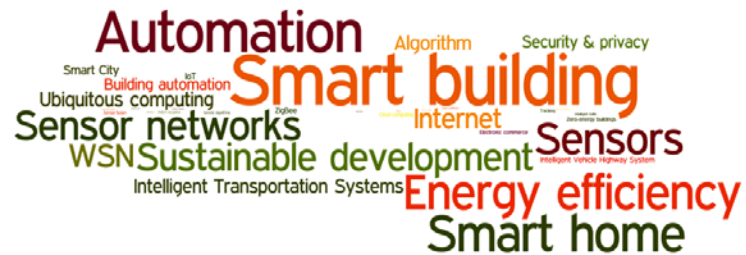


# Smart city: research landscape 2006-2014

## Analysis of research publications



Anssi Neuvonen

17.11.2014

VTT, Knowledge Solutions

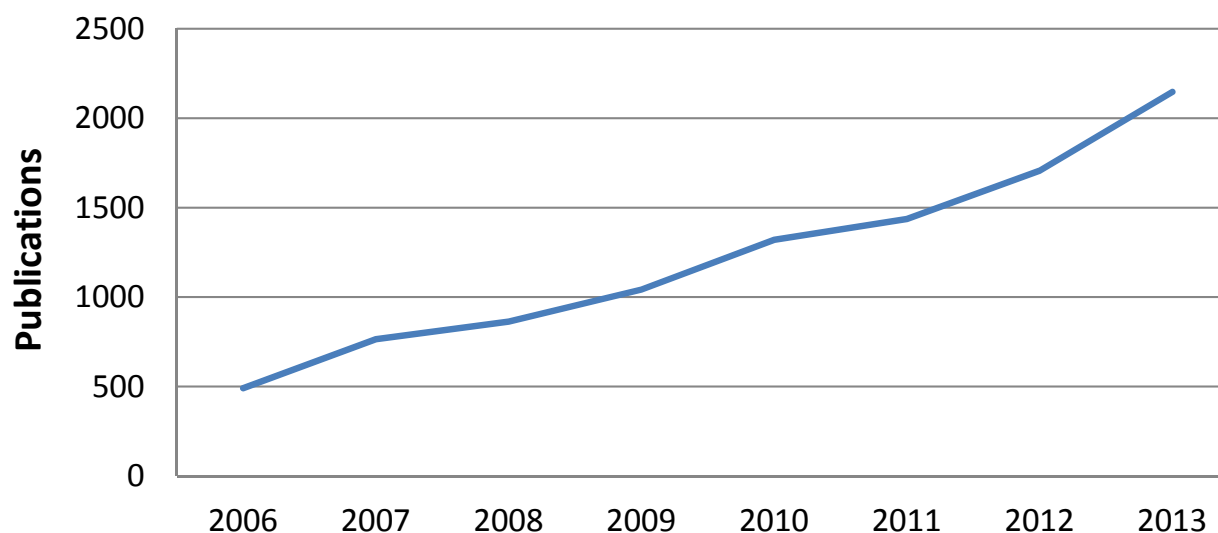
# Content

- Data
- About smart city
- Topics
  - Drivers
  - Technologies and applications
- Stakeholders
  - Countries
  - RTOs and universities
  - Companies
- Appendix

# Data

- Source: Elsevier Scopus
- Period covered: 2006-2014
- Publications: 10 884
  - Average annual publication growth 2006-2013: 23,5 %
  - Most cited publications: see Appendix
- Data used for analysis
  - Keywords (Elsevier's index & authors'): covering 95% of publications
    - 50 162 different keywords & phrases
  - "Smart grid" was excluded from the set due the massive volume of related publications (see: Appendix)

**Data volumes 2006-2013**



# About smart city

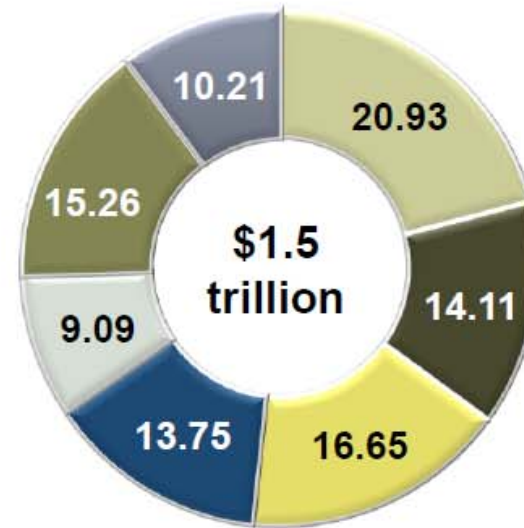
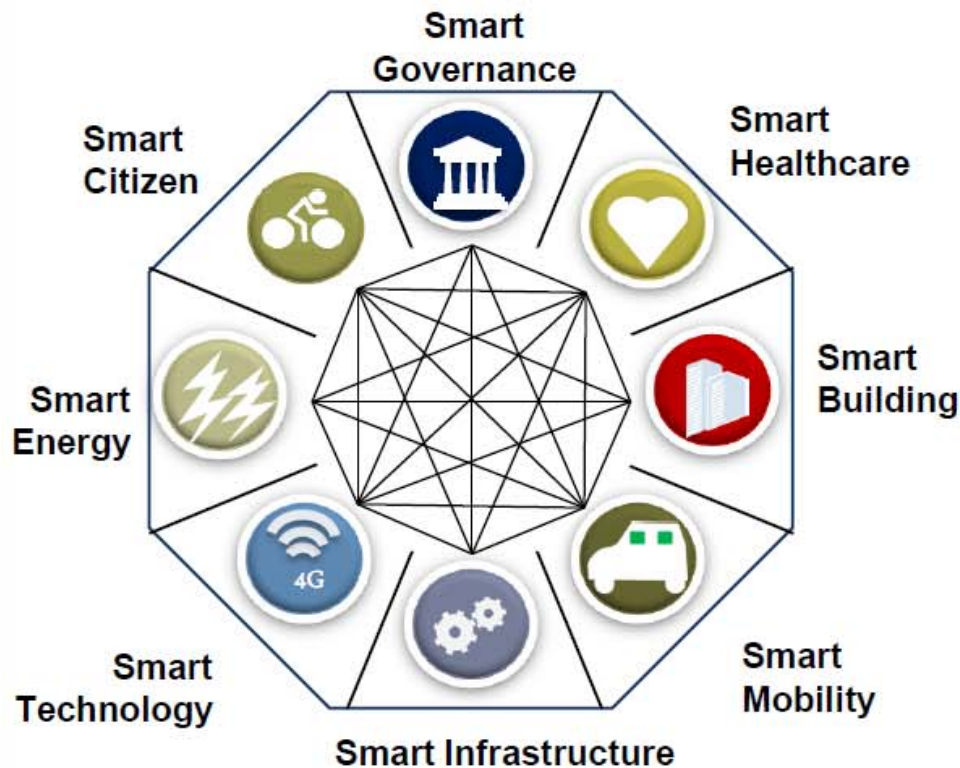
# On smart city concept

- Smart cities are cities built on ‘smart’ and ‘intelligent’ solutions and technology that will lead to the adoption of smart solutions in at least 5 of the 8 following areas:
  - Energy, building, mobility, healthcare, infrastructure, technology, governance, citizens
- There is no commonly agreed-upon definition of smart cities
  - Key elements:
    - **technologies** used (e.g., energy, information, and communication, green technologies)
    - **output** (e.g., transforming our cities into sustainable, safe, and attractive places to live in)
- Smart cities can be also characterised by their abilities to
  1. enable **interactions** between their various systems and networks
  2. to deliver high levels of **mobility** to their citizens
  3. to involve various **stakeholders** in policymaking
- Information and communication technologies (ICT) are the key enablers
- Focus of smart city studies and projects has been mainly on **mobility, energy**, and the effective use of **resources**
  - only a few have paid attention to **healthcare** and **government**

# Smart city: applications and markets

## Smart Diamond to define Smart city

## Smart City Market by Segments<sup>1</sup>, Global, 2020



- ☑ Smart Governance and Smart Education<sup>2</sup>
- ☑ Smart Security
- ☑ Smart Energy
- ☑ Smart Infrastructure<sup>3</sup>
- ☑ Smart Transportation
- ☑ Smart Healthcare
- ☑ Smart Building

<sup>1</sup> Smart citizen and smart technology is covered in other segments such as governance and infrastructure  
<sup>2</sup> Smart Education includes eLearning services for schools, universities, enterprises, and government entities.  
<sup>3</sup> Smart Infrastructure includes sensor networks, digital management of water utilities not included in other segments.

Source: IBM, Cisco, Frost & Sullivan Analysis

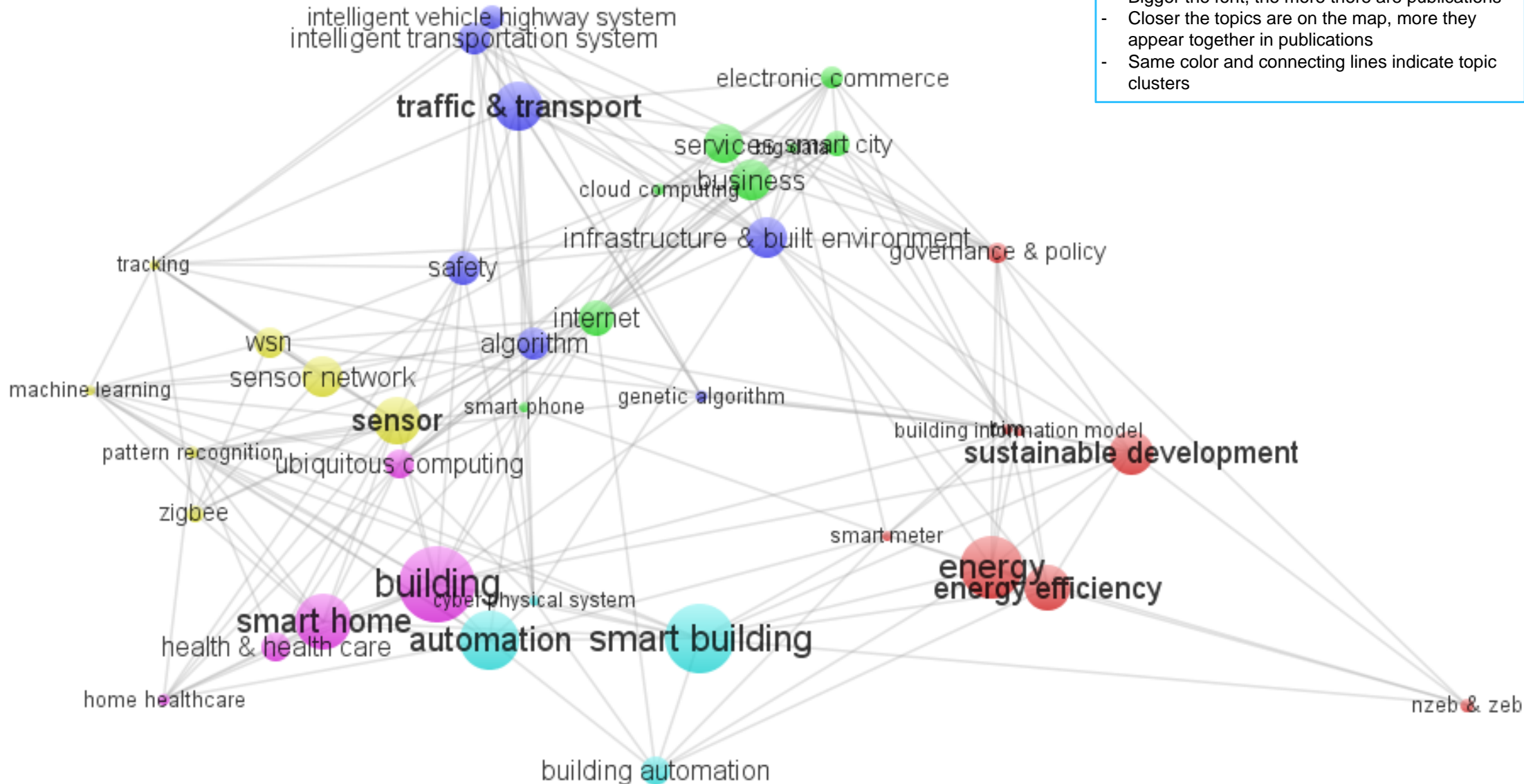
# Most common publication keywords 2006-2014



# Research hot spots and connections

**Key:**

- Bigger the bubble, the more there are publications
- Bigger the font, the more there are publications
- Closer the topics are on the map, more they appear together in publications
- Same color and connecting lines indicate topic clusters





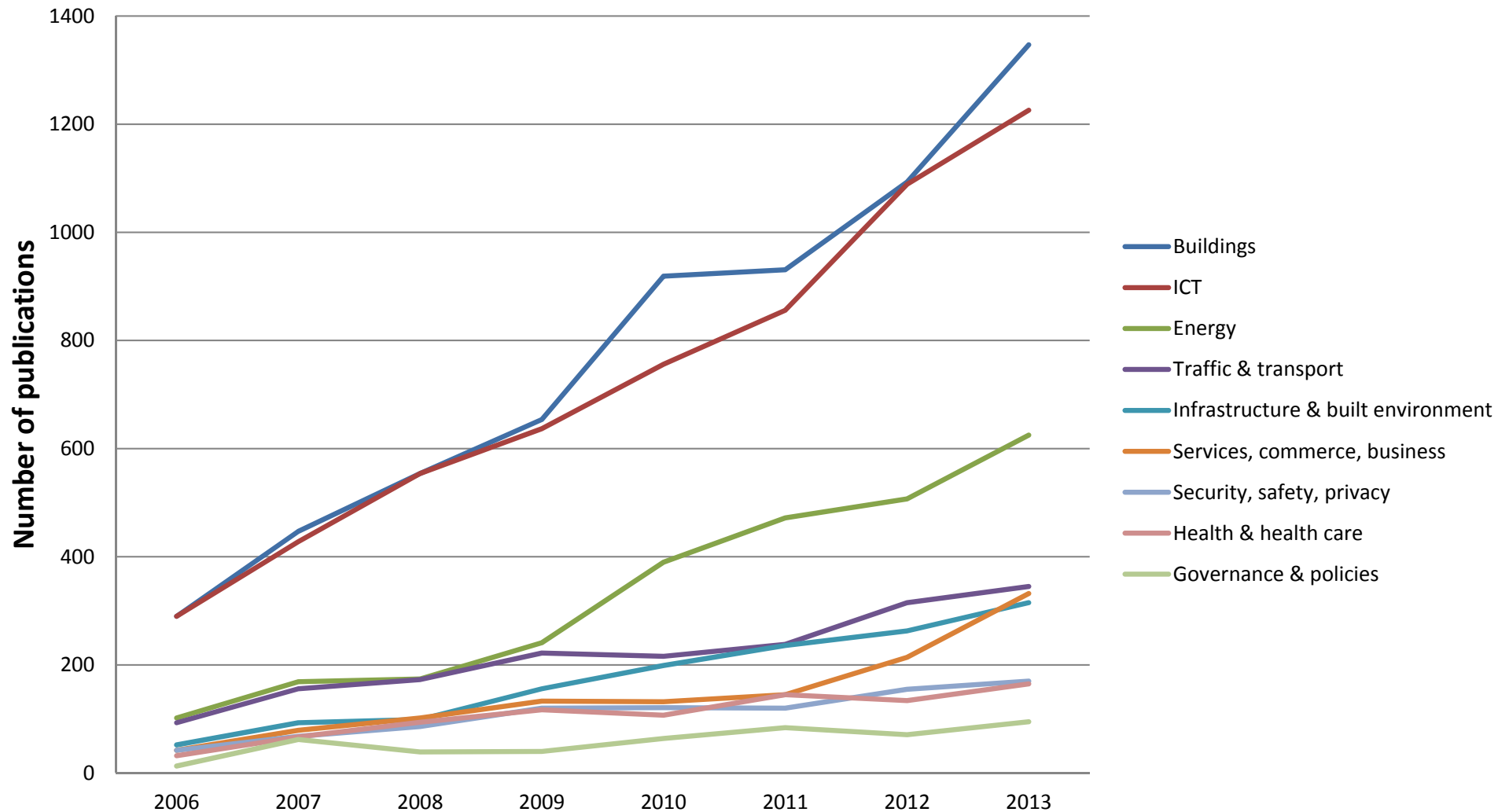
# Drivers

# Keyword groupings for drivers

1. **Security** + safety; privacy; unsafe; safe; surveillance; civil defence; biometrics; crime protection
2. **Health** + health care; mHealth; eHealth; aging; tele-monitoring; tele-medicine
3. **Mobility** + traffic; transportation; logistics; parking; charging station; pedestrian; commuter; commuting; drivers; vehicles; cars
4. **Energy** + power; electricity; heating; solar
5. **ICT** + vehicle to vehicle; V2V; Vehicle to everything; V2X; dynamic driver behaviour; mobile applications; open data; open datum; broadband; WiFi; cloud; big data; big datum; WSN; wireless sensor network; zigbee; mobile phone; IT; android; iphone; web based; augmented reality; web; semantic; ontology; fuzzy; algorithm; protocol; software; XML; open source; agent; 3G; 4G; 5G; tele communication; network; networks; data; communication; NFC; near field; internet; IoT; computing; information technology; recognition
6. **Infrastructure** + utility manage; water; waste manage; sewage; recycling; streets; road management; road maintenance; road building; road development; city planning; city development; town planning; town development; land use; land usage; urban planning; urban area; urban zone; urban development; street light; flood; urban space; urban area; urban plan; parks; parking area; parking space; built environment; landscape; pipeline; underground; shopping mall; estate; property; grounds; city design; cities & ...
7. **Building** + house; houses; home; homes; HVACsmart meter; office
8. **Services** + commerce; business; consumer; markets; shopping
9. **Governance** + government; politics; policies; administration; federal; legislation; laws; regulation; rules

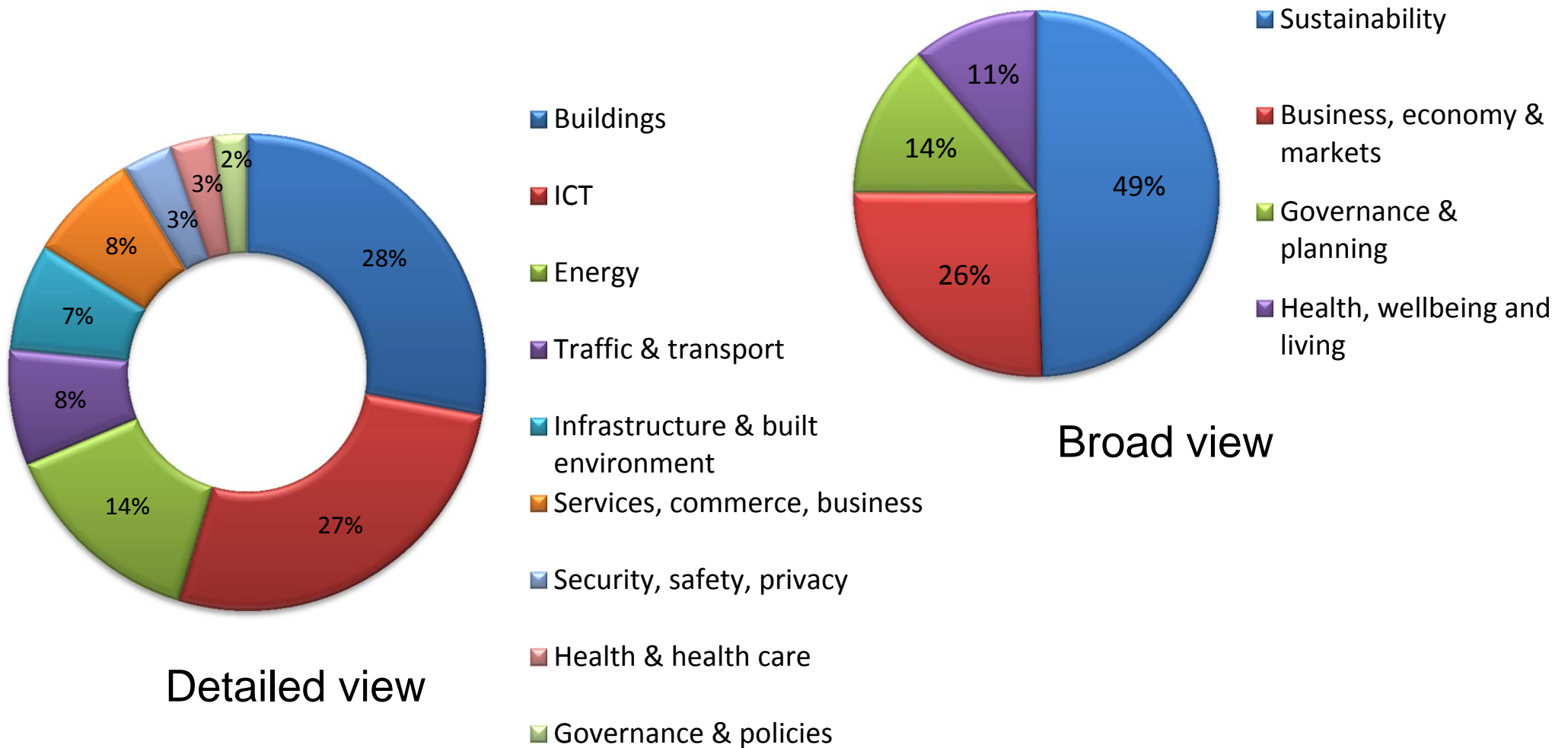
The lists are not exhaustive, only the main publication keywords used for groupings are shown

