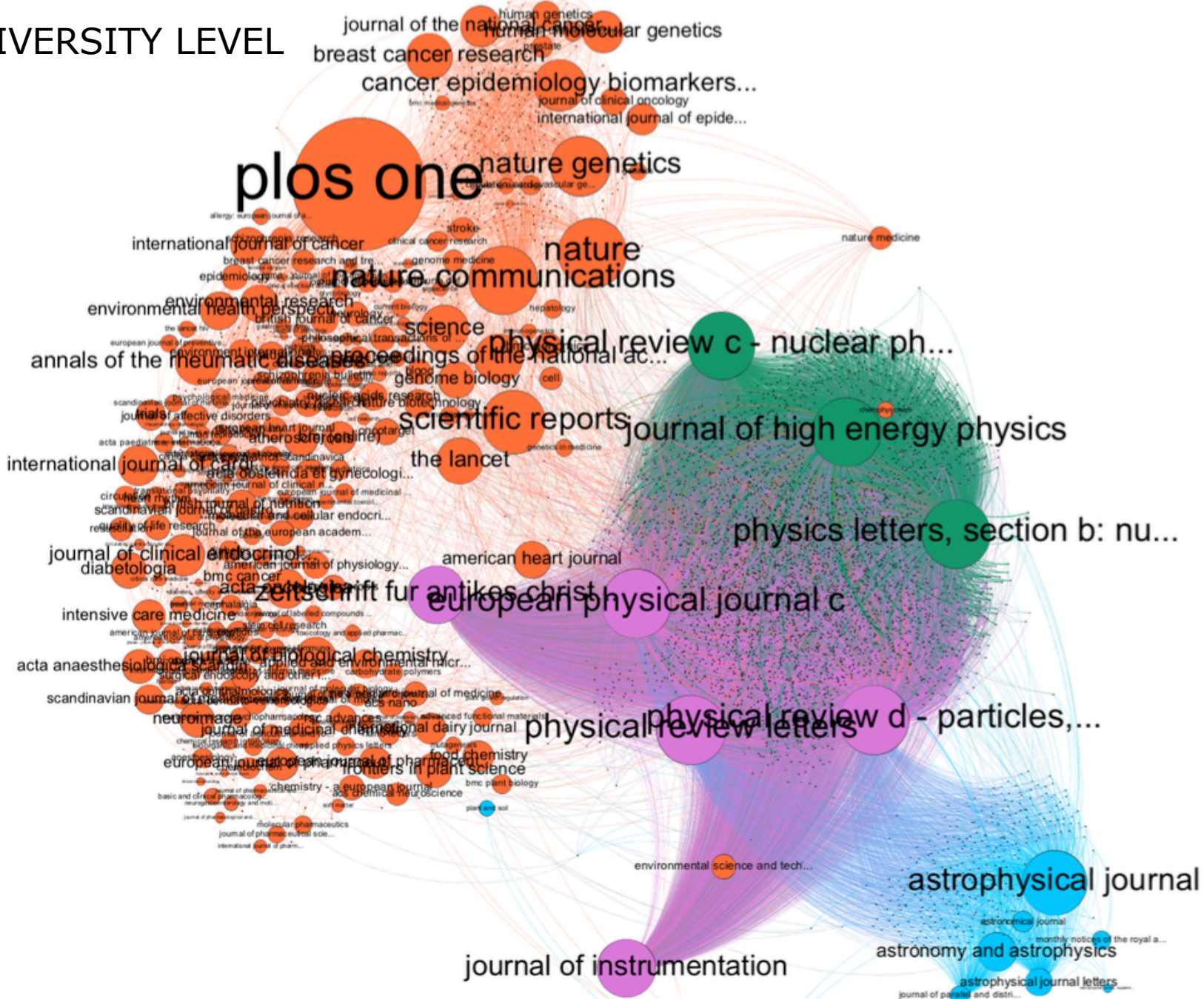
Holistic knowledge mapping VS counting



[illegible]

[illegible]

UNIVERSITY LEVEL





DTU Knowledge Landscape

Data-driven network insights

WELCOME KNOWLEDGE LANDSCAPE INTER-ORGANISATIONAL LANDSCAPE HELP ABOUT

Welcome

This website provides rich interactive visualisations for two important sets of data at DTU: 1) knowledge assets, including publications, projects, activities and the people that produces these knowledge assets. 2) The interactions of DTU's departments with external organisations.



1) DTU's Knowledge Landscape

The first interactive visualisation (1) shows different views of what we call **the knowledge landscape**, which includes a map that allows to identify groups of knowledge assets, search and filter by departments and keywords.



2) DTU's inter-organisational landscape

The second interactive visualisation (2) shows what we call the **inter-organisational landscape**, which allows for a network view of the connections between each department and external organisations.

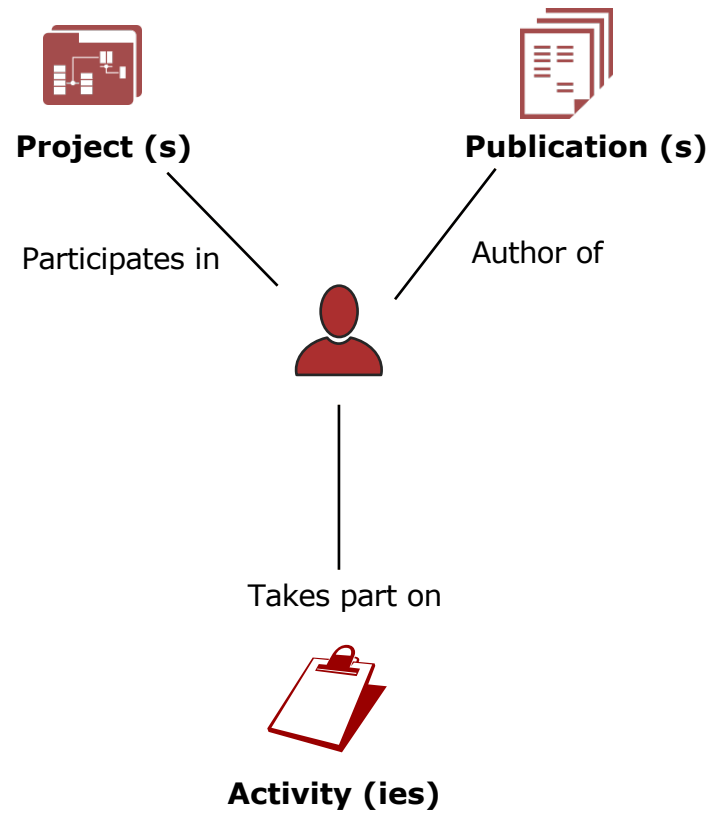
For more information about this tool and its functionalities please visit the [help section](#). To contact the team behind this initiative and other issues please visit our [about page](#).

DTU's Knowledge Landscape by <http://www.psm.man.dtu.dk/Research/Engineering-Systems-Group>.



