



ISSI2009

Detection of emerging research fronts in solar cell research

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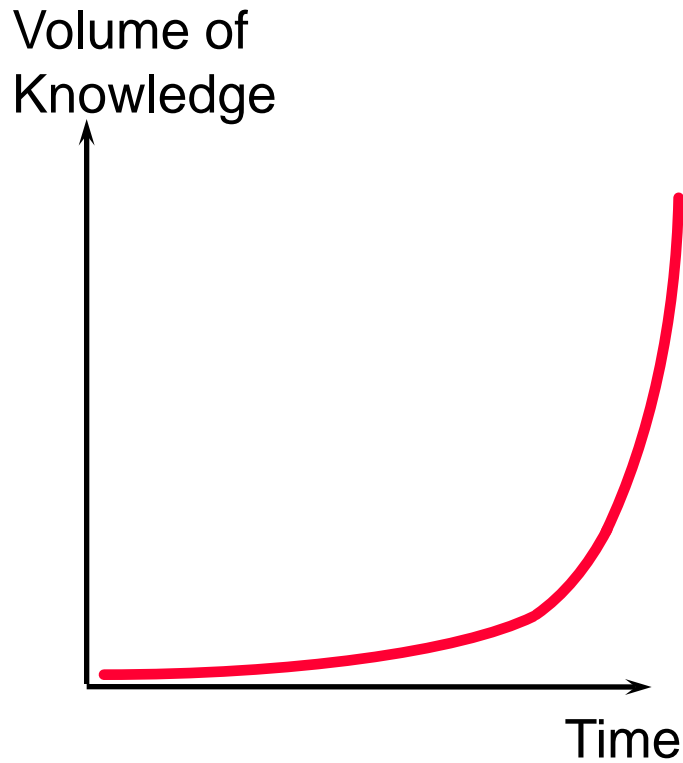
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Technology

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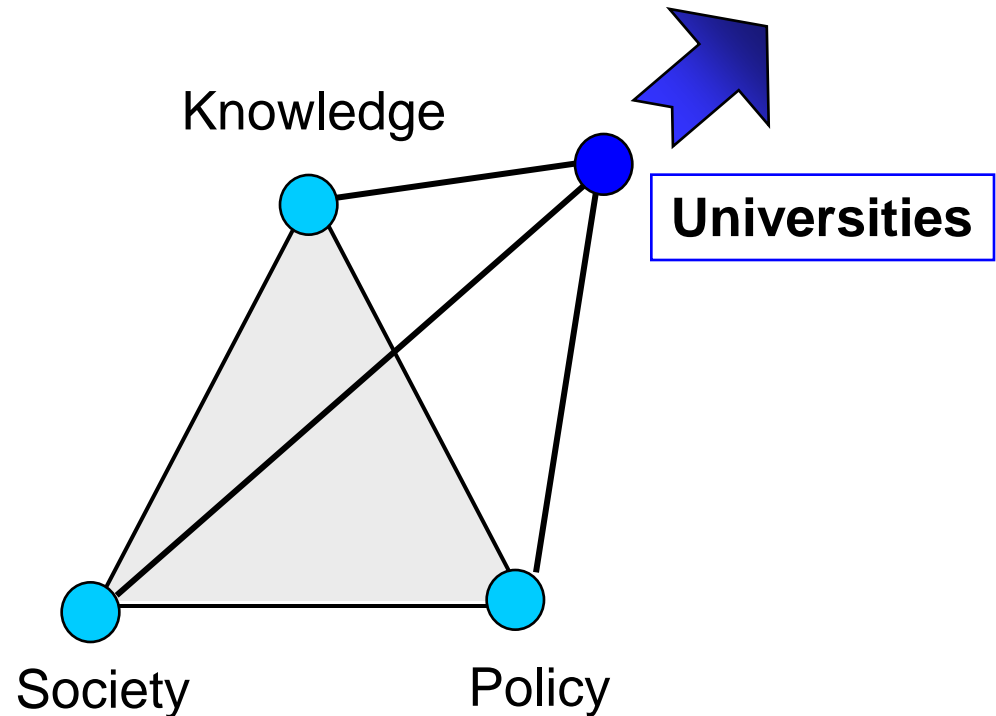
Information flood & New roles of leading university

We are drowning in the information sea.

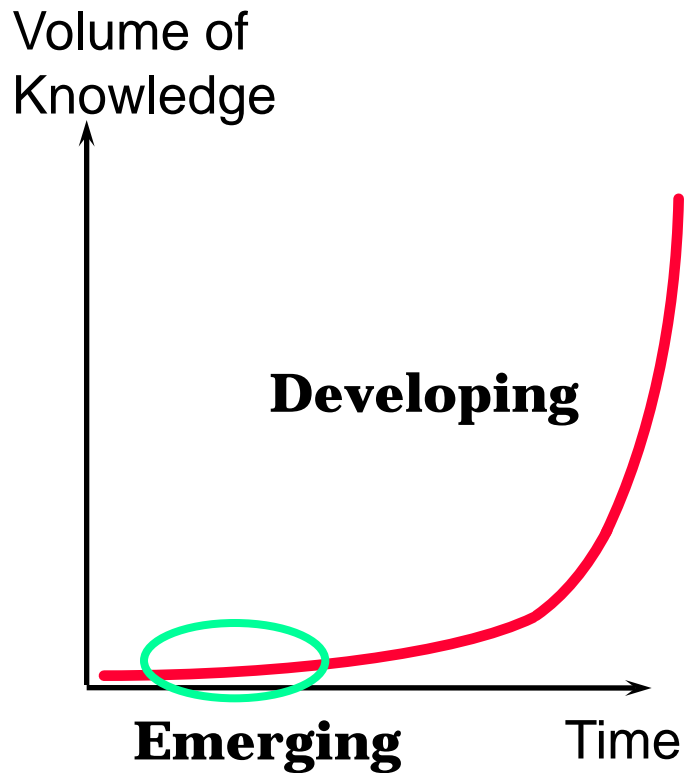


Driving Engine for Movements

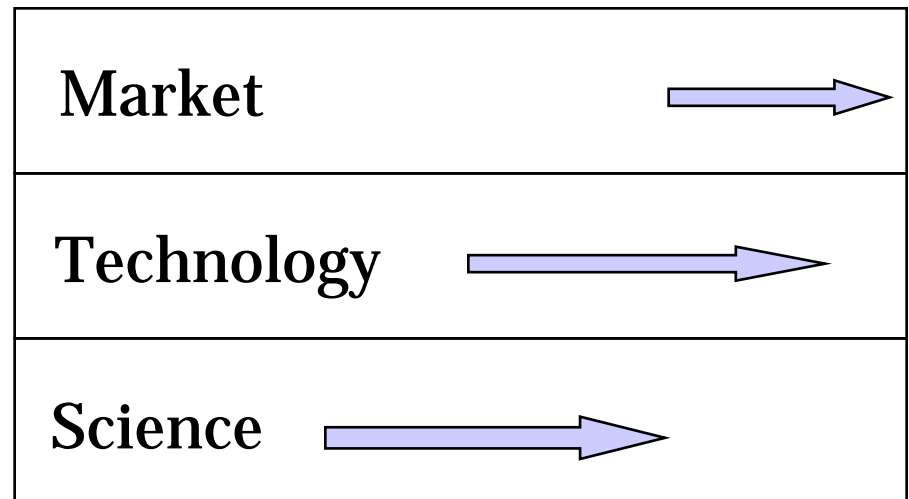
National competence?
Sustainable Society?