# Smart city drivers: changes in publication intensity 2006-2013



# Drivers: distribution of publications 2013-2014

## Percentage of publications



# Connections between smart city drivers

Drivers cross-correlated with selected technologies / applications topics\*

| TOPIC                              | Buildings | ICT  | Energy | Traffic & transport | Infrastructure & built environment | Services, commerce, business | Security, safety, privacy | Health & health care | Governance & policies |
|------------------------------------|-----------|------|--------|---------------------|------------------------------------|------------------------------|---------------------------|----------------------|-----------------------|
| Buildings                          |           | 0,91 | 0,86   | 0,21                | 0,62                               | 0,43                         | 0,48                      | 0,81                 | 0,36                  |
| ICT                                | 0,91      |      | 0,77   | 0,49                | 0,84                               | 0,57                         | 0,50                      | 0,84                 | 0,48                  |
| Energy                             | 0,86      | 0,77 |        | 0,23                | 0,64                               | 0,37                         | 0,32                      | 0,63                 | 0,46                  |
| Traffic & transport                | 0,21      | 0,49 | 0,23   |                     | 0,75                               | 0,24                         | 0,33                      | 0,31                 | 0,53                  |
| Infrastructure & built environment | 0,62      | 0,84 | 0,64   | 0,75                |                                    | 0,64                         | 0,42                      | 0,69                 | 0,71                  |
| Services, commerce, business       | 0,43      | 0,57 | 0,37   | 0,24                | 0,64                               |                              | 0,32                      | 0,39                 | 0,81                  |
| Security, safety, privacy          | 0,48      | 0,50 | 0,32   | 0,33                | 0,42                               | 0,32                         |                           | 0,43                 | 0,47                  |
| Health & health care               | 0,81      | 0,84 | 0,63   | 0,31                | 0,69                               | 0,39                         | 0,43                      |                      | 0,28                  |
| Governance & policies              | 0,36      | 0,48 | 0,46   | 0,53                | 0,71                               | 0,81                         | 0,47                      | 0,28                 |                       |

Based on cross-correlation with keywords in publications, max corr. 1, correlation level indicated by colour

17/11/2014

\* TOPICS: Sensors; WSN; Ubiquitous computing; Building automation; Security & privacy; Intelligent Vehicle Highway System; Electronic commerce; IoT; ZigBee; NZEB & ZEB; Cloud computing; Tracking; Intelligent traffic; Genetic algorithms; Sensor Fusion; Pattern recognition; Home healthcare; Smart phone; Machine Learning; Retrofitting; Building Information Model - BIM; Big data; Cyber physical systems (CPSs); Smart meters; V2X Communication

# Drivers and technologies / applications together

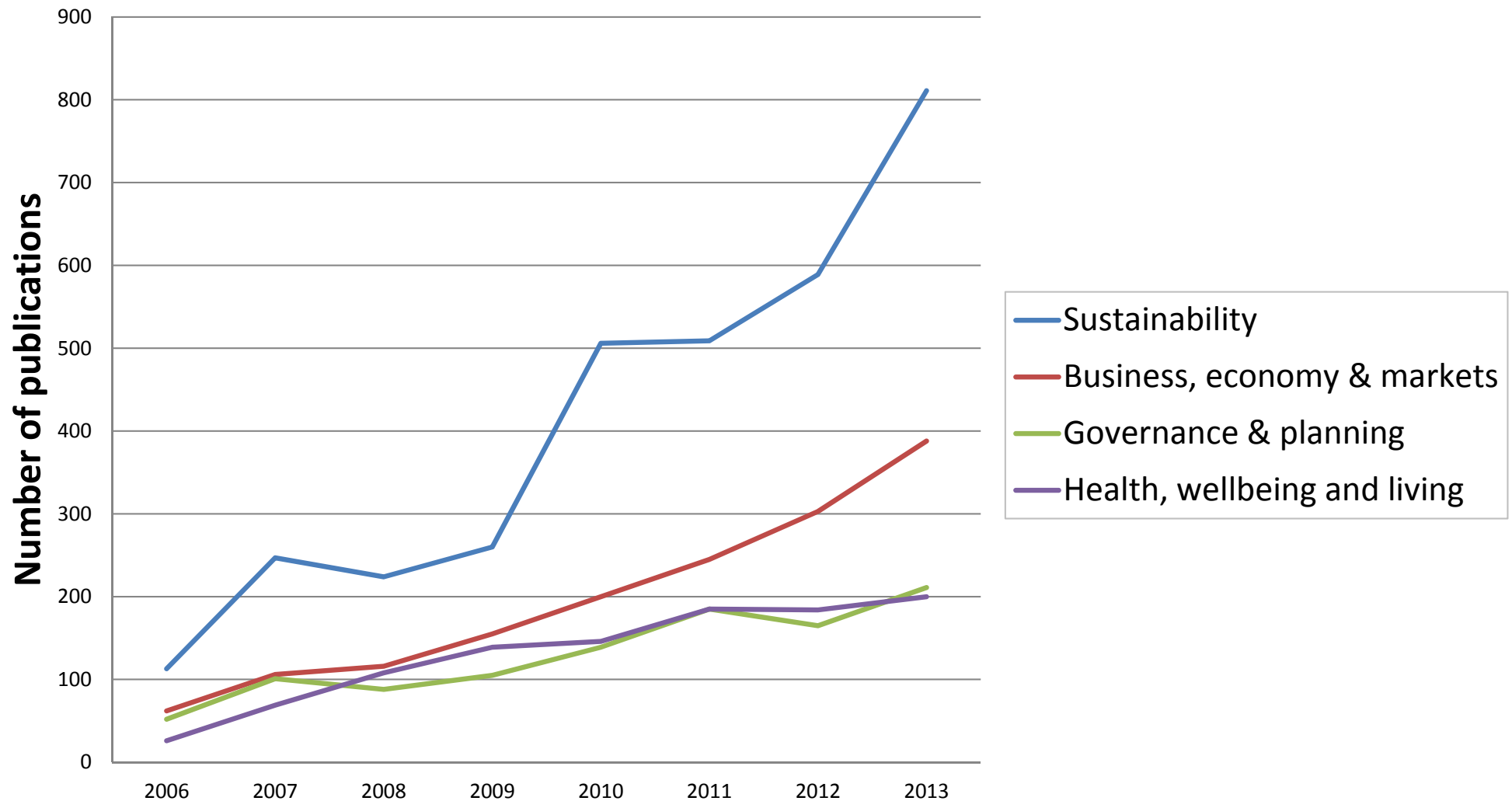
Percentages\* of technology / application topics appearing in publications on driver theme

| Publications total:                           | 1754    | 1156  | 878                  | 750                 | 658                | 495                                | 430                 | 357  | 309    | 266        | 216             | 196      | 187                 | 173                | 162           | 160                 | 143             | 93          | 88               | 67           | 62                               | 60       | 60                            | 59           | 55                |
|---|---------|-------|----------------------|---------------------|--------------------|------------------------------------|---------------------|------|--------|------------|-----------------|----------|---------------------|--------------------|---------------|---------------------|-----------------|-------------|------------------|--------------|----------------------------------|----------|-------------------------------|--------------|-------------------|
|   | Sensors | WSN   | Ubiquitous computing | Building automation | Security & privacy | Intelligent Vehicle Highway System | Electronic commerce | IoT  | ZigBee | NZEB & ZEB | Cloud computing | Tracking | Intelligent traffic | Genetic algorithms | Sensor Fusion | Pattern recognition | Home healthcare | Smart phone | Machine Learning | Retrofitting | Building Information Model - BIM | Big data | Cyber physical systems (CPSs) | Smart meters | V2X Communication |
| <b>DRIVER</b>                                 |         |       |                      |                     |                    |                                    |                     |      |        |            |                 |          |                     |                    |               |                     |                 |             |                  |              |                                  |          |                               |              |                   |
| <b>Buildings</b>                              | 58 %    | 56 %  | 81 %                 | 96 %                | 64 %               | 3 %                                | 11 %                | 58 % | 75 %   | 96 %       | 44 %            | 52 %     | 2 %                 | 61 %               | 45 %          | 74 %                | 80 %            | 61 %        | 76 %             | 99 %         | 90 %                             | 20 %     | 75 %                          | 83 %         | 4 %               |
| <b>ICT</b>                                    | 82 %    | 100 % | 96 %                 | 74 %                | 82 %               | 74 %                               | 79 %                | 99 % | 99 %   | 16 %       | 96 %            | 75 %     | 82 %                | 100 %              | 96 %          | 99 %                | 90 %            | 91 %        | 88 %             | 28 %         | 58 %                             | 100 %    | 78 %                          | 64 %         | 89 %              |
| <b>Energy</b>                                 | 22 %    | 30 %  | 10 %                 | 42 %                | 16 %               | 6 %                                | 15 %                | 17 % | 33 %   | 99 %       | 17 %            | 12 %     | 4 %                 | 25 %               | 9 %           | 10 %                | 9 %             | 14 %        | 14 %             | 79 %         | 45 %                             | 12 %     | 30 %                          | 75 %         | 9 %               |
| <b>Traffic &amp; transport</b>                | 14 %    | 16 %  | 6 %                  | 2 %                 | 19 %               | 97 %                               | 21 %                | 15 % | 6 %    | 0 %        | 31 %            | 37 %     | 99 %                | 28 %               | 26 %          | 11 %                | 1 %             | 26 %        | 15 %             | 0 %          | 0 %                              | 17 %     | 20 %                          | 2 %          | 87 %              |
| <b>Infrastructure &amp; built environment</b> | 16 %    | 14 %  | 6 %                  | 5 %                 | 12 %               | 31 %                               | 31 %                | 13 % | 8 %    | 14 %       | 19 %            | 17 %     | 26 %                | 10 %               | 28 %          | 6 %                 | 3 %             | 12 %        | 6 %              | 15 %         | 16 %                             | 27 %     | 18 %                          | 8 %          | 45 %              |
| <b>Services, commerce, business</b>           | 12 %    | 12 %  | 20 %                 | 11 %                | 18 %               | 7 %                                | 100 %               | 33 % | 6 %    | 8 %        | 31 %            | 11 %     | 10 %                | 9 %                | 5 %           | 12 %                | 12 %            | 16 %        | 6 %              | 6 %          | 10 %                             | 42 %     | 8 %                           | 15 %         | 20 %              |
| <b>Security, safety, privacy</b>              | 12 %    | 13 %  | 12 %                 | 12 %                | 99 %               | 19 %                               | 11 %                | 11 % | 8 %    | 0 %        | 10 %            | 19 %     | 12 %                | 5 %                | 12 %          | 9 %                 | 15 %            | 11 %        | 6 %              | 3 %          | 2 %                              | 12 %     | 15 %                          | 5 %          | 24 %              |
| <b>Health &amp; health care</b>               | 16 %    | 12 %  | 13 %                 | 5 %                 | 12 %               | 2 %                                | 2 %                 | 4 %  | 5 %    | 2 %        | 4 %             | 9 %      | 1 %                 | 8 %                | 7 %           | 21 %                | 100 %           | 9 %         | 18 %             | 4 %          | 0 %                              | 5 %      | 10 %                          | 2 %          | 0 %               |
| <b>Governance &amp; policies</b>              | 2 %     | 2 %   | 2 %                  | 3 %                 | 6 %                | 8 %                                | 16 %                | 3 %  | 2 %    | 12 %       | 5 %             | 2 %      | 8 %                 | 2 %                | 1 %           | 0 %                 | 0 %             | 3 %         | 1 %              | 10 %         | 2 %                              | 10 %     | 2 %                           | 2 %          | 2 %               |

\* Percentage of all publications on the driver theme

# Big drivers in smart city development

## Changes in publications intensity 2006-2013



# Smart city big drivers

Percentages of big technology / application topics appearing in publications on mega driver theme

| Publications total | Topic ↓                    | Publications total      |                             |                       |                              |
|--------------------|----------------------------|-------------------------|-----------------------------|-----------------------|------------------------------|
|                    |                            | Driver → Sustainability | Business, economy & markets | Governance & planning | Health, wellbeing and living |
| 5084               | Smart building             | 49,3 %                  | 15,2 %                      | 9,0 %                 | 10,2 %                       |
| 2789               | Automation                 | 24,2 %                  | 14,6 %                      | 6,3 %                 | 14,7 %                       |
| 2479               | Smart Home                 | 13,4 %                  | 12,9 %                      | 3,8 %                 | 20,9 %                       |
| 1744               | Energy efficiency          | 99,8 %                  | 23,7 %                      | 15,3 %                | 5,0 %                        |
| 1691               | Sensors                    | 22,4 %                  | 12,7 %                      | 7,5 %                 | 20,5 %                       |
| 1372               | Sensor networks            | 25,1 %                  | 15,5 %                      | 6,3 %                 | 14,0 %                       |
| 1032               | Internet                   | 16,3 %                  | 22,9 %                      | 7,8 %                 | 9,7 %                        |
|                    | Intelligent Transportation |                         |                             |                       |                              |
| 911                | Systems                    | 12,7 %                  | 15,3 %                      | 14,5 %                | 2,1 %                        |
| 878                | Algorithm                  | 20,4 %                  | 13,8 %                      | 9,0 %                 | 8,7 %                        |
| 590                | Smart City                 | 22,5 %                  | 60,3 %                      | 24,4 %                | 6,8 %                        |

Percentages of all publications on the driver theme



# Smart city big drivers

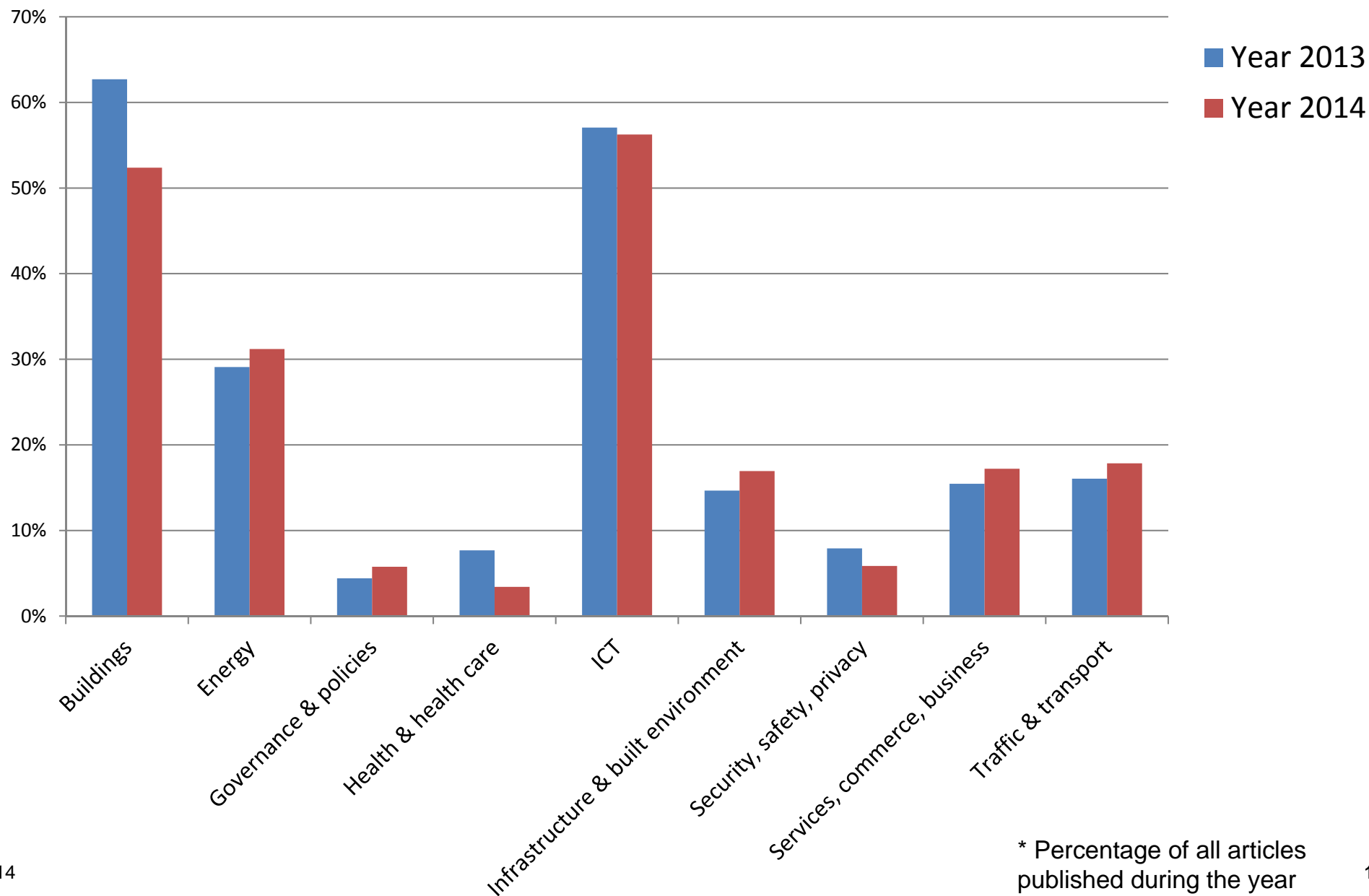
Percentages of selected technology / application topics appearing in publications on mega driver theme