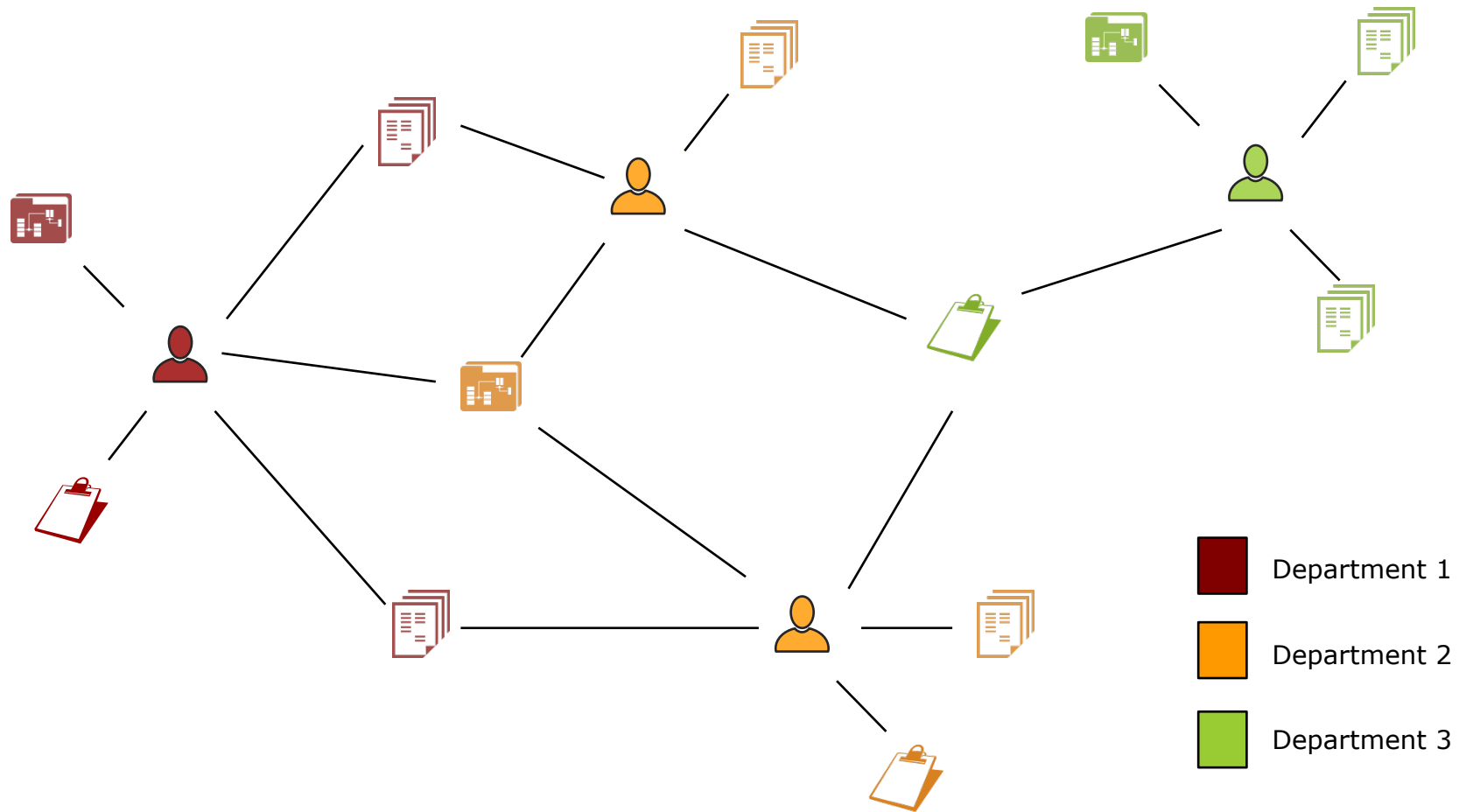
Baseline network model

Knowledge Landscape



Baseline network model

Knowledge Landscape



Source Data

Knowledge Landscape

ORBIT

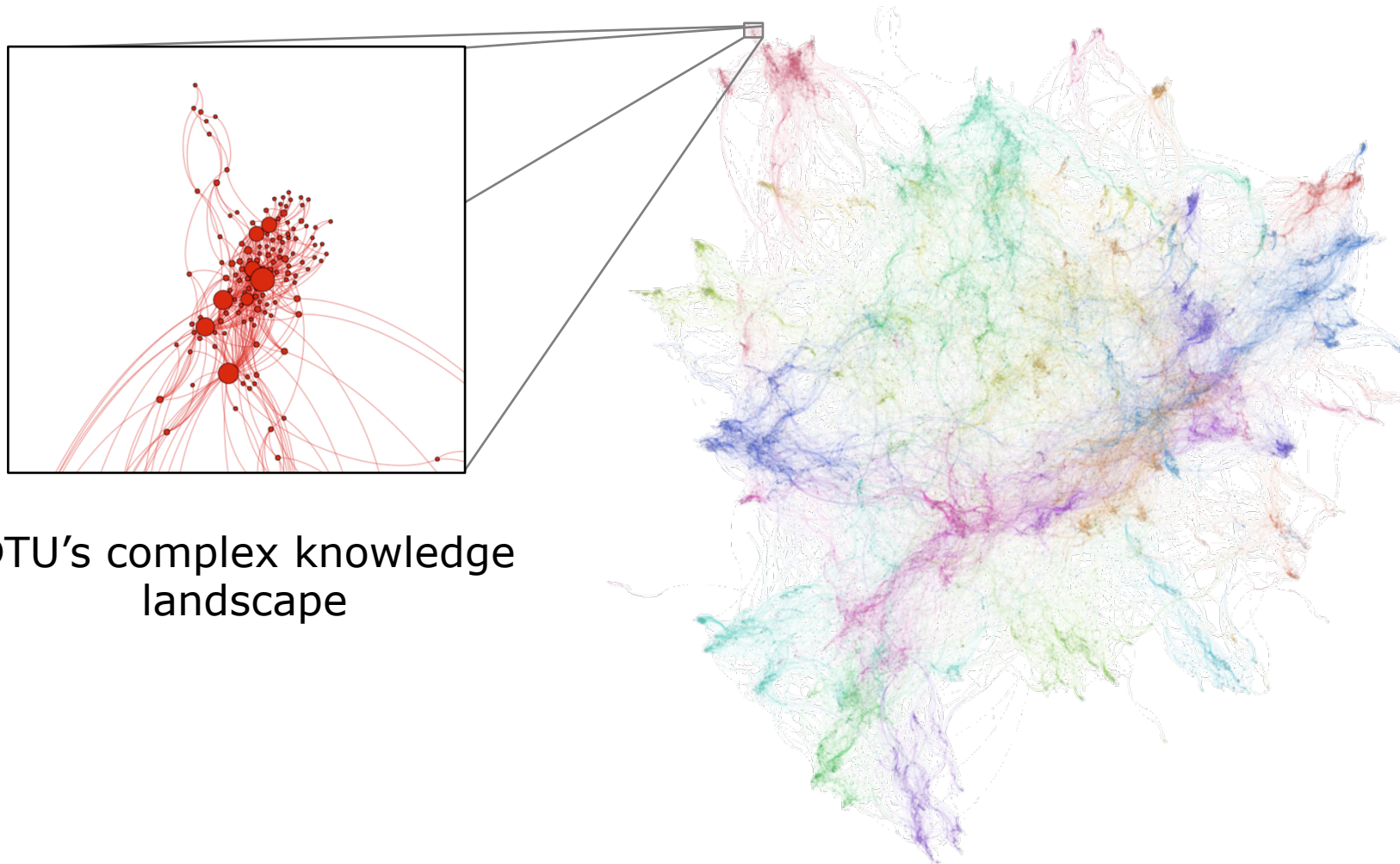
2009 - 2015

Entity Type

Activities	655
People	7,293
Projects	7,472
Publications	13,256

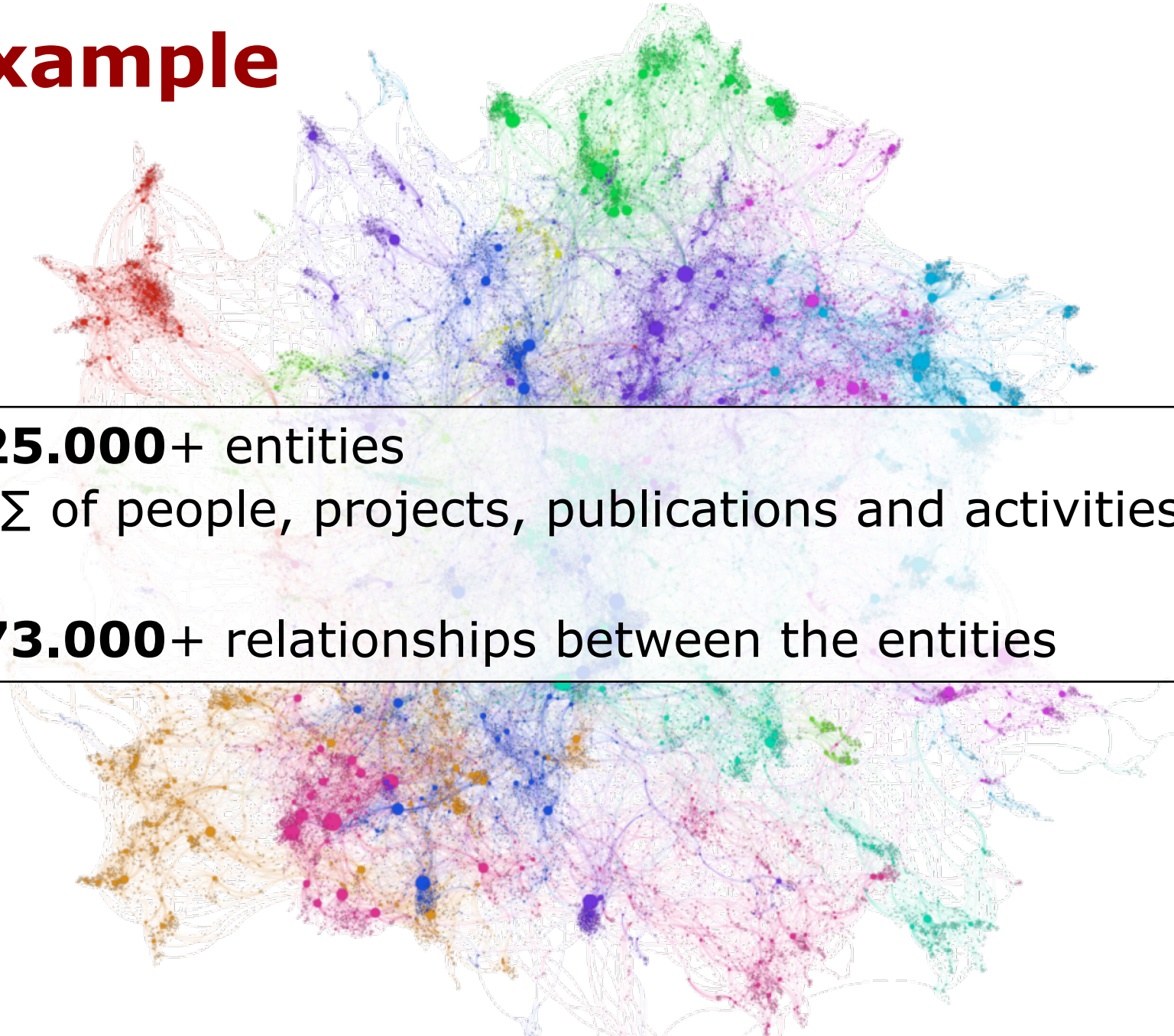
A networked and systemic perspective

Actual network model with 25.333 entities



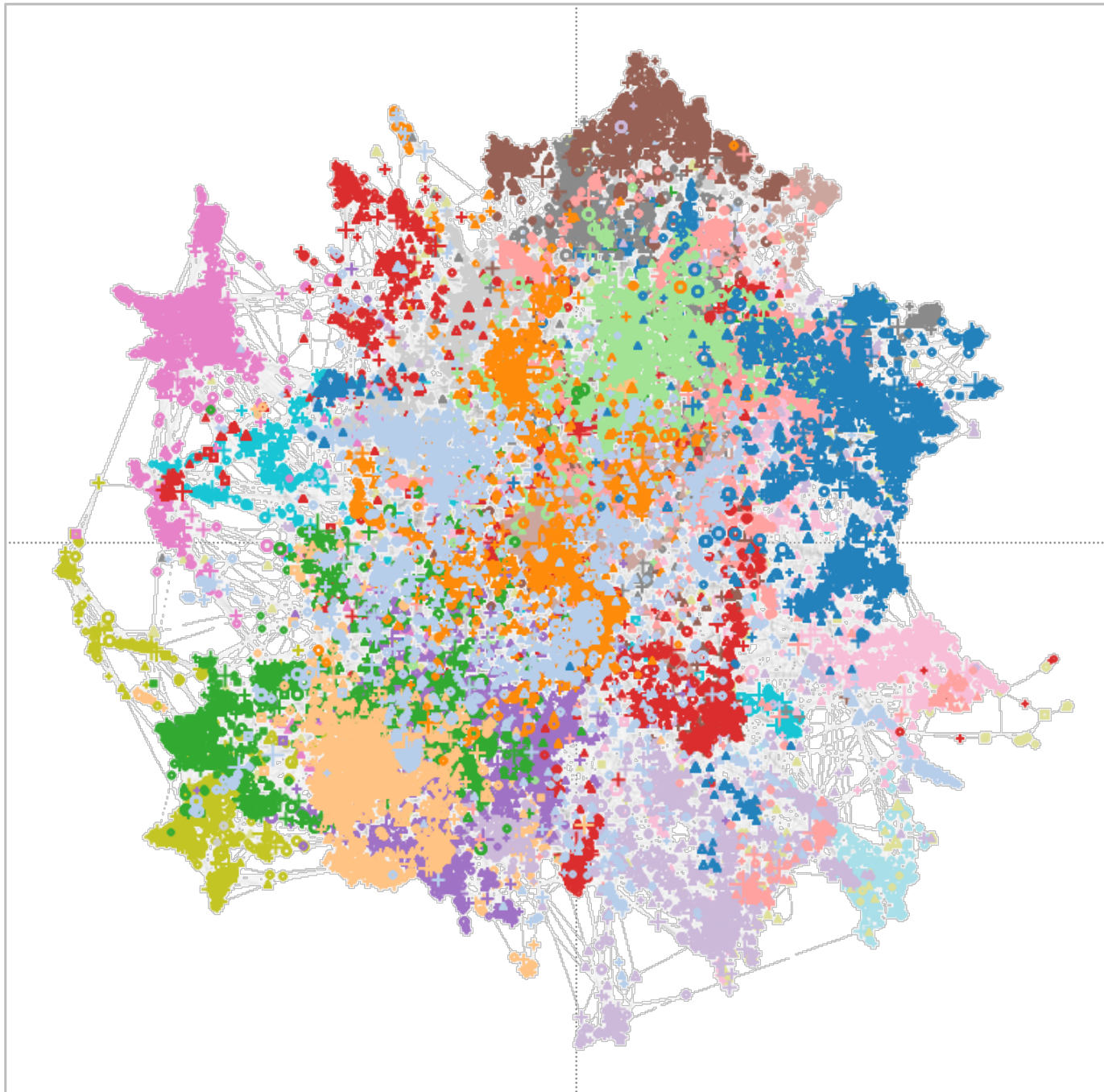
DTU's complex knowledge
landscape

Example

- 
- **25.000+** entities
(Σ of people, projects, publications and activities)
 - **73.000+** relationships between the entities

- Department
- Fotonik
 - Compute
 - Chemical Engin..
 - Environment
 - Food
 - Nanotech
 - Electrical Engin..
 - Mechanical Engi..
 - Systems Biology
 - Management En..
 - Energy
 - Wind
 - Aqua
 - Civil Engineering
 - Physics
 - Chemistry
 - Vet
 - Others
 - Space
 - Transport
 - Center for Electr..
 - National Laborat..
 - Center for Nucle..
 - Biosustain
 - DTU Danchip

Overall Knowledge Landscape



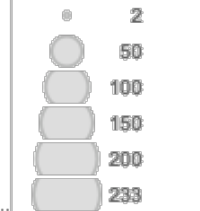
- Entity Type
- (All)
 - Activity
 - Person
 - Project
 - Publication

Description search..

Refine descriptio..

