PAAMS'13

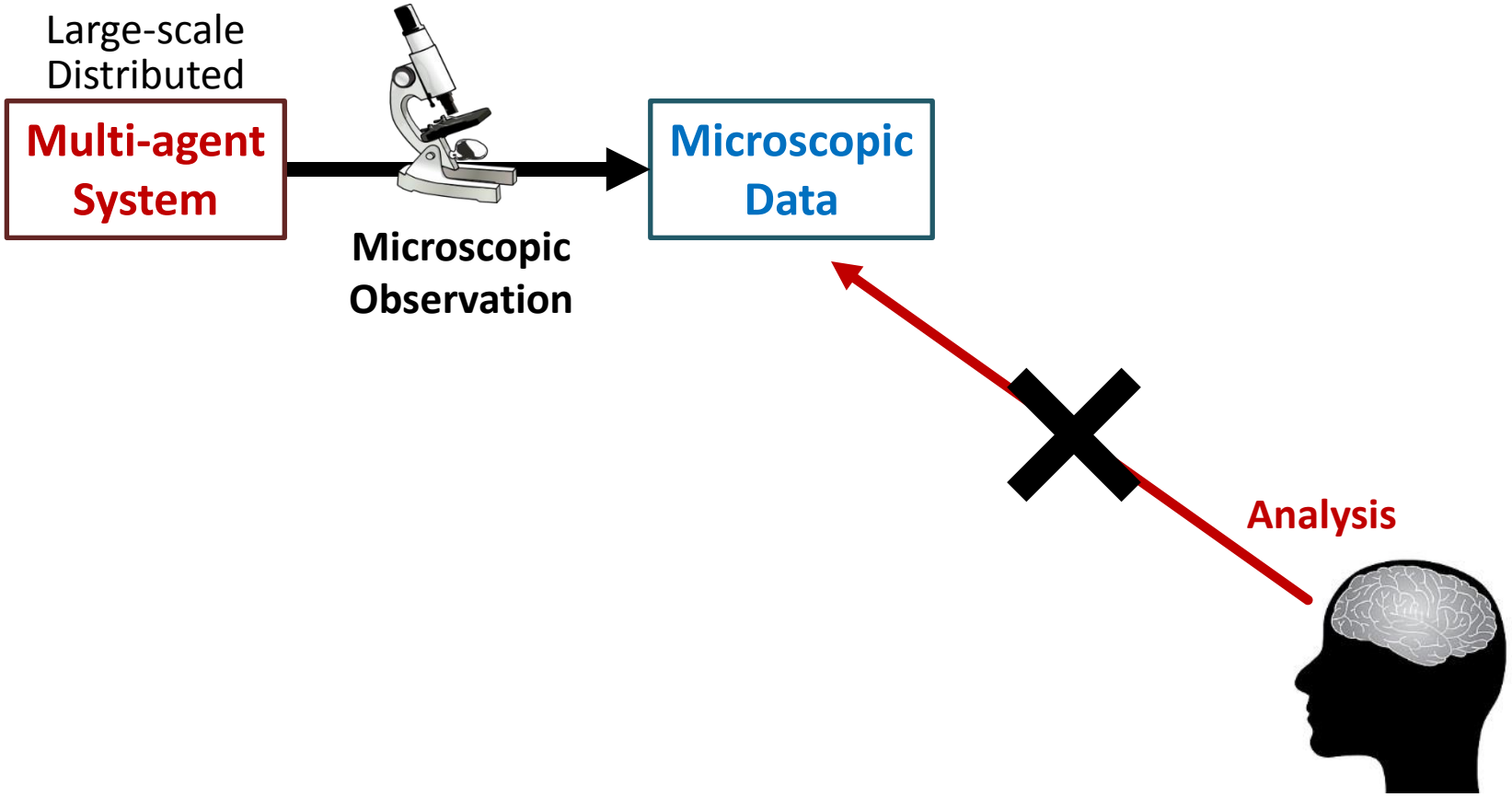
Salamanca, 22th May 2013

How to Build the **Best Macroscopic Description** of your Multi-agent System?

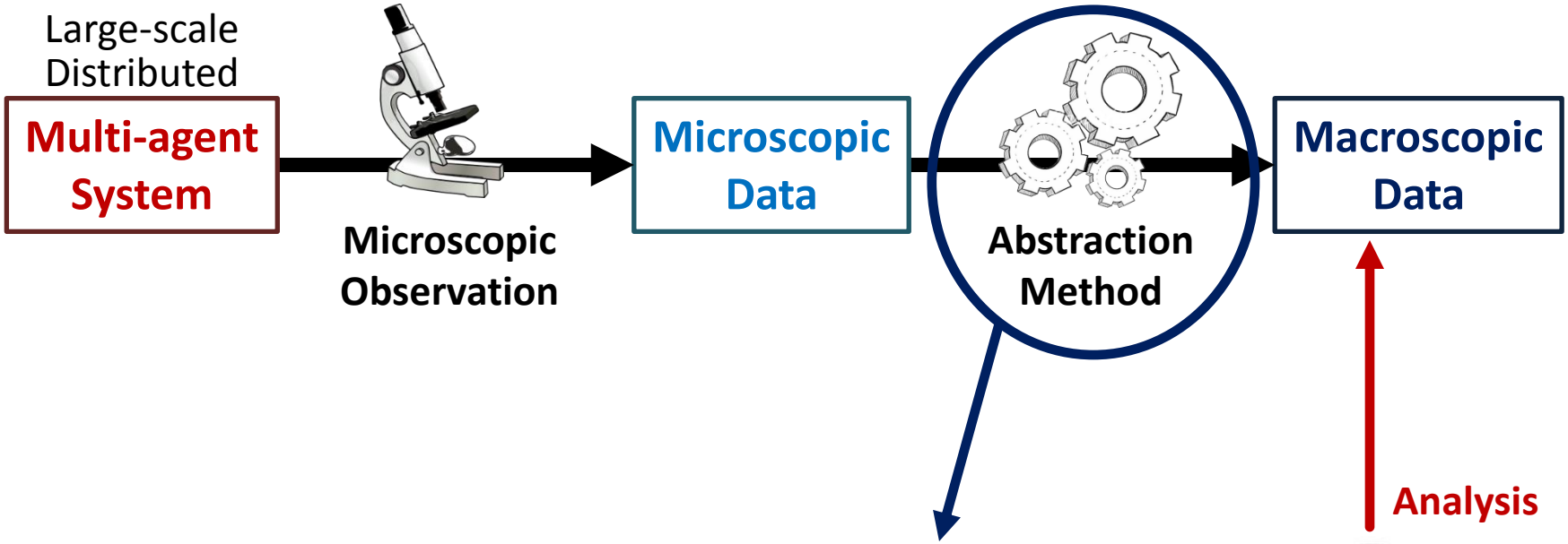
Laboratoire d'Informatique de Grenoble

Robin Lamarche-Perrin
Yves Demazeau
Jean-Marc Vincent

Problem: Analysis of Large-scale MAS



Problem: Analysis of Large-scale MAS



How to build meaningful abstractions out of microscopic data?