Percentages of all publications on the technology / application topic

| Publications total | TOPIC ↓                            | Publications total | 3650           | 1809                        | 1168                  | 1129                         |
|--------------------|------------------------------------|--------------------|----------------|-----------------------------|-----------------------|------------------------------|
|                    |                                    | DRIVER →           | Sustainability | Business, economy & markets | Governance & planning | Health, wellbeing and living |
| 1754               | Sensors                            |                    | 22,2 %         | 12,6 %                      | 7,5 %                 | 20,1 %                       |
| 1156               | WSN                                |                    | 27,1 %         | 14,9 %                      | 6,8 %                 | 14,5 %                       |
| 878                | Ubiquitous computing               |                    | 10,0 %         | 12,4 %                      | 5,6 %                 | 19,0 %                       |
| 750                | Building automation                |                    | 33,1 %         | 18,4 %                      | 8,3 %                 | 6,8 %                        |
| 658                | Security & privacy                 |                    | 13,7 %         | 20,4 %                      | 9,0 %                 | 15,0 %                       |
| 495                | Intelligent Vehicle Highway System |                    | 10,9 %         | 15,8 %                      | 17,4 %                | 1,8 %                        |
| 430                | Electronic commerce                |                    | 24,9 %         | 100,0 %                     | 25,3 %                | 7,0 %                        |
| 357                | IoT                                |                    | 17,4 %         | 28,3 %                      | 5,9 %                 | 5,6 %                        |
| 309                | ZigBee                             |                    | 21,7 %         | 16,2 %                      | 2,9 %                 | 7,8 %                        |
| 266                | NZEB & ZEB                         |                    | 99,6 %         | 24,1 %                      | 18,8 %                | 1,9 %                        |
| 216                | Cloud computing                    |                    | 18,5 %         | 29,6 %                      | 9,3 %                 | 6,5 %                        |
| 196                | Tracking                           |                    | 10,2 %         | 10,7 %                      | 8,7 %                 | 10,2 %                       |
| 187                | Intelligent traffic                |                    | 6,4 %          | 11,2 %                      | 13,4 %                | 1,6 %                        |
| 173                | Genetic algorithms                 |                    | 22,0 %         | 16,2 %                      | 8,1 %                 | 8,7 %                        |
| 162                | Sensor Fusion                      |                    | 9,9 %          | 5,6 %                       | 10,5 %                | 13,6 %                       |
| 160                | Pattern recognition                |                    | 9,4 %          | 6,9 %                       | 2,5 %                 | 35,0 %                       |
| 143                | Home healthcare                    |                    | 5,6 %          | 10,5 %                      | 1,4 %                 | 100,0 %                      |
| 93                 | Smart phone                        |                    | 12,9 %         | 19,4 %                      | 3,2 %                 | 15,1 %                       |
| 88                 | Machine Learning                   |                    | 14,8 %         | 10,2 %                      | 4,5 %                 | 25,0 %                       |
| 67                 | Retrofitting                       |                    | 86,6 %         | 22,4 %                      | 25,4 %                | 7,5 %                        |
| 62                 | Building Information Model - BIM   |                    | 64,5 %         | 12,9 %                      | 6,5 %                 | 3,2 %                        |
| 60                 | Big data                           |                    | 16,7 %         | 43,3 %                      | 11,7 %                | 3,3 %                        |
| 60                 | Cyber physical systems (CPSs)      |                    | 23,3 %         | 8,3 %                       | 6,7 %                 | 13,3 %                       |
| 59                 | Smart meters                       |                    | 54,2 %         | 33,9 %                      | 10,2 %                | 3,4 %                        |
| 55                 | V2X Communication                  |                    | 10,9 %         | 20,0 %                      | 7,3 %                 | 1,8 %                        |

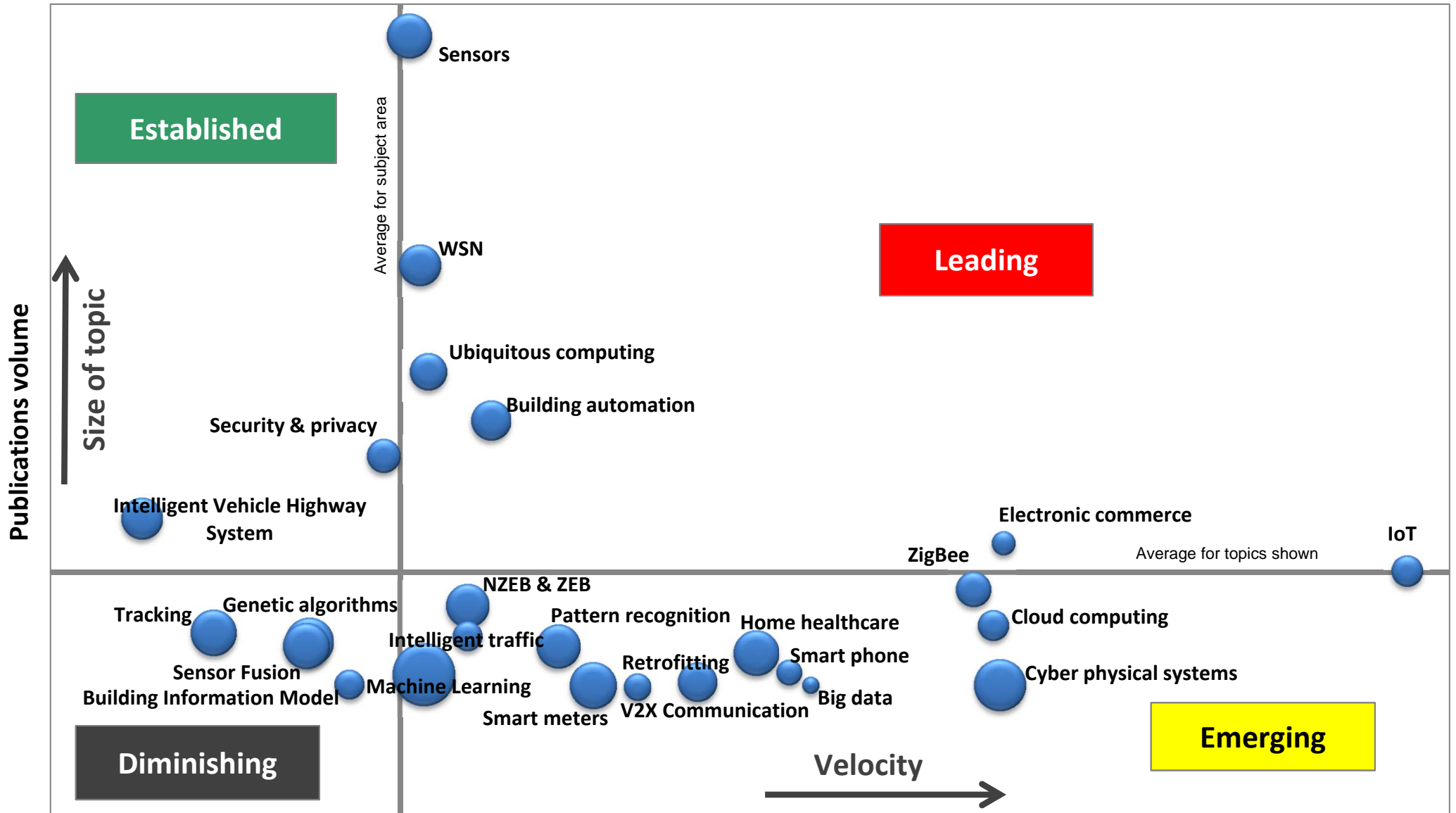
# Research theme changes 2013-2014

Percentage\* of publications on driver topics



# Technologies and applications

# Selected technology and application topics 2006-2013: topic volume, growth rate & impact\* (number of citations)



\* Size of bubble

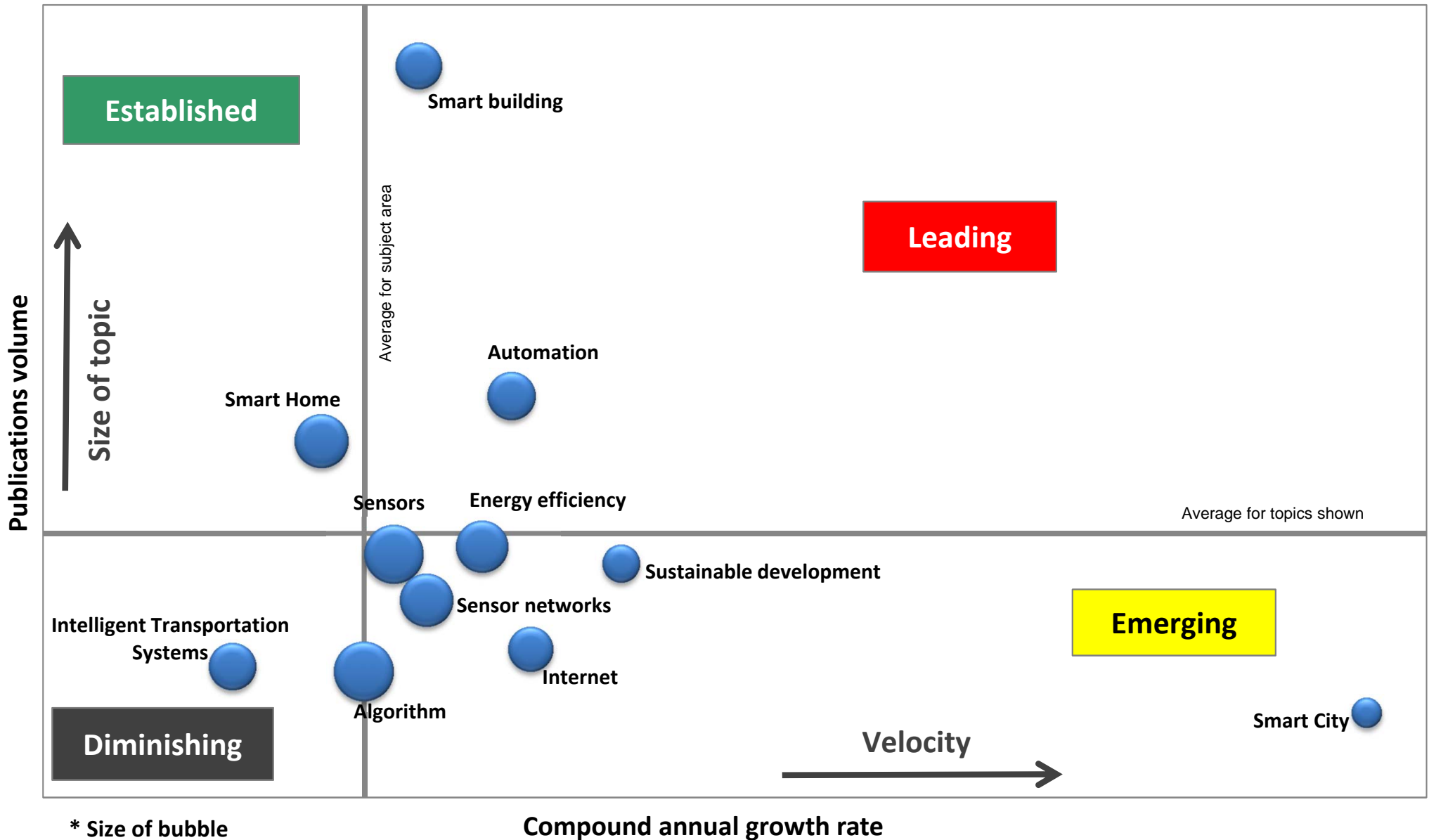
Compound annual growth rate

# Selected technologies & applications 2006-2014: percentages\* of topics appearing together in publications

| Publications total | TOPIC                         | Sensors |     | Ubiquitous computing |     | Building automation |     | Security & privacy |     | Intelligent Vehicle Highway System |     | Electronic commerce |     | Cloud computing |     | Intelligent traffic |     | Genetic algorithms |     | Pattern recognition |     | Home healthcare |     | Smart phone |     | Machine Learning |     | Building Information Model |     | Big data |     | Cyber physical systems |     | V2X Communication |    |    |    |
|--------------------|-------------------------------|---------|-----|----------------------|-----|---------------------|-----|--------------------|-----|------------------------------------|-----|---------------------|-----|-----------------|-----|---------------------|-----|--------------------|-----|---------------------|-----|-----------------|-----|-------------|-----|------------------|-----|----------------------------|-----|----------|-----|------------------------|-----|-------------------|----|----|----|
|                    |                               | WSN     | WSN | WSN                  | WSN | WSN                 | WSN | WSN                | WSN | WSN                                | WSN | WSN                 | WSN | WSN             | WSN | WSN                 | WSN | WSN                | WSN | WSN                 | WSN | WSN             | WSN | WSN         | WSN | WSN              | WSN | WSN                        | WSN | WSN      | WSN | WSN                    | WSN |                   |    |    |    |
| 1754               | Sensors                       | 35%     | 10% | 9%                   | 8%  | 3%                  | 3%  | 4%                 | 6%  | 0%                                 | 3%  | 4%                  | 1%  | 1%              | 7%  | 3%                  | 3%  | 1%                 | 1%  | 0%                  | 0%  | 1%              | 1%  | 1%          | 1%  | 1%               | 1%  | 1%                         | 1%  | 1%       | 1%  | 1%                     | 1%  | 1%                |    |    |    |
| 1156               | WSN                           | 54%     | 11% | 11%                  | 10% | 3%                  | 4%  | 7%                 | 13% | 3%                                 | 3%  | 1%                  | 1%  | 3%              | 1%  | 2%                  | 1%  | 1%                 | 0%  | 0%                  | 1%  | 1%              | 1%  | 1%          | 1%  | 1%               | 1%  | 1%                         | 1%  | 1%       | 1%  | 1%                     | 1%  | 1%                |    |    |    |
| 878                | Ubiquitous computing          | 19%     | 15% | 7%                   | 10% | 1%                  | 5%  | 4%                 | 2%  | 2%                                 | 2%  | 0%                  | 2%  | 2%              | 3%  | 3%                  | 3%  | 2%                 |     |                     | 1%  | 1%              | 1%  | 1%          | 1%  | 1%               | 1%  | 1%                         | 1%  | 1%       | 1%  | 1%                     | 1%  | 1%                |    |    |    |
| 750                | Building automation           | 20%     | 18% | 8%                   | 11% | 0%                  | 1%  | 5%                 | 7%  | 1%                                 | 1%  |                     | 1%  | 1%              | 1%  | 1%                  | 1%  | 1%                 | 1%  | 1%                  | 1%  | 1%              | 1%  | 1%          | 1%  | 1%               | 1%  | 1%                         | 1%  | 1%       | 1%  | 1%                     | 1%  | 1%                |    |    |    |
| 658                | Security & privacy            | 22%     | 18% | 14%                  | 13% | 4%                  | 6%  | 6%                 | 3%  | 0%                                 | 2%  | 3%                  | 2%  | 1%              | 2%  | 2%                  | 2%  | 2%                 | 1%  | 0%                  | 0%  | 0%              | 0%  | 1%          | 1%  | 1%               | 1%  | 1%                         | 1%  | 1%       | 1%  | 1%                     | 1%  | 1%                |    |    |    |
| 495                | Intell. Vehicle Highway Syst. | 12%     | 8%  | 2%                   | 0%  | 6%                  |     | 2%                 | 1%  | 0%                                 |     | 2%                  | 5%  | 4%              | 3%  | 3%                  | 1%  |                    | 0%  | 1%                  |     |                 | 0%  | 1%          |     |                  |     |                            |     |          |     |                        | 5%  |                   |    |    |    |
| 430                | Electronic commerce           | 14%     | 11% | 9%                   | 2%  | 9%                  | 2%  |                    | 19% | 1%                                 |     | 9%                  | 1%  | 1%              | 1%  | 1%                  | 1%  | 1%                 |     |                     | 0%  | 0%              | 5%  | 0%          | 0%  | 0%               | 0%  | 0%                         | 0%  | 0%       | 0%  | 0%                     | 0%  | 1%                |    |    |    |
| 357                | IoT                           | 20%     | 24% | 10%                  | 10% | 11%                 | 1%  | 23%                |     | 8%                                 |     | 9%                  | 1%  | 3%              | 1%  | 1%                  | 1%  | 1%                 | 1%  | 1%                  | 2%  | 1%              |     | 0%          | 4%  | 1%               | 1%  | 1%                         | 1%  | 1%       | 1%  | 1%                     | 1%  | 1%                | 1% |    |    |
| 309                | ZigBee                        | 37%     | 50% | 5%                   | 18% | 7%                  | 1%  | 2%                 | 9%  |                                    |     | 5%                  | 2%  | 1%              | 0%  | 1%                  |     |                    | 2%  | 1%                  |     |                 |     |             | 1%  |                  |     |                            |     |          |     |                        |     | 1%                |    |    |    |
| 266                | NZEB & ZEB                    | 1%      | 0%  |                      | 0%  |                     |     |                    | 0%  |                                    |     | 0%                  | 0%  |                 | 1%  |                     |     |                    |     |                     | 2%  | 1%              |     |             |     |                  |     |                            |     |          |     |                        |     |                   | 0% |    |    |
| 216                | Cloud computing               | 21%     | 13% | 9%                   | 3%  | 7%                  | 5%  | 18%                | 14% | 6%                                 | 0%  |                     | 2%  | 2%              |     | 1%                  | 1%  | 0%                 | 5%  | 0%                  | 0%  |                 |     | 5%          | 1%  | 0%               | 0%  | 0%                         | 0%  | 0%       | 0%  | 0%                     | 0%  | 0%                | 0% | 0% |    |
| 196                | Tracking                      | 32%     | 18% | 10%                  | 5%  | 12%                 | 12% | 2%                 | 1%  | 4%                                 | 1%  | 3%                  |     | 2%              | 2%  | 7%                  | 3%  | 2%                 | 2%  | 1%                  |     |                 | 0%  |             |     | 1%               |     |                            |     |          |     |                        | 1%  | 1%                | 1% | 1% |    |
| 187                | Intelligent traffic           | 12%     | 8%  | 2%                   |     | 6%                  | 12% | 3%                 | 5%  | 2%                                 |     | 3%                  | 2%  |                 | 4%  | 2%                  | 2%  |                    | 1%  | 2%                  |     |                 | 1%  |             |     |                  |     |                            |     |          |     |                        |     |                   | 2% |    |    |
| 173                | Genetic algorithms            | 14%     | 6%  | 8%                   | 5%  | 3%                  | 8%  | 3%                 | 1%  | 1%                                 | 2%  |                     | 2%  | 4%              |     | 2%                  | 4%  | 1%                 |     | 10%                 |     |                 | 1%  |             |     |                  |     |                            |     |          |     |                        |     |                   |    | 1% |    |
| 162                | Sensor Fusion                 | 71%     | 24% | 9%                   | 5%  | 8%                  | 10% | 2%                 | 2%  | 2%                                 |     | 2%                  | 9%  | 2%              | 2%  |                     | 2%  | 4%                 | 1%  |                     |     | 2%              |     | 2%          |     | 1%               |     |                            |     |          |     |                        | 1%  | 1%                | 1% |    |    |
| 160                | Pattern recognition           | 28%     | 11% | 14%                  | 3%  | 6%                  | 2%  | 2%                 | 1%  |                                    |     | 2%                  | 3%  | 2%              | 4%  | 2%                  |     | 6%                 | 3%  | 6%                  |     |                 | 1%  |             |     |                  |     |                            |     |          |     |                        |     |                   |    |    |    |
| 143                | Home healthcare               | 36%     | 20% | 15%                  | 3%  | 10%                 |     |                    | 2%  | 3%                                 |     |                     | 2%  |                 | 1%  | 5%                  | 6%  |                    | 1%  | 1%                  |     |                 |     |             |     |                  |     |                            |     |          |     |                        |     |                   | 1% |    |    |
| 93                 | Smart phone                   | 26%     | 11% | 25%                  | 6%  | 5%                  | 1%  | 6%                 | 9%  | 3%                                 |     | 11%                 | 4%  | 1%              | 1%  | 4%                  | 2%  |                    |     |                     |     |                 |     |             |     |                  |     |                            |     |          |     |                        |     |                   | 1% | 1% | 2% |
| 88                 | Machine Learning              | 26%     | 17% | 20%                  | 5%  | 1%                  | 5%  |                    | 2%  |                                    |     | 1%                  | 2%  | 3%              | 20% |                     | 11% | 1%                 |     |                     |     |                 |     |             |     |                  |     |                            |     |          |     |                        |     |                   | 3% |    |    |
| 67                 | Retrofitting                  | 6%      | 4%  |                      | 7%  | 1%                  |     |                    | 1%  |                                    |     | 7%                  | 1%  |                 |     |                     |     |                    |     |                     |     |                 |     |             |     |                  |     |                            |     |          |     |                        |     |                   |    | 1% |    |
| 62                 | Building Information Model    | 6%      | 3%  |                      | 8%  | 2%                  |     | 2%                 | 2%  |                                    |     | 3%                  |     |                 | 3%  |                     |     |                    |     |                     | 2%  |                 |     |             |     |                  |     |                            |     |          |     |                        |     |                   |    | 2% |    |
| 60                 | Big data                      | 23%     | 13% | 17%                  | 3%  | 10%                 | 3%  | 38%                | 25% | 3%                                 |     | 18%                 |     | 3%              |     | 5%                  | 2%  |                    |     |                     |     |                 |     |             |     |                  |     |                            |     |          |     |                        |     |                   |    | 2% |    |
| 60                 | Cyber physical systems        | 23%     | 15% | 10%                  | 12% | 10%                 | 5%  | 3%                 | 7%  |                                    | 2%  | 3%                  |     |                 |     |                     |     | 2%                 | 2%  | 5%                  |     |                 |     |             |     |                  |     |                            |     |          |     |                        |     |                   |    | 2% |    |
| 59                 | Smart meters                  | 19%     | 19% | 10%                  | 31% | 5%                  |     | 2%                 | 8%  | 7%                                 |     | 2%                  | 3%  |                 | 2%  |                     |     | 2%                 |     |                     |     |                 | 2%  |             |     |                  |     |                            |     |          |     |                        |     |                   |    | 2% |    |
| 55                 | V2X Communication             | 5%      | 7%  | 2%                   | 0%  | 7%                  | 45% | 5%                 |     |                                    |     | 2%                  | 4%  | 5%              | 2%  | 2%                  |     |                    |     |                     |     |                 | 4%  |             |     |                  |     |                            |     |          |     |                        |     |                   |    | 2% |    |