Detection of emerging field

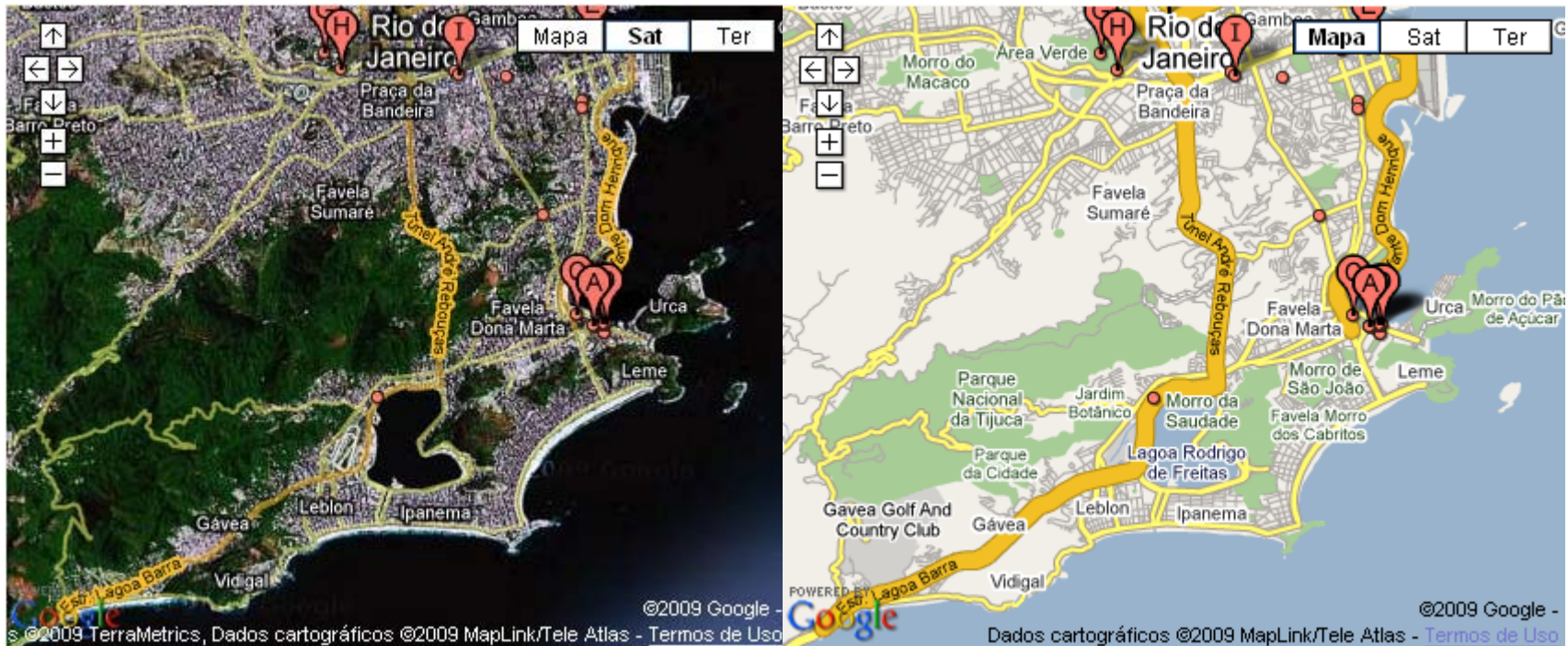


Science and Technology Roadmap



What is a Roadmap?

“road map” is a layout of paths or routes that exists (or could exist) in some particular geographical space.



road map is used to know where we are, came from, will go.

What is a S&T Roadmap?

“A consensus articulation of scientifically informed vision of attractive technology futures”

~Branscomb (Former Science and Technology Adviser for U.S. President)

Science and Technology (S&T) roadmap offers a map about a certain S&T domain to show where we are, came from, will go.

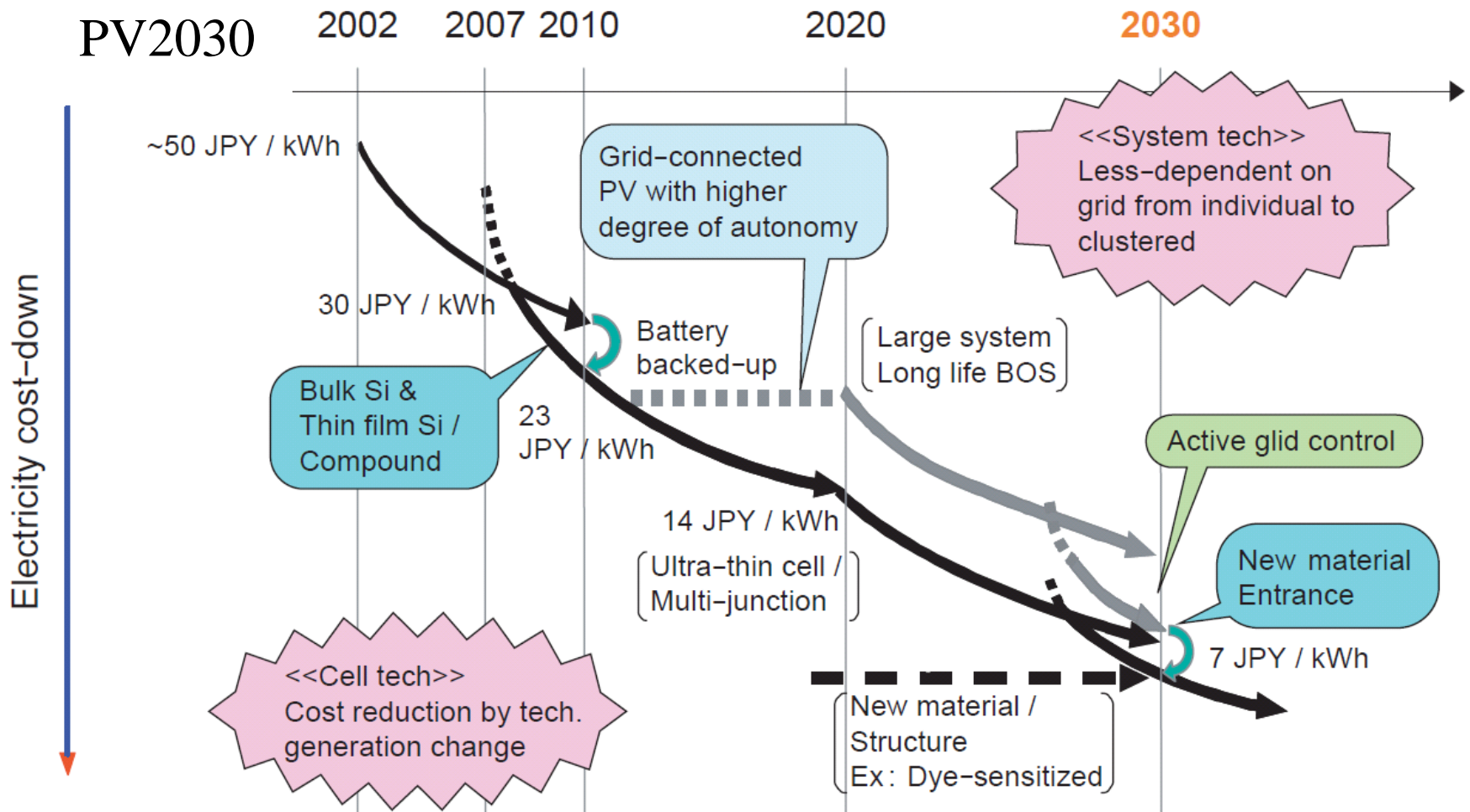
Example 1 quantitative roadmap

ITRS (International Technology Roadmap for Semiconductors) 2007 Edition

| <i>YEAR OF PRODUCTION</i> | <i>2007</i> | <i>2008</i> | <i>2009</i> | <i>2010</i> |
|---|-------------|-------------|-------------|-------------|
| <i>DRAM stagger-contacted Metal 1 (M1) 1/2 Pitch (nm)</i> | 65 | 57 | 50 | 45 |
| <i>MPU/ASIC stagger-contacted Metal 1 (M1) 1/2 Pitch (nm)</i> | 68 | 59 | 52 | 45 |
| <i>Flash Uncontacted Poly Si 1/2 Pitch (nm)</i> | 54 | 45 | 40 | 36 |
| <i>MPU Printed Gate Length (nm)</i> | 42 | 38 | 34 | 30 |
| <i>MPU Physical Gate Length (nm)</i> | 25 | 23 | 20 | 18 |

What is a S&T Roadmap?