Name search

Connections



Entity Type

- Activity
- Person
- Project
- Publication

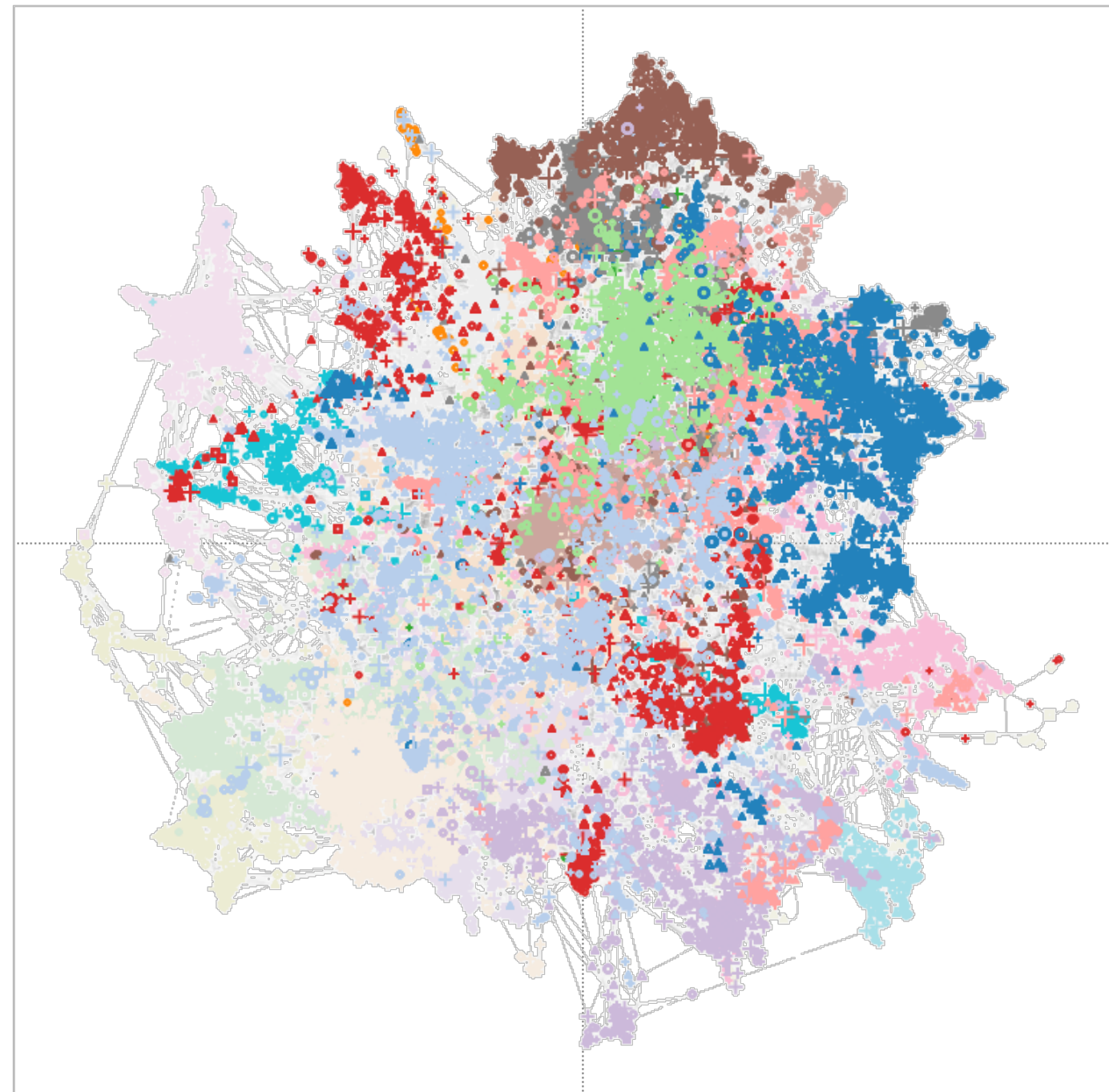
Connections



Department

- Fotonik
- Compute
- Chemical Engin..
- Environment
- Food
- Nanotech
- Electrical Engin..
- Mechanical Engi..
- Systems Biology
- Management En..
- Energy
- Wind
- Aqua
- Civil Engineering
- Physics
- Chemistry
- V&T
- Offshore
- Space
- Transport
- Center for Electr..
- National Laborat..
- Center for Nucle..
- Biostructure
- DTU Danchip

Overall Knowledge Landscape “Dry Labs”



Entity Type

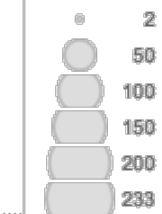
- (All)
- Activity
- Person
- Project
- Publication

Description search..

Refine description..

Name search

Connections



Entity Type

- Activity
- Person
- Project
- Publication

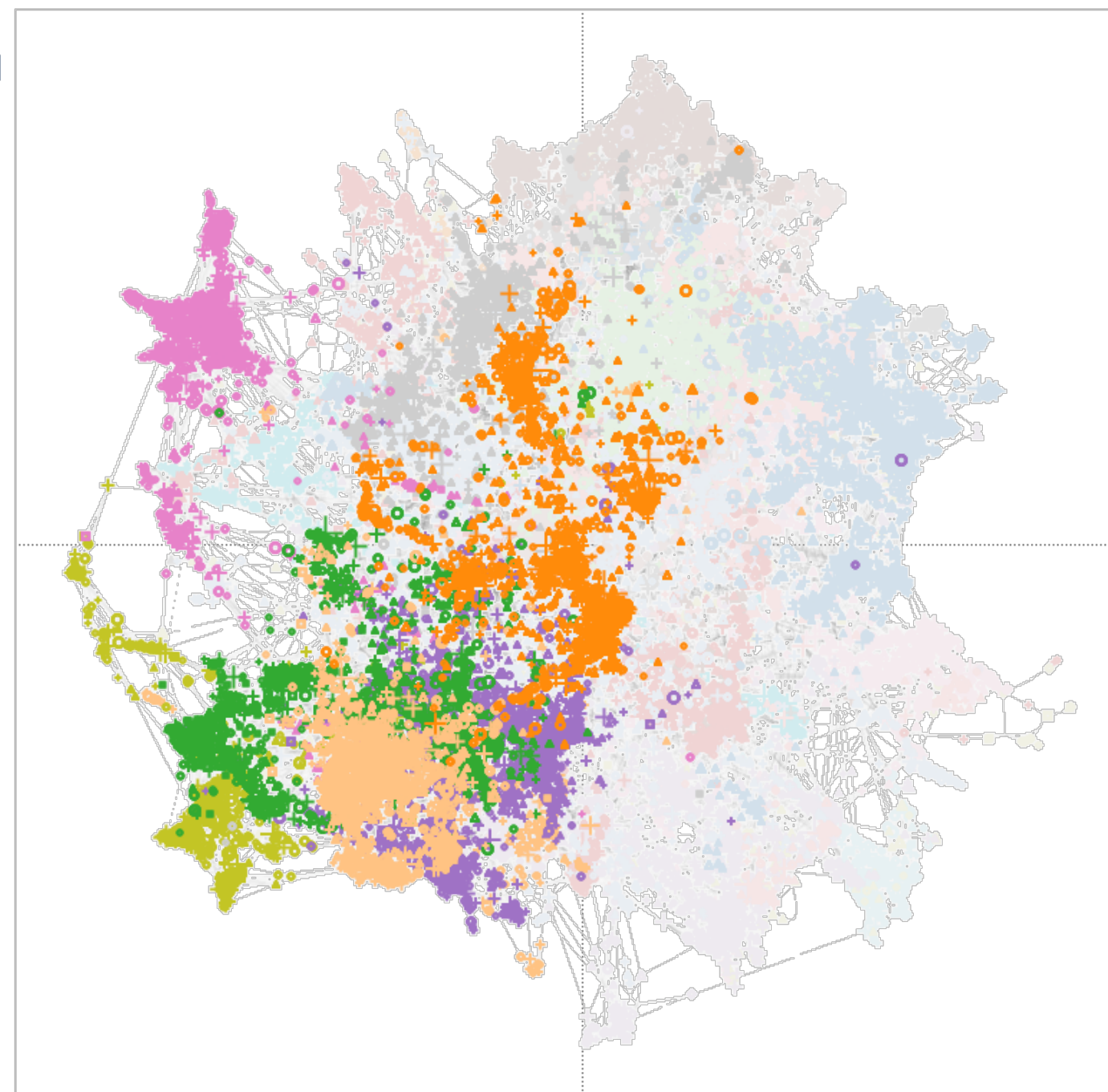
Connections



Department

- Robotik
- Compute
- Chemical Engin...
- Environment
- Food
- Nanotech
- Electrical Engin..
- Mechanical Engl..
- Systems Biology
- Management En..
- Energy
- Wind
- Aqua
- Civil Engineering
- Physics
- Chemistry
- Vet
- Others
- Space
- Transport
- Center for Electr..
- National Laborat..
- Center for Nuclea..
- Biosustain
- DTU Danchip

Overall Knowledge Landscape "Wet Labs"



Entity Type

- (All)
- Activity
- Person
- Project
- Publication

Description search..

Refine descriptio..

Name search

Connections

- 2
- 50
- 100
- 150
- 200
- 233

Entity Type

- Activity
- + Person
- Δ Project
- Publication

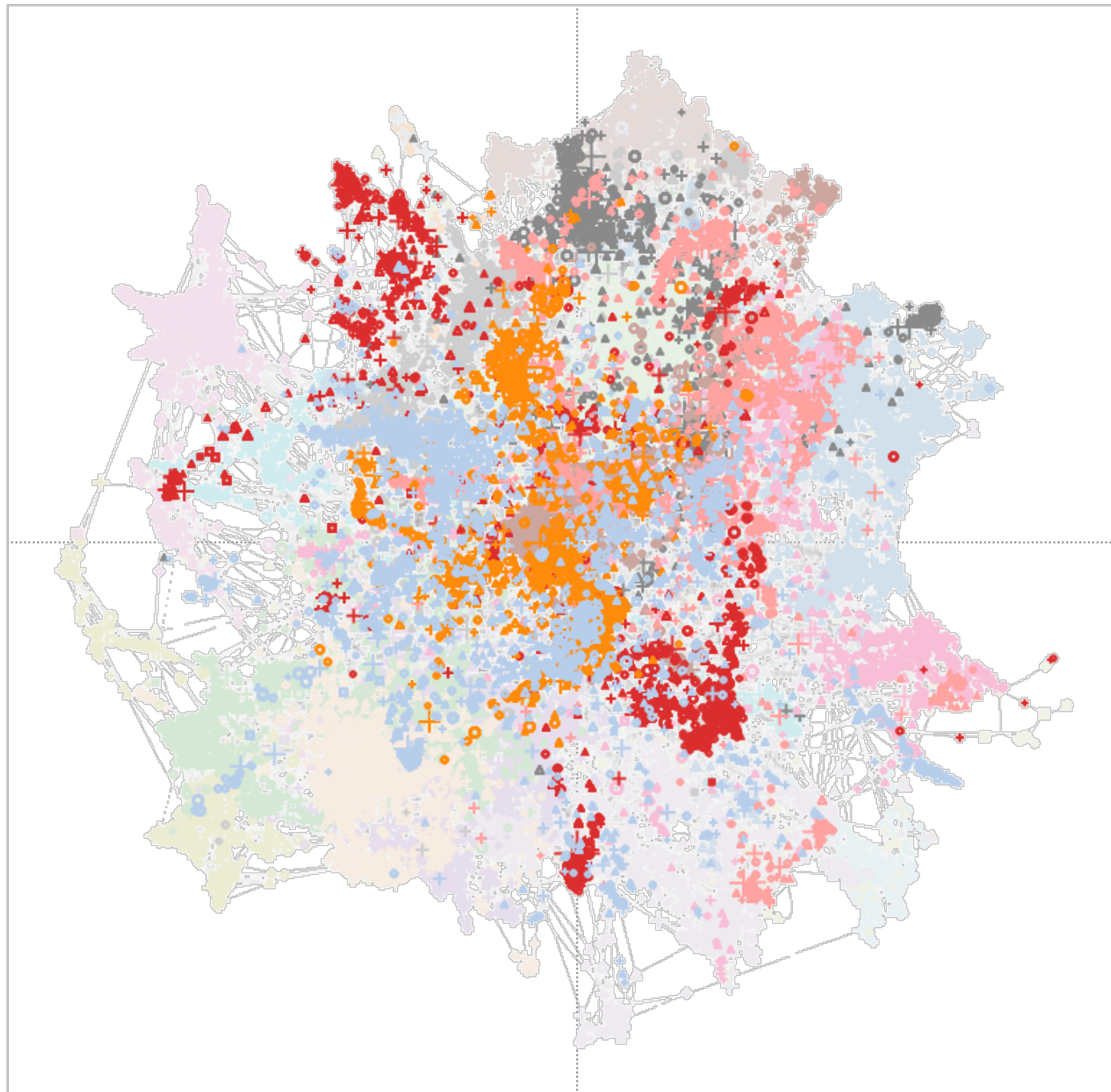
Connections

- 2
- 233

Department

- Robotik
- Compute
- Chemical Engin..
- Environment
- Food
- Nanotech
- Electrical Engin..
- Mechanical Engi..
- Systems Biology
- Management En..
- Energy
- Wind
- Aqua
- Civil Engineering
- Physics
- Chemistry
- Vet
- Others
- Space
- Transport
- Center for Electr..
- National Laborat..
- Center for Nuclea..
- Bioasustain
- DTU Danchip

Overall Knowledge Landscape “Distributed” Departments



Entity Type

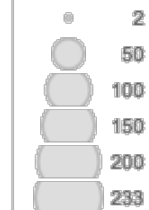
- (All)
- Activity
- Person
- Project
- Publication

Description search..