\* Percentages of all publications on the technology / application topic

# Big topics 2006-2013: topic volume, growth rate & impact\* (number of citations)



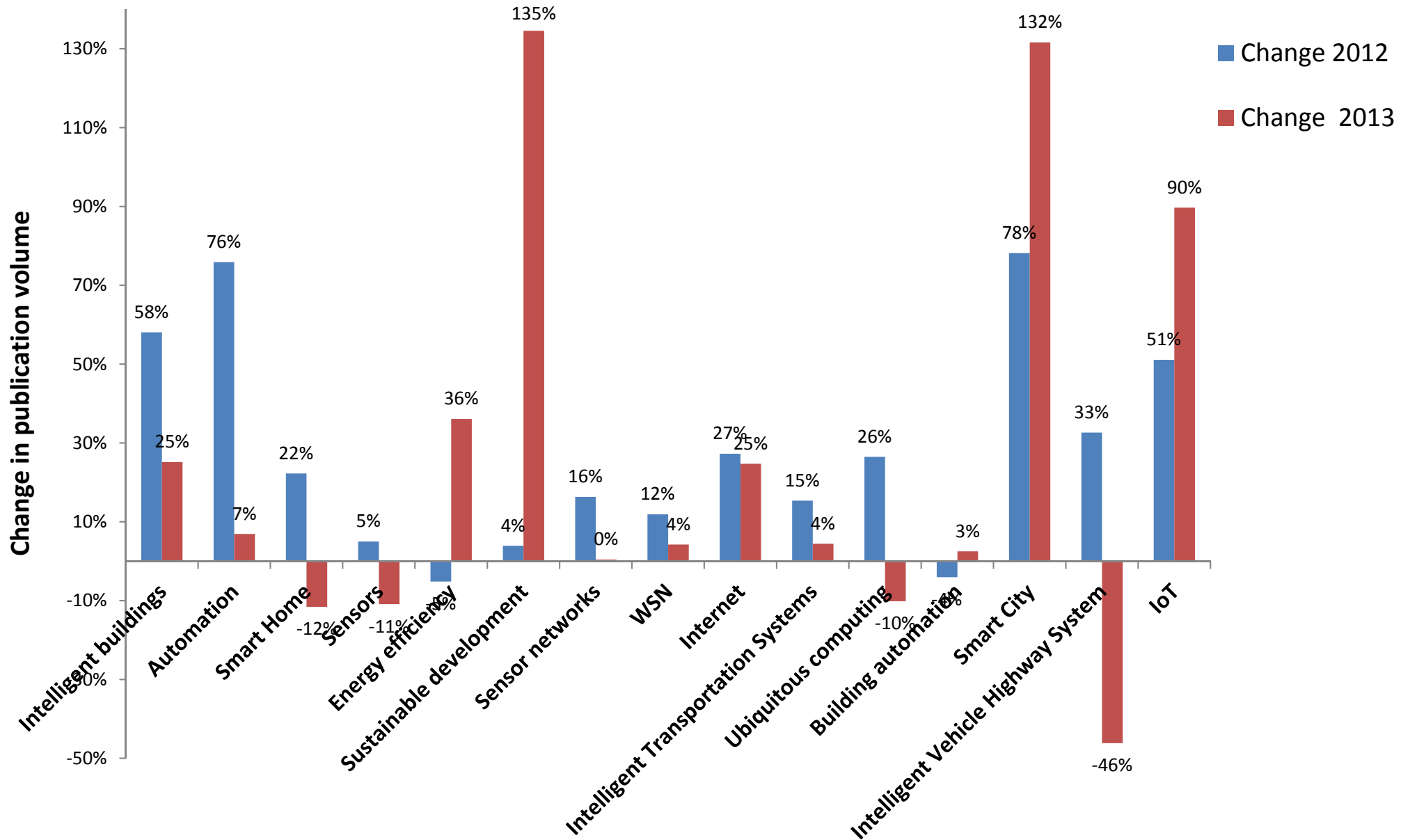
## Big technologies & applications 2006-2014: percentages\* of topics appearing together in publications

| Publications total | TOPIC                              | Smart building | Automation | Smart Home | Energy efficiency | Sensors | Sustainable development | Sensor networks | Internet | Intelligent Transportation Systems | Algorithm | Smart City |
|--------------------|------------------------------------|----------------|------------|------------|-------------------|---------|-------------------------|-----------------|----------|------------------------------------|-----------|------------|
| 5084               | Smart building                     |                | 43,8 %     | 24,0 %     | 23,6 %            | 12,1 %  | 26,3 %                  | 10,6 %          | 10,0 %   | 0,3 %                              | 7,1 %     | 0,3 %      |
| 2789               | Automation                         | 79,8 %         |            | 46,0 %     | 16,0 %            | 19,1 %  | 3,5 %                   | 16,6 %          | 14,3 %   | 3,0 %                              | 10,4 %    | 0,8 %      |
| 2479               | Smart Home                         | 49,1 %         | 51,8 %     |            | 7,1 %             | 21,0 %  | 1,7 %                   | 16,6 %          | 13,8 %   | 0,2 %                              | 8,8 %     | 0,3 %      |
| 1744               | Energy efficiency                  | 68,7 %         | 25,5 %     | 10,1 %     |                   | 10,7 %  | 32,0 %                  | 11,1 %          | 4,8 %    | 1,8 %                              | 5,7 %     | 2,1 %      |
| 1691               | Sensors                            | 36,5 %         | 31,5 %     | 30,8 %     | 11,1 %            |         | 2,0 %                   | 41,0 %          | 10,9 %   | 3,8 %                              | 11,9 %    | 3,7 %      |
| 1625               | Sustainable development            | 82,2 %         | 6,0 %      | 2,5 %      | 34,3 %            | 2,1 %   |                         | 1,8 %           | 2,7 %    | 2,2 %                              | 1,4 %     | 4,4 %      |
| 1372               | Sensor networks                    | 39,2 %         | 33,8 %     | 30,0 %     | 14,1 %            | 50,5 %  | 2,1 %                   |                 | 17,9 %   | 5,8 %                              | 10,3 %    | 5,2 %      |
| 1032               | Internet                           | 49,0 %         | 38,6 %     | 33,0 %     | 8,0 %             | 17,9 %  | 4,3 %                   | 23,8 %          |          | 6,6 %                              | 4,5 %     | 13,3 %     |
| 911                | Intelligent Transportation Systems | 1,8 %          | 9,3 %      | 0,5 %      | 3,4 %             | 7,0 %   | 4,0 %                   | 8,7 %           | 7,5 %    |                                    | 13,2 %    | 2,2 %      |
| 878                | Algorithm                          | 41,0 %         | 32,9 %     | 24,8 %     | 11,4 %            | 23,0 %  | 2,5 %                   | 16,2 %          | 5,2 %    | 13,7 %                             |           | 3,1 %      |
| 590                | Smart City                         | 2,9 %          | 3,7 %      | 1,4 %      | 6,1 %             | 10,7 %  | 12,0 %                  | 12,2 %          | 23,2 %   | 3,4 %                              | 4,6 %     |            |

\* Percentages of all publications on big technology / application topic

# Research topic changes 2012-2013

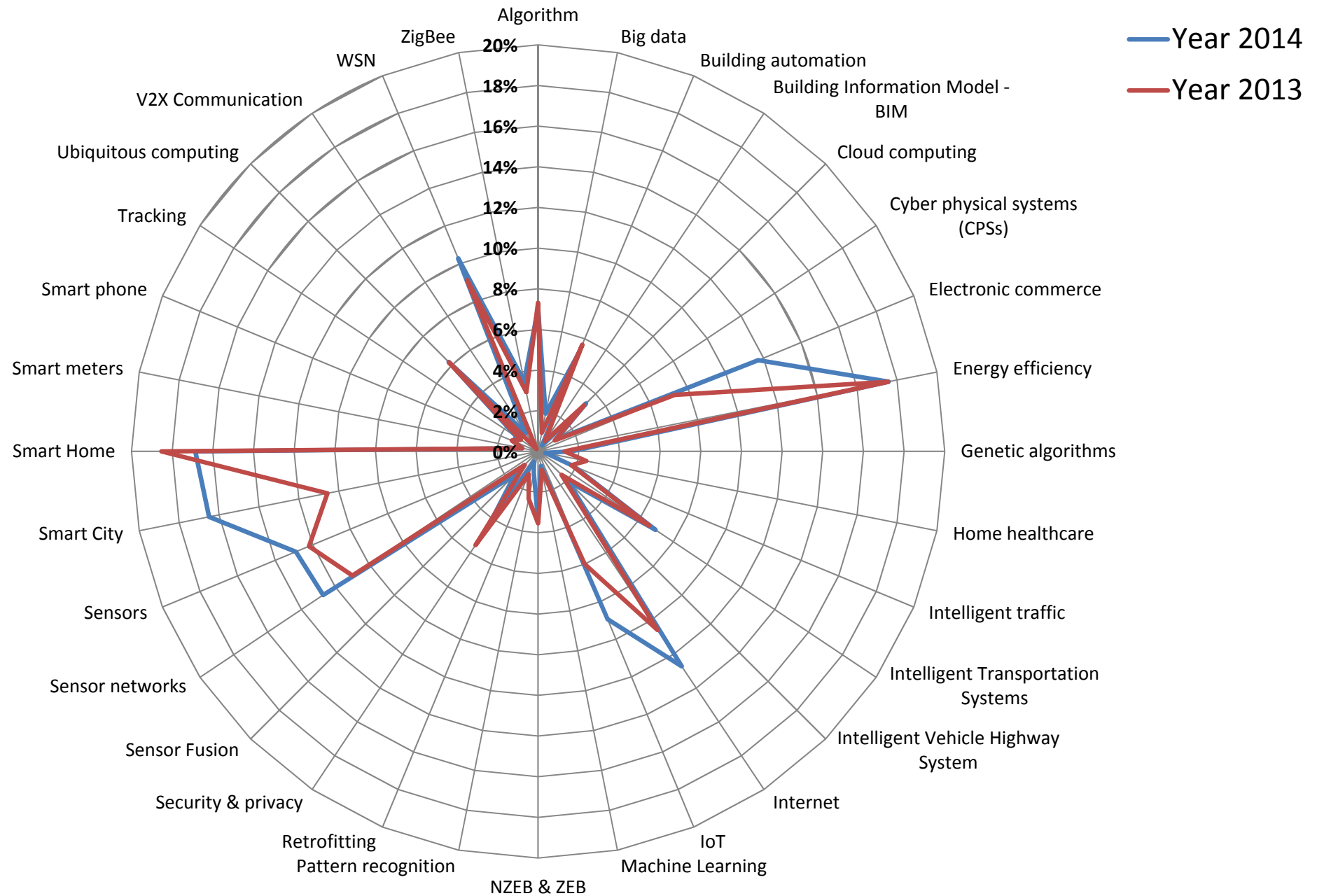
Change percentage on selected large topics





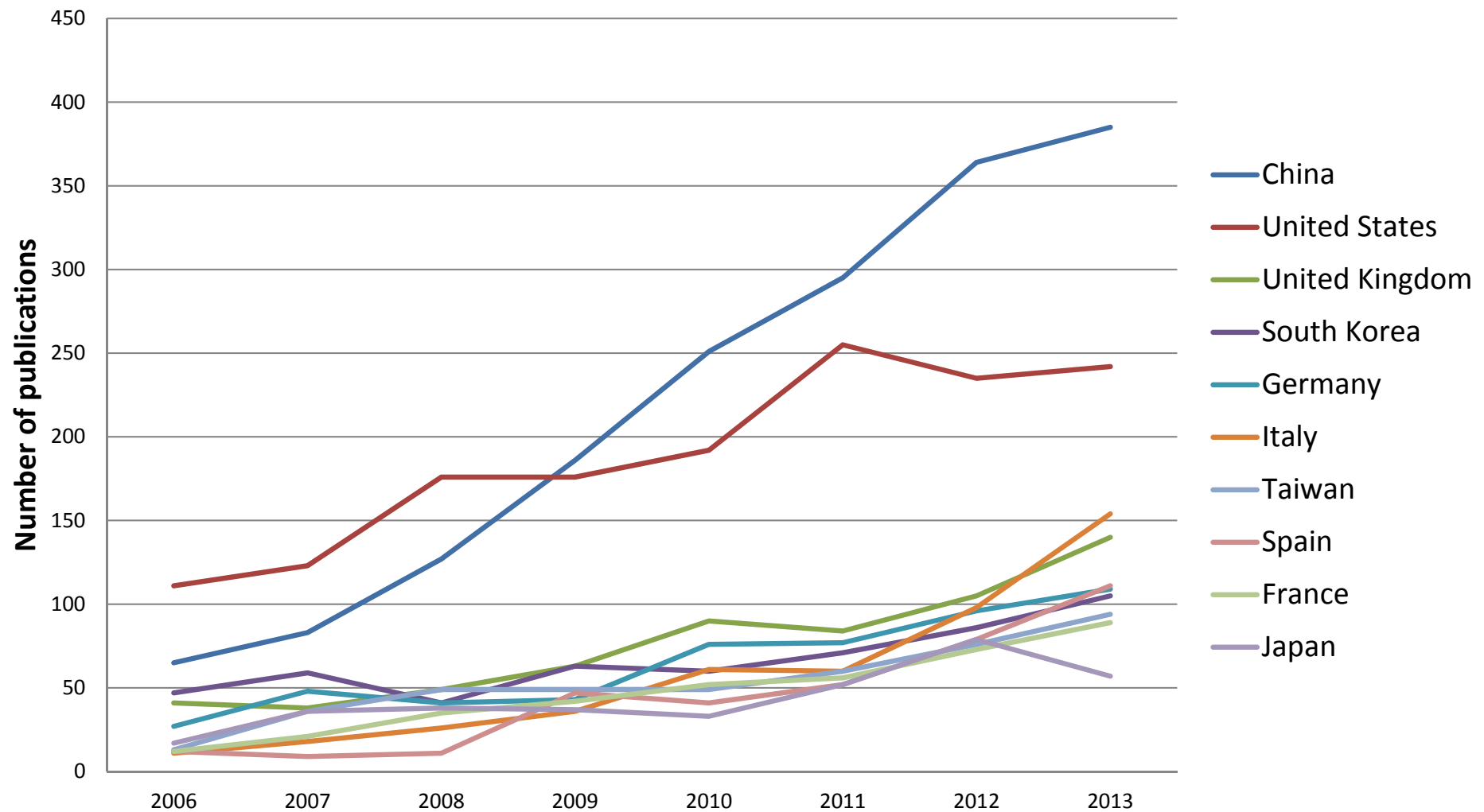
# Research topic changes 2013-2014

## Percentage of publications on selected topics



# Countries

# Changes in publication intensity of top countries 2006-2013



# Changes\* in publication intensity by country\*\* 2006-2013

| Publications total | COUNTRY        | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--------------------|----------------|------|------|------|------|------|------|------|------|
| 2031               | China          | 4 %  | 5 %  | 7 %  | 11 % | 14 % | 17 % | 21 % | 22 % |
| 1607               | United States  | 7 %  | 8 %  | 12 % | 12 % | 13 % | 17 % | 16 % | 16 % |
| 665                | United Kingdom | 7 %  | 6 %  | 8 %  | 10 % | 15 % | 14 % | 17 % | 23 % |
| 580                | South Korea    | 9 %  | 11 % | 8 %  | 12 % | 11 % | 13 % | 16 % | 20 % |
| 568                | Germany        | 5 %  | 9 %  | 8 %  | 8 %  | 15 % | 15 % | 19 % | 21 % |
| 558                | Italy          | 2 %  | 4 %  | 6 %  | 8 %  | 13 % | 13 % | 21 % | 33 % |
| 472                | Taiwan         | 3 %  | 8 %  | 12 % | 12 % | 12 % | 14 % | 18 % | 22 % |
| 443                | Spain          | 3 %  | 2 %  | 3 %  | 13 % | 11 % | 14 % | 22 % | 31 % |
| 413                | France         | 3 %  | 6 %  | 9 %  | 11 % | 14 % | 15 % | 19 % | 23 % |
| 400                | Japan          | 5 %  | 10 % | 11 % | 11 % | 9 %  | 15 % | 23 % | 16 % |
| 390                | Canada         | 4 %  | 6 %  | 8 %  | 13 % | 11 % | 21 % | 18 % | 19 % |
| 260                | Czech Republic | 1 %  | 16 % | 2 %  | 4 %  | 27 % | 4 %  | 5 %  | 41 % |
| 251                | Austria        | 3 %  | 10 % | 7 %  | 9 %  | 19 % | 11 % | 20 % | 21 % |
| 224                | India          | 4 %  | 3 %  | 6 %  | 10 % | 16 % | 17 % | 18 % | 26 % |
| 208                | Netherlands    | 6 %  | 3 %  | 8 %  | 13 % | 11 % | 16 % | 21 % | 24 % |
| 196                | Australia      | 8 %  | 11 % | 8 %  | 12 % | 12 % | 15 % | 16 % | 18 % |
| 196                | Greece         | 3 %  | 7 %  | 7 %  | 13 % | 15 % | 13 % | 19 % | 23 % |
| 148                | Finland        | 3 %  | 10 % | 10 % | 10 % | 16 % | 13 % | 11 % | 27 % |
| 143                | Malaysia       | 3 %  | 4 %  | 10 % | 10 % | 13 % | 22 % | 17 % | 22 % |
| 143                | Sweden         | 6 %  | 8 %  | 8 %  | 7 %  | 11 % | 12 % | 16 % | 30 % |
| 136                | Portugal       | 3 %  | 9 %  | 9 %  | 8 %  | 14 % | 20 % | 19 % | 19 % |
| 126                | Ireland        | 2 %  | 1 %  | 9 %  | 16 % | 12 % | 17 % | 20 % | 24 % |
| 117                | Singapore      | 2 %  | 7 %  | 7 %  | 13 % | 11 % | 19 % | 20 % | 22 % |
| 113                | Poland         | 5 %  | 13 % | 7 %  | 3 %  | 21 % | 14 % | 6 %  | 31 % |
| 113                | Switzerland    | 5 %  | 7 %  | 5 %  | 5 %  | 9 %  | 12 % | 23 % | 33 % |
| 108                | Romania        | 1 %  | 3 %  | 5 %  | 9 %  | 15 % | 13 % | 27 % | 27 % |
| 103                | Belgium        | 1 %  | 3 %  | 5 %  | 7 %  | 9 %  | 20 % | 22 % | 33 % |
| 100                | Brazil         | 7 %  | 8 %  | 7 %  | 8 %  | 9 %  | 10 % | 25 % | 26 % |