Example 2 qualitative roadmap



NEDO (New Energy and industrial technology Development Organization), JPN

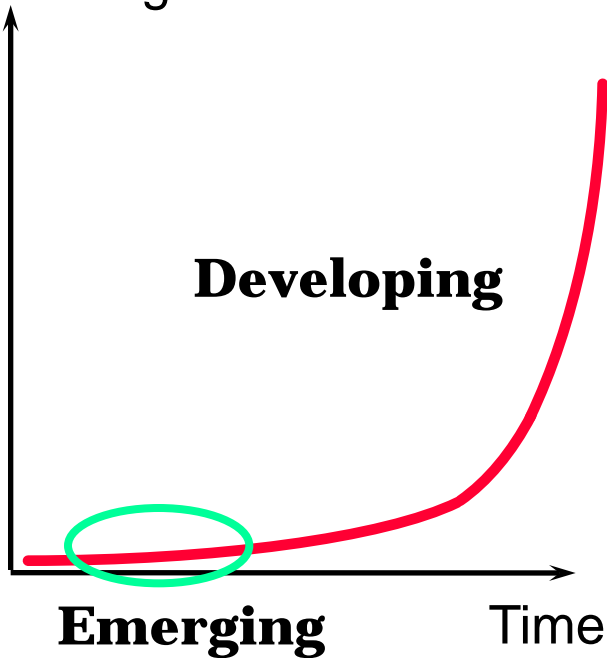
Our Approach

Citation Network Analysis

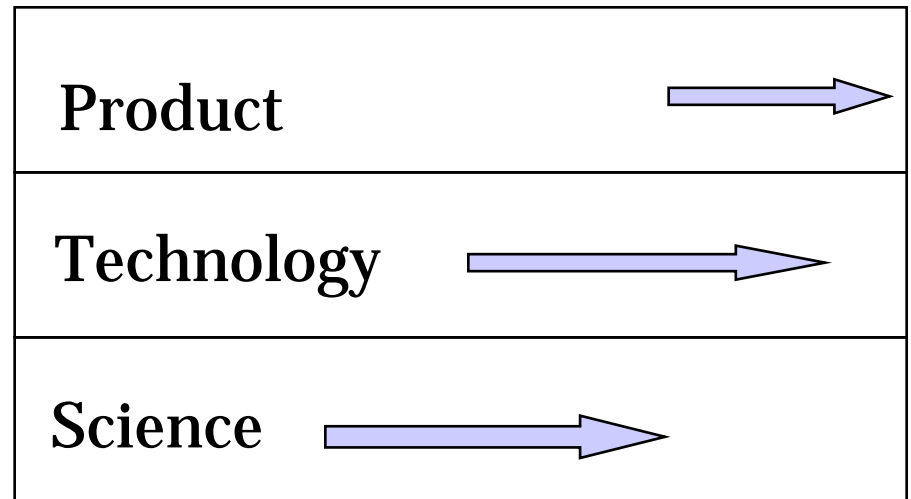


Science and Technology Roadmap

Volume of Knowledge



Case study in solar cell research.



Data & Method

- Data**
1. Energy & Fuels (E&F) 152,514 papers
 2. Solar cell (SC) 15,600 papers

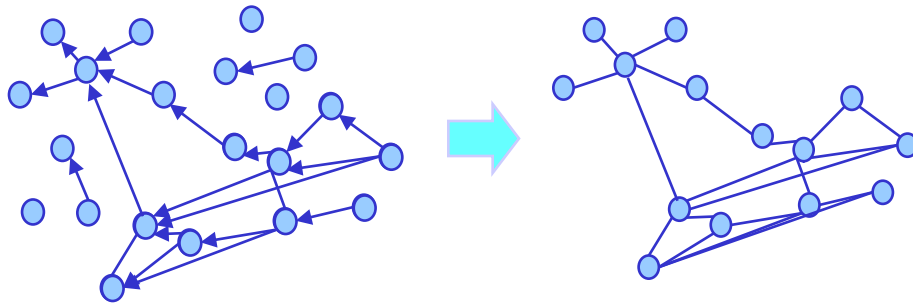
Query: All papers in 63 journals categorized as *Energy and Fuels* in JCR.

Query: solar cell*

Period: 1970-2006

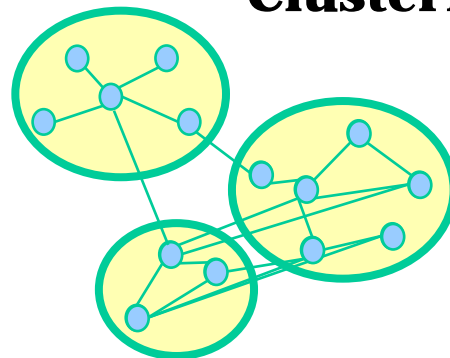


Citation Network Analysis

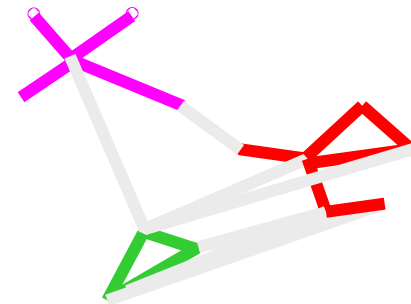


Identification of characteristics of clusters

Clustering



Visualization

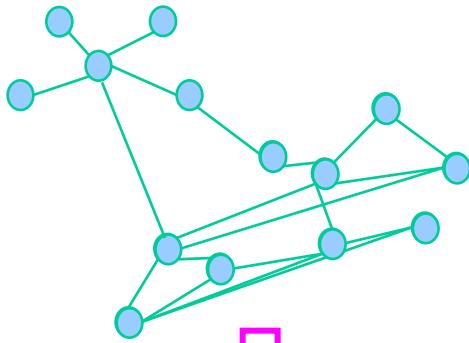


Method Citation network analysis

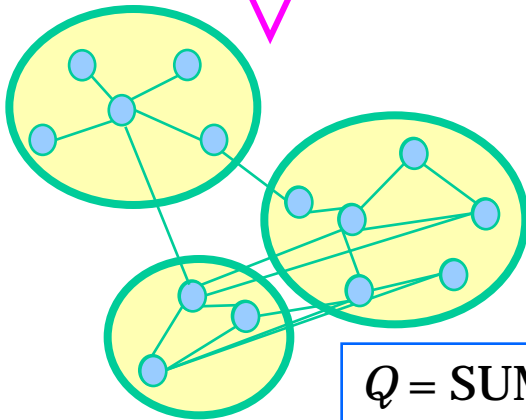
Clustering

Newman-Girvan method

Newman & Girvan, Phys. Rev. E (2004).



Clustering is stopped at Q_{max}



Modularity Q

$$Q = \sum_{s=1}^M \left[\frac{l_s}{l} - \left(\frac{d_s}{2l} \right)^2 \right]$$

M : number of module

l : total number of links

l_s : number of links in module s

d_s : total number of links of nodes in module s

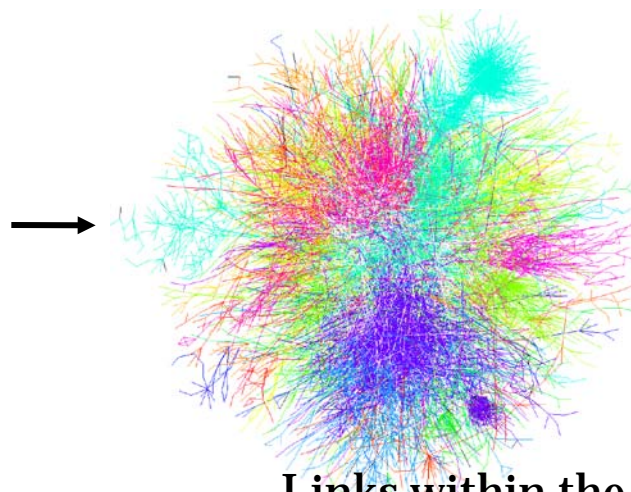
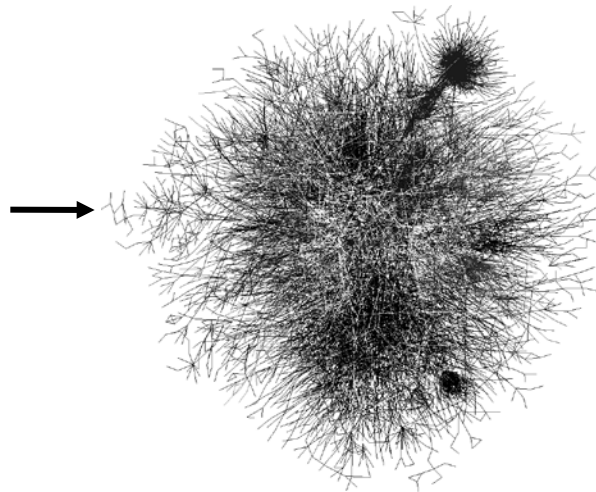
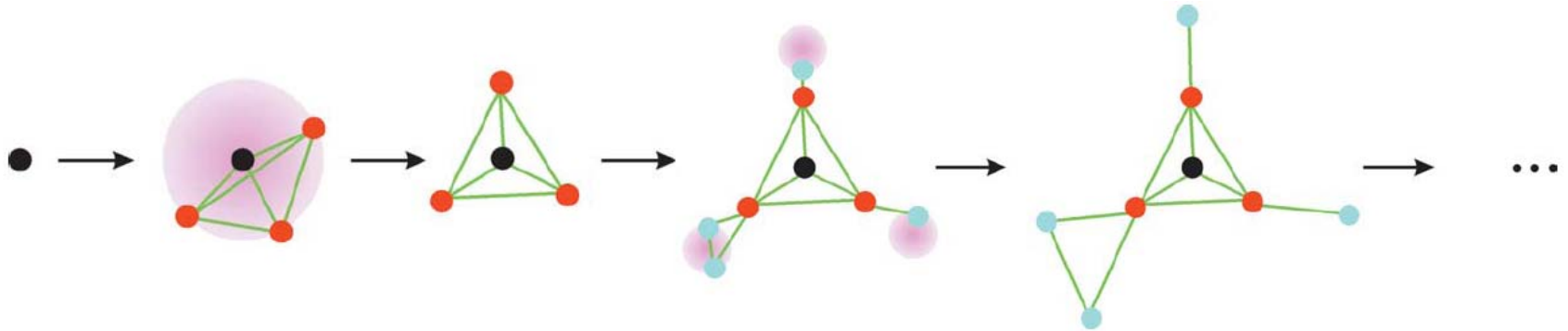
$Q = \text{SUM}(\text{probability of the existence of a link between nodes in the cluster}) - (\text{theoretical value of the probability in random network})$

Method Citation network analysis

Visualization Large Graph Layout (LGL)

Adai et al. J. Mol. Biol. (2004).