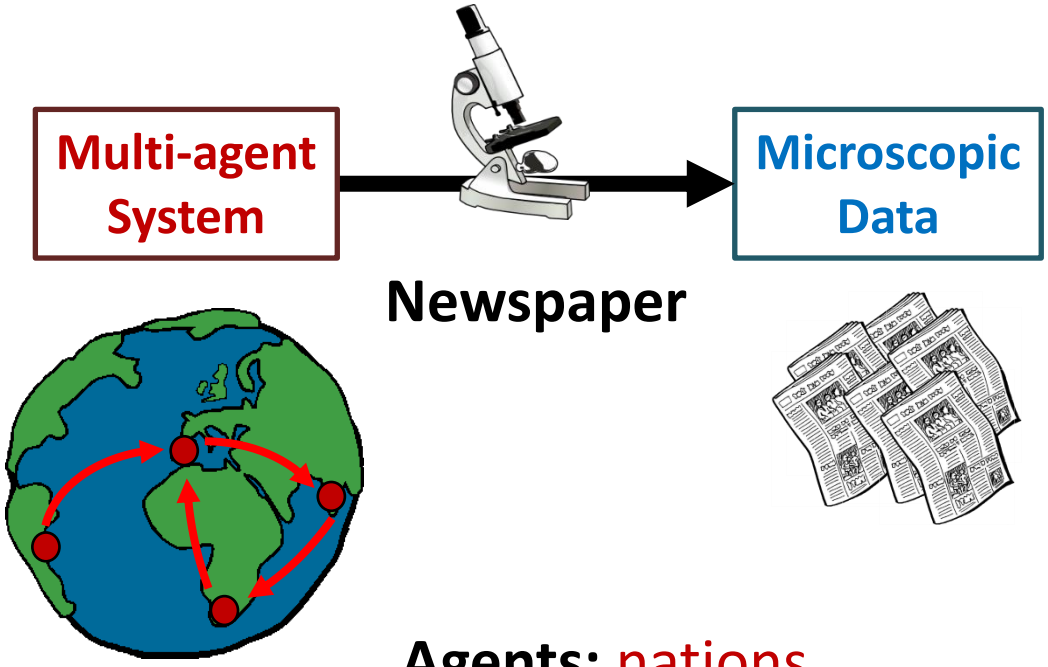
Properly interpreted

Useful for the observer

The GEOMEDIA Project

Analysis of **international relations**

through **print media** observation

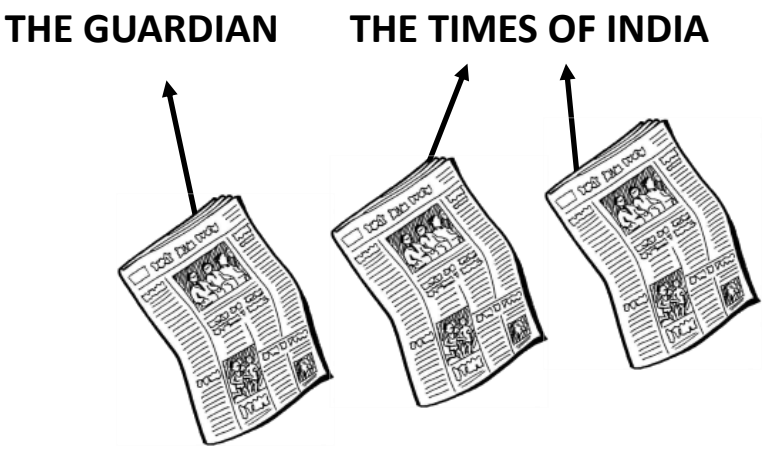


Agents: nations

Interactions: international relations

Organisation: geopolitical context

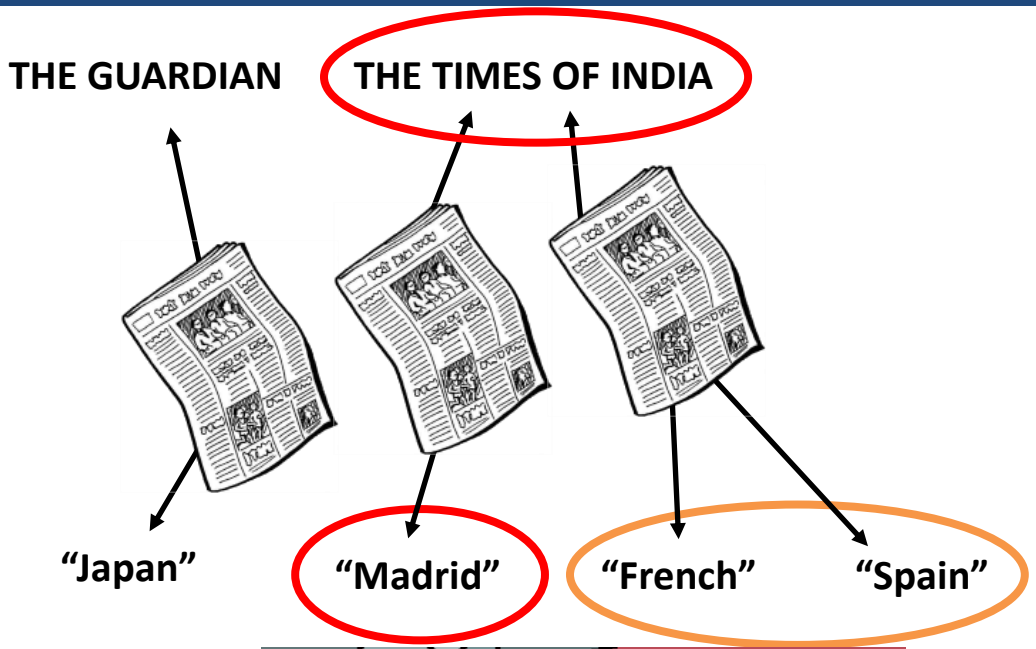
Counting Citations