# Differences in country profiles, 2006-2014

## Percentages\* of publications on a driver theme

| Country ↓      | Driver →  |      |        |                     |                                    |                              |                           |                      |                       |      |  |  |
|----------------|-----------|------|--------|---------------------|------------------------------------|------------------------------|---------------------------|----------------------|-----------------------|------|--|--|
|                | Buildings | ICT  | Energy | Traffic & transport | Infrastructure & built environment | Services, commerce, business | Security, safety, privacy | Health & health care | Governance & policies |      |  |  |
| China          |           | 56 % | 70 %   | 26 %                | 29 %                               | 16 %                         | 10 %                      | 10 %                 | 3 %                   | 4 %  |  |  |
| United States  |           | 61 % | 56 %   | 32 %                | 18 %                               | 17 %                         | 10 %                      | 10 %                 | 12 %                  | 7 %  |  |  |
| United Kingdom |           | 68 % | 59 %   | 22 %                | 13 %                               | 16 %                         | 13 %                      | 8 %                  | 9 %                   | 6 %  |  |  |
| South Korea    |           | 70 % | 79 %   | 20 %                | 14 %                               | 6 %                          | 21 %                      | 12 %                 | 12 %                  | 3 %  |  |  |
| Germany        |           | 69 % | 57 %   | 29 %                | 14 %                               | 14 %                         | 14 %                      | 10 %                 | 6 %                   | 3 %  |  |  |
| Italy          |           | 60 % | 59 %   | 35 %                | 13 %                               | 19 %                         | 18 %                      | 6 %                  | 7 %                   | 6 %  |  |  |
| Taiwan         |           | 66 % | 76 %   | 17 %                | 17 %                               | 8 %                          | 15 %                      | 11 %                 | 11 %                  | 3 %  |  |  |
| Spain          |           | 52 % | 65 %   | 25 %                | 17 %                               | 20 %                         | 25 %                      | 8 %                  | 7 %                   | 5 %  |  |  |
| France         |           | 69 % | 74 %   | 21 %                | 14 %                               | 11 %                         | 15 %                      | 8 %                  | 20 %                  | 2 %  |  |  |
| Japan          |           | 54 % | 51 %   | 32 %                | 17 %                               | 14 %                         | 13 %                      | 8 %                  | 10 %                  | 4 %  |  |  |
| Canada         |           | 68 % | 64 %   | 24 %                | 15 %                               | 13 %                         | 12 %                      | 8 %                  | 15 %                  | 4 %  |  |  |
| Czech Republic |           | 93 % | 27 %   | 36 %                | 6 %                                | 12 %                         | 3 %                       | 3 %                  | 6 %                   | 3 %  |  |  |
| Austria        |           | 77 % | 56 %   | 29 %                | 12 %                               | 10 %                         | 15 %                      | 15 %                 | 4 %                   | 4 %  |  |  |
| India          |           | 50 % | 64 %   | 31 %                | 28 %                               | 13 %                         | 8 %                       | 17 %                 | 7 %                   | 6 %  |  |  |
| Netherlands    |           | 64 % | 44 %   | 30 %                | 13 %                               | 19 %                         | 14 %                      | 5 %                  | 12 %                  | 4 %  |  |  |
| Australia      |           | 58 % | 54 %   | 30 %                | 18 %                               | 23 %                         | 13 %                      | 13 %                 | 13 %                  | 8 %  |  |  |
| Greece         |           | 54 % | 70 %   | 27 %                | 14 %                               | 13 %                         | 20 %                      | 8 %                  | 10 %                  | 7 %  |  |  |
| Finland        |           | 66 % | 65 %   | 22 %                | 15 %                               | 11 %                         | 18 %                      | 6 %                  | 11 %                  | 5 %  |  |  |
| Malaysia       |           | 68 % | 65 %   | 24 %                | 18 %                               | 22 %                         | 8 %                       | 8 %                  | 11 %                  | 3 %  |  |  |
| Sweden         |           | 66 % | 52 %   | 29 %                | 15 %                               | 12 %                         | 18 %                      | 10 %                 | 16 %                  | 3 %  |  |  |
| Portugal       |           | 68 % | 51 %   | 37 %                | 17 %                               | 19 %                         | 10 %                      | 7 %                  | 9 %                   | 7 %  |  |  |
| Ireland        |           | 58 % | 80 %   | 29 %                | 11 %                               | 22 %                         | 21 %                      | 6 %                  | 10 %                  | 7 %  |  |  |
| Singapore      |           | 69 % | 60 %   | 31 %                | 15 %                               | 14 %                         | 15 %                      | 5 %                  | 16 %                  | 6 %  |  |  |
| Poland         |           | 61 % | 38 %   | 32 %                | 19 %                               | 17 %                         | 11 %                      | 4 %                  | 5 %                   | 6 %  |  |  |
| Switzerland    |           | 73 % | 65 %   | 35 %                | 5 %                                | 12 %                         | 14 %                      | 5 %                  | 5 %                   | 4 %  |  |  |
| Romania        |           | 70 % | 59 %   | 41 %                | 15 %                               | 19 %                         | 19 %                      | 5 %                  | 6 %                   | 5 %  |  |  |
| Belgium        |           | 55 % | 45 %   | 34 %                | 13 %                               | 16 %                         | 13 %                      | 4 %                  | 8 %                   | 7 %  |  |  |
| Brazil         |           | 60 % | 53 %   | 19 %                | 16 %                               | 24 %                         | 11 %                      | 2 %                  | 5 %                   | 10 % |  |  |

# Differences in country profiles, 2006-2014

## Percentages of publications on big technology / application themes

| COUNTRY ↓      | TOPIC →        |            |            |                   |         |                 |          |                                    |           |            |
|----------------|----------------|------------|------------|-------------------|---------|-----------------|----------|------------------------------------|-----------|------------|
|                | Smart building | Automation | Smart Home | Energy efficiency | Sensors | Sensor networks | Internet | Intelligent Transportation Systems | Algorithm | Smart City |
| China          | 43 %           | 28 %       | 24 %       | 18 %              | 13 %    | 17 %            | 14 %     | 14 %                               | 12 %      | 4 %        |
| United States  | 45 %           | 22 %       | 18 %       | 17 %              | 19 %    | 11 %            | 5 %      | 9 %                                | 9 %       | 3 %        |
| United Kingdom | 51 %           | 20 %       | 25 %       | 14 %              | 18 %    | 9 %             | 9 %      | 7 %                                | 6 %       | 7 %        |
| South Korea    | 44 %           | 33 %       | 45 %       | 10 %              | 20 %    | 19 %            | 10 %     | 7 %                                | 12 %      | 3 %        |
| Germany        | 54 %           | 32 %       | 27 %       | 16 %              | 17 %    | 11 %            | 9 %      | 4 %                                | 7 %       | 5 %        |
| Italy          | 48 %           | 25 %       | 16 %       | 23 %              | 15 %    | 13 %            | 13 %     | 5 %                                | 5 %       | 15 %       |
| Taiwan         | 44 %           | 28 %       | 38 %       | 7 %               | 20 %    | 18 %            | 11 %     | 8 %                                | 13 %      | 2 %        |
| Spain          | 38 %           | 26 %       | 22 %       | 15 %              | 17 %    | 16 %            | 13 %     | 7 %                                | 6 %       | 19 %       |
| France         | 43 %           | 37 %       | 37 %       | 13 %              | 24 %    | 14 %            | 12 %     | 8 %                                | 7 %       | 6 %        |
| Japan          | 33 %           | 16 %       | 16 %       | 16 %              | 23 %    | 12 %            | 7 %      | 7 %                                | 5 %       | 7 %        |
| Canada         | 43 %           | 28 %       | 33 %       | 14 %              | 17 %    | 7 %             | 8 %      | 8 %                                | 10 %      | 4 %        |
| Czech Republic | 89 %           | 12 %       | 8 %        | 20 %              | 4 %     | 2 %             | 3 %      | 2 %                                | 3 %       | 0 %        |
| Austria        | 65 %           | 47 %       | 27 %       | 20 %              | 9 %     | 4 %             | 12 %     | 5 %                                | 2 %       | 4 %        |
| India          | 38 %           | 28 %       | 17 %       | 21 %              | 23 %    | 24 %            | 9 %      | 13 %                               | 12 %      | 3 %        |
| Netherlands    | 49 %           | 25 %       | 22 %       | 20 %              | 10 %    | 7 %             | 7 %      | 7 %                                | 3 %       | 5 %        |
| Australia      | 42 %           | 21 %       | 21 %       | 19 %              | 13 %    | 12 %            | 9 %      | 10 %                               | 7 %       | 5 %        |
| Greece         | 39 %           | 28 %       | 21 %       | 18 %              | 14 %    | 13 %            | 23 %     | 7 %                                | 6 %       | 20 %       |
| Finland        | 45 %           | 24 %       | 28 %       | 14 %              | 15 %    | 14 %            | 18 %     | 6 %                                | 4 %       | 9 %        |
| Malaysia       | 47 %           | 29 %       | 34 %       | 13 %              | 14 %    | 13 %            | 10 %     | 8 %                                | 13 %      | 9 %        |
| Sweden         | 50 %           | 22 %       | 21 %       | 13 %              | 15 %    | 15 %            | 7 %      | 6 %                                | 1 %       | 9 %        |
| Portugal       | 56 %           | 23 %       | 12 %       | 24 %              | 11 %    | 10 %            | 9 %      | 10 %                               | 6 %       | 7 %        |
| Ireland        | 43 %           | 21 %       | 16 %       | 15 %              | 33 %    | 19 %            | 12 %     | 2 %                                | 10 %      | 17 %       |
| Singapore      | 48 %           | 32 %       | 26 %       | 15 %              | 22 %    | 12 %            | 4 %      | 5 %                                | 8 %       | 4 %        |
| Poland         | 60 %           | 15 %       | 4 %        | 19 %              | 12 %    | 6 %             | 5 %      | 9 %                                | 9 %       | 3 %        |
| Switzerland    | 64 %           | 29 %       | 14 %       | 18 %              | 15 %    | 12 %            | 26 %     | 2 %                                | 11 %      | 9 %        |
| Romania        | 60 %           | 26 %       | 12 %       | 22 %              | 19 %    | 12 %            | 14 %     | 6 %                                | 6 %       | 7 %        |
| Belgium        | 44 %           | 15 %       | 8 %        | 16 %              | 13 %    | 12 %            | 7 %      | 7 %                                | 6 %       | 16 %       |
| Brazil         | 50 %           | 22 %       | 13 %       | 10 %              | 14 %    | 14 %            | 5 %      | 5 %                                | 7 %       | 10 %       |

# Similarities of publication profiles in Europe 2006-2104

## Countries cross-correlated\* with selected technology / application topics

| Publications total | COUNTRY               | United Kingdom | Germany | Italy | Spain | France | Czech Republic | Austria | Netherlands | Greece | Finland | Sweden | Portugal | Ireland | Poland | Switzerland | Romania | Belgium | Denmark | Slovakia | Norway |
|--------------------|-----------------------|----------------|---------|-------|-------|--------|----------------|---------|-------------|--------|---------|--------|----------|---------|--------|-------------|---------|---------|---------|----------|--------|
| 665                | <b>United Kingdom</b> |                | 0,87    | 0,82  | 0,84  | 0,93   | 0,55           | 0,36    | 0,84        | 0,81   | 0,89    | 0,87   | 0,68     | 0,95    | 0,79   | 0,71        | 0,85    | 0,83    | 0,60    | 0,24     | 0,51   |
| 568                | <b>Germany</b>        | 0,87           |         | 0,91  | 0,79  | 0,90   | 0,84           | 0,75    | 0,88        | 0,81   | 0,88    | 0,87   | 0,86     | 0,86    | 0,74   | 0,88        | 0,83    | 0,82    | 0,61    | 0,21     | 0,56   |
| 558                | <b>Italy</b>          | 0,82           | 0,91    |       | 0,91  | 0,83   | 0,80           | 0,63    | 0,88        | 0,92   | 0,85    | 0,92   | 0,88     | 0,85    | 0,74   | 0,89        | 0,87    | 0,91    | 0,72    | 0,12     | 0,64   |
| 443                | <b>Spain</b>          | 0,84           | 0,79    | 0,91  |       | 0,78   | 0,53           | 0,40    | 0,84        | 0,98   | 0,84    | 0,86   | 0,72     | 0,84    | 0,61   | 0,75        | 0,78    | 0,85    | 0,63    | 0,11     | 0,48   |
| 413                | <b>France</b>         | 0,93           | 0,90    | 0,83  | 0,78  |        | 0,65           | 0,50    | 0,90        | 0,77   | 0,89    | 0,83   | 0,77     | 0,93    | 0,76   | 0,76        | 0,80    | 0,82    | 0,61    | 0,23     | 0,55   |
| 260                | <b>Czech Republic</b> | 0,55           | 0,84    | 0,80  | 0,53  | 0,65   |                | 0,85    | 0,67        | 0,55   | 0,62    | 0,71   | 0,87     | 0,61    | 0,67   | 0,81        | 0,68    | 0,71    | 0,65    | 0,15     | 0,63   |
| 251                | <b>Austria</b>        | 0,36           | 0,75    | 0,63  | 0,40  | 0,50   | 0,85           |         | 0,52        | 0,47   | 0,45    | 0,46   | 0,69     | 0,39    | 0,37   | 0,76        | 0,45    | 0,40    | 0,32    | 0,09     | 0,29   |
| 208                | <b>Netherlands</b>    | 0,84           | 0,88    | 0,88  | 0,84  | 0,90   | 0,67           | 0,52    |             | 0,83   | 0,95    | 0,82   | 0,84     | 0,86    | 0,66   | 0,80        | 0,72    | 0,88    | 0,74    | 0,31     | 0,69   |
| 196                | <b>Greece</b>         | 0,81           | 0,81    | 0,92  | 0,98  | 0,77   | 0,55           | 0,47    | 0,83        |        | 0,83    | 0,86   | 0,71     | 0,81    | 0,55   | 0,80        | 0,76    | 0,83    | 0,62    | 0,08     | 0,47   |
| 148                | <b>Finland</b>        | 0,89           | 0,88    | 0,85  | 0,84  | 0,89   | 0,62           | 0,45    | 0,95        | 0,83   |         | 0,86   | 0,79     | 0,87    | 0,65   | 0,80        | 0,78    | 0,86    | 0,70    | 0,25     | 0,64   |
| 143                | <b>Sweden</b>         | 0,87           | 0,87    | 0,92  | 0,86  | 0,83   | 0,71           | 0,46    | 0,82        | 0,86   | 0,86    |        | 0,81     | 0,86    | 0,75   | 0,76        | 0,89    | 0,92    | 0,70    | 0,12     | 0,63   |
| 136                | <b>Portugal</b>       | 0,68           | 0,86    | 0,88  | 0,72  | 0,77   | 0,87           | 0,69    | 0,84        | 0,71   | 0,79    | 0,81   |          | 0,70    | 0,72   | 0,80        | 0,75    | 0,87    | 0,79    | 0,35     | 0,76   |
| 126                | <b>Ireland</b>        | 0,95           | 0,86    | 0,85  | 0,84  | 0,93   | 0,61           | 0,39    | 0,86        | 0,81   | 0,87    | 0,86   | 0,70     |         | 0,77   | 0,72        | 0,82    | 0,84    | 0,59    | 0,09     | 0,51   |
| 113                | <b>Poland</b>         | 0,79           | 0,74    | 0,74  | 0,61  | 0,76   | 0,67           | 0,37    | 0,66        | 0,55   | 0,65    | 0,75   | 0,72     | 0,77    |        | 0,58        | 0,88    | 0,76    | 0,56    | 0,38     | 0,59   |
| 113                | <b>Switzerland</b>    | 0,71           | 0,88    | 0,89  | 0,75  | 0,76   | 0,81           | 0,76    | 0,80        | 0,80   | 0,80    | 0,76   | 0,80     | 0,72    | 0,58   |             | 0,75    | 0,77    | 0,67    | 0,05     | 0,57   |
| 108                | <b>Romania</b>        | 0,85           | 0,83    | 0,87  | 0,78  | 0,80   | 0,68           | 0,45    | 0,72        | 0,76   | 0,78    | 0,89   | 0,75     | 0,82    | 0,88   | 0,75        |         | 0,81    | 0,60    | 0,26     | 0,55   |
| 103                | <b>Belgium</b>        | 0,83           | 0,82    | 0,91  | 0,85  | 0,82   | 0,71           | 0,40    | 0,88        | 0,83   | 0,86    | 0,92   | 0,87     | 0,84    | 0,76   | 0,77        | 0,81    |         | 0,87    | 0,22     | 0,83   |
| 87                 | <b>Denmark</b>        | 0,60           | 0,61    | 0,72  | 0,63  | 0,61   | 0,65           | 0,32    | 0,74        | 0,62   | 0,70    | 0,70   | 0,79     | 0,59    | 0,56   | 0,67        | 0,60    | 0,87    |         | 0,33     | 0,91   |
| 71                 | <b>Slovakia</b>       | 0,24           | 0,21    | 0,12  | 0,11  | 0,23   | 0,15           | 0,09    | 0,31        | 0,08   | 0,25    | 0,12   | 0,35     | 0,09    | 0,38   | 0,05        | 0,26    | 0,22    | 0,33    |          | 0,40   |
| 67                 | <b>Norway</b>         | 0,51           | 0,56    | 0,64  | 0,48  | 0,55   | 0,63           | 0,29    | 0,69        | 0,47   | 0,64    | 0,63   | 0,76     | 0,51    | 0,59   | 0,57        | 0,55    | 0,83    | 0,91    | 0,40     |        |

\* Based on cross-correlation with keywords in publications, max corr. 1, correlation level indicated by colour

COUNTRIES: Top 20 European countries

17/11/2014

\* TOPICS used in correlation analysis: Sensors; WSN; Ubiquitous computing; Building automation; Security & privacy; Intelligent Vehicle Highway System; Electronic commerce; IoT; ZigBee; NZEB & ZEB; Cloud computing; Tracking; Intelligent traffic; Genetic algorithms; Sensor Fusion; Pattern recognition; Home healthcare; Smart phone; Machine Learning; Retrofitting; Building Information Model - BIM; Big data; 31 Cyber physical systems (CPSs); Smart meters; V2X Communication

# Collaboration between countries 2006-2014

## Percentage of existing common publications

| Publicat. total | COUNTRY               | China | United States | United Kingdom | South Korea | Germany | Italy | Taiwan | Spain | France | Japan | Canada | Czech Republic | Austria | India | Netherlands | Finland |
|-----------------|-----------------------|-------|---------------|----------------|-------------|---------|-------|--------|-------|--------|-------|--------|----------------|---------|-------|-------------|---------|
| 2031            | <b>China</b>          |       | 4,6 %         | 0,8 %          | 0,9 %       | 0,3 %   | 0,1 % | 0,5 %  |       | 1,3 %  | 1,0 % | 1,1 %  | 0,0 %          | 0,0 %   |       |             | 0,2 %   |
| 1607            | <b>United States</b>  | 5,8 % |               | 1,7 %          | 2,2 %       | 1,3 %   | 1,4 % | 1,6 %  | 1,2 % | 1,3 %  | 1,1 % | 2,1 %  | 0,1 %          | 0,3 %   | 0,7 % | 0,5 %       | 0,6 %   |
| 665             | <b>United Kingdom</b> | 2,4 % | 4,1 %         |                | 0,5 %       | 2,7 %   | 3,5 % | 0,5 %  | 4,5 % | 2,1 %  | 1,1 % | 1,4 %  | 0,2 %          | 0,9 %   | 0,3 % | 2,1 %       | 1,1 %   |
| 580             | <b>South Korea</b>    | 3,1 % | 6,2 %         | 0,5 %          |             | 0,3 %   |       | 0,5 %  |       | 1,0 %  | 0,5 % | 2,2 %  | 0,2 %          | 0,2 %   | 0,3 % | 0,2 %       | 0,5 %   |
| 568             | <b>Germany</b>        | 1,2 % | 3,7 %         | 3,2 %          | 0,4 %       |         | 3,7 % |        | 2,8 % | 2,6 %  | 0,9 % | 0,5 %  | 0,7 %          | 4,0 %   | 0,4 % | 2,8 %       | 1,4 %   |
| 558             | <b>Italy</b>          | 0,5 % | 4,1 %         | 4,1 %          |             | 3,8 %   |       |        | 5,0 % | 2,3 %  | 0,5 % | 0,7 %  | 0,2 %          | 1,3 %   | 0,2 % | 2,7 %       | 1,1 %   |
| 472             | <b>Taiwan</b>         | 2,3 % | 5,3 %         | 0,6 %          | 0,6 %       |         |       |        |       |        | 0,2 % | 0,2 %  |                | 0,2 %   |       |             |         |
| 443             | <b>Spain</b>          | 0,2 % | 4,3 %         | 6,8 %          | 0,0 %       | 3,6 %   | 6,3 % |        |       | 3,4 %  | 0,5 % | 1,4 %  | 0,7 %          | 4,7 %   |       | 0,5 %       | 0,9 %   |
| 413             | <b>France</b>         | 6,5 % | 5,1 %         | 3,4 %          | 1,5 %       | 3,6 %   | 3,1 % |        | 3,6 % |        | 1,2 % | 5,1 %  | 0,2 %          | 0,5 %   | 0,2 % | 1,5 %       | 0,7 %   |
| 400             | <b>Japan</b>          | 5,3 % | 4,5 %         | 1,8 %          | 0,8 %       | 1,3 %   | 0,8 % | 0,3 %  |       | 1,3 %  |       | 0,8 %  |                |         | 0,3 % | 0,8 %       | 0,3 %   |
| 390             | <b>Canada</b>         | 5,6 % | 8,7 %         | 2,3 %          | 3,3 %       | 0,8 %   | 1,0 % | 0,3 %  | 1,5 % | 5,4 %  | 0,8 % |        |                | 0,3 %   | 0,3 % | 0,8 %       | 0,8 %   |
| 260             | <b>Czech Republic</b> | 0,0 % | 0,4 %         | 0,4 %          | 0,4 %       | 1,5 %   | 0,4 % |        | 1,2 % | 0,4 %  |       |        |                | 1,2 %   |       | 2,3 %       | 0,8 %   |
| 251             | <b>Austria</b>        | 0,4 % | 2,0 %         | 2,4 %          | 0,4 %       | 9,2 %   | 2,8 % | 0,4 %  | 8,4 % | 0,8 %  |       | 0,4 %  | 1,2 %          |         |       | 2,0 %       | 0,4 %   |
| 224             | <b>India</b>          |       | 5,4 %         | 0,9 %          | 0,9 %       | 0,9 %   | 0,4 % |        |       | 0,4 %  | 0,4 % | 0,4 %  |                |         |       |             |         |
| 208             | <b>Netherlands</b>    |       | 3,8 %         | 6,7 %          | 0,5 %       | 7,7 %   | 7,2 % |        | 1,0 % | 2,9 %  | 1,4 % | 1,4 %  | 2,9 %          | 2,4 %   |       |             | 2,4 %   |
| 148             | <b>Finland</b>        | 3,4 % | 6,1 %         | 4,7 %          | 2,0 %       | 5,4 %   | 4,1 % |        | 2,7 % | 2,0 %  | 0,7 % | 2,0 %  | 1,4 %          | 0,7 %   |       | 3,4 %       |         |