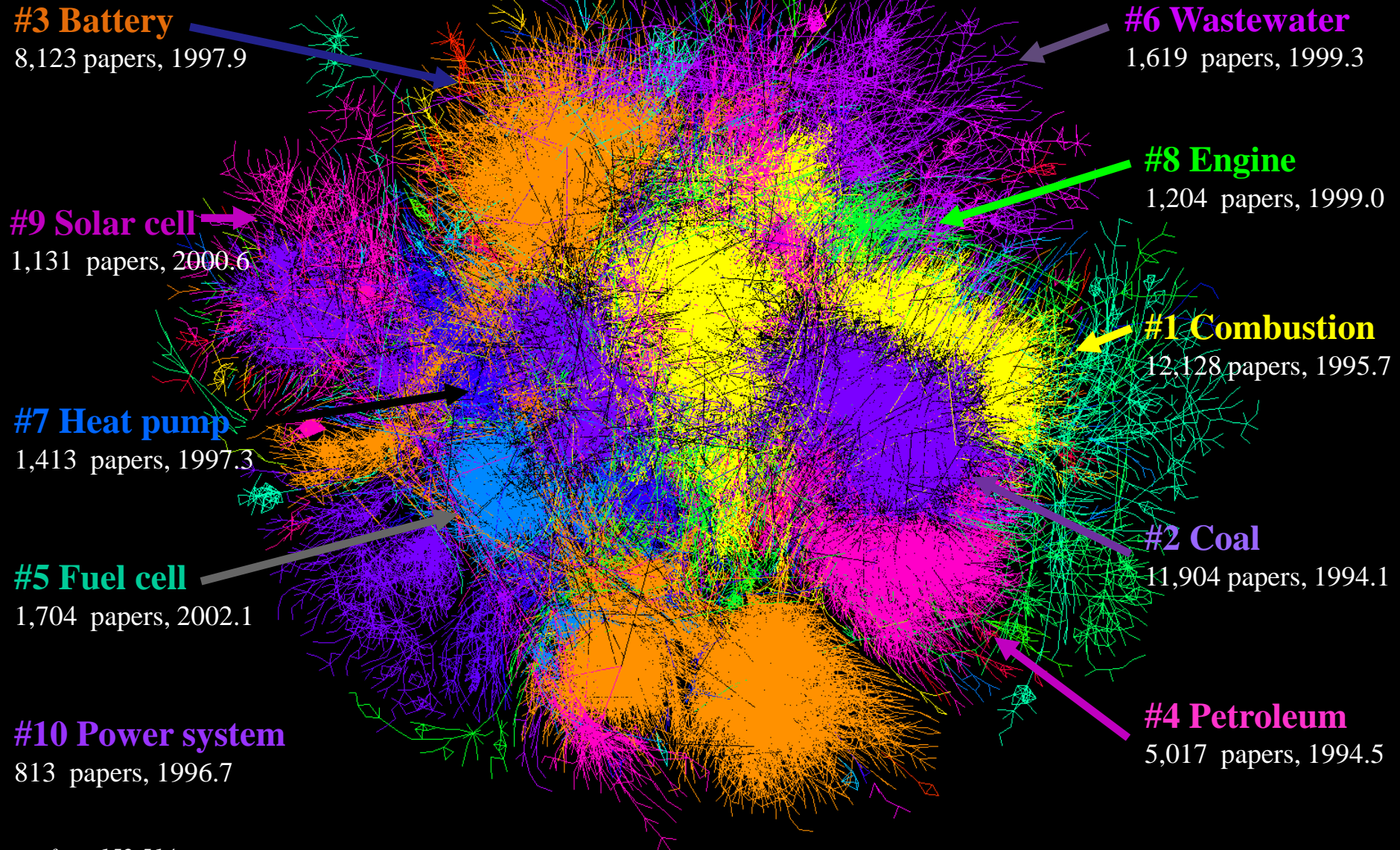
Locally-optimized spring model



Links within the same cluster are colored with the same color.