Refine descriptio..

Name search

Connections



Entity Type

- Activity
- Person
- Project
- Publication

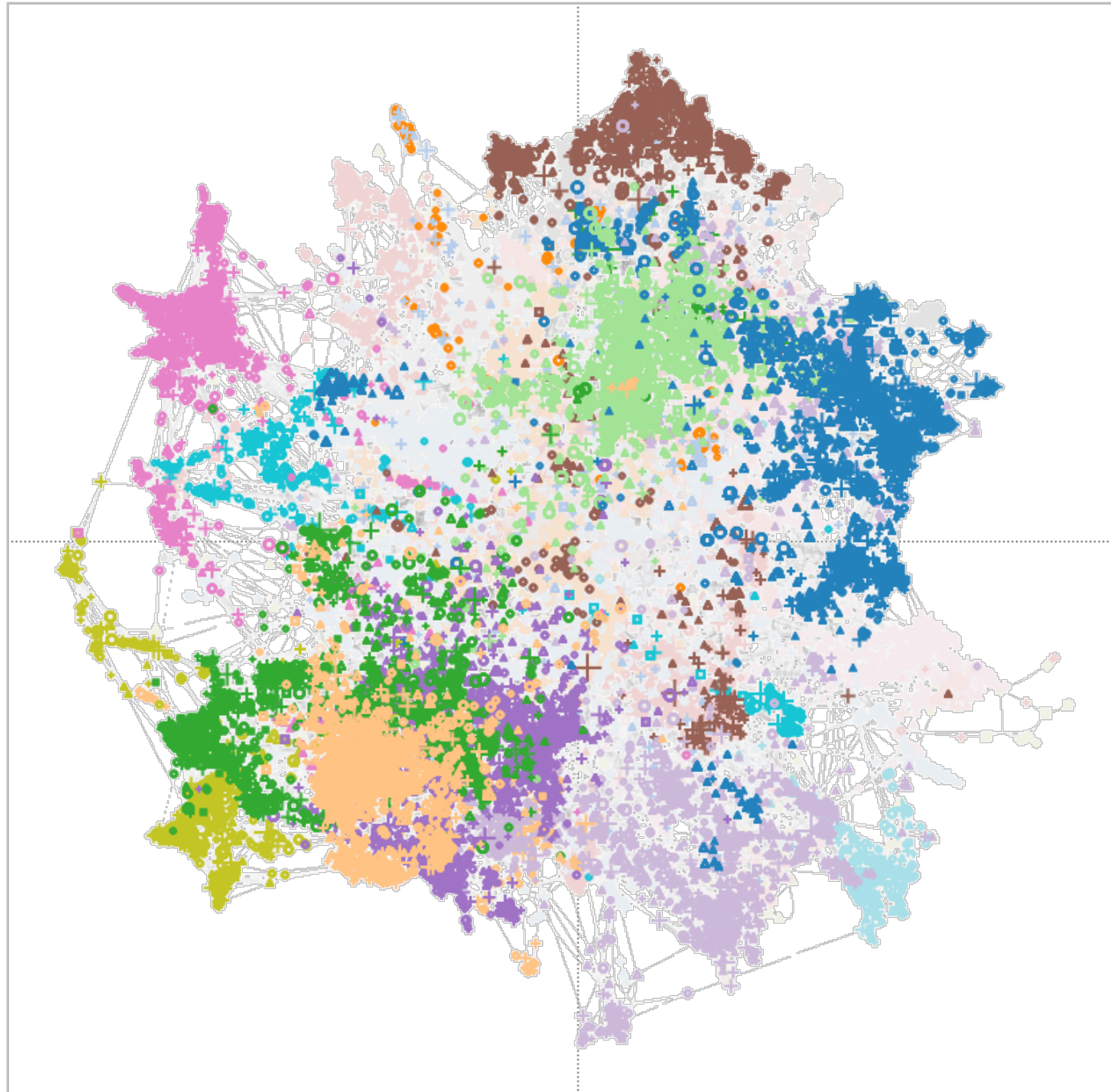
Connections



Department

- Fotonik
- Compute
- Chemical Engin..
- Environment
- Food
- Nanotech
- Electrical Engin..
- Mechanical Engin..
- Systems Biology
- Management En..
- Energy
- Wind
- Aqua
- Civil Engineering
- Physics
- Chemistry
- Vet
- Others
- Space
- Transport
- Center for Electr..
- National Laborat..
- Center for Nucle..
- Biosustain
- DTU Danchip

Overall Knowledge Landscape “Focused” Departments



Entity Type

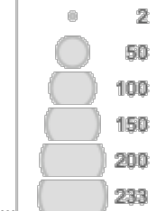
- (All)
- Activity
- Person
- Project
- Publication

Description search..

Refine descriptio..