150 Newspapers

1,530,000 Articles

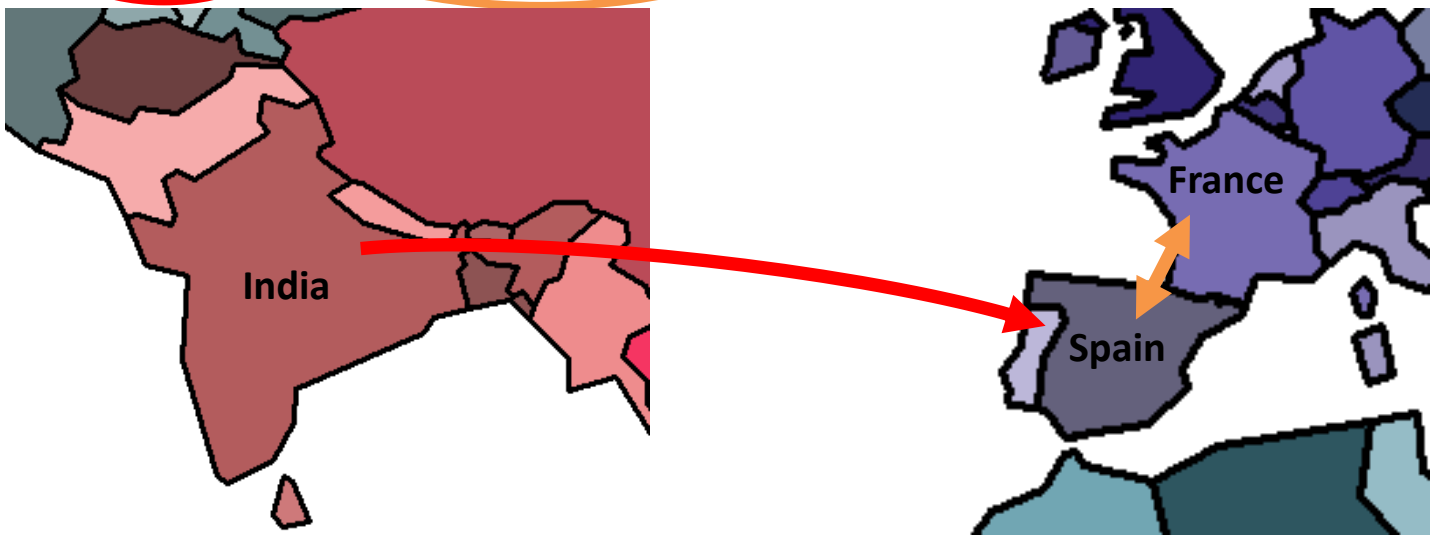
Counting Citations



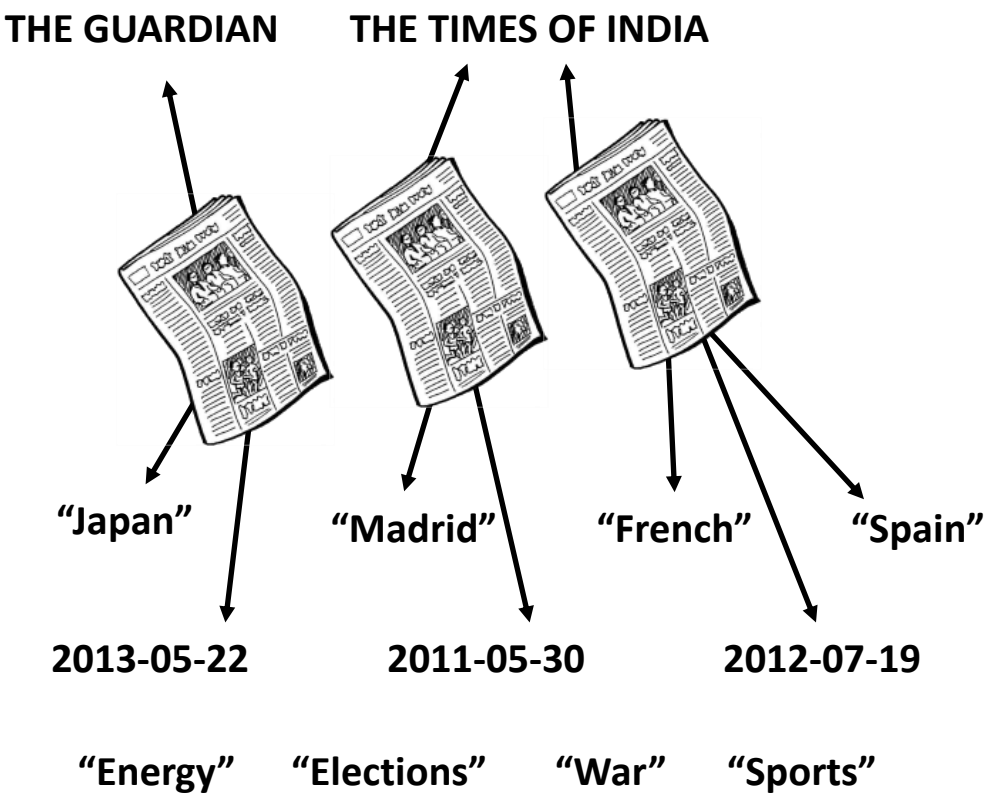
150 Newspapers
1,530,000 Articles

193 Countries

Spatial Information



Counting Citations



150 Newspapers
1,530,000 Articles

193 Countries
720 Days
→ 20,844,000 cells

Spatial Information

Temporal Information

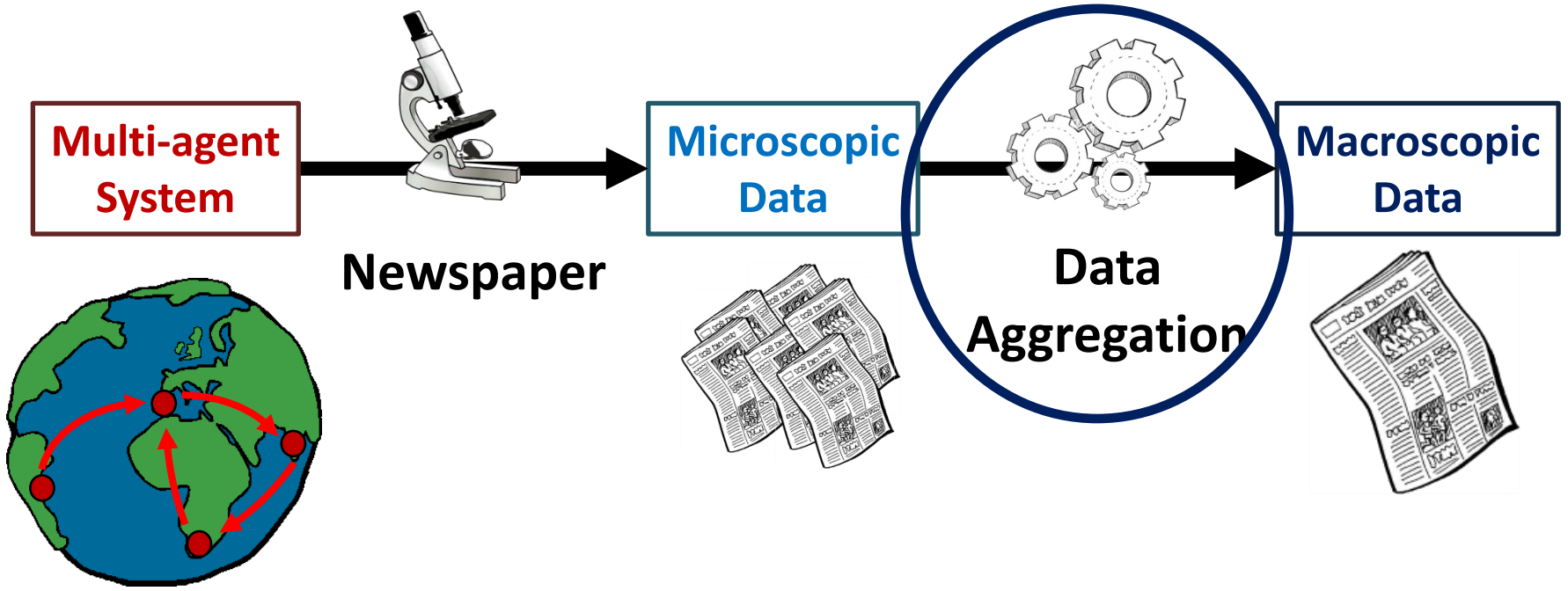