Results & Discussions

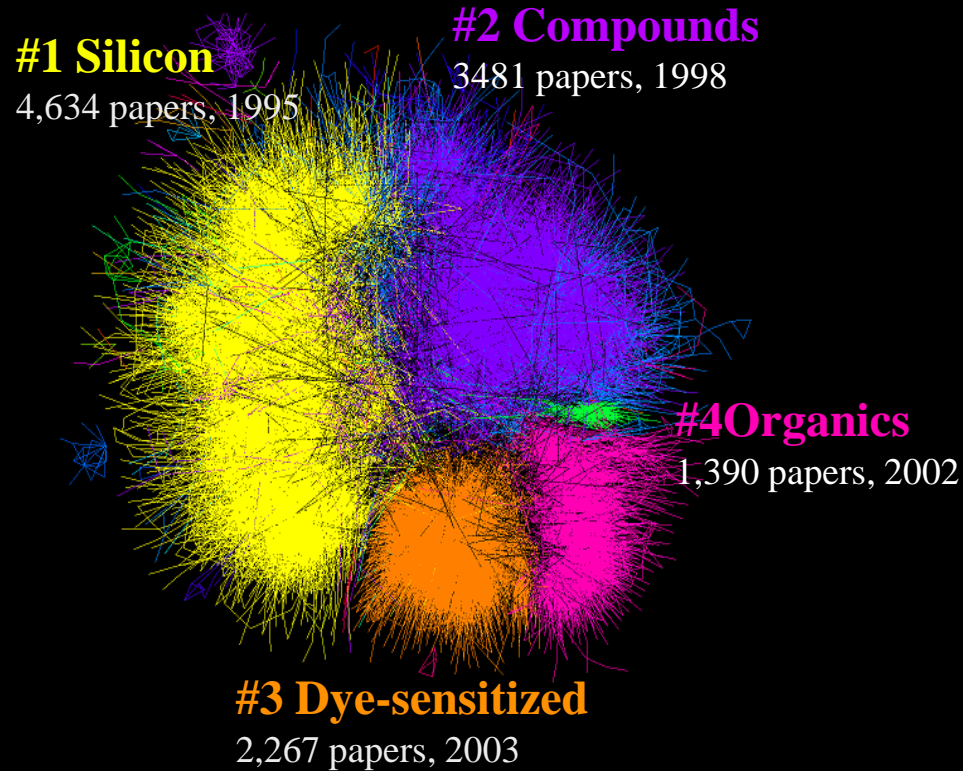
Academic Landscape of Energy and Fuels



*from 152,514 papers
(1970-2005, connected component = 53,033 papers)*

| |
|---|
| # Rank, Cluster name Cluster size, Average years publication |
|---|

Academic Landscape of Solar Cell Research

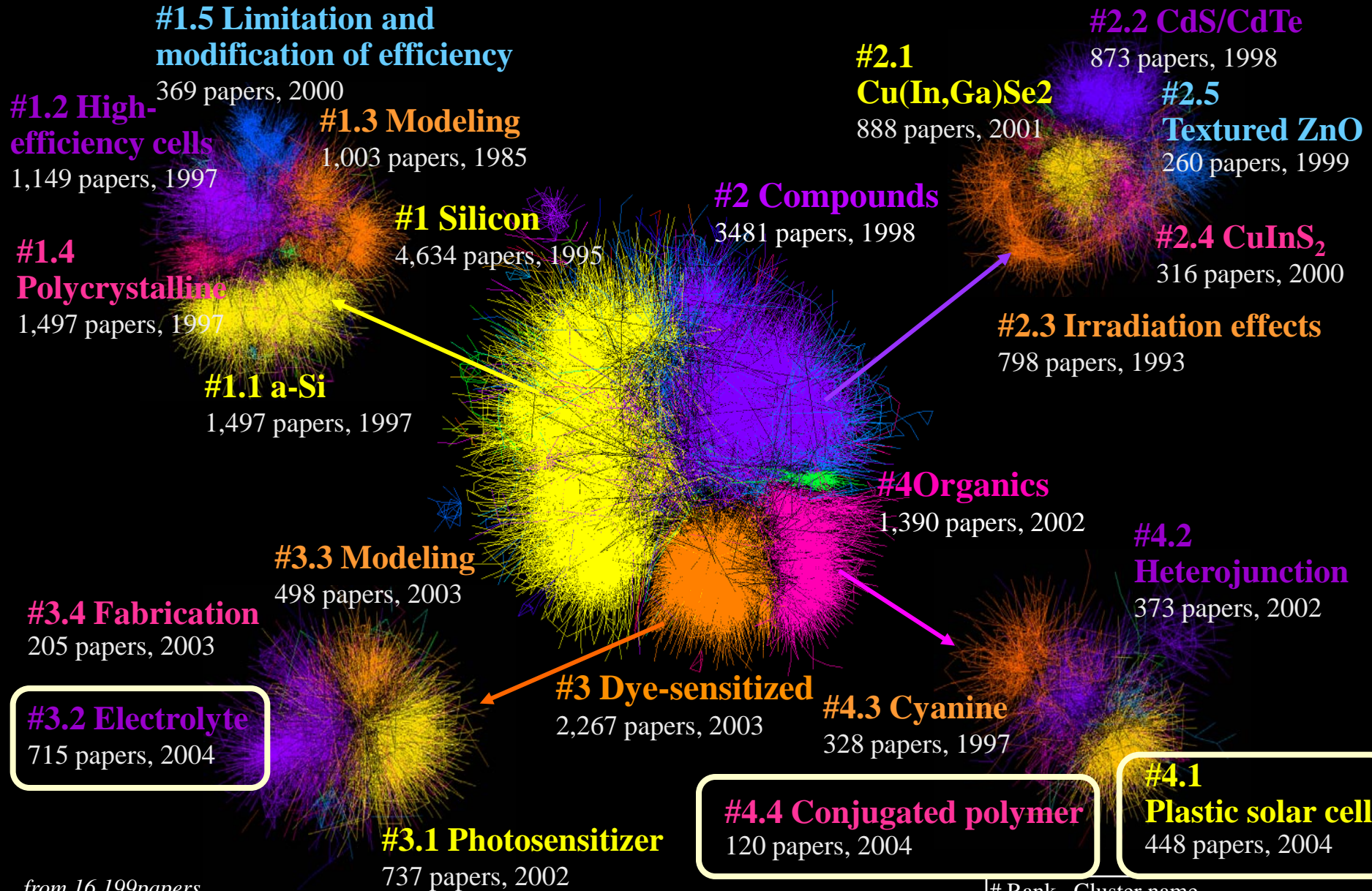


from 16,199 papers

(1959-2006, connected component = 13,682 papers)

| |
|---|
| # Rank, Cluster name Cluster size, Average years publication |
|---|

Academic Landscape of Solar Cell Research

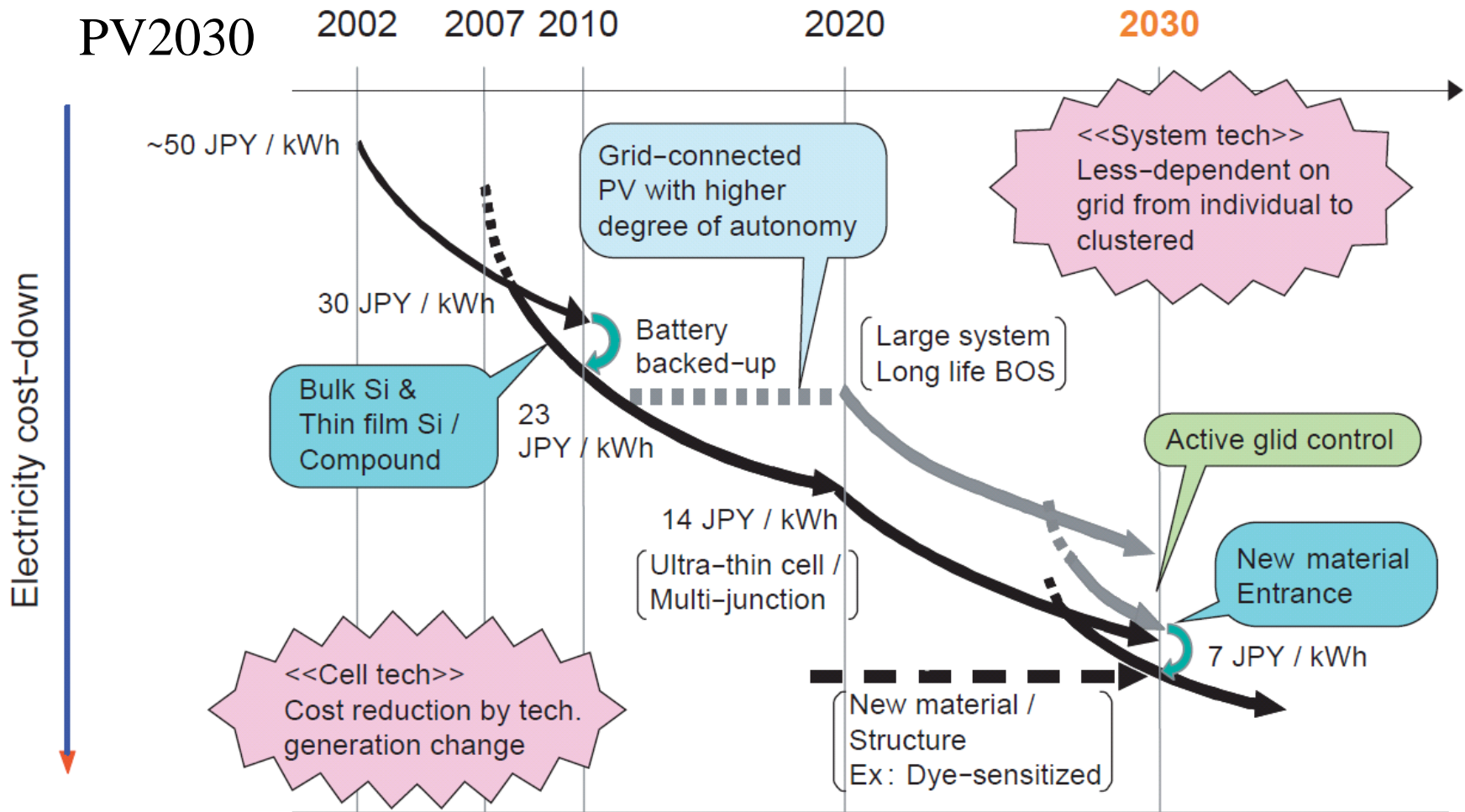


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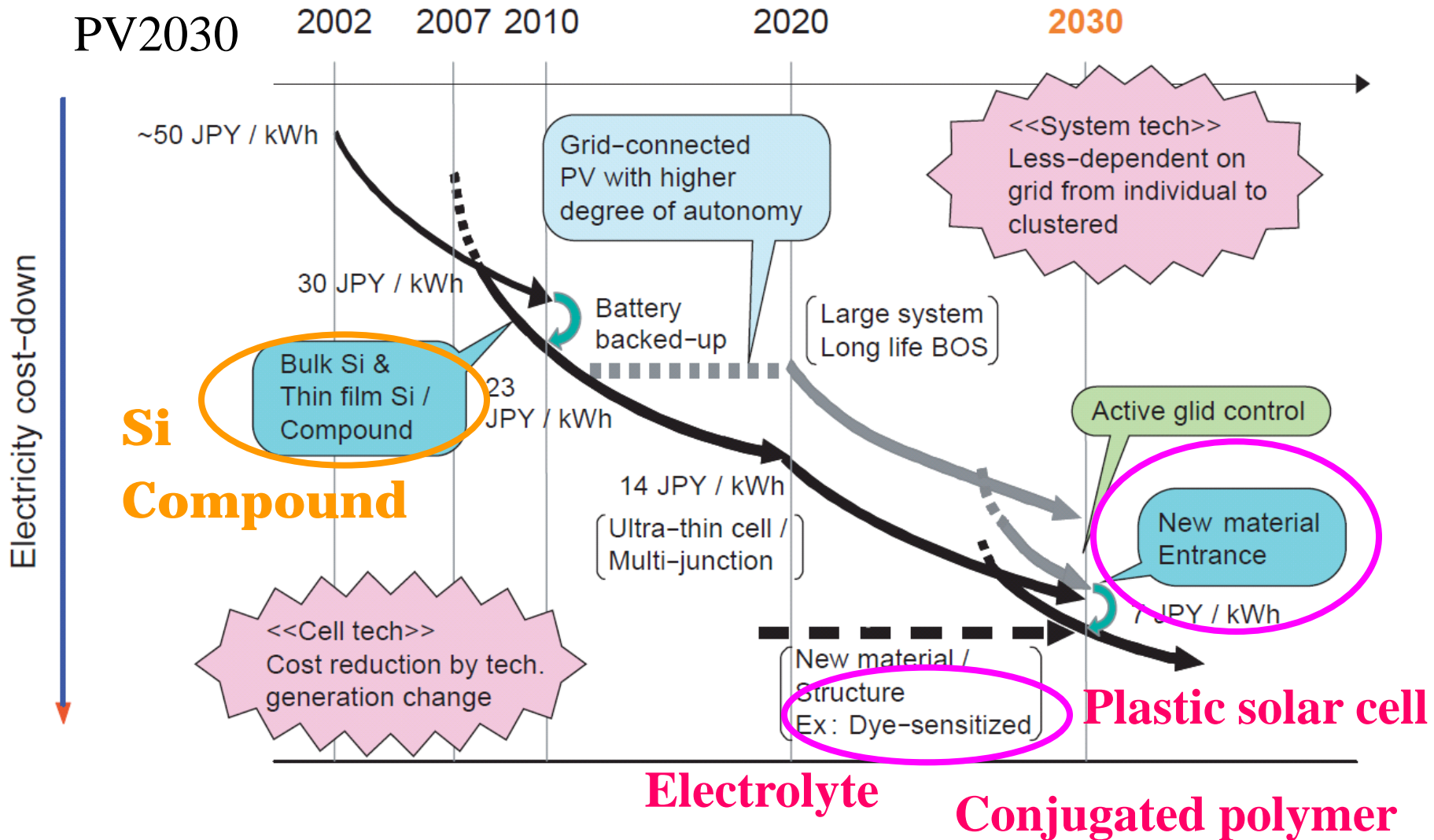
Rank, Cluster name
Cluster size, Average years publication