Note: collaboration across countries is commonly relatively low

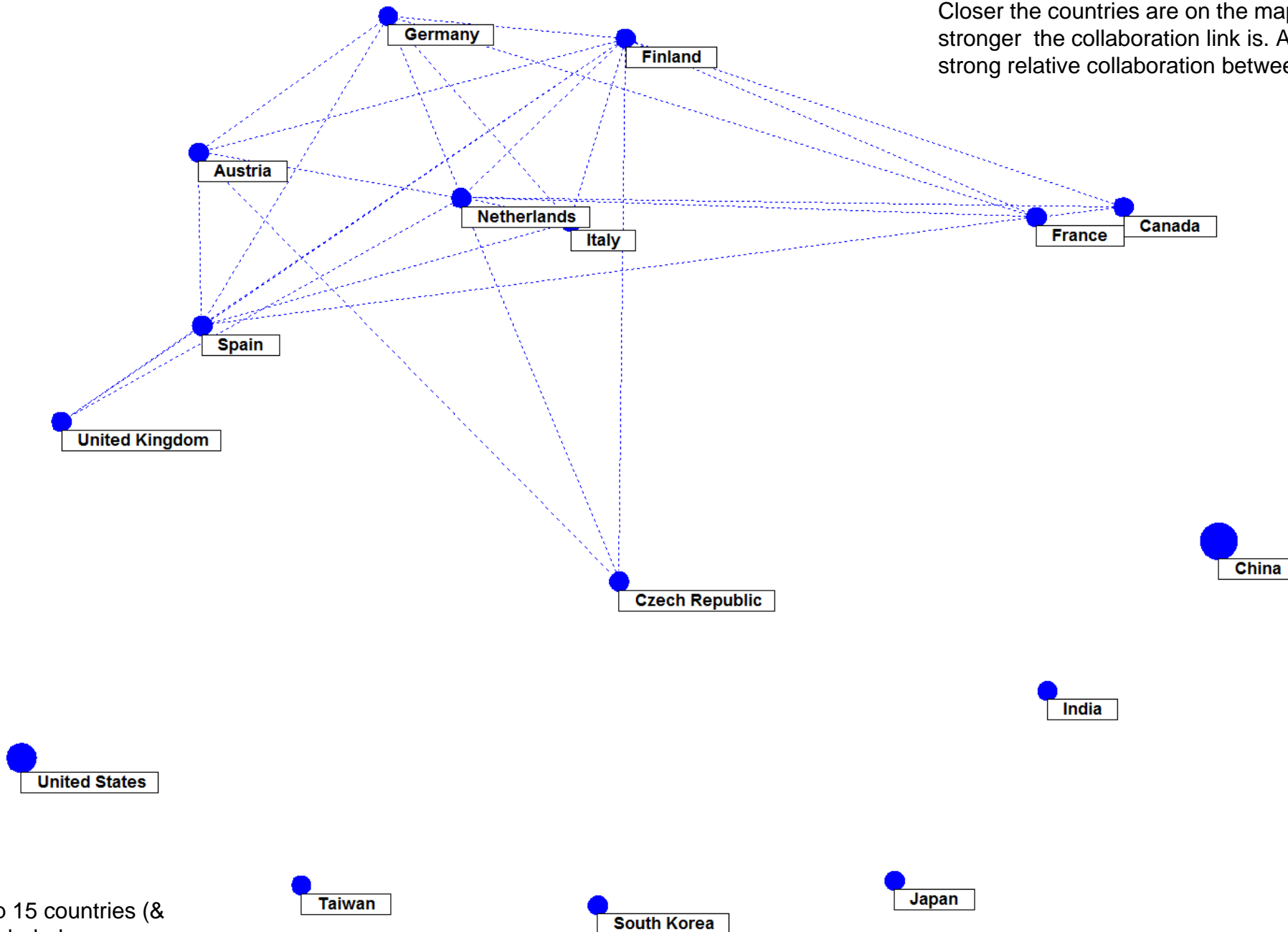
Only the top 15 countries (& Finland) included



# Research collaboration map 2006-2014



Key: bigger the bubble more there are publications.  
Closer the countries are on the map, relatively stronger the collaboration link is. Also lines indicate strong relative collaboration between organisations



Only the top 15 countries (& Finland) included

# RTOs and universities

# Top global universities and RTOs 2006-2013: publications volume, growth rate & impact\* (number of citations)



\* Size of bubble

Compound annual growth rate

NB. Czech Technical University in Prague excluded from the map because the CESB 2013 PRAGUE conference skews the results

## Changes\* in publication intensity by organisation\*\*

| Publications total | RTO                              | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|--------------------|----------------------------------|------|------|------|------|------|------|------|------|
| 98                 | Vienna U. of Tech                | 3 %  | 6 %  | 10 % | 12 % | 19 % | 14 % | 13 % | 13 % |
| 97                 | National Taiwan U.               | 1 %  | 14 % | 10 % | 13 % | 9 %  | 11 % | 15 % | 19 % |
| 90                 | U. of Ulster, UK                 | 7 %  | 3 %  | 18 % | 13 % | 17 % | 14 % | 13 % | 9 %  |
| 82                 | Wuhan U.                         | 2 %  | 4 %  | 7 %  | 6 %  | 9 %  | 17 % | 17 % | 18 % |
| 79                 | Nat. Cheng Kung U.               | 3 %  | 5 %  | 13 % | 14 % | 8 %  | 13 % | 16 % | 22 % |
| 74                 | Tsinghua U., Beijing             | 4 %  | 5 %  | 8 %  | 12 % | 14 % | 11 % | 14 % | 14 % |
| 68                 | Beijing Jiaotong U.              | 7 %  | 4 %  | 6 %  | 9 %  | 22 % | 19 % | 15 % | 13 % |
| 65                 | IBM Research                     | 2 %  | 5 %  | 2 %  | 6 %  | 12 % | 22 % | 18 % | 20 % |
| 61                 | Fraunhofer                       | 11 % | 10 % | 8 %  | 7 %  | 16 % | 0 %  | 16 % | 23 % |
| 56                 | Zhejiang U.                      | 5 %  | 4 %  | 9 %  | 9 %  | 13 % | 14 % | 18 % | 18 % |
| 54                 | INRIA                            | 4 %  | 4 %  | 4 %  | 7 %  | 19 % | 17 % | 20 % | 15 % |
| 53                 | U. of California, Berkeley       | 11 % | 17 % | 13 % | 2 %  | 13 % | 17 % | 9 %  | 13 % |
| 52                 | Hong Kong Polytechnic U.         | 8 %  | 15 % | 15 % | 15 % | 12 % | 8 %  | 6 %  | 12 % |
| 52                 | Massey U., NZ                    | 2 %  | 4 %  | 12 % | 12 % | 19 % | 12 % | 21 % | 17 % |
| 51                 | Delft U. of Tech.                | 6 %  | 4 %  | 10 % | 10 % | 12 % | 14 % | 18 % | 20 % |
| 51                 | Eindhoven U. of Tech.            | 8 %  | 4 %  | 6 %  | 22 % | 8 %  | 14 % | 10 % | 22 % |
| 51                 | Washington State U., Pullman, WA | 0 %  | 10 % | 10 % | 10 % | 12 % | 18 % | 18 % | 22 % |
| 50                 | Beijing U. of Posts and Telecom. | 2 %  | 6 %  | 4 %  | 8 %  | 14 % | 14 % | 14 % | 30 % |
| 50                 | Carnegie Mellon U.               | 4 %  | 6 %  | 8 %  | 14 % | 8 %  | 16 % | 16 % | 20 % |
| 50                 | Kyung Hee U., SK                 | 4 %  | 0 %  | 4 %  | 0 %  | 10 % | 10 % | 28 % | 40 % |
| 49                 | ETH Zurich                       | 6 %  | 6 %  | 0 %  | 6 %  | 10 % | 10 % | 29 % | 29 % |
| 49                 | Nat. Chiao Tung U., Taiwan       | 4 %  | 10 % | 12 % | 4 %  | 10 % | 10 % | 20 % | 16 % |
| 49                 | U. of Sherbrooke, Canada         | 10 % | 10 % | 14 % | 14 % | 14 % | 8 %  | 18 % | 10 % |
| 48                 | Penn State                       | 4 %  | 4 %  | 2 %  | 6 %  | 15 % | 19 % | 17 % | 27 % |
| 48                 | Politecnico di Milano            | 4 %  | 2 %  | 0 %  | 4 %  | 4 %  | 4 %  | 21 % | 44 % |

# Differences in top organisations' profiles, 2006-2014

## Percentages\* of publications on a driver theme

| Publications total | RTO ↓                            | DRIVER → | DRIVER    |      |        |                     |                                    |                              |                           |                      |                       |  |  |
|--------------------|----------------------------------|----------|-----------|------|--------|---------------------|------------------------------------|------------------------------|---------------------------|----------------------|-----------------------|--|--|
|                    |                                  |          | Buildings | ICT  | Energy | Traffic & transport | Infrastructure & built environment | Services, commerce, business | Security, safety, privacy | Health & health care | Governance & policies |  |  |
| 98                 | Vienna U. of Tech                |          | 90 %      | 74 % | 27 %   | 8 %                 | 7 %                                | 14 %                         | 22 %                      | 0 %                  | 4 %                   |  |  |
| 97                 | National Taiwan U.               |          | 77 %      | 82 % | 8 %    | 12 %                | 7 %                                | 20 %                         | 9 %                       | 11 %                 | 5 %                   |  |  |
| 90                 | U. of Ulster, UK                 |          | 89 %      | 89 % | 2 %    | 3 %                 | 4 %                                | 8 %                          | 1 %                       | 23 %                 | 1 %                   |  |  |
| 82                 | Wuhan U.                         |          | 45 %      | 71 % | 27 %   | 32 %                | 23 %                               | 16 %                         | 10 %                      | 1 %                  | 5 %                   |  |  |
| 79                 | Nat. Cheng Kung U.               |          | 75 %      | 59 % | 14 %   | 10 %                | 8 %                                | 14 %                         | 11 %                      | 11 %                 | 3 %                   |  |  |
| 74                 | Tsinghua U., Beijing             |          | 68 %      | 62 % | 32 %   | 15 %                | 16 %                               | 19 %                         | 8 %                       | 3 %                  | 3 %                   |  |  |
| 68                 | Beijing Jiaotong U.              |          | 41 %      | 76 % | 15 %   | 47 %                | 15 %                               | 6 %                          | 9 %                       | 4 %                  | 1 %                   |  |  |
| 65                 | IBM Research                     |          | 38 %      | 74 % | 20 %   | 20 %                | 20 %                               | 29 %                         | 11 %                      | 6 %                  | 9 %                   |  |  |
| 61                 | Fraunhofer                       |          | 66 %      | 64 % | 36 %   | 7 %                 | 16 %                               | 15 %                         | 8 %                       | 8 %                  | 5 %                   |  |  |
| 56                 | Zhejiang U.                      |          | 36 %      | 80 % | 18 %   | 36 %                | 11 %                               | 20 %                         | 5 %                       | 5 %                  | 5 %                   |  |  |
| 54                 | INRIA                            |          | 59 %      | 89 % | 11 %   | 17 %                | 13 %                               | 22 %                         | 9 %                       | 7 %                  | 2 %                   |  |  |
| 53                 | U. of California, Berkeley       |          | 42 %      | 58 % | 30 %   | 28 %                | 17 %                               | 6 %                          | 4 %                       | 15 %                 | 0 %                   |  |  |
| 52                 | Hong Kong Polytechnic U.         |          | 77 %      | 54 % | 38 %   | 10 %                | 15 %                               | 10 %                         | 4 %                       | 2 %                  | 4 %                   |  |  |
| 52                 | Massey U., NZ                    |          | 77 %      | 75 % | 12 %   | 0 %                 | 0 %                                | 0 %                          | 4 %                       | 8 %                  | 0 %                   |  |  |
| 51                 | Delft U. of Tech.                |          | 57 %      | 45 % | 22 %   | 22 %                | 20 %                               | 22 %                         | 6 %                       | 14 %                 | 4 %                   |  |  |
| 51                 | Eindhoven U. of Tech.            |          | 84 %      | 37 % | 43 %   | 0 %                 | 18 %                               | 8 %                          | 0 %                       | 14 %                 | 0 %                   |  |  |
| 51                 | Washington State U., Pullman, WA |          | 90 %      | 88 % | 2 %    | 2 %                 | 6 %                                | 4 %                          | 0 %                       | 39 %                 | 6 %                   |  |  |
| 50                 | Beijing U. of Posts and Telecom. |          | 56 %      | 94 % | 20 %   | 24 %                | 10 %                               | 8 %                          | 6 %                       | 0 %                  | 4 %                   |  |  |
| 50                 | Carnegie Mellon U.               |          | 70 %      | 68 % | 28 %   | 8 %                 | 24 %                               | 10 %                         | 4 %                       | 16 %                 | 4 %                   |  |  |
| 50                 | Kyung Hee U., SK                 |          | 80 %      | 80 % | 12 %   | 8 %                 | 4 %                                | 14 %                         | 8 %                       | 46 %                 | 2 %                   |  |  |
| 49                 | ETH Zurich                       |          | 73 %      | 55 % | 37 %   | 6 %                 | 24 %                               | 8 %                          | 6 %                       | 2 %                  | 8 %                   |  |  |
| 49                 | Nat. Chiao Tung U., Taiwan       |          | 53 %      | 84 % | 27 %   | 33 %                | 2 %                                | 10 %                         | 4 %                       | 10 %                 | 0 %                   |  |  |
| 49                 | U. of Sherbrooke, Canada         |          | 98 %      | 88 % | 0 %    | 2 %                 | 0 %                                | 12 %                         | 12 %                      | 27 %                 | 0 %                   |  |  |
| 48                 | Penn State                       |          | 75 %      | 56 % | 44 %   | 0 %                 | 17 %                               | 6 %                          | 8 %                       | 15 %                 | 6 %                   |  |  |
| 48                 | Politecnico di Milano            |          | 56 %      | 44 % | 54 %   | 10 %                | 17 %                               | 21 %                         | 2 %                       | 2 %                  | 6 %                   |  |  |
| 43                 | VTT                              |          | 72 %      | 65 % | 23 %   | 19 %                | 12 %                               | 12 %                         | 7 %                       | 9 %                  | 7 %                   |  |  |

# Differences in RTO profiles, 2006-2014

Percentages of publications in selected **application / technology** topics

| Publications total | RTO ↓                                 | TOPIC → | Intelligent |            |                   |                         |          |                 |         |                |            |            |                         |
|--------------------|---------------------------------------|---------|-------------|------------|-------------------|-------------------------|----------|-----------------|---------|----------------|------------|------------|-------------------------|
|                    |                                       |         | Algorithm   | Automation | Energy efficiency | Transportati on Systems | Internet | Sensor networks | Sensors | Smart building | Smart City | Smart Home | Sustainable development |
| 61                 | Fraunhofer                            |         | 3 %         | 28 %       | 20 %              |                         | 10 %     | 11 %            | 15 %    | 51 %           | 7 %        | 31 %       | 18 %                    |
| 54                 | INRIA                                 |         | 7 %         | 41 %       | 7 %               | 11 %                    | 22 %     | 15 %            | 22 %    | 46 %           | 11 %       | 33 %       | 4 %                     |
| 43                 | VTT                                   |         | 2 %         | 16 %       | 14 %              | 12 %                    | 9 %      | 12 %            | 19 %    | 47 %           | 2 %        | 33 %       | 23 %                    |
| 36                 | Karlsruhe Inst. of Tech.              |         | 8 %         | 19 %       | 19 %              |                         | 8 %      | 3 %             | 3 %     | 69 %           | 8 %        | 25 %       | 42 %                    |
| 21                 | Nat. Renewable Energy Lab, Golden, CO |         |             | 5 %        | 67 %              |                         |          |                 | 14 %    | 24 %           |            |            | 5 %                     |
| 19                 | DFKI                                  |         |             | 42 %       | 5 %               |                         | 16 %     |                 | 11 %    | 53 %           |            | 37 %       |                         |
| 19                 | SINTEF                                |         |             | 11 %       | 26 %              | 11 %                    | 11 %     | 5 %             |         | 68 %           |            | 16 %       | 37 %                    |
| 18                 | TNO                                   |         | 6 %         | 39 %       | 11 %              | 17 %                    | 6 %      | 11 %            | 11 %    | 33 %           | 6 %        | 17 %       | 6 %                     |
| 15                 | RT-RK, Novi Sad, Serbia               |         | 7 %         | 67 %       | 7 %               |                         | 7 %      | 47 %            | 60 %    | 67 %           |            | 67 %       |                         |

Percentages of publications in **driver** themes

| Publications total | RTO ↓                                 | DRIVER → | Intelligent |        |                       |                      |      |                                    |                           |                              |                     |      |      |
|--------------------|---------------------------------------|----------|-------------|--------|-----------------------|----------------------|------|------------------------------------|---------------------------|------------------------------|---------------------|------|------|
|                    |                                       |          | Buildings   | Energy | Governance & policies | Health & health care | ICT  | Infrastructure & built environment | Security, safety, privacy | Services, commerce, business | Traffic & transport |      |      |
| 61                 | Fraunhofer                            |          | 66 %        | 36 %   | 5 %                   | 8 %                  | 64 % |                                    | 16 %                      | 8 %                          |                     | 15 % | 7 %  |
| 54                 | INRIA                                 |          | 59 %        | 11 %   | 2 %                   | 7 %                  | 89 % |                                    | 13 %                      | 9 %                          |                     | 22 % | 17 % |
| 43                 | VTT                                   |          | 72 %        | 23 %   | 7 %                   | 9 %                  | 65 % |                                    | 12 %                      | 7 %                          |                     | 12 % | 19 % |
| 36                 | Karlsruhe Inst. of Tech.              |          | 72 %        | 44 %   | 6 %                   | 6 %                  | 36 % |                                    | 25 %                      | 11 %                         |                     | 19 % | 14 % |
| 21                 | Nat. Renewable Energy Lab, Golden, CO |          | 95 %        | 86 %   |                       |                      | 38 % |                                    | 24 %                      |                              |                     | 10 % |      |
| 19                 | DFKI                                  |          | 74 %        | 5 %    | 5 %                   | 5 %                  | 63 % |                                    | 11 %                      | 16 %                         |                     |      | 5 %  |
| 19                 | SINTEF                                |          | 84 %        | 53 %   | 16 %                  | 5 %                  | 32 % |                                    | 16 %                      |                              |                     | 11 % | 16 % |
| 18                 | TNO                                   |          | 44 %        | 22 %   | 6 %                   | 17 %                 | 56 % |                                    | 11 %                      | 11 %                         |                     | 17 % | 39 % |
| 15                 | RT-RK, Novi Sad, Serbia               |          | 87 %        | 40 %   |                       |                      | 80 % |                                    | 13 %                      | 13 %                         |                     |      |      |