Thematic Information

And so on…

The GEOMEDIA Project

Analysis of **international relations**

through **print media** observation

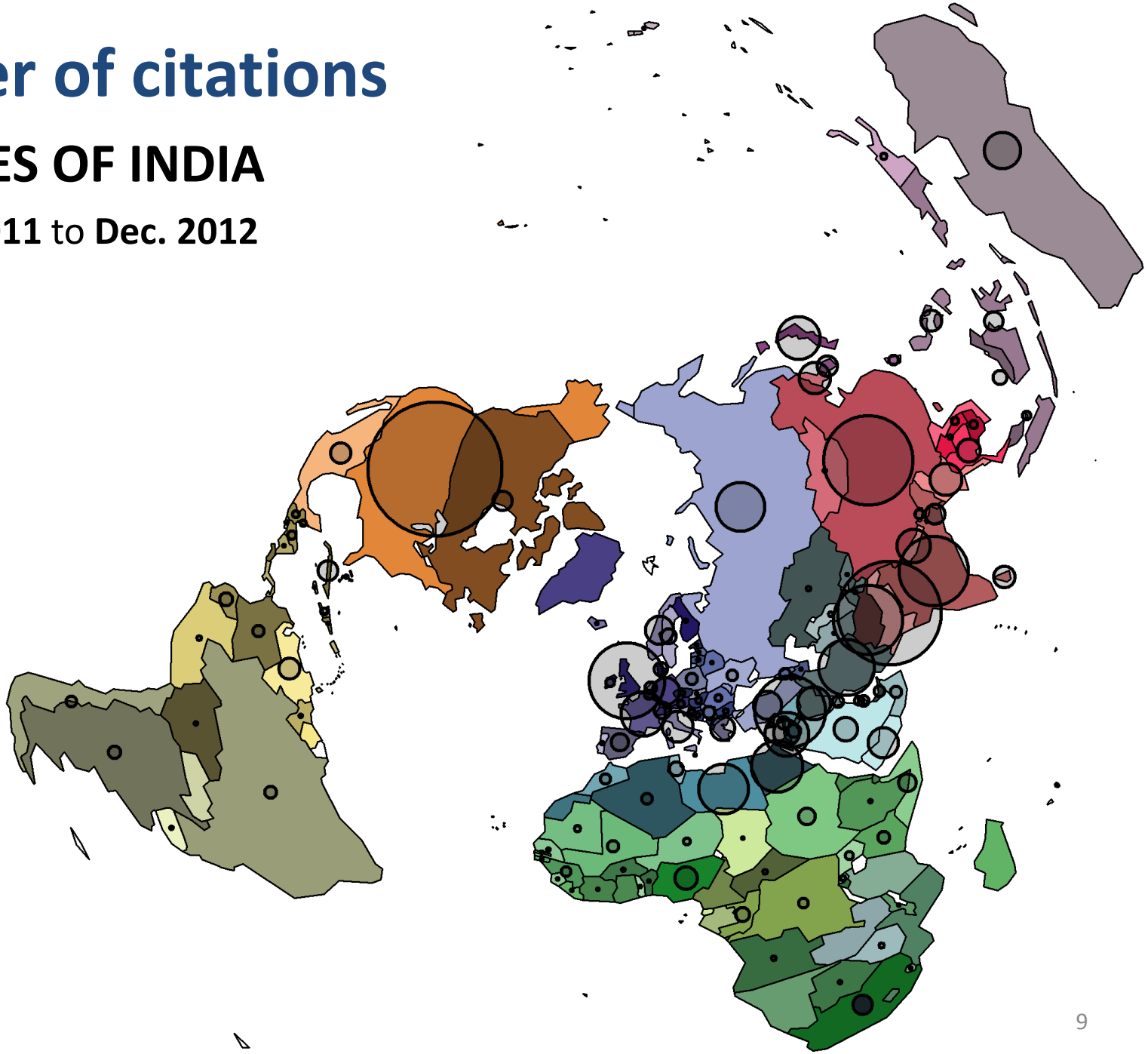


Number of citations

THE TIMES OF INDIA

from **May 2011** to **Dec. 2012**

8710 articles



Number of citations

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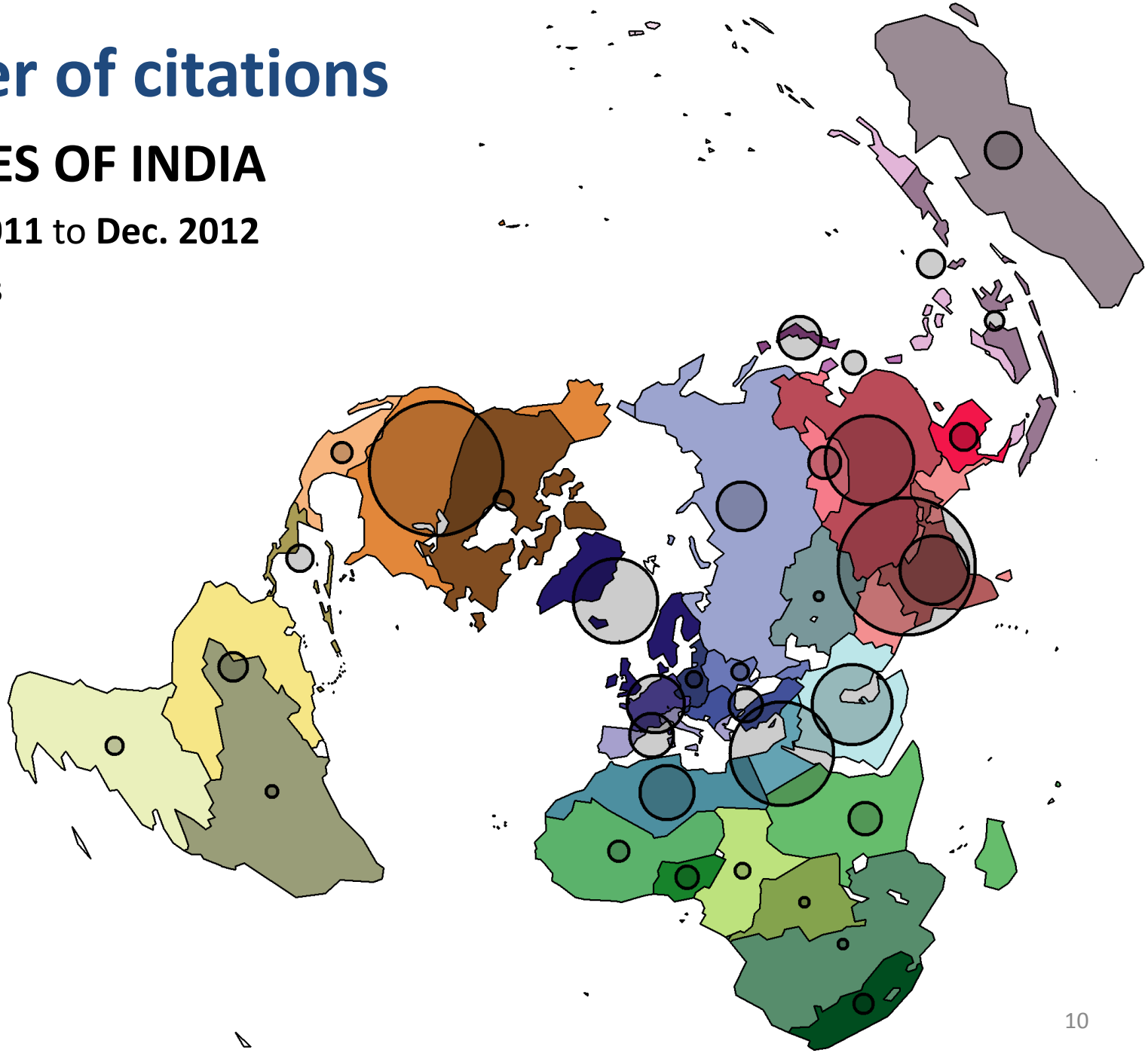