Citation network analysis supporting S&T Roadmapping

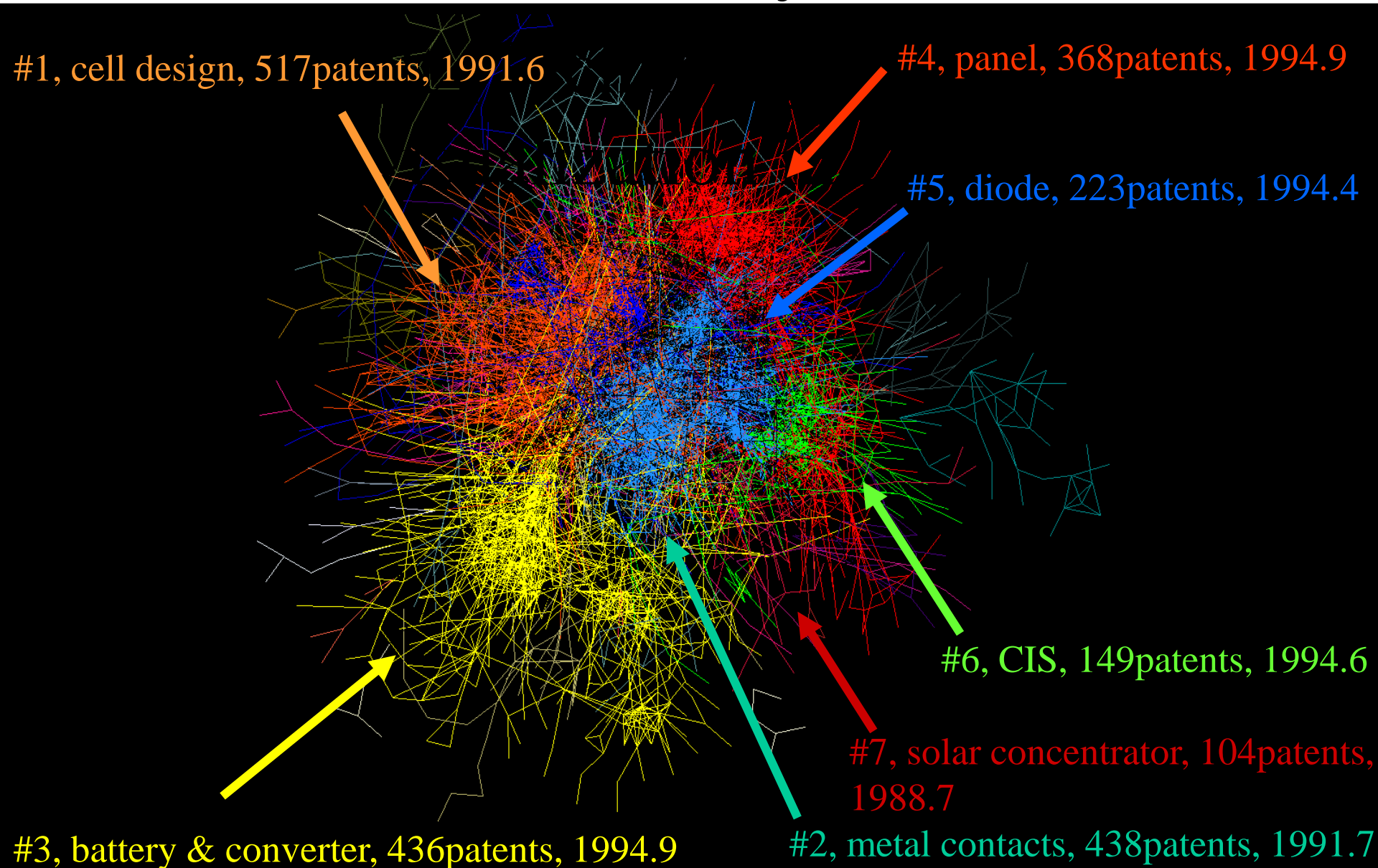


NEDO (New Energy and industrial technology Development Organization), JPN

Citation network analysis supporting S&T Roadmapping



Citation Network Analysis of Patents



Only clusters whose #patents \geq 100 were named.

Relationship between Science and technology

Patents

Exist

Not Exist

Papers

Exist

Science-linkage

A

Chances for industry
or basic research

B

Not Exist

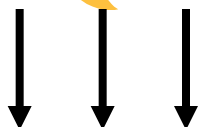
C

Too applied or
lack of science

D

| | | |
|-----------|--|--|
| Exist | Science-linkage A | Chances for industry or basic research B |
| Not Exist | Too applied or lack of science C | D |

Gap between Science and technology



Paper clusters
Patent clusters

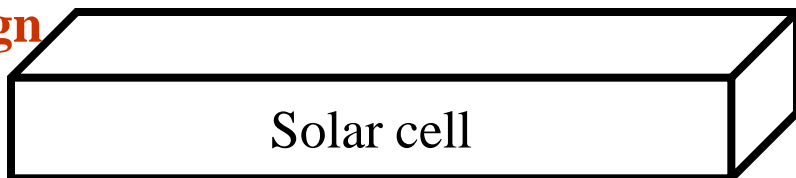
#4, panel

#7, solar

concentrator

#1, cell design

#6, CIS



#1, silicon

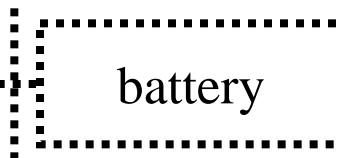
#2, compounds

#3, dye-sensitized

#4, polymer

#5, diode

#2, metal contacts



#3, battery & converter

Conclusion

Citation network analysis

can be used as a tool for technological forecasting, and its feasibility is demonstrated in solar cell research.

successfully illustrated academic landscape of the energy and solar cell domains and emerging research fields there.

can detect emerging fields whose parts are not listed in the previous S&T roadmap.

can extract different research front between papers and patents.

Limitations and future works

Limitation

- *not* S&T roadmap itself *but* its trend
- Citation bias (self citation bias, prominent paper bias, etc.)
- Query dependent results (we must know what query should be used to know what we want to know its details.)

Future works

- Data cleansing
- Comparison between text-mining and link-mining.