# Differences in top organisations' profiles, 2006-2014

## Percentages\* of publications on big technology / application themes

| RTO ↓                            | TOPIC | Smart building |            |                   |         | Sustainable development | Sensor networks | Intelligent Transportation Systems |      |      |      |      |
|----------------------------------|-------|----------------|------------|-------------------|---------|-------------------------|-----------------|------------------------------------|------|------|------|------|
|                                  | →     | Automation     | Smart Home | Energy efficiency | Sensors | Internet                | Algorithm       | Smart City                         |      |      |      |      |
| Vienna U. of Tech                |       | 79 %           | 77 %       | 26 %              | 16 %    | 10 %                    | 8 %             | 6 %                                | 15 % | 3 %  | 3 %  | 6 %  |
| National Taiwan U.               |       | 52 %           | 26 %       | 39 %              | 4 %     | 24 %                    | 3 %             | 24 %                               | 18 % | 6 %  | 10 % | 0 %  |
| U. of Ulster, UK                 |       | 34 %           | 32 %       | 70 %              | 2 %     | 42 %                    | 0 %             | 8 %                                | 7 %  | 0 %  | 14 % | 0 %  |
| Wuhan U.                         |       | 44 %           | 29 %       | 16 %              | 21 %    | 18 %                    | 7 %             | 16 %                               | 26 % | 20 % | 13 % | 17 % |
| Nat. Cheng Kung U.               |       | 51 %           | 23 %       | 41 %              | 4 %     | 9 %                     | 13 %            | 9 %                                | 4 %  | 0 %  | 6 %  | 0 %  |
| Tsinghua U., Beijing             |       | 53 %           | 20 %       | 23 %              | 26 %    | 15 %                    | 8 %             | 9 %                                | 8 %  | 4 %  | 12 % | 7 %  |
| Beijing Jiaotong U.              |       | 28 %           | 22 %       | 15 %              | 10 %    | 18 %                    | 1 %             | 22 %                               | 13 % | 25 % | 13 % | 3 %  |
| IBM Research                     |       | 28 %           | 12 %       | 11 %              | 9 %     | 17 %                    | 2 %             | 9 %                                | 9 %  | 8 %  | 11 % | 23 % |
| Fraunhofer                       |       | 51 %           | 28 %       | 31 %              | 20 %    | 15 %                    | 18 %            | 11 %                               | 10 % | 0 %  | 3 %  | 7 %  |
| Zhejiang U.                      |       | 20 %           | 21 %       | 21 %              | 14 %    | 16 %                    | 4 %             | 18 %                               | 14 % | 11 % | 16 % | 16 % |
| INRIA                            |       | 46 %           | 41 %       | 33 %              | 7 %     | 22 %                    | 4 %             | 15 %                               | 22 % | 11 % | 7 %  | 11 % |
| U. of California, Berkeley       |       | 38 %           | 17 %       | 11 %              | 9 %     | 26 %                    | 6 %             | 19 %                               | 6 %  | 13 % | 13 % | 4 %  |
| Hong Kong Polytechnic U.         |       | 75 %           | 29 %       | 6 %               | 27 %    | 10 %                    | 27 %            | 13 %                               | 8 %  | 4 %  | 13 % | 0 %  |
| Massey U., NZ                    |       | 40 %           | 42 %       | 69 %              | 8 %     | 62 %                    | 2 %             | 46 %                               | 2 %  | 0 %  | 8 %  | 0 %  |
| Delft U. of Tech.                |       | 39 %           | 22 %       | 16 %              | 12 %    | 8 %                     | 20 %            | 6 %                                | 6 %  | 8 %  | 0 %  | 2 %  |
| Eindhoven U. of Tech.            |       | 67 %           | 24 %       | 29 %              | 29 %    | 4 %                     | 29 %            | 8 %                                | 10 % | 0 %  | 4 %  | 0 %  |
| Washington State U., Pullman, WA |       | 51 %           | 57 %       | 80 %              | 2 %     | 29 %                    | 4 %             | 2 %                                | 0 %  | 2 %  | 39 % | 0 %  |
| Beijing U. of Posts and Telecom  |       | 38 %           | 36 %       | 38 %              | 14 %    | 16 %                    | 2 %             | 36 %                               | 30 % | 20 % | 8 %  | 0 %  |
| Carnegie Mellon U.               |       | 66 %           | 32 %       | 28 %              | 8 %     | 24 %                    | 20 %            | 4 %                                | 4 %  | 0 %  | 12 % | 8 %  |
| Kyung Hee U., SK                 |       | 54 %           | 44 %       | 52 %              | 6 %     | 22 %                    | 6 %             | 10 %                               | 6 %  | 4 %  | 20 % | 0 %  |
| ETH Zurich                       |       | 61 %           | 20 %       | 14 %              | 16 %    | 16 %                    | 29 %            | 12 %                               | 12 % | 0 %  | 12 % | 4 %  |
| Nat. Chiao Tung U., Taiwan       |       | 39 %           | 31 %       | 37 %              | 10 %    | 27 %                    | 0 %             | 18 %                               | 14 % | 22 % | 18 % | 0 %  |
| U. of Sherbrooke, Canada         |       | 41 %           | 31 %       | 65 %              | 0 %     | 16 %                    | 0 %             | 0 %                                | 8 %  | 0 %  | 2 %  | 0 %  |
| Penn State                       |       | 69 %           | 25 %       | 21 %              | 21 %    | 19 %                    | 23 %            | 10 %                               | 2 %  | 0 %  | 19 % | 6 %  |
| Politecnico di Milano            |       | 42 %           | 13 %       | 6 %               | 35 %    | 4 %                     | 27 %            | 6 %                                | 8 %  | 0 %  | 8 %  | 13 % |
| VTT                              |       | 47 %           | 16 %       | 33 %              | 14 %    | 19 %                    | 23 %            | 12 %                               | 9 %  | 12 % | 2 %  | 2 %  |







# Differences in Nordic research profiles, 2006-2014



## Percentages of publications in selected **application / technology** topics

| Publications total | RTO↓             | TOPIC → | Energy    |            | Intelligent transport. | Sensor            |         | Smart    | Smart      | Sustainable |             |      |      |
|--------------------|------------------|---------|-----------|------------|------------------------|-------------------|---------|----------|------------|-------------|-------------|------|------|
|                    |                  |         | Algorithm | Automation | efficiency systems     | Internet networks | Sensors | building | Smart City | Home        | development |      |      |
| 43                 | VTT              |         | 2 %       | 16 %       | 14 %                   | 12 %              | 9 %     | 12 %     | 19 %       | 47 %        | 2 %         | 33 % | 23 % |
| 37                 | Aalto U.         |         | 5 %       | 24 %       | 30 %                   | 5 %               | 19 %    | 3 %      | 0 %        | 57 %        | 11 %        | 11 % | 22 % |
| 35                 | Aalborg U.       |         | 0 %       | 14 %       | 26 %                   | 6 %               | 3 %     | 0 %      | 3 %        | 66 %        | 0 %         | 9 %  | 37 % |
| 30                 | TUT Tampere      |         | 3 %       | 50 %       | 10 %                   | 0 %               | 17 %    | 30 %     | 30 %       | 53 %        | 3 %         | 50 % | 3 %  |
| 22                 | Chalmers U.      |         | 5 %       | 14 %       | 18 %                   | 14 %              | 0 %     | 0 %      | 0 %        | 64 %        | 0 %         | 5 %  | 41 % |
| 20                 | KTH, Stockholm   |         | 0 %       | 30 %       | 15 %                   | 5 %               | 0 %     | 20 %     | 10 %       | 60 %        | 10 %        | 15 % | 20 % |
| 19                 | SINTEF           |         | 0 %       | 11 %       | 26 %                   | 11 %              | 11 %    | 5 %      | 0 %        | 68 %        | 0 %         | 16 % | 37 % |
| 18                 | NTNU Trondheim   |         | 0 %       | 11 %       | 17 %                   | 11 %              | 0 %     | 0 %      | 6 %        | 56 %        | 0 %         | 6 %  | 39 % |
| 14                 | Luleå U. of Tech |         | 0 %       | 36 %       | 14 %                   | 0 %               | 21 %    | 14 %     | 14 %       | 43 %        | 36 %        | 43 % | 7 %  |
| 12                 | Lund U.          |         | 0 %       | 8 %        | 17 %                   | 0 %               | 0 %     | 0 %      | 0 %        | 92 %        | 0 %         | 8 %  | 42 % |
| 8                  | Aarhus U.        |         | 0 %       | 25 %       | 0 %                    | 13 %              | 13 %    | 13 %     | 0 %        | 25 %        | 13 %        | 13 % | 13 % |

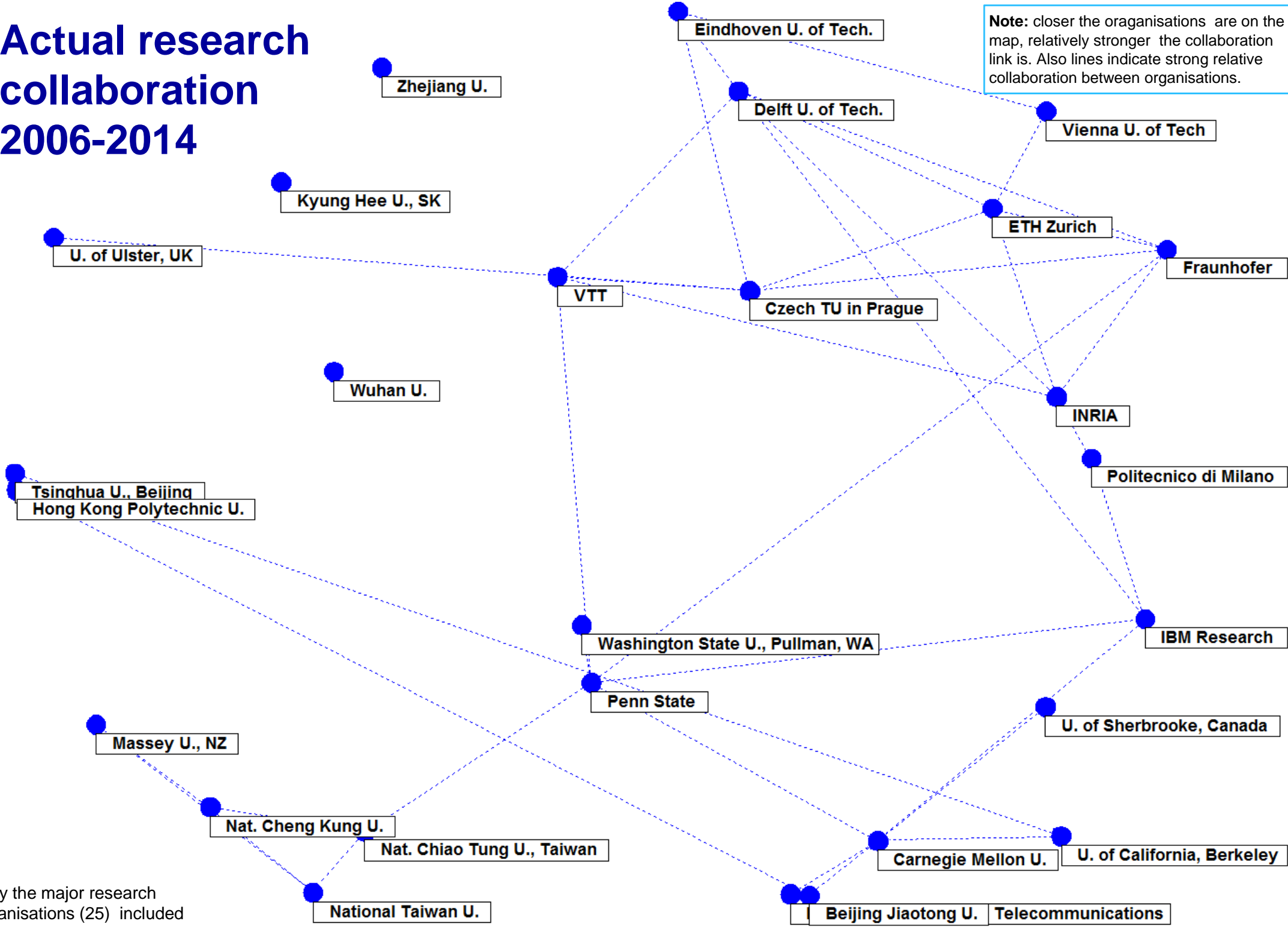
## Percentages of publications in a **driver** theme

Percentages are of all organisation's publications

| Publications total | RTO↓             | DRIVER → | Governance |        | Health &   | Infrastructure & built |      | Security, safety, | Services, commerce, | Traffic & |           |
|--------------------|------------------|----------|------------|--------|------------|------------------------|------|-------------------|---------------------|-----------|-----------|
|                    |                  |          | Buildings  | Energy | & policies | health care            | ICT  | environment       | privacy             | business  | transport |
| 43                 | VTT              |          | 72 %       | 23 %   | 7 %        | 9 %                    | 65 % | 12 %              | 7 %                 | 12 %      | 19 %      |
| 37                 | Aalto U.         |          | 73 %       | 38 %   | 3 %        | 3 %                    | 51 % | 5 %               | 3 %                 | 11 %      | 8 %       |
| 35                 | Aalborg U.       |          | 80 %       | 69 %   | 9 %        | 3 %                    | 17 % | 11 %              | 3 %                 | 9 %       | 11 %      |
| 30                 | TUT Tampere      |          | 83 %       | 23 %   | 0 %        | 17 %                   | 87 % | 10 %              | 3 %                 | 17 %      | 13 %      |
| 22                 | Chalmers U.      |          | 73 %       | 27 %   | 0 %        | 9 %                    | 36 % | 14 %              | 14 %                | 14 %      | 27 %      |
| 20                 | KTH, Stockholm   |          | 65 %       | 35 %   | 0 %        | 10 %                   | 50 % | 15 %              | 15 %                | 15 %      | 20 %      |
| 19                 | SINTEF           |          | 84 %       | 53 %   | 16 %       | 5 %                    | 32 % | 16 %              | 0 %                 | 11 %      | 16 %      |
| 18                 | NTNU Trondheim   |          | 67 %       | 44 %   | 17 %       | 6 %                    | 6 %  | 17 %              | 0 %                 | 0 %       | 11 %      |
| 14                 | Luleå U. of Tech |          | 57 %       | 21 %   | 0 %        | 7 %                    | 71 % | 0 %               | 7 %                 | 29 %      | 14 %      |
| 12                 | Lund U.          |          | 100 %      | 50 %   | 17 %       | 33 %                   | 8 %  | 0 %               | 0 %                 | 8 %       | 0 %       |
| 8                  | Aarhus U.        |          | 38 %       | 25 %   | 0 %        | 0 %                    | 38 % | 13 %              | 0 %                 | 25 %      | 13 %      |

# Actual research collaboration 2006-2014

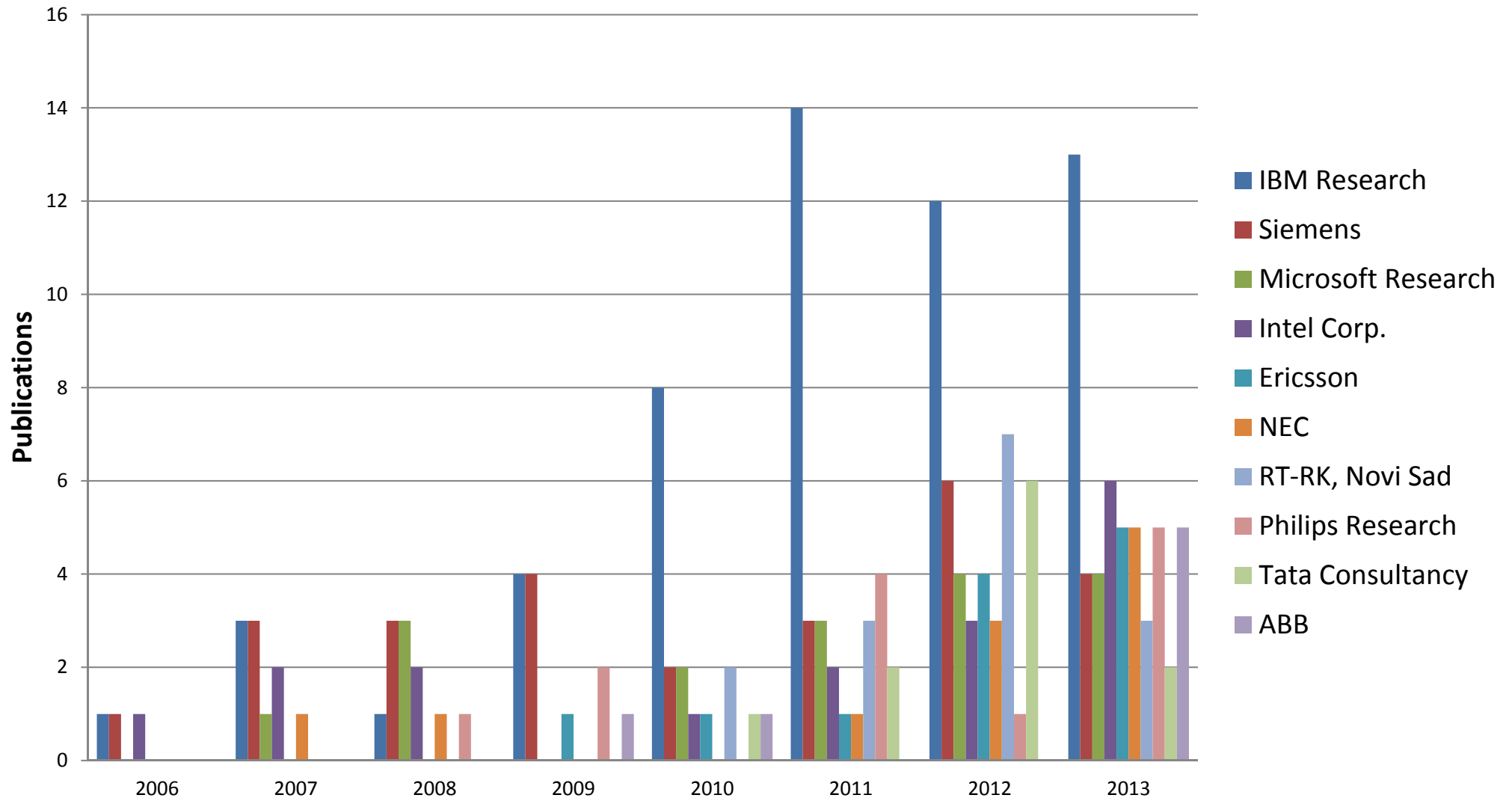
Note: closer the organisations are on the map, relatively stronger the collaboration link is. Also lines indicate strong relative collaboration between organisations.