Number of citations

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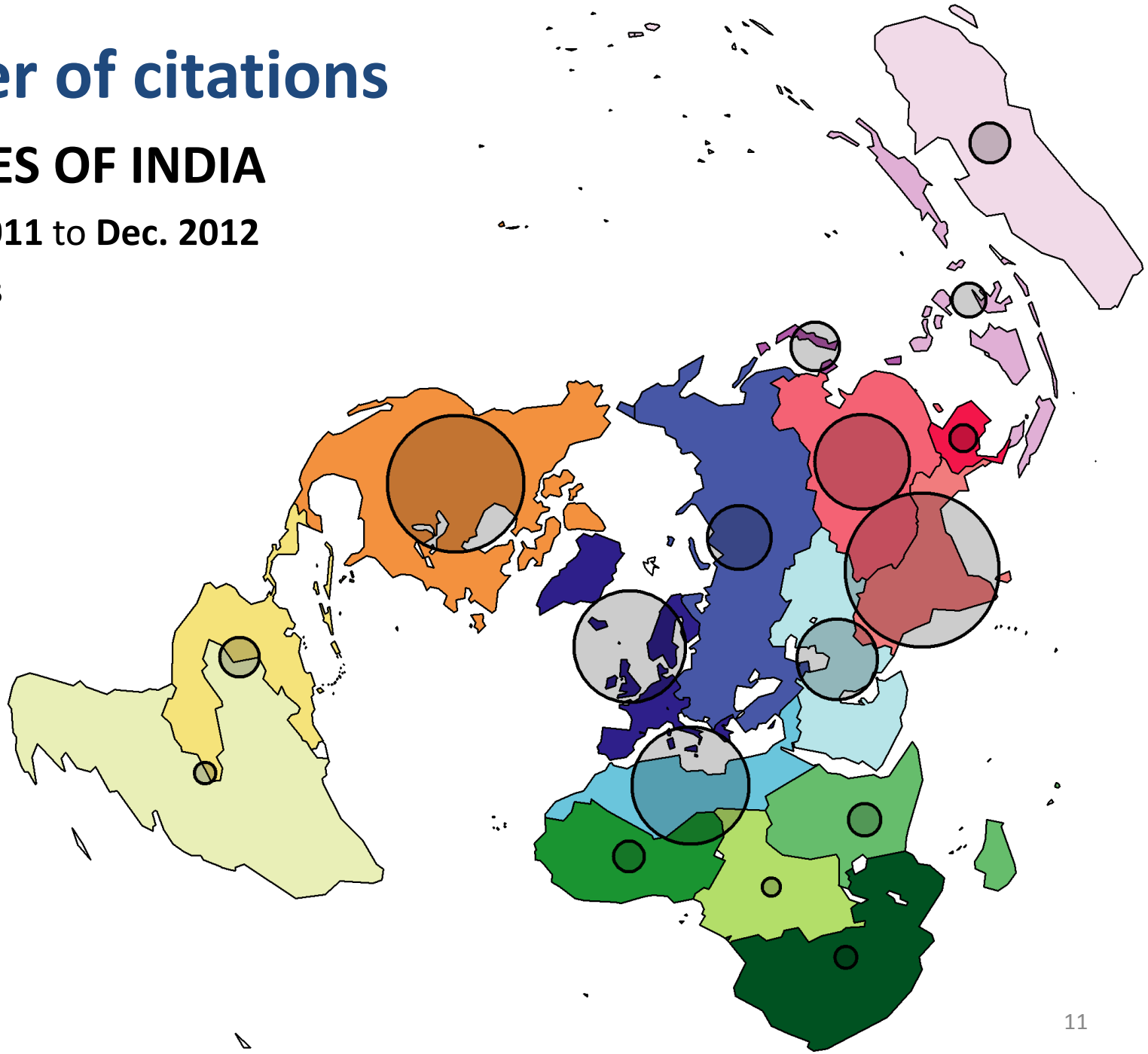

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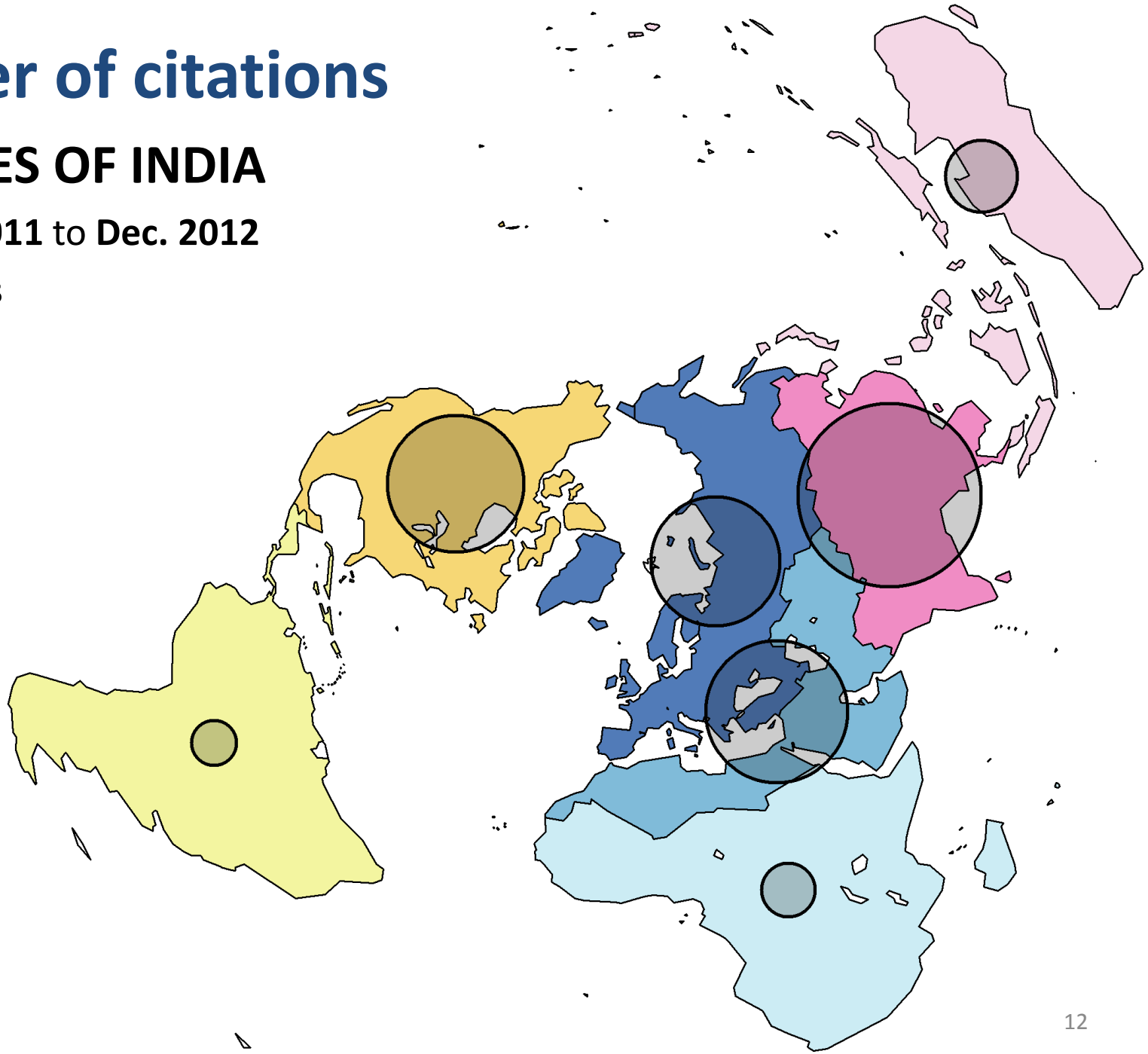