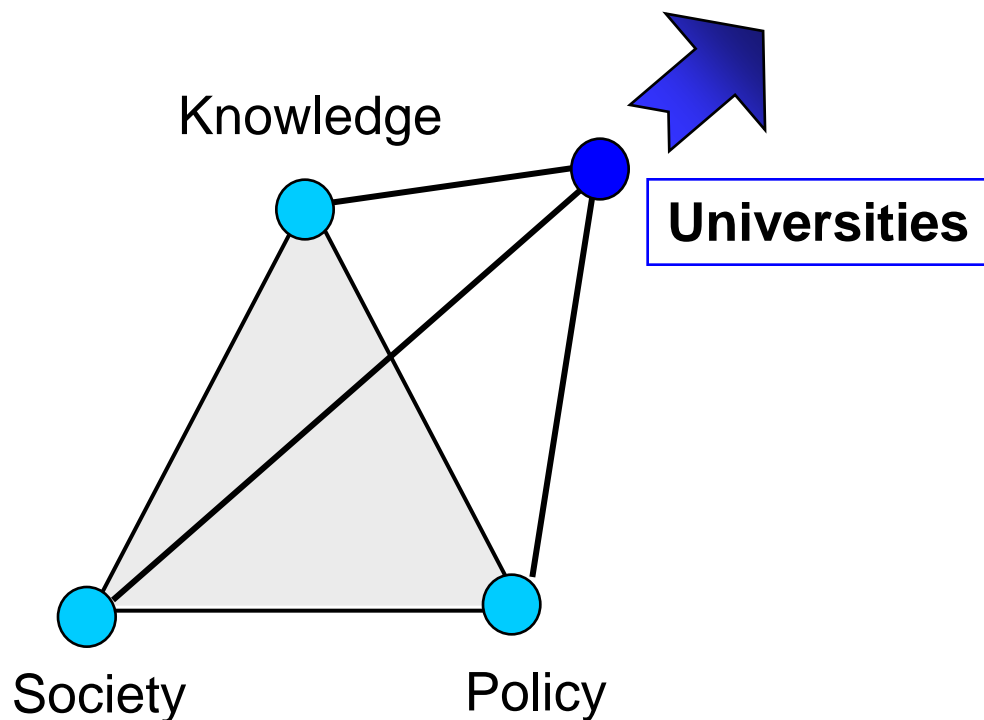
Toward a university as a hub of S&T policy-making

Development of methodology for academic overviewing and implementation of the system to assist technology roadmapping.

Grant for Industrial Technology Research (NEDO)

PI: Yuya Kajikawa

2009-2011



Thank you for your listening!

Any questions, comments, suggestions, and proposals are welcome!

Correspondence: Yuya Kajikawa, Ph. D

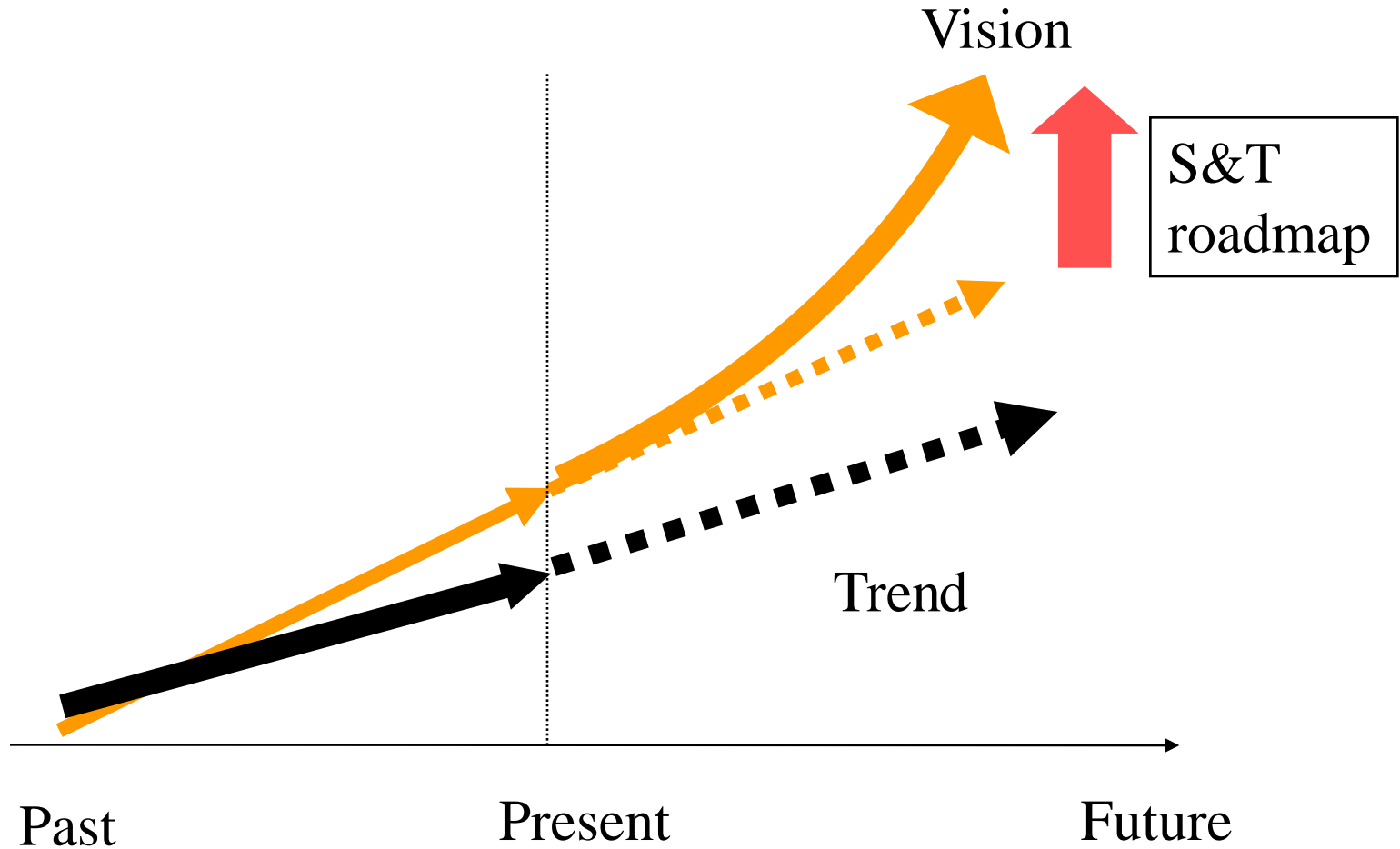
kaji@ipr-ctr.t.u-tokyo.ac.jp

Innovation Policy Research Center (IPR-CTR)