Name search

Connections



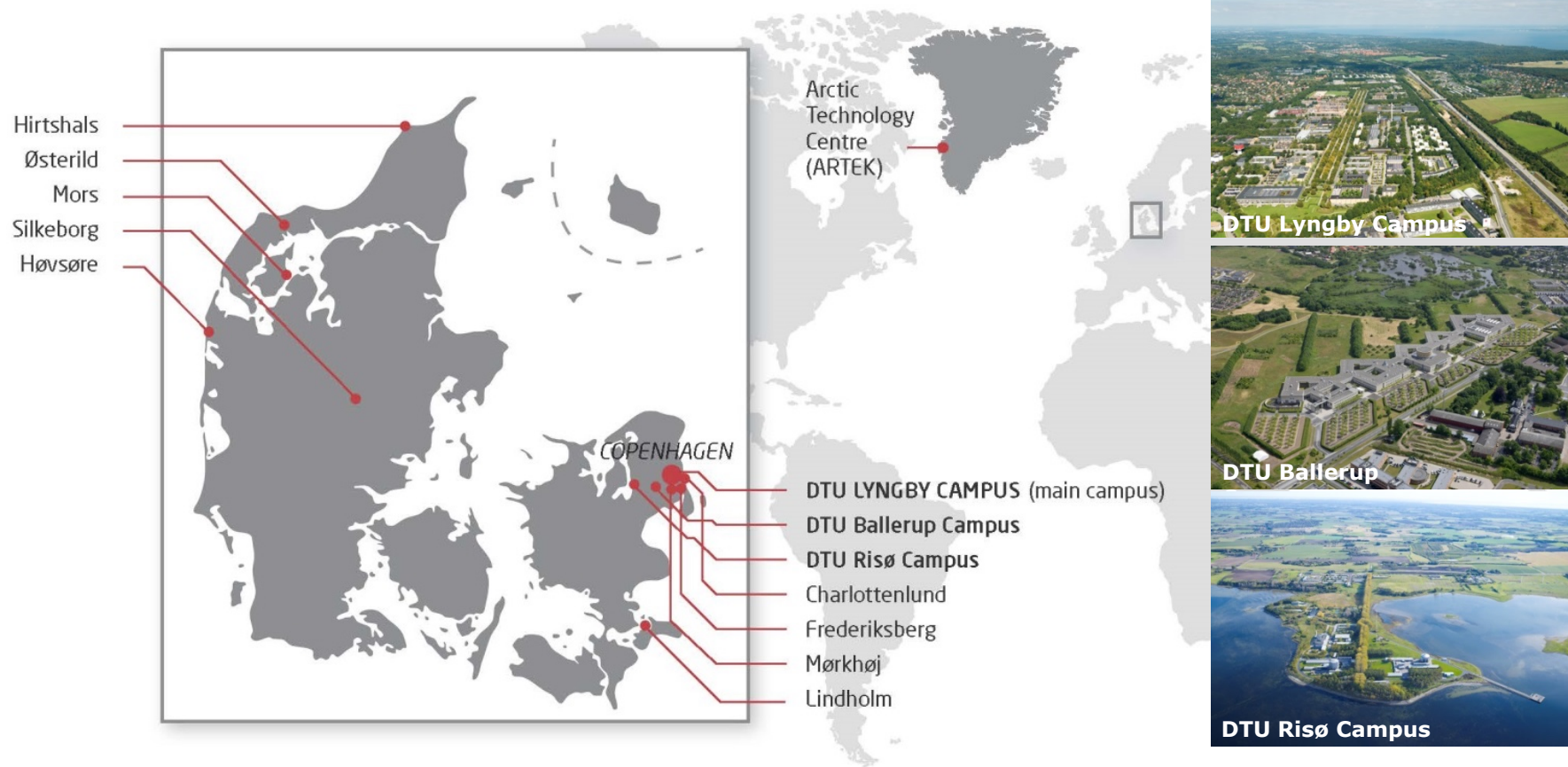
Entity Type

- Activity
- Person
- Project
- Publication

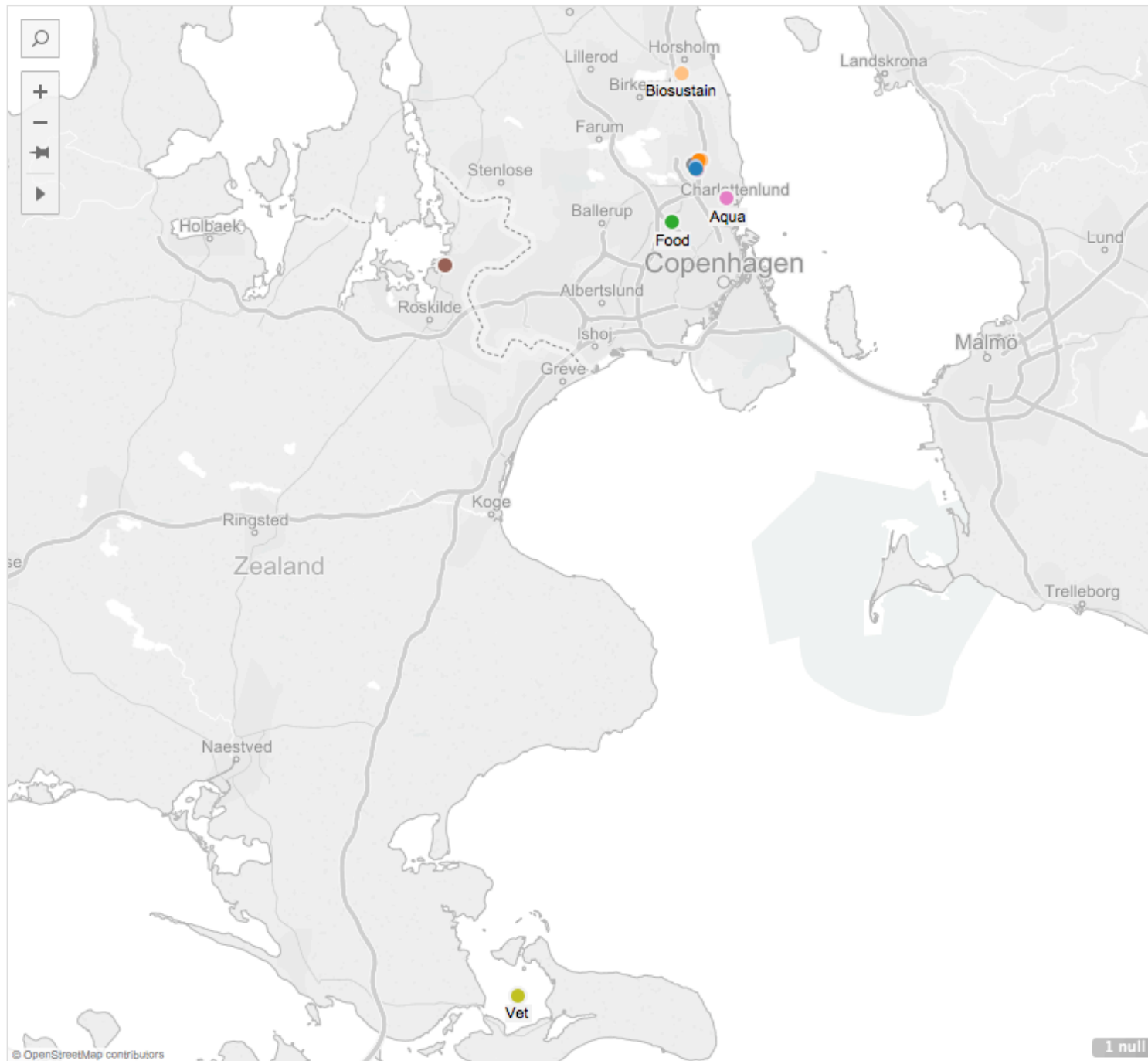
Connections



One university



Geo Map



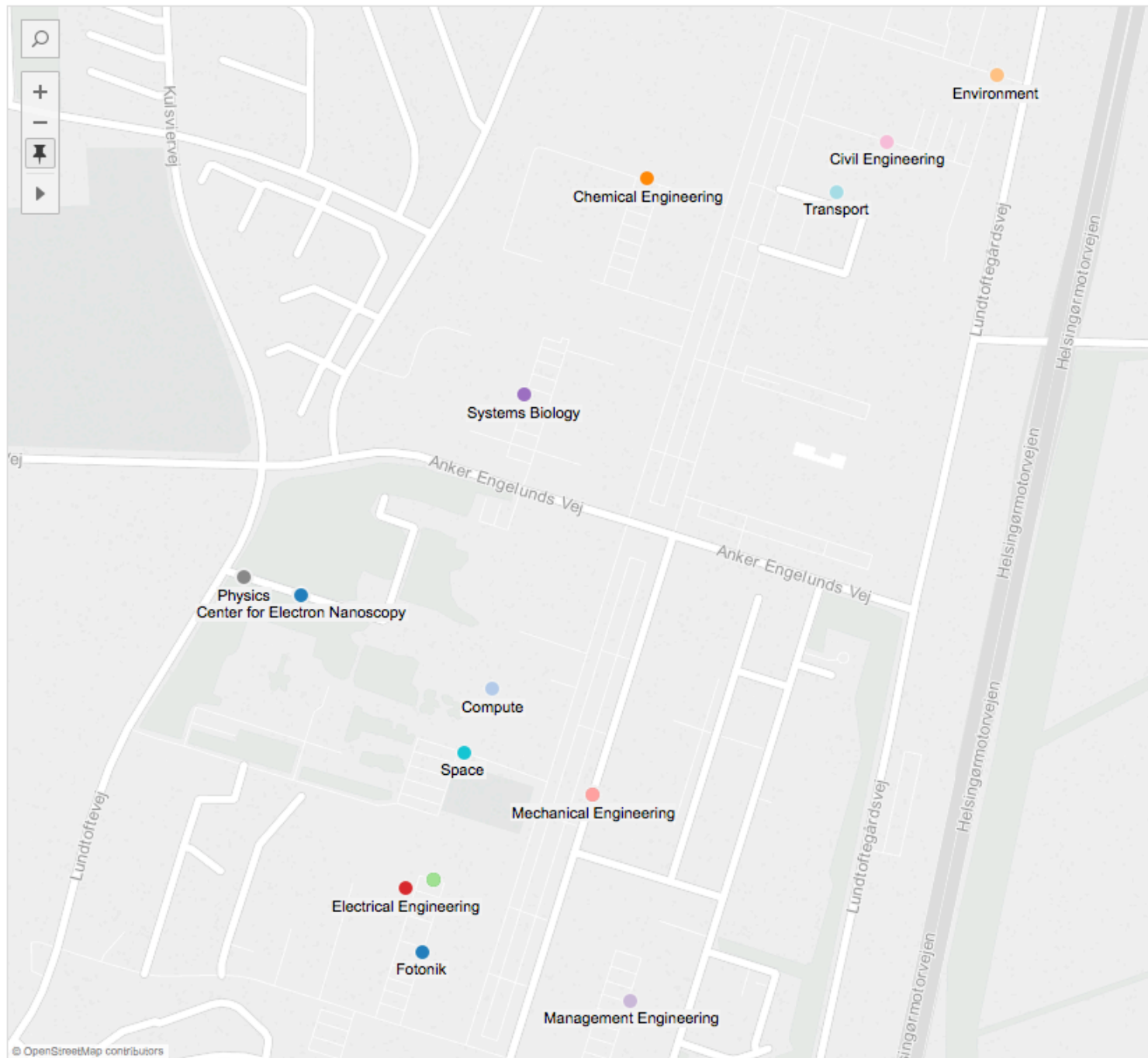
Owner (group)

- Fotonik
- Compute
- Chemical Engineering
- Environment
- Food
- Nanotech
- Electrical Engineering
- Mechanical Engineering
- Systems Biology
- Management Engineeri..
- Energy
- Wind
- Aqua
- Civil Engineering
- Physics
- Chemistry
- Vet
- Others
- Space
- Transport
- Center for Electron Nan..
- National Laboratory for ..
- Center for Nuclear Tec..
- Biosustain
- DTU Danchip

Department filter

(All)

Geo Map



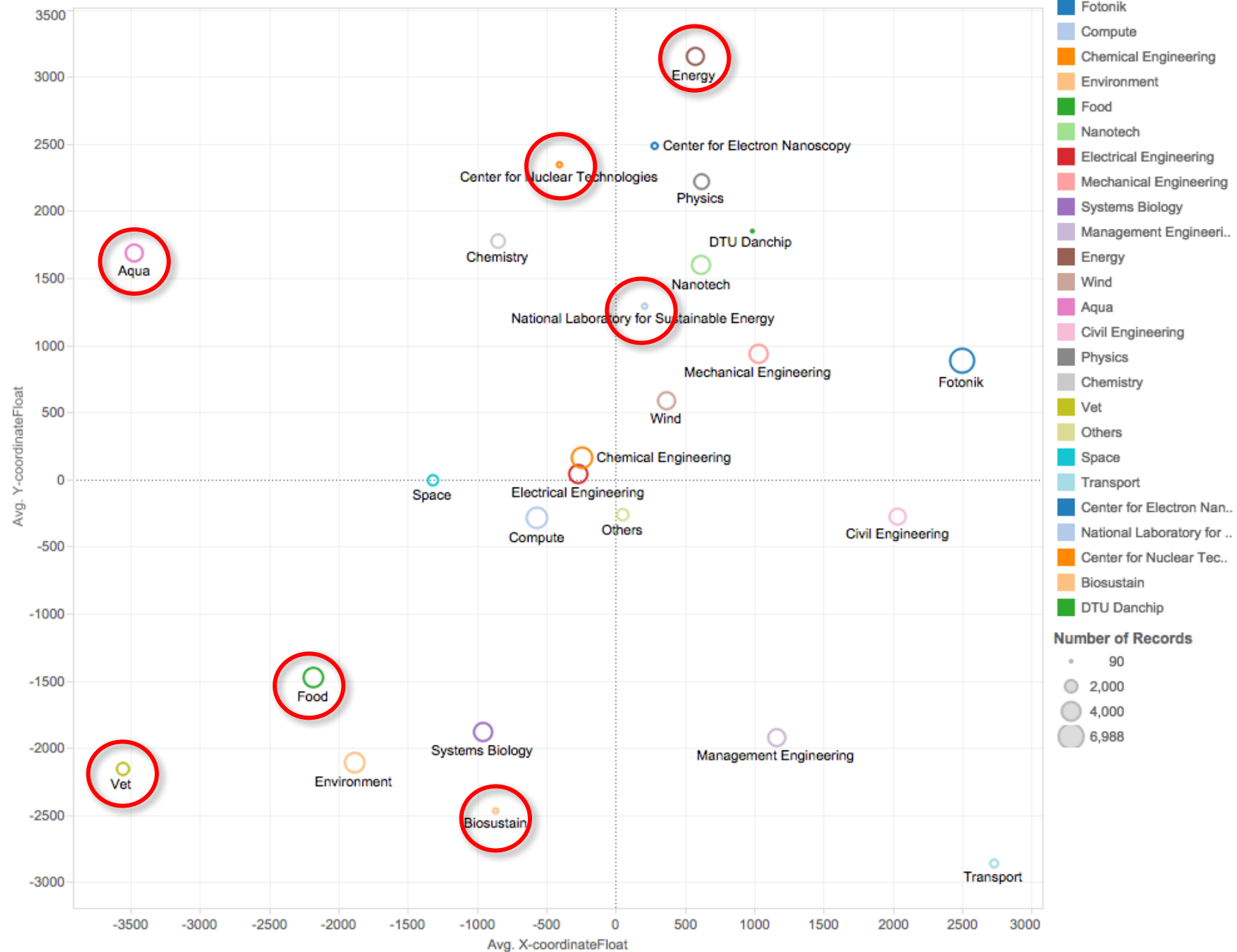
Owner (group)

- Fotonik
- Compute
- Chemical Engineering
- Environment
- Nanotech
- Electrical Engineering
- Mechanical Engineering
- Systems Biology
- Management Engineeri..
- Wind
- Civil Engineering
- Physics
- Chemistry
- Space
- Transport
- Center for Electron Nan..
- DTU Danchip