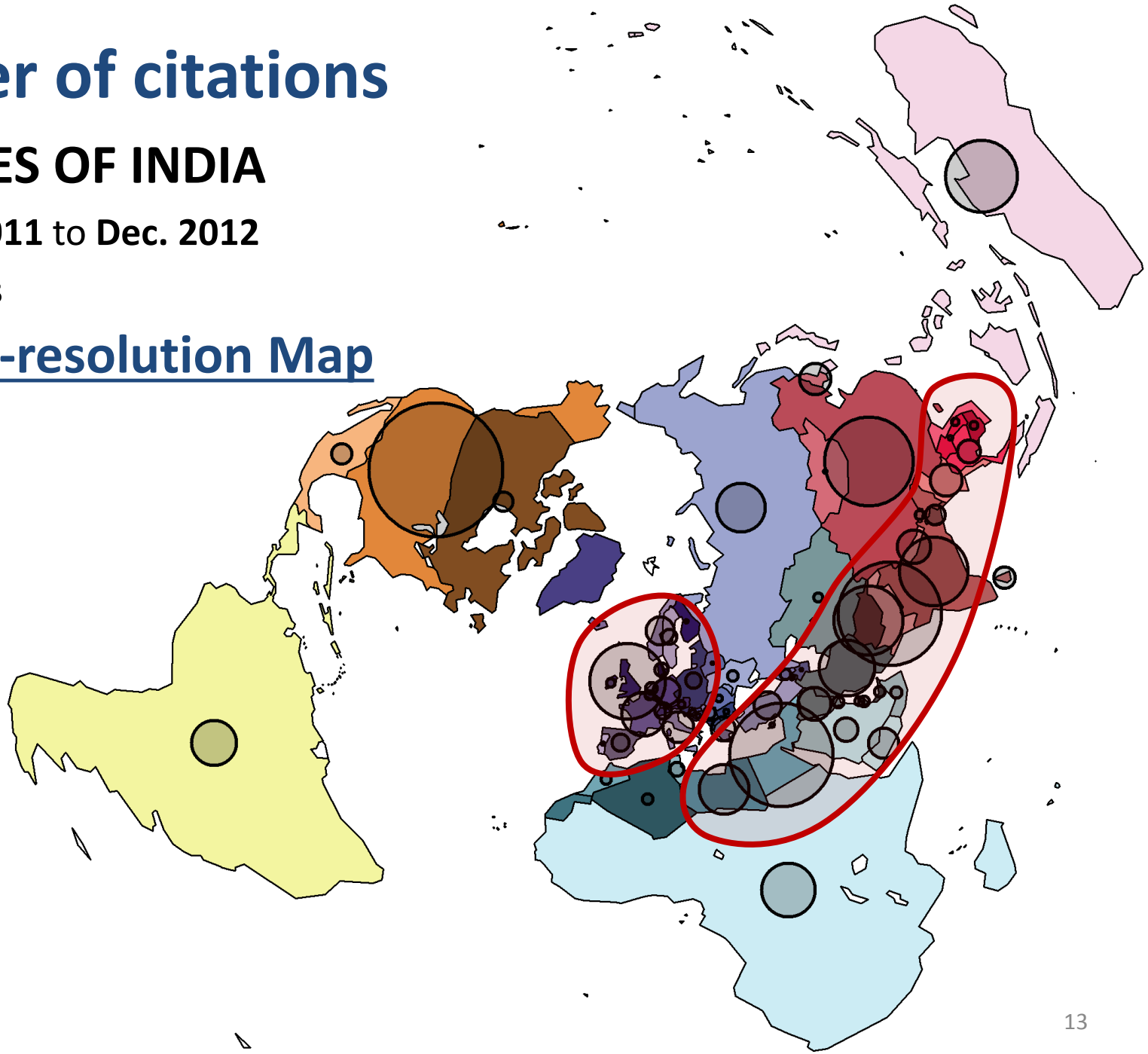
Number of citations

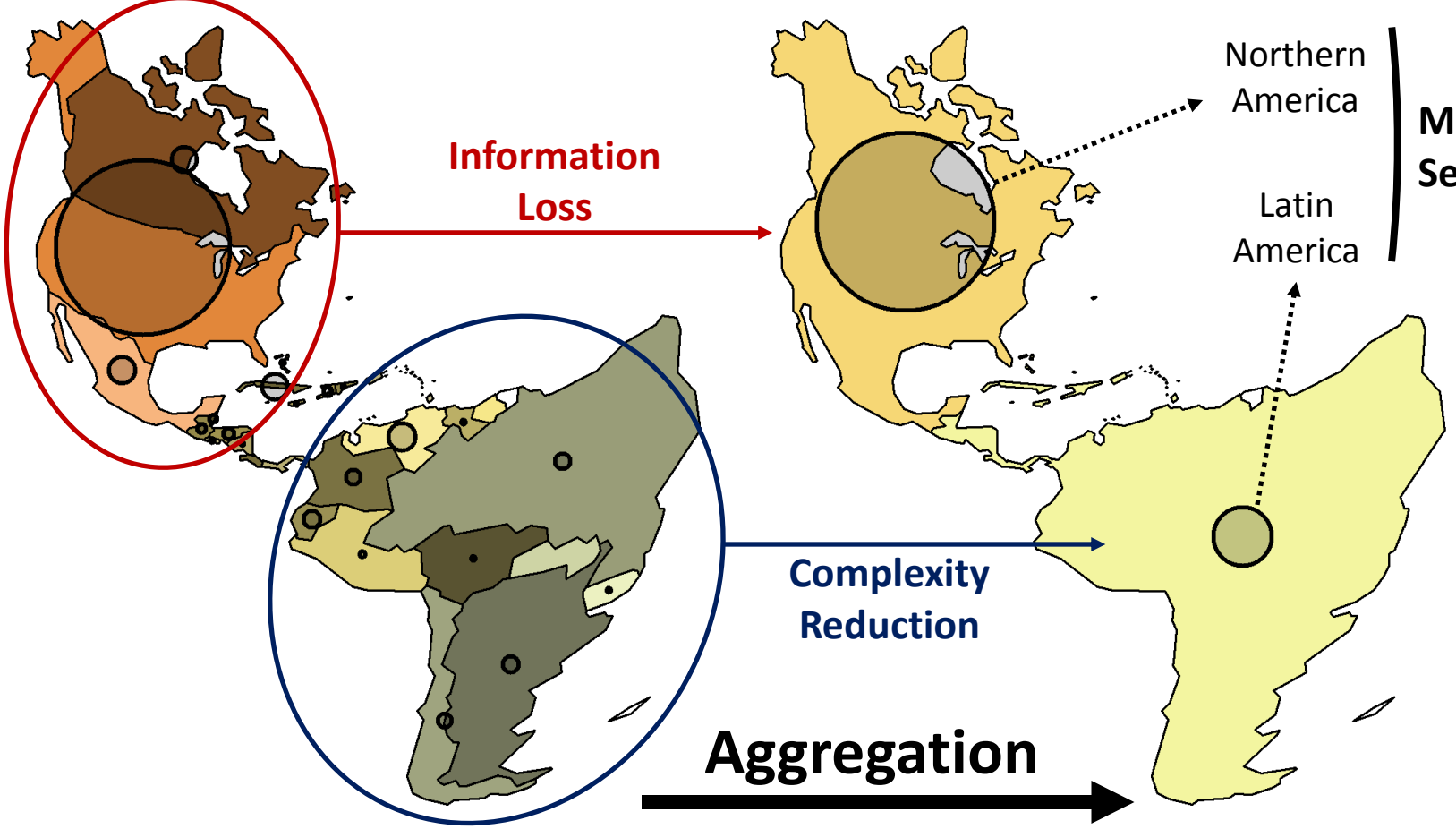
THE TIMES OF INDIA

from **May 2011** to **Dec. 2012**

8710 articles

→ **Multi-resolution Map**





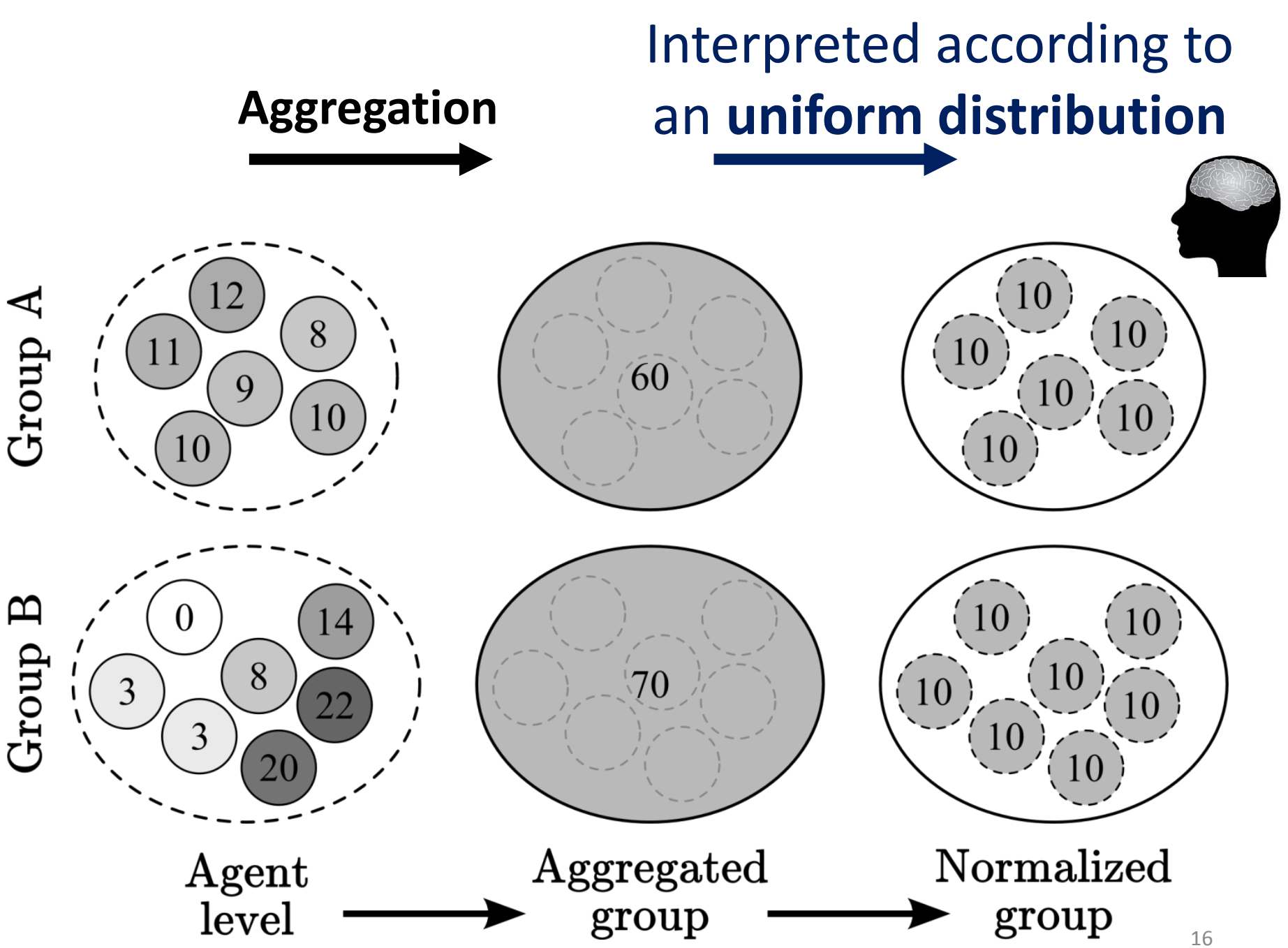
Outline:

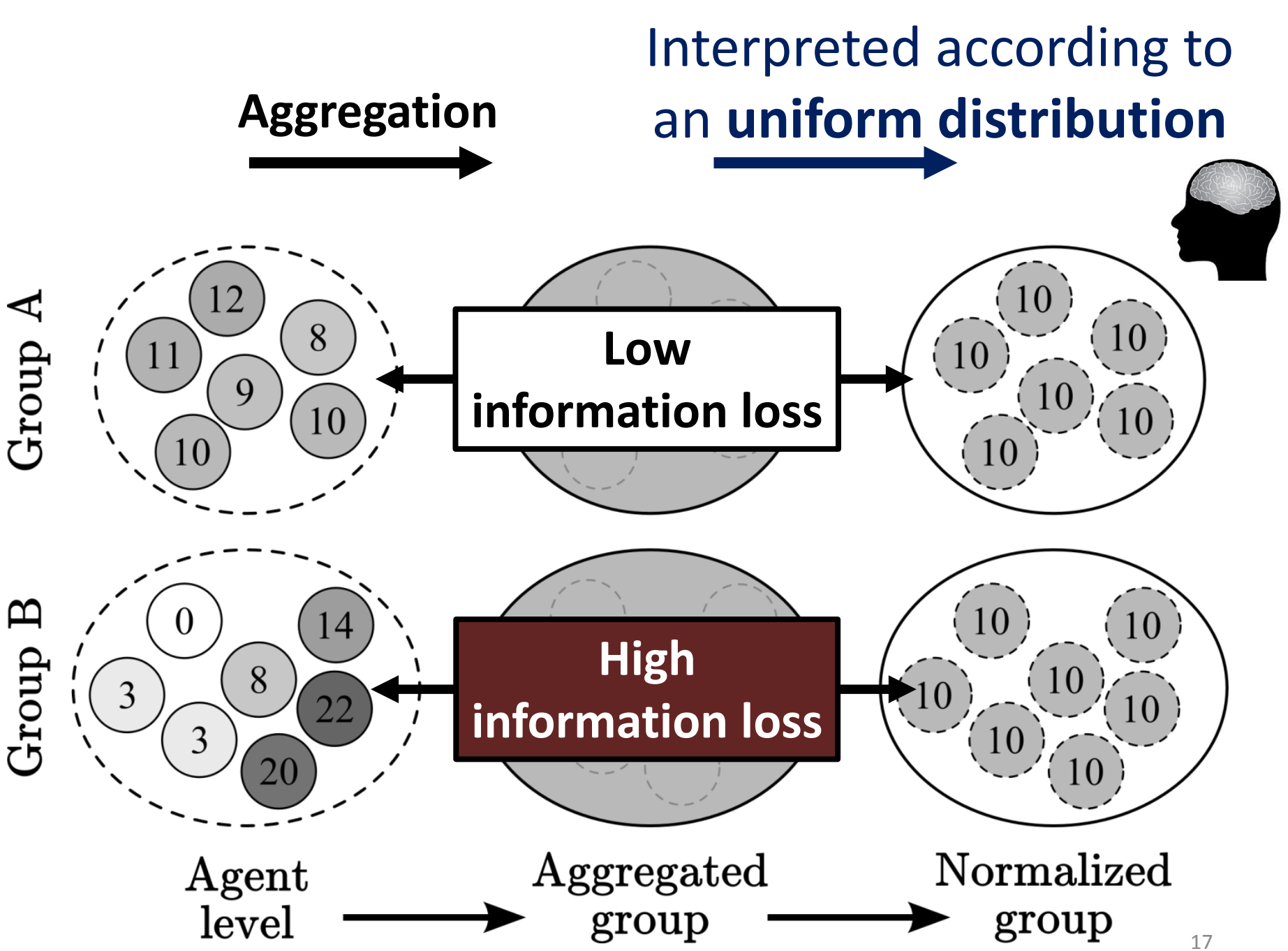
1. **Information Loss**
2. **Complexity Reduction**

Information Theory

3. **Macroscopic Semantics**

MEASURING THE INFORMATION LOSS


Aggregation
Interpreted according to an uniform distribution
Group A
Group B
12
11
8
9
10
10
0
14
3
8
22
3
20
60
70
10
10
10
10
10
10
10
10
10
10
10
10
10
Agent level
Aggregated group
Normalized group


Aggregation
Interpreted according to an uniform distribution
Group A
Group B
12
11
8
9
10
10
Low information loss
10
10
10
10
10
10
0
14
3
8
22
3
20
High information loss
10
10
10
10
10
10
10
Agent level
Aggregated group
Normalized group