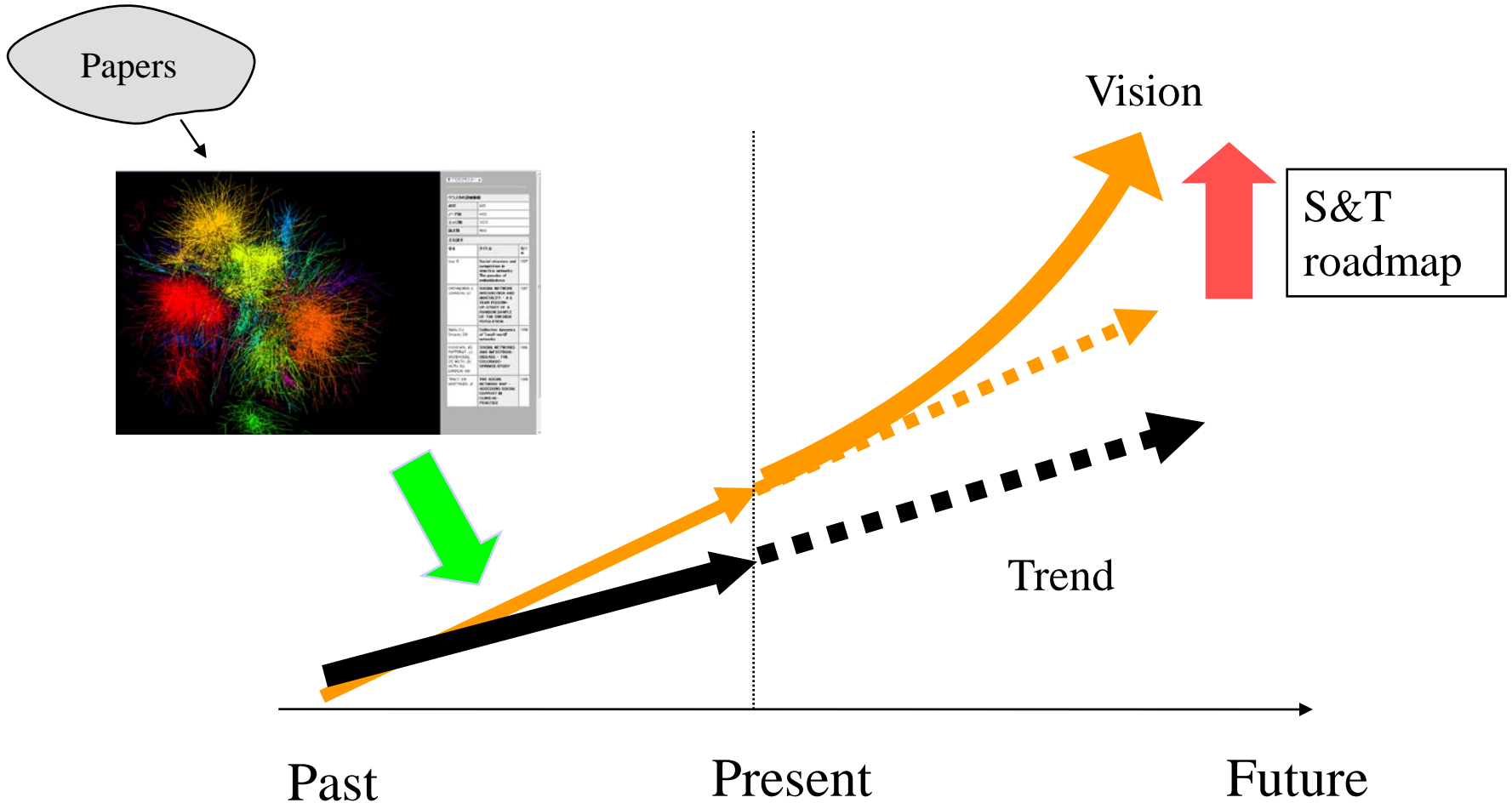
University of Tokyo, Japan

Prior role of S&T roadmap

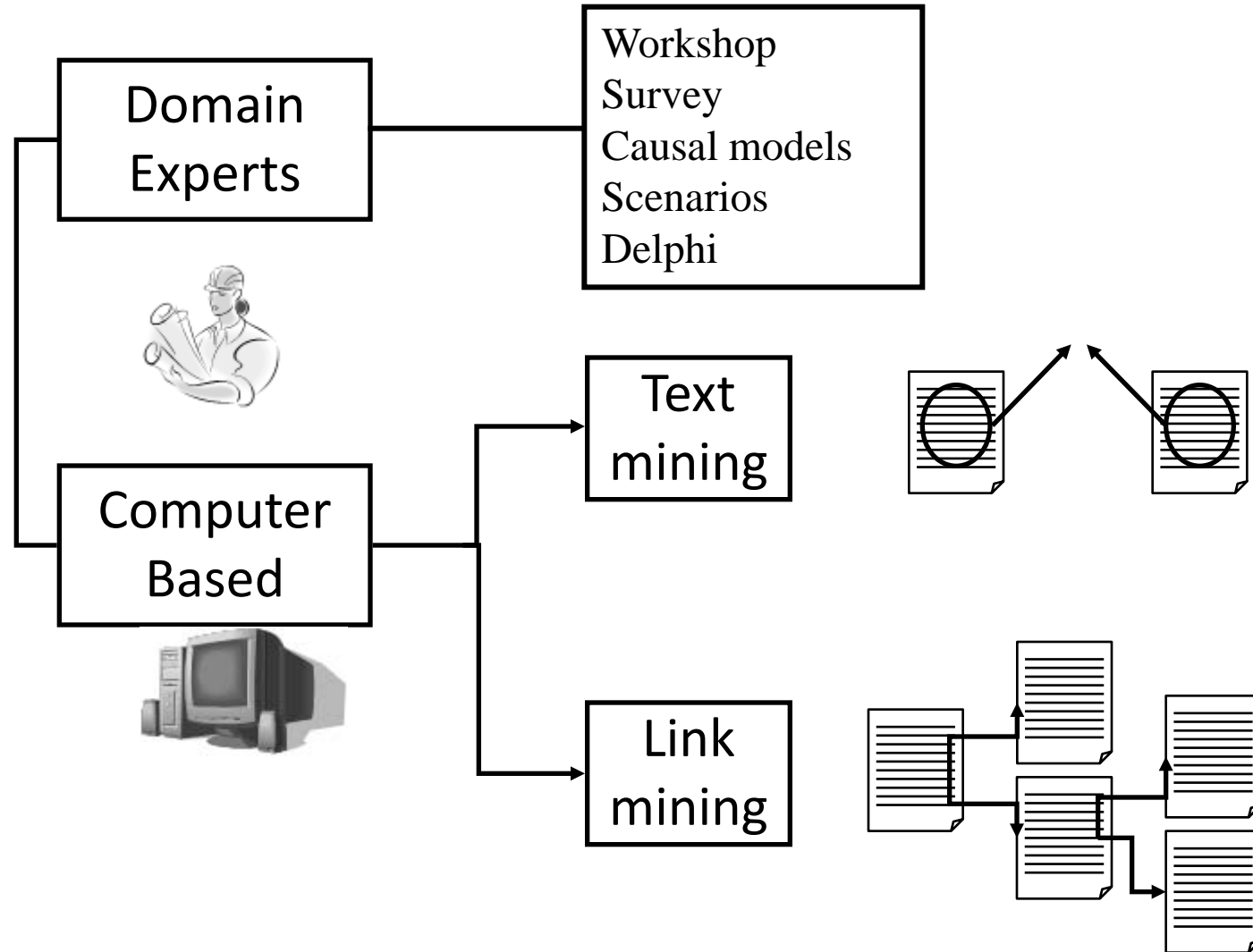
Accelerating Innovation!



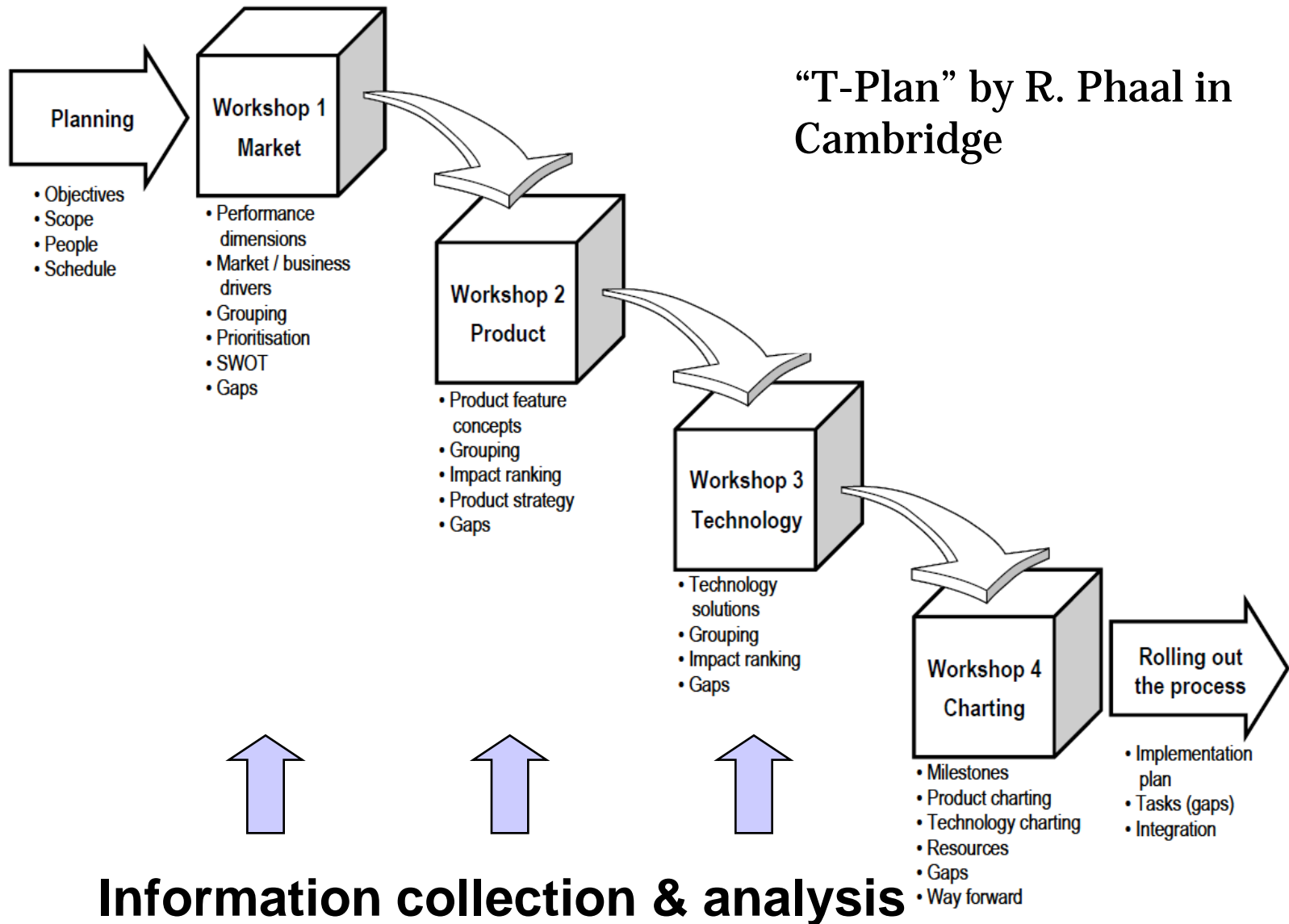
Efficient Roadmapping using Citation Network Analysis



Methodology of S&T Roadmapping



Example of Expert-based Roadmapping



Research Purpose

1. Developing a tool supporting roadmapping by using computer based approach.
2. Illustrating an academic landscape of solar cell researches and emerging research fields within them to support roadmapping.