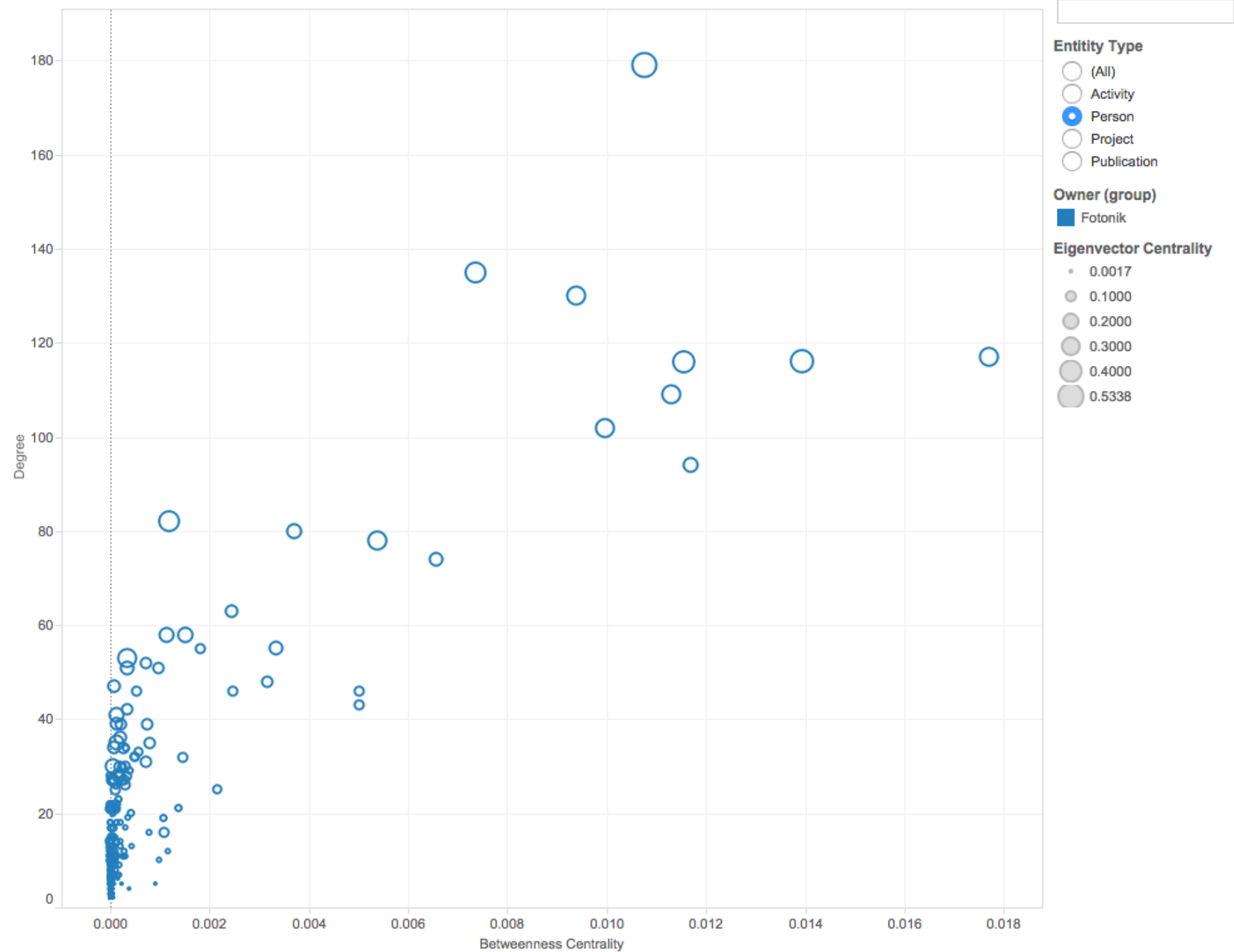
Department filter

(All)

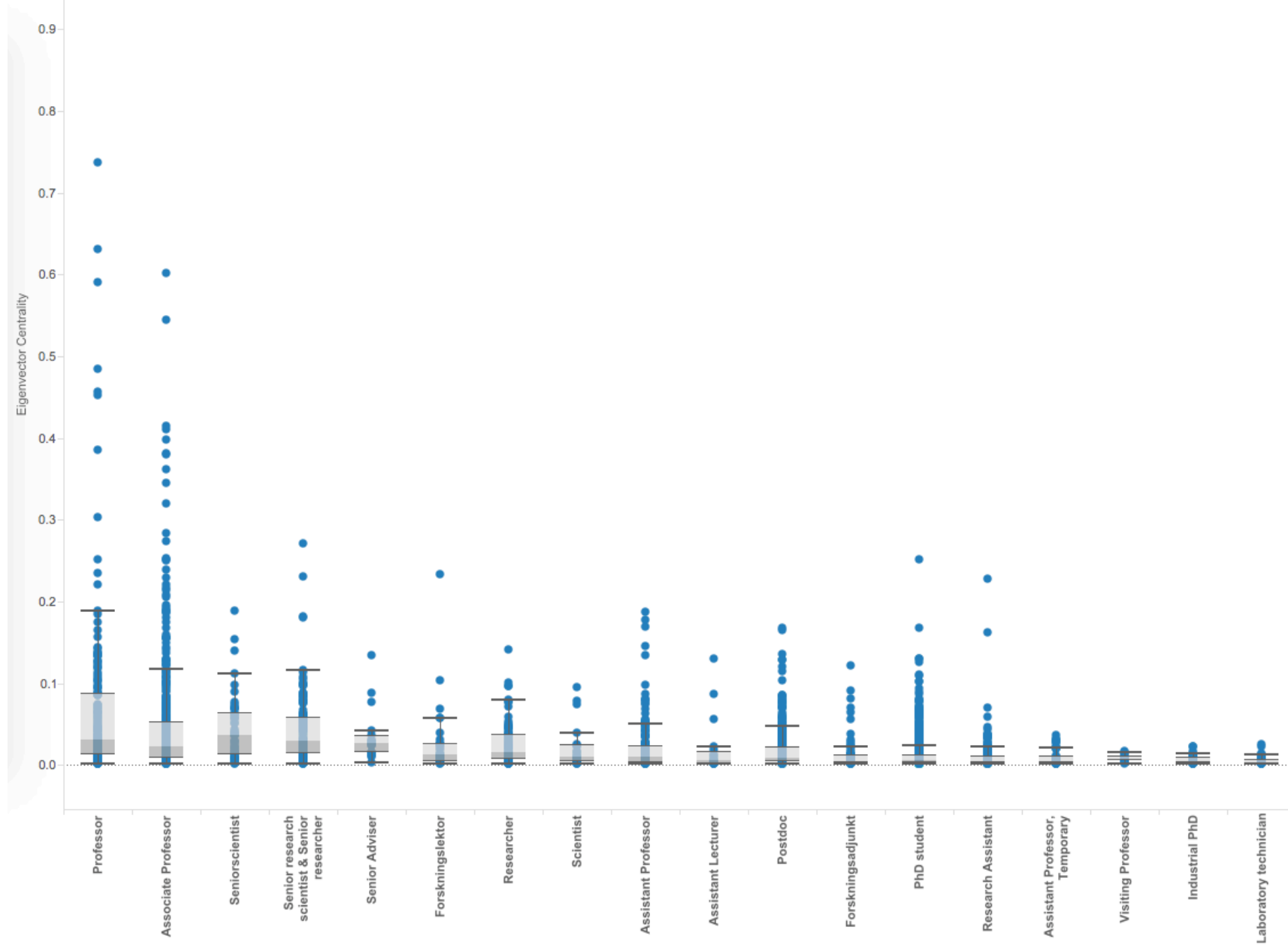
Simplified Knowledge Landscape



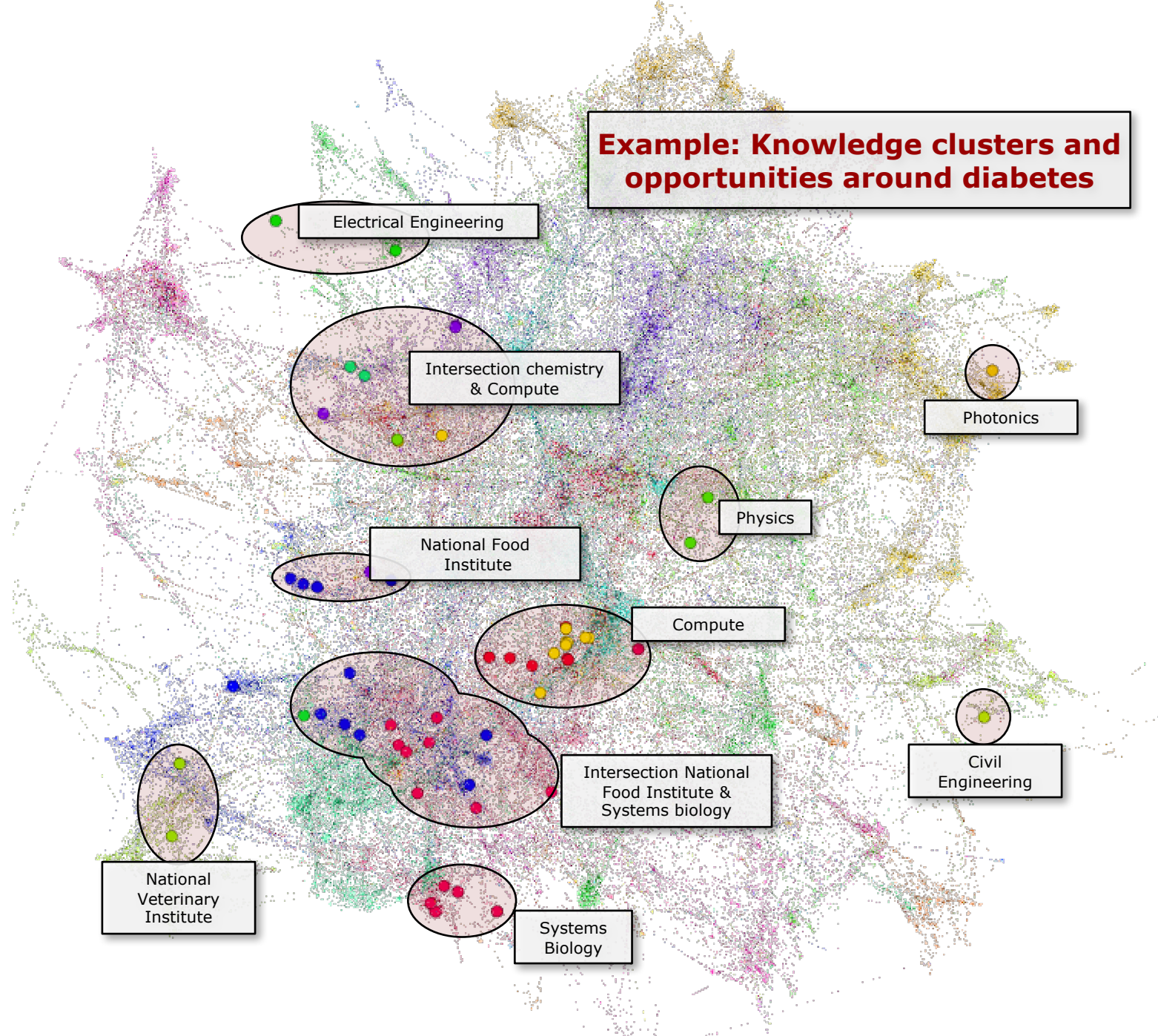
Centrality plot



Network and Formal Organisational Functions



Example: Knowledge clusters and opportunities around diabetes



Electrical Engineering:
e.g. Internal strain estimation for quantification of human heel pad elastic modulus... changes in heel pad elasticity, as seen in e.g. long-distance runners, **diabetes patients...**

Intersection chemistry & Compute

Physics:
e.g. ...The typical biphasic insulin secretion pattern observed with a square **wave glucose stimulation**

Photonics:
*POF based **glucose sensor** incorporating grating wavelength filters*