Only the major research organisations (25) included

# Companies

# Changes in publication intensity of top companies 2006-2013



# Differences in company profiles, 2006-2014

## Percentages of publications on a driver theme

| Publications total | COMPANY                            | Buildings | ICT  | Energy | Traffic & transport | Infrastructure & built environment | Services, commerce, business | Security, safety, privacy | Health & health care | Governance & policies |
|--------------------|------------------------------------|-----------|------|--------|---------------------|------------------------------------|------------------------------|---------------------------|----------------------|-----------------------|
| 10                 | <b>ABB</b>                         | 60 %      | 50 % | 60 %   | 0 %                 | 10 %                               | 10 %                         | 10 %                      | 10 %                 | 0 %                   |
| 9                  | <b>Building Intelligence Group</b> | 89 %      | 22 % | 56 %   | 0 %                 | 0 %                                | 0 %                          | 0 %                       | 0 %                  | 0 %                   |
| 7                  | <b>Cisco</b>                       | 57 %      | 71 % | 14 %   | 29 %                | 29 %                               | 14 %                         | 14 %                      | 0 %                  | 14 %                  |
| 17                 | <b>Ericsson</b>                    | 41 %      | 94 % | 12 %   | 24 %                | 18 %                               | 59 %                         | 6 %                       | 0 %                  | 6 %                   |
| 8                  | <b>Fujitsu</b>                     | 13 %      | 63 % | 50 %   | 13 %                | 13 %                               | 75 %                         | 0 %                       | 25 %                 | 13 %                  |
| 65                 | <b>IBM Research</b>                | 38 %      | 74 % | 20 %   | 20 %                | 20 %                               | 29 %                         | 11 %                      | 6 %                  | 9 %                   |
| 18                 | <b>Intel Corp.</b>                 | 61 %      | 94 % | 28 %   | 17 %                | 28 %                               | 0 %                          | 22 %                      | 17 %                 | 6 %                   |
| 19                 | <b>Microsoft Research</b>          | 68 %      | 63 % | 11 %   | 11 %                | 0 %                                | 5 %                          | 16 %                      | 0 %                  | 5 %                   |
| 16                 | <b>NEC</b>                         | 50 %      | 75 % | 38 %   | 44 %                | 25 %                               | 13 %                         | 19 %                      | 0 %                  | 0 %                   |
| 14                 | <b>Philips Research</b>            | 71 %      | 57 % | 29 %   | 0 %                 | 7 %                                | 29 %                         | 0 %                       | 14 %                 | 0 %                   |
| 9                  | <b>Robert Bosch</b>                | 78 %      | 89 % | 44 %   | 22 %                | 11 %                               | 22 %                         | 33 %                      | 0 %                  | 0 %                   |
| 15                 | <b>RT-RK, Novi Sad</b>             | 87 %      | 80 % | 40 %   | 0 %                 | 13 %                               | 0 %                          | 13 %                      | 0 %                  | 0 %                   |
| 7                  | <b>SAP</b>                         | 86 %      | 57 % | 0 %    | 14 %                | 0 %                                | 71 %                         | 57 %                      | 57 %                 | 0 %                   |
| 8                  | <b>Schneider-Electric</b>          | 100 %     | 38 % | 88 %   | 0 %                 | 0 %                                | 25 %                         | 0 %                       | 0 %                  | 13 %                  |
| 28                 | <b>Siemens</b>                     | 64 %      | 71 % | 25 %   | 25 %                | 7 %                                | 32 %                         | 14 %                      | 4 %                  | 4 %                   |
| 11                 | <b>Tata Consultancy</b>            | 36 %      | 91 % | 27 %   | 27 %                | 9 %                                | 27 %                         | 18 %                      | 9 %                  | 0 %                   |
| 43                 | <b>VTT</b>                         | 72 %      | 65 % | 23 %   | 19 %                | 12 %                               | 12 %                         | 7 %                       | 9 %                  | 7 %                   |

\* Percentage of all company's publications

# Differences in Company profiles, 2006-2014

Percentages\* of publications on big technology / application themes

| COMPANY                  | Smart building | Smart Automation | Smart Home | Energy efficiency | Sensors | Sustainable development | Sensor networks | Internet | Intelligent Transportation Systems | Algorithm | Smart City |
|--------------------------|----------------|------------------|------------|-------------------|---------|-------------------------|-----------------|----------|------------------------------------|-----------|------------|
| ABB                      | 50 %           | 50 %             | 0 %        | 40 %              | 30 %    | 0 %                     | 10 %            | 0 %      | 0 %                                | 0 %       | 0 %        |
| Building Intellig. Group | 89 %           | 67 %             | 0 %        | 56 %              | 0 %     | 0 %                     | 0 %             | 11 %     | 0 %                                | 11 %      | 0 %        |
| Cisco                    | 57 %           | 43 %             | 0 %        | 0 %               | 0 %     | 0 %                     | 0 %             | 43 %     | 0 %                                | 14 %      | 0 %        |
| Ericsson                 | 41 %           | 35 %             | 18 %       | 6 %               | 6 %     | 6 %                     | 0 %             | 47 %     | 18 %                               | 0 %       | 29 %       |
| Fujitsu                  | 0 %            | 0 %              | 0 %        | 13 %              | 0 %     | 13 %                    | 0 %             | 13 %     | 0 %                                | 0 %       | 63 %       |
| IBM Research             | 28 %           | 12 %             | 11 %       | 9 %               | 17 %    | 2 %                     | 9 %             | 9 %      | 8 %                                | 11 %      | 23 %       |
| Intel Corp.              | 39 %           | 39 %             | 39 %       | 0 %               | 33 %    | 6 %                     | 28 %            | 11 %     | 6 %                                | 22 %      | 0 %        |
| Microsoft Research       | 37 %           | 37 %             | 47 %       | 5 %               | 11 %    | 5 %                     | 5 %             | 5 %      | 5 %                                | 5 %       | 0 %        |
| NEC                      | 50 %           | 25 %             | 19 %       | 38 %              | 31 %    | 13 %                    | 25 %            | 13 %     | 25 %                               | 25 %      | 19 %       |
| Philips Research         | 57 %           | 29 %             | 21 %       | 29 %              | 36 %    | 0 %                     | 7 %             | 0 %      | 0 %                                | 7 %       | 0 %        |
| Robert Bosch             | 67 %           | 56 %             | 22 %       | 33 %              | 56 %    | 0 %                     | 33 %            | 11 %     | 11 %                               | 22 %      | 0 %        |
| RT-RK, Novi Sad          | 67 %           | 67 %             | 67 %       | 7 %               | 60 %    | 0 %                     | 47 %            | 7 %      | 0 %                                | 7 %       | 0 %        |
| SAP                      | 29 %           | 14 %             | 57 %       | 0 %               | 14 %    | 0 %                     | 14 %            | 14 %     | 0 %                                | 0 %       | 0 %        |
| Schneider-Electric       | 63 %           | 50 %             | 0 %        | 63 %              | 0 %     | 0 %                     | 0 %             | 13 %     | 0 %                                | 13 %      | 0 %        |
| Siemens                  | 50 %           | 43 %             | 29 %       | 14 %              | 14 %    | 4 %                     | 11 %            | 18 %     | 4 %                                | 7 %       | 7 %        |
| Tata Consultancy         | 27 %           | 36 %             | 18 %       | 9 %               | 9 %     | 0 %                     | 18 %            | 18 %     | 18 %                               | 18 %      | 27 %       |
| VTT                      | 47 %           | 16 %             | 33 %       | 14 %              | 19 %    | 23 %                    | 12 %            | 9 %      | 12 %                               | 2 %       | 2 %        |

\* Percentage of all company's publications

# Similarities of research profiles

Companies cross-correlated\* with selected technology / application topics\*\*

| COMPANY                     | IBM Research | VTT  | Siemens | Microsoft Research | Intel Corp. | Ericsson | NEC  | RT-RK, Novi Sad, Serbia | Philips Research | Tata Consultancy | ABB  | Building Intelligence Group | Robert Bosch | Fujitsu | Schneider-Electric | Cisco | SAP  |
|-----------------------------|--------------|------|---------|--------------------|-------------|----------|------|-------------------------|------------------|------------------|------|-----------------------------|--------------|---------|--------------------|-------|------|
| ABB                         | 0,39         | 0,39 | 0,78    | 0,57               | 0,54        |          | 0,63 | 0,57                    | 0,74             | 0,33             |      | 0,91                        | 0,85         |         | 0,78               | 0,61  |      |
| Building Intelligence Group | 0,32         | 0,39 | 0,82    | 0,61               | 0,38        | 0,45     | 0,49 | 0,39                    | 0,64             |                  | 0,91 |                             | 0,66         |         | 0,83               | 0,76  |      |
| Cisco                       | 0,32         | 0,37 | 0,81    | 0,54               | 0,44        | 0,80     | 0,31 | 0,39                    | 0,44             | 0,41             | 0,61 | 0,76                        | 0,50         |         | 0,60               |       |      |
| Ericsson                    | 0,44         |      | 0,62    | 0,37               |             |          | 0,30 |                         |                  | 0,55             |      | 0,45                        |              |         | 0,40               | 0,80  |      |
| Fujitsu                     | 0,45         |      |         |                    |             |          |      |                         |                  |                  |      |                             |              |         |                    |       |      |
| IBM Research                |              | 0,56 | 0,50    | 0,36               | 0,55        | 0,44     | 0,69 | 0,59                    | 0,66             | 0,81             | 0,39 | 0,32                        | 0,59         | 0,45    | 0,45               | 0,32  | 0,35 |
| Intel Corp.                 | 0,55         | 0,69 | 0,76    | 0,77               | 1,00        |          | 0,57 | 0,97                    | 0,70             | 0,60             | 0,54 | 0,38                        | 0,80         |         | 0,34               | 0,44  | 0,61 |
| Microsoft Research          | 0,36         | 0,61 | 0,88    |                    | 0,77        | 0,37     | 0,32 | 0,75                    | 0,65             | 0,45             | 0,57 | 0,61                        | 0,61         |         | 0,40               | 0,54  | 0,70 |
| NEC                         | 0,69         | 0,66 | 0,51    | 0,32               | 0,57        | 0,30     |      | 0,59                    | 0,64             | 0,50             | 0,63 | 0,49                        | 0,74         |         | 0,66               | 0,31  |      |
| Philips Research            | 0,66         | 0,72 | 0,73    | 0,65               | 0,70        |          | 0,64 | 0,76                    |                  | 0,57             | 0,74 | 0,64                        | 0,84         |         | 0,70               | 0,44  | 0,55 |
| Robert Bosch                | 0,59         | 0,59 | 0,76    | 0,61               | 0,80        |          | 0,74 | 0,85                    | 0,84             | 0,57             | 0,85 | 0,66                        |              |         | 0,65               | 0,50  | 0,31 |
| RT-RK, Novi Sad, Serbia     | 0,59         | 0,70 | 0,75    | 0,75               | 0,97        |          | 0,59 |                         | 0,76             | 0,61             | 0,57 | 0,39                        | 0,85         |         | 0,41               | 0,39  | 0,57 |
| SAP                         | 0,35         | 0,47 | 0,49    | 0,70               | 0,61        |          |      | 0,57                    | 0,55             | 0,48             |      |                             | 0,31         |         |                    |       |      |
| Schneider-Electric          | 0,45         | 0,50 | 0,66    | 0,40               | 0,34        | 0,40     | 0,66 | 0,41                    | 0,70             | 0,41             | 0,78 | 0,83                        | 0,65         |         |                    | 0,60  |      |
| Siemens                     | 0,50         | 0,60 |         | 0,88               | 0,76        | 0,62     | 0,51 | 0,75                    | 0,73             | 0,57             | 0,78 | 0,82                        | 0,76         |         | 0,66               | 0,81  | 0,49 |
| Tata Consultancy            | 0,81         | 0,41 | 0,57    | 0,45               | 0,60        | 0,55     | 0,50 | 0,61                    | 0,57             |                  | 0,33 |                             | 0,57         |         | 0,41               | 0,41  | 0,48 |
| VTT                         | 0,56         |      | 0,60    | 0,61               | 0,69        |          | 0,66 | 0,70                    | 0,72             | 0,41             | 0,39 | 0,39                        | 0,59         |         | 0,50               | 0,37  | 0,47 |

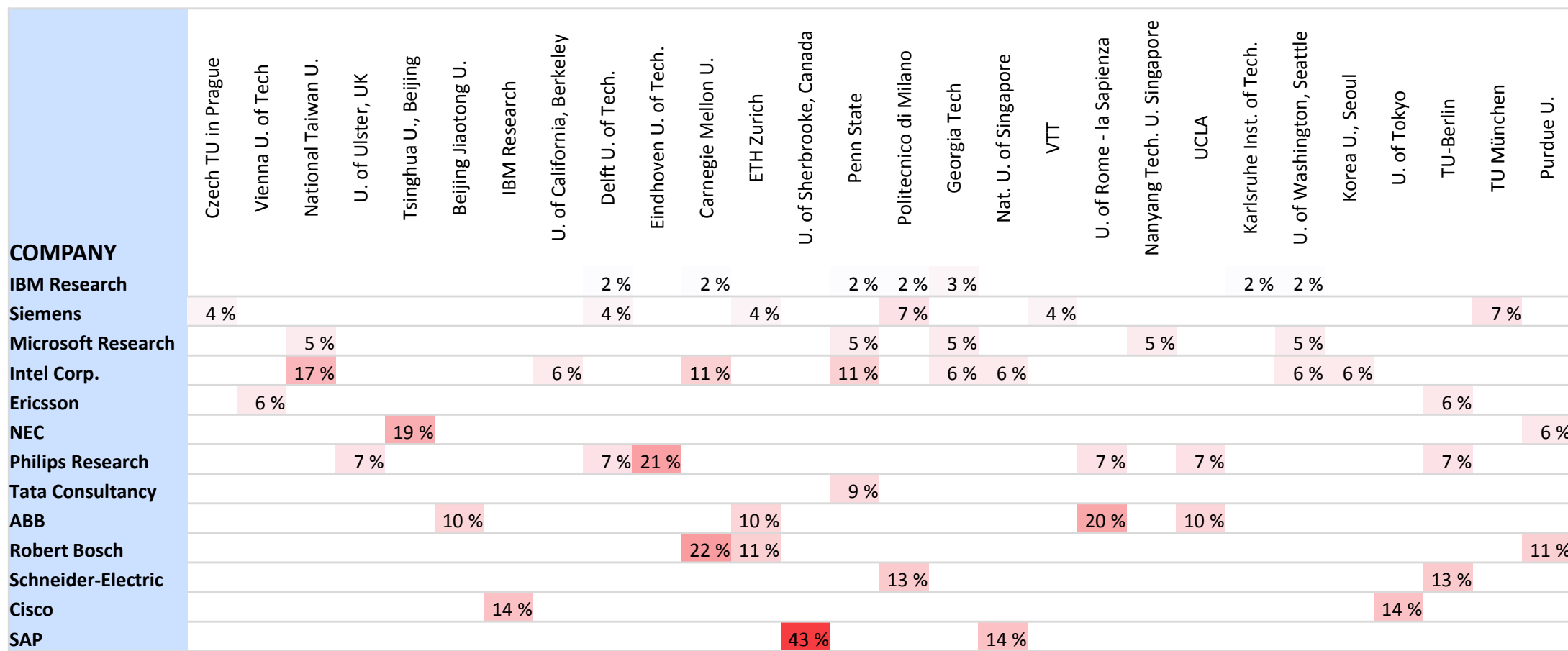
\* Based on cross-correlation with keywords in publications, max corr. 1, correlation level indicated by colour, min. correlation included: 0,2

\*\* TOPICS used in correlation analysis: Intelligent buildings; Automation; Smart Home; Sensors; Energy efficiency; Sustainable development; Sensor networks; WSN; Internet; Intelligent Transportation Systems; Ubiquitous computing; Building automation; Smart City; Intelligent Vehicle Highway System; IoT; Indoor air pollution; Air quality; Indoor air quality



# Collaboration between companies and RTOs / universities

## Percentage\* of existing common publications



\* Percentage of all company's publications

Only the most active organisations and companies included

# Appendix

# The 10 most cited publications 2011-2012

| Document Title   | Authors  | Year | Journal Title   | Cites |
|--|--|------|---|-------|
| <a href="#">Zero Energy Building - A review of definitions and calculation methodologies</a>   | Marszal A.J., Heiselberg P., Bourrelle J.S., Musall E., Voss K., Sartori I., Napolitano A. | 2011 | Energy and Buildings                                    | 128   |
| <a href="#">Discovering activities to recognize and track in a smart environment</a>   | Rashidi P., Cook D.J., Holder L.B., Schmitter-Edgecombe M.                                 | 2011 | IEEE Transactions on Knowledge and Data Engineering     | 97    |
| <a href="#">Data-driven intelligent transportation systems: A survey</a>   | Zhang J., Wang F.-Y., Wang K., Lin W.-H., Xu X., Chen C.                                   | 2011 | IEEE Transactions on Intelligent Transportation Systems | 64    |
| <a href="#">A systematic review of built environment factors related to physical activity and obesity risk: Implications for smart growth urban planning</a> | Durand C.P., Andalib M., Dunton G.F., Wolch J., Pentz M.A.                                 | 2011 | Obesity Reviews   | 59    |
| <a href="#">GRS: The green, reliability, and security of emerging machine to machine communications</a>  | Lu R., Li X., Liang X., Shen X., Lin X.  | 2011 | IEEE Communications Magazine                            | 59    |
| <a href="#">Net zero energy buildings: A consistent definition framework</a>   | Sartori I., Napolitano A., Voss K.   | 2012 | Energy and Buildings                                    | 55    |
| <a href="#">A knowledge-driven approach to activity recognition in smart homes</a>   | Chen L., Nugent C.D., Wang H.  | 2012 | IEEE Transactions on Knowledge and Data Engineering     | 47    |
| <a href="#">A review of wearable sensors and systems with application in rehabilitation</a>  | Patel S., Park H., Bonato P., Chan L., Rodgers M.  | 2012 | Journal of NeuroEngineering and Rehabilitation          | 47    |
| <a href="#">Machine-to-machine communications: Architectures, standards and applications</a>   | Chen M., Wan J., Li F.   | 2012 | KSII Transactions on Internet and Information Systems   | 43    |
| <a href="#">Data fusion in intelligent transportation systems: Progress and challenges - A survey</a>  | Faouzi N.-E.E., Leung H., Kurian A.  | 2011 | Information Fusion                                      | 42    |

# Scopus search

## Elsevier Scopus search formulation

- TITLE ( smart W/2 ( city OR cities OR urban OR town\* OR road OR roads OR street\* OR parking OR mobility OR transport\* OR traffic OR transit OR "public safety" OR "waste\*water" OR "water supply" OR "water distribution system\*" OR "town planning" OR living OR commuting OR housing OR pedestrian ) OR "smart building\*" OR "smart home\*" OR "smart house\*" OR "sustainable building\*" OR "future city" ) OR TITLE ( intelligent W/2 ( city OR cities OR urban OR road OR roads OR street\* OR parking OR mobility OR transport\* OR traffic OR transit OR "public safety" OR "waste\*water" OR "water supply" OR "water distribution system\*" OR "town planning" OR living OR commuting OR housing OR pedestrian ) OR "intelligent building\*" OR "intelligent home" OR "intelligent house\*" OR nzeb OR zeb ) OR KEY ( "smart city" OR "smart cities" OR "future city" OR "intelligent city" OR "smart building\*" OR "intelligent building" OR "smart home\*" OR "intelligent home" OR "smart living" OR "smart commuting" OR "smart housing" ) OR TITLE ( ( city OR cities OR town\* OR urban OR home\* OR house\* ) AND ( sensor\* OR wsn OR "public safety" OR "energy conservation" OR "zero energy" OR "net\*zero" OR "energy\*saving" OR ( smart AND spaces ) OR ( smart AND waste\* ) OR ( smart AND infrastructure\* ) OR ( smart AND networking ) OR ( smart AND pipeline ) OR ( smart AND "energy network" ) OR ( smart AND "energy consumption" ) OR ( smart AND "energy saving" ) OR ( smart AND "energy conservation" ) OR ( smart AND heating ) ) ) OR TITLE ( building\* AND ( "energy conservation" OR "zero energy" OR "net\*zero" OR "energy\*saving" OR ( smart AND "energy network" OR "energy consumption" OR "energy saving" OR "energy conservation" ) OR ( smart AND heating ) ) ) AND NOT TITLE ( "street smart\*" OR maritime OR "air traffic" OR "flight traffic" OR "smart grid\*" ) AND NOT KEY ( maritime OR "air traffic" OR "flight traffic" OR "smart grid\*" )

Date of search: 8.10.2014

### “Smart grid” excluded:

- “Smart grid” was excluded from the search due to massive volume of publications involved, e.g. there have been in 2013-2014 ca. 13% more smart grid related publications than publications on all the other above mentioned smart city topics together. Including “smart grid” would have meant that level of resolution on other topics would have been much too low and therefore the analysis distorted



# TECHNOLOGY FOR BUSINESS