National Food Institute

Compute

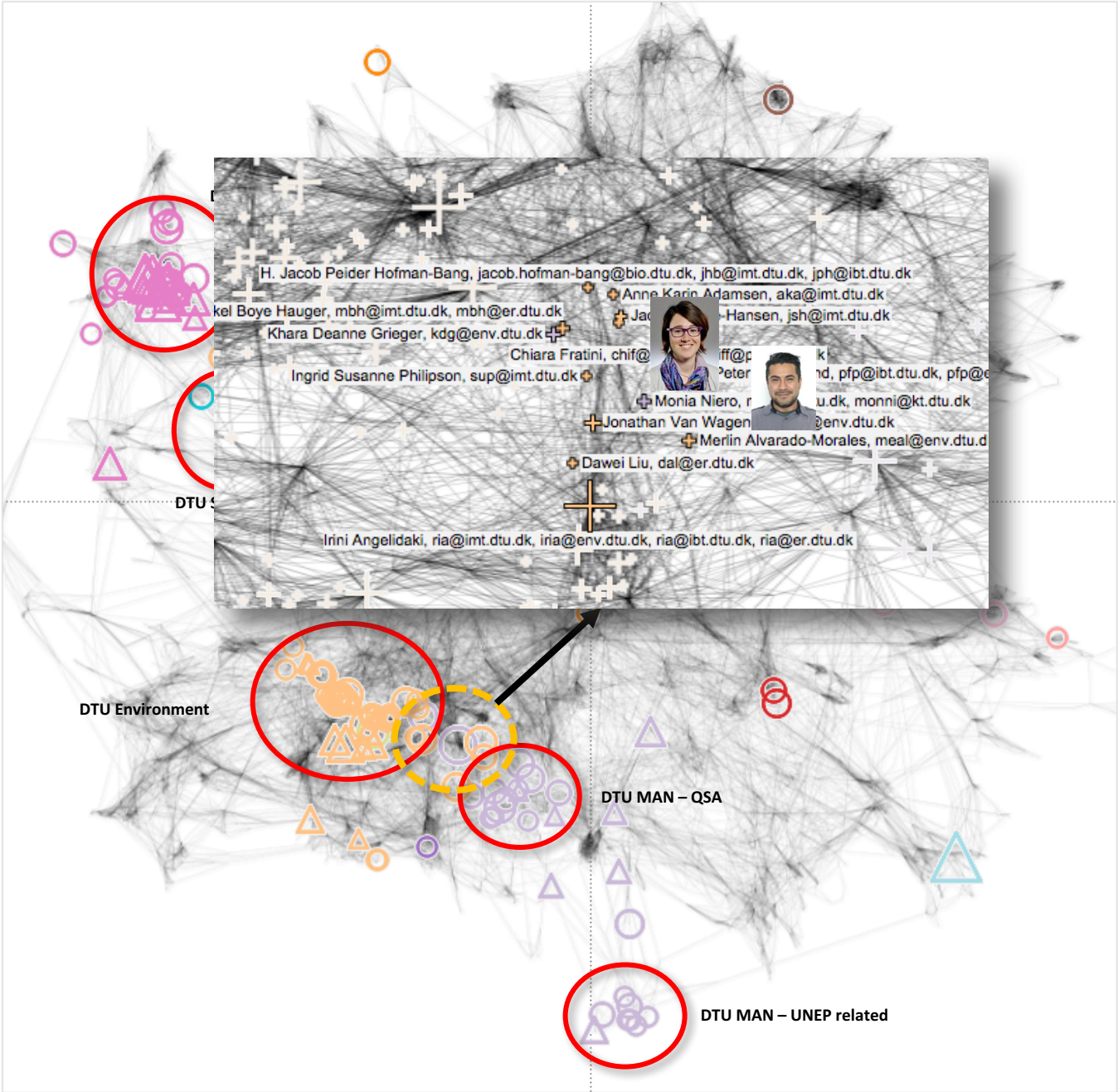
Intersection National Food Institute & Systems biology

Civil Engineering:
Outdoor and indoor exposure to fine and ultrafine particulate matter...
"Statistically significant associations were found between indoor PNC, dominated by indoor use of candles, and lower lung function, **the prediabetic marker HbA1c** and..."

National Veterinary Institute

Systems Biology

Overall Knowledge Landscape : “Climate Change”



Entity Type

- ☒ (All)
- ☐ Activity
- ☐ Person
- ☐ Project
- ☐ Publication

Description search..

:climate change x

Refine descriptio..

Name search

Connections

- ☐ 2
- ☐ 5
- ☐ 10
- ☐ 15

Entity Type

- ☒ Project
- ☐ Publication

Connections

- ☐ 2
- ☐ 15

Department

- ☐ Environment
- ☐ Aqua
- ☐ Management En..
- ☐ Chemical Engin..
- ☐ Civil Engineering
- ☐ Space
- ☐ Transport
- ☐ Electrical Engin..
- ☐ Others
- ☐ Energy
- ☐ Center for Nucle..
- ☐ Mechanical Engi..
- ☐ Systems Biology

Current reach, interest and support

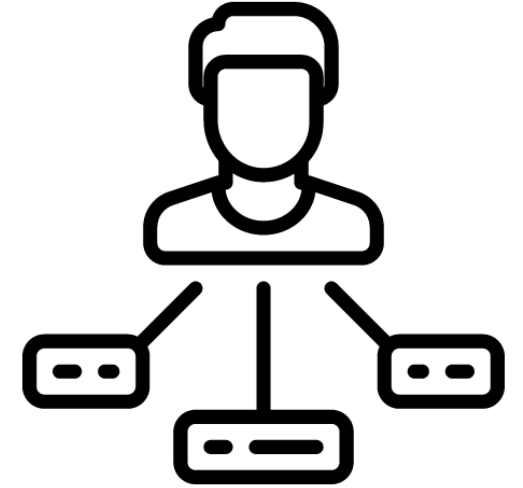
Within DTU

it has draw the attention of

- DTU Aqua
- DTU Elektro
- DTU Systems Biology
- DTU Vet
- DTU Man
- 101, AIS and general management
- DTU Life Science Bioengineering (LSBE) initiative

Outside DTU

- Industriens Fond
- UNEP
- Pontificia Universidad Católica de Chile
- CLEAN
- State of Green
- Copenhagen University

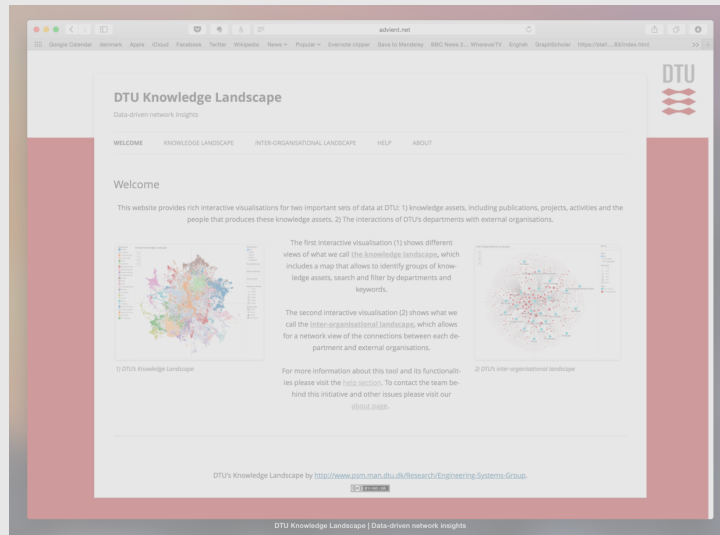


Key Lesson

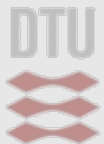
Effective decision
making support? →

Only when it supports
what you already
believe on

We can and should do more about this



Danmarks
Tekniske
Universitet



Knowledge Landscape

Net-Sights

Network Insights for Collaborative Sustainable Production





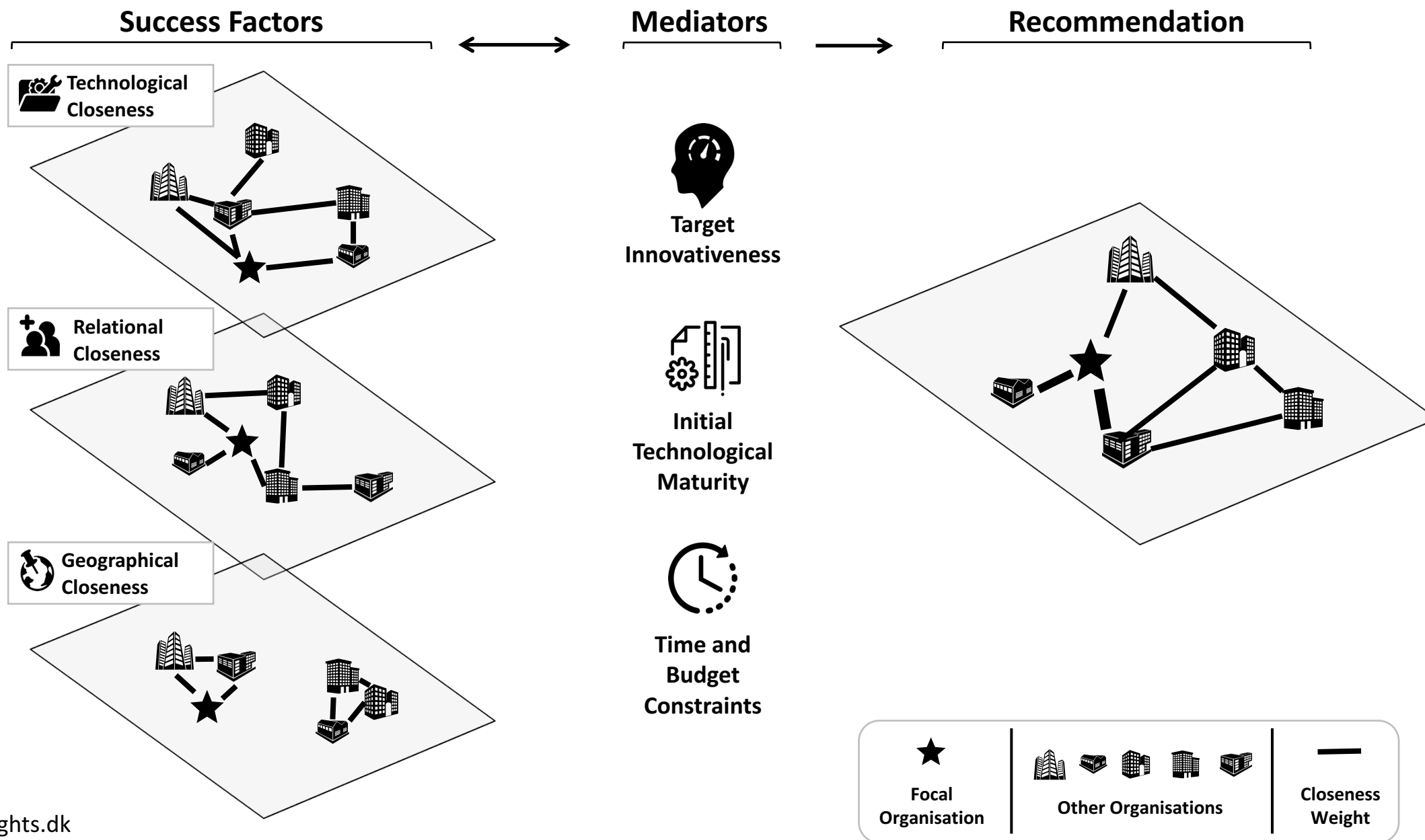
Network Insights for Collaborative Sustainable Production

Finding the right partner

The urgent need for sustainability



Diagrammatic overview of the framework



Overview of interlocking technologies in Cleantech

Energy Efficiency,
Intelligent energy,
Climate adaptation,
Industry and governmental agencies

Heating
and cooling

Bioenergy

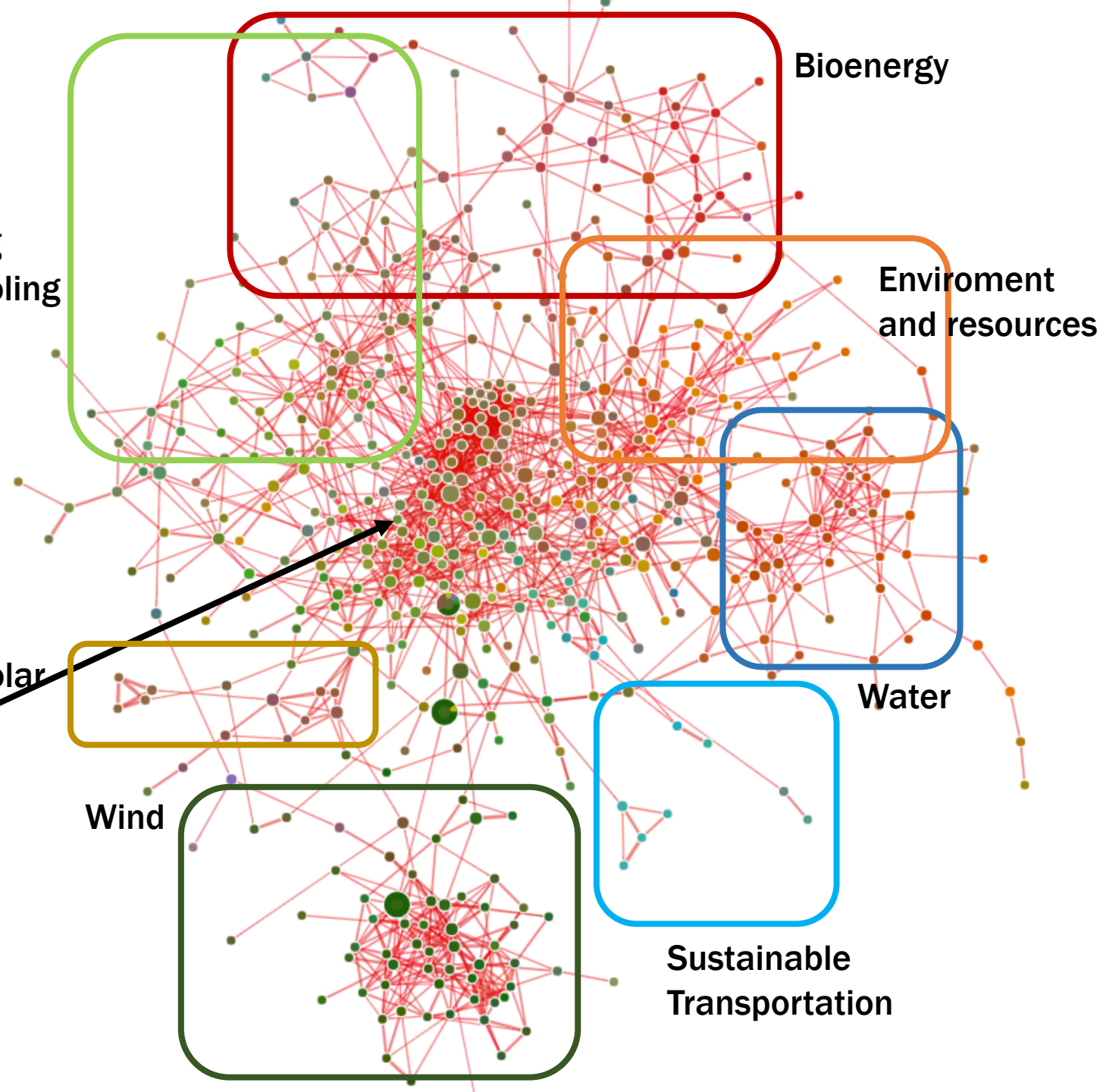
Environment
and resources

Solar

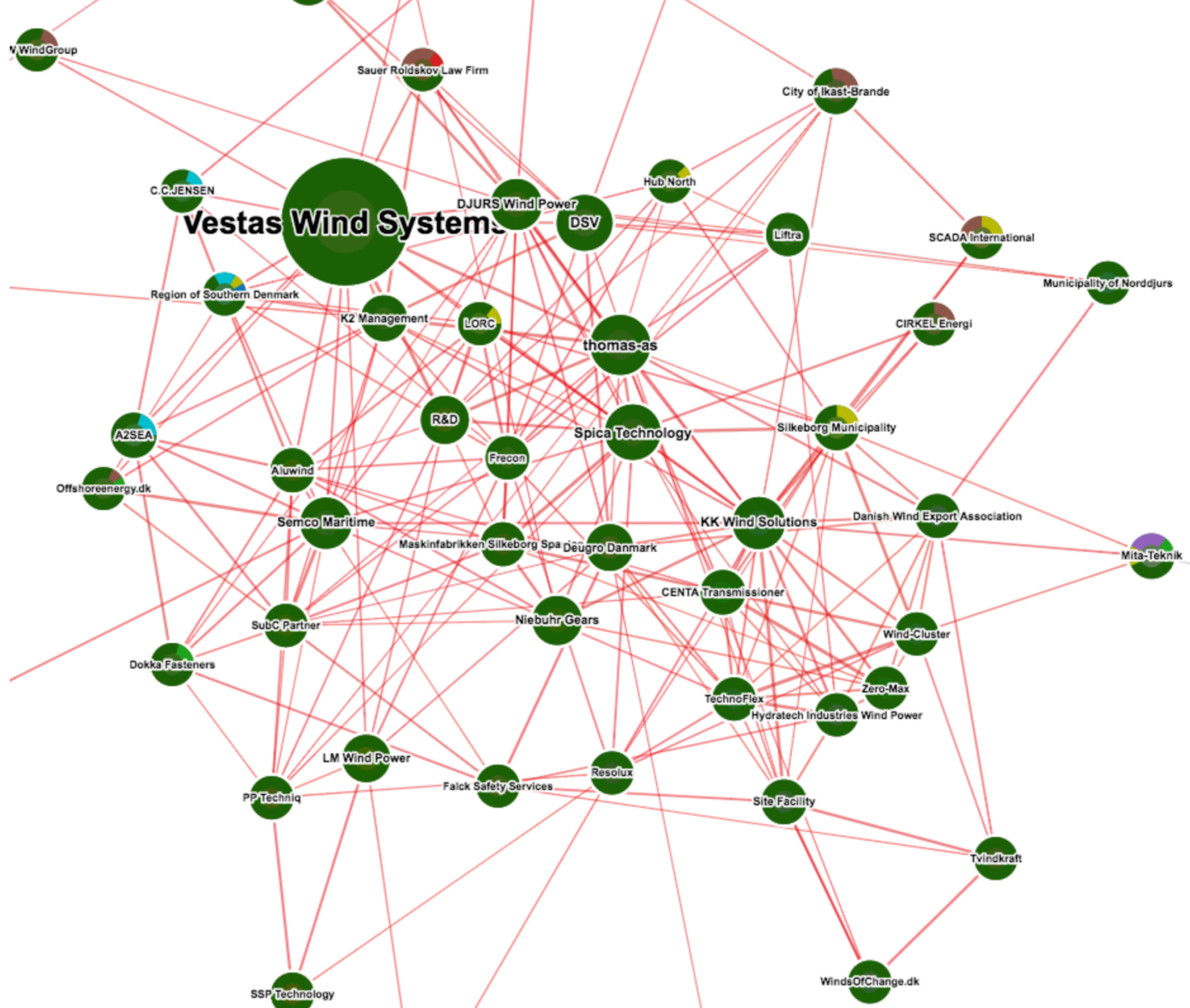
Water

Wind

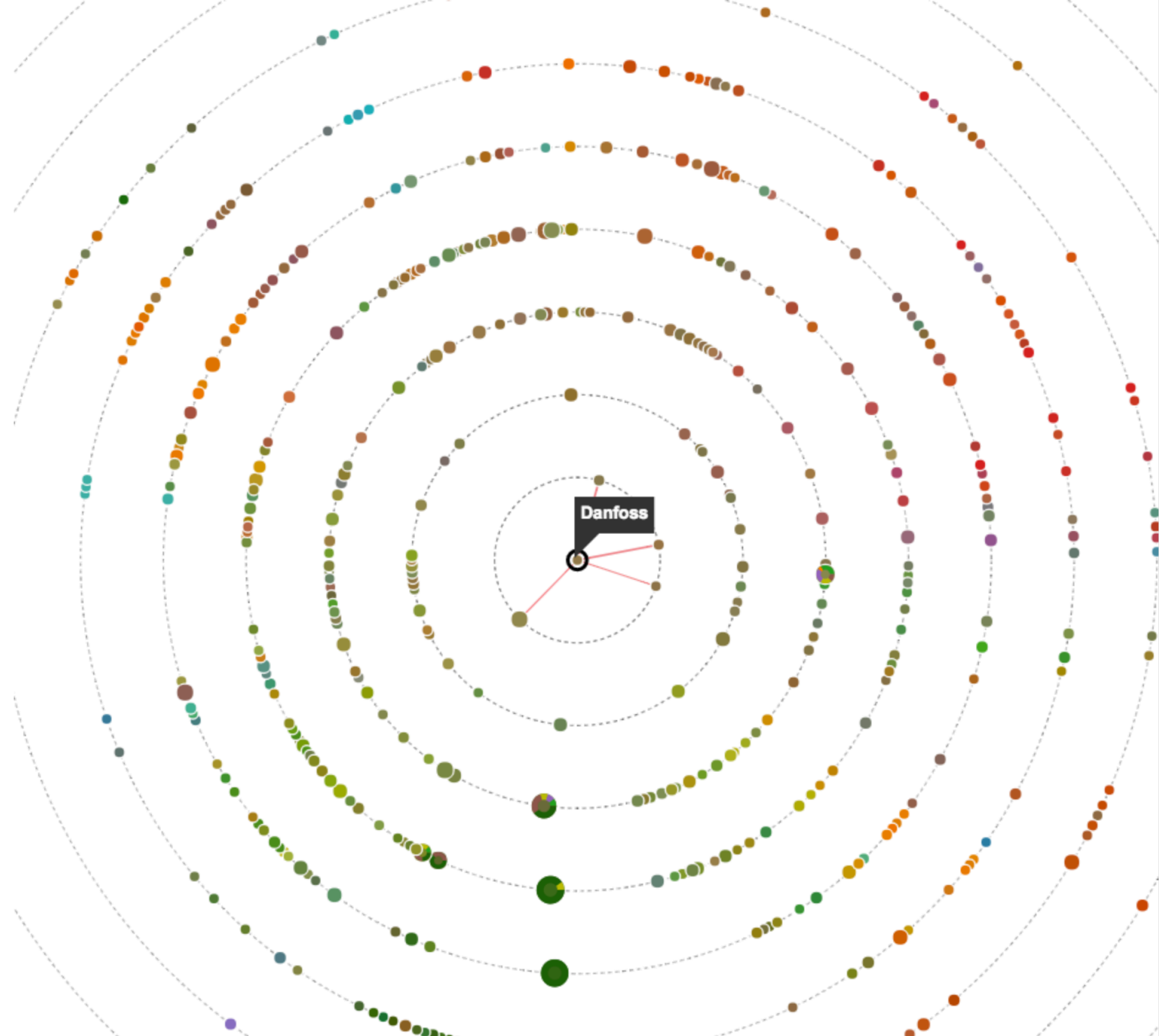
Sustainable
Transportation



Wind energy



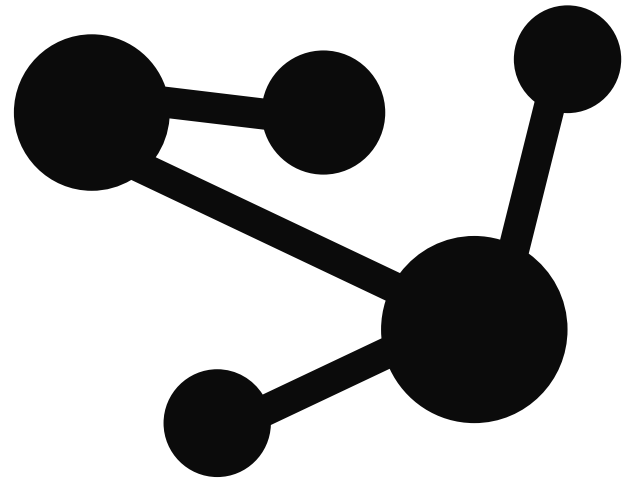
Danfoss



Opportunities and next steps

Analyses of

- EU and national science funding
- Knowledge landscapes
- New interdisciplinary collaboration KPIs (and KPPs)
- Trends through content and structure
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