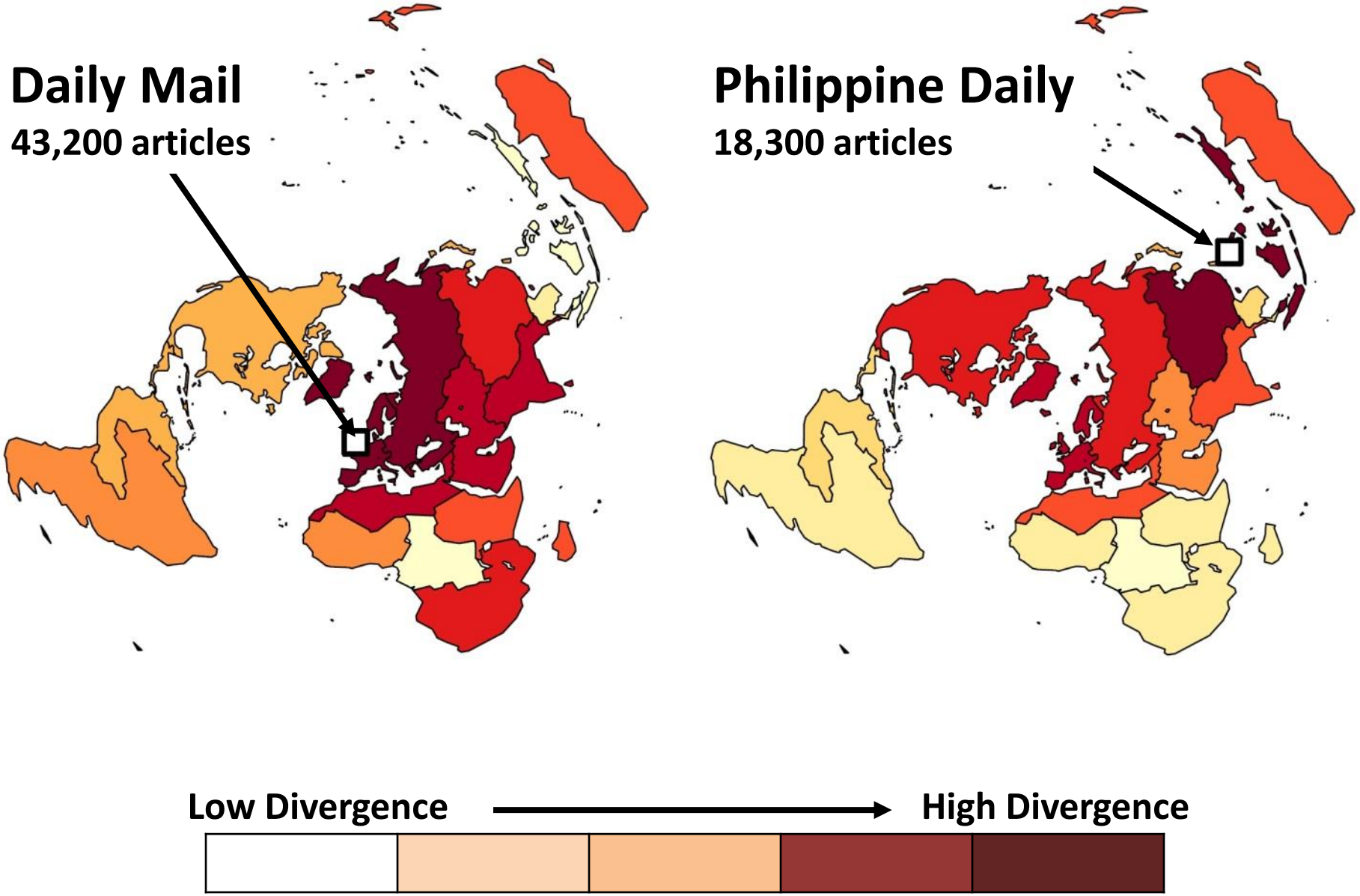
Kullback-Leibler Divergence

$$loss(p \parallel q) = \sum p(x) \times \log_2 \left(\frac{p(x)}{q(x)} \right)$$ **in bits/citation**

Microscopic distribution

Aggregated distribution

Quantity of information that one loses by using an **aggregated description** instead of the **microscopic description**


Daily Mail
43,200 articles
Philippine Daily
18,300 articles
Low Divergence
High Divergence

MEASURING
THE COMPLEXITY REDUCTION

Shannon Entropy

$$H(p) = \sum p(x) \times \log_2 p(x)$$ **in bits/citation**

Entropy Reduction: $$gain(p \parallel q) = H(p) - H(q)$$

Microscopic distribution

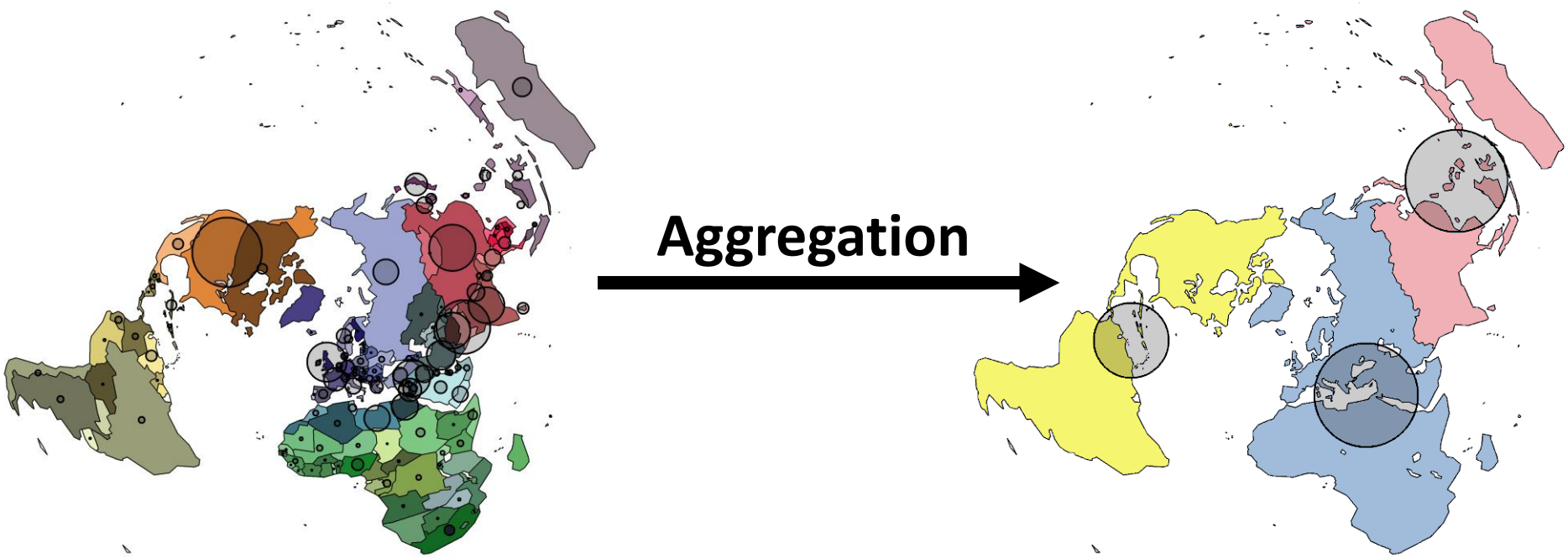
Aggregated distribution

Quantity of information that one saves by encoding the **aggregated description** instead of the **microscopic description**

High Complexity

Shannon Entropy

Low Complexity



Low Information Loss

Kullback-Leiber Divergence

High Information Loss

Parameterized Information Criterion

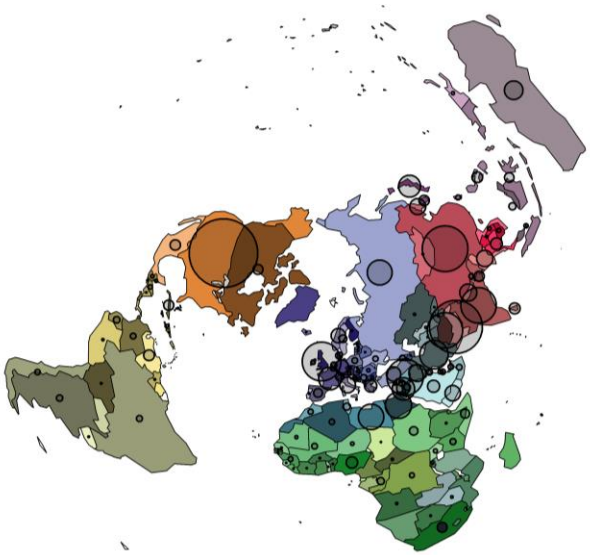
Complexity Reduction

Information Loss

Maximize $IC_p = p.gain - (1-p).loss$

$IC_0 = -loss$ $\longrightarrow$ $IC_1 = gain$

$p \in]0,1[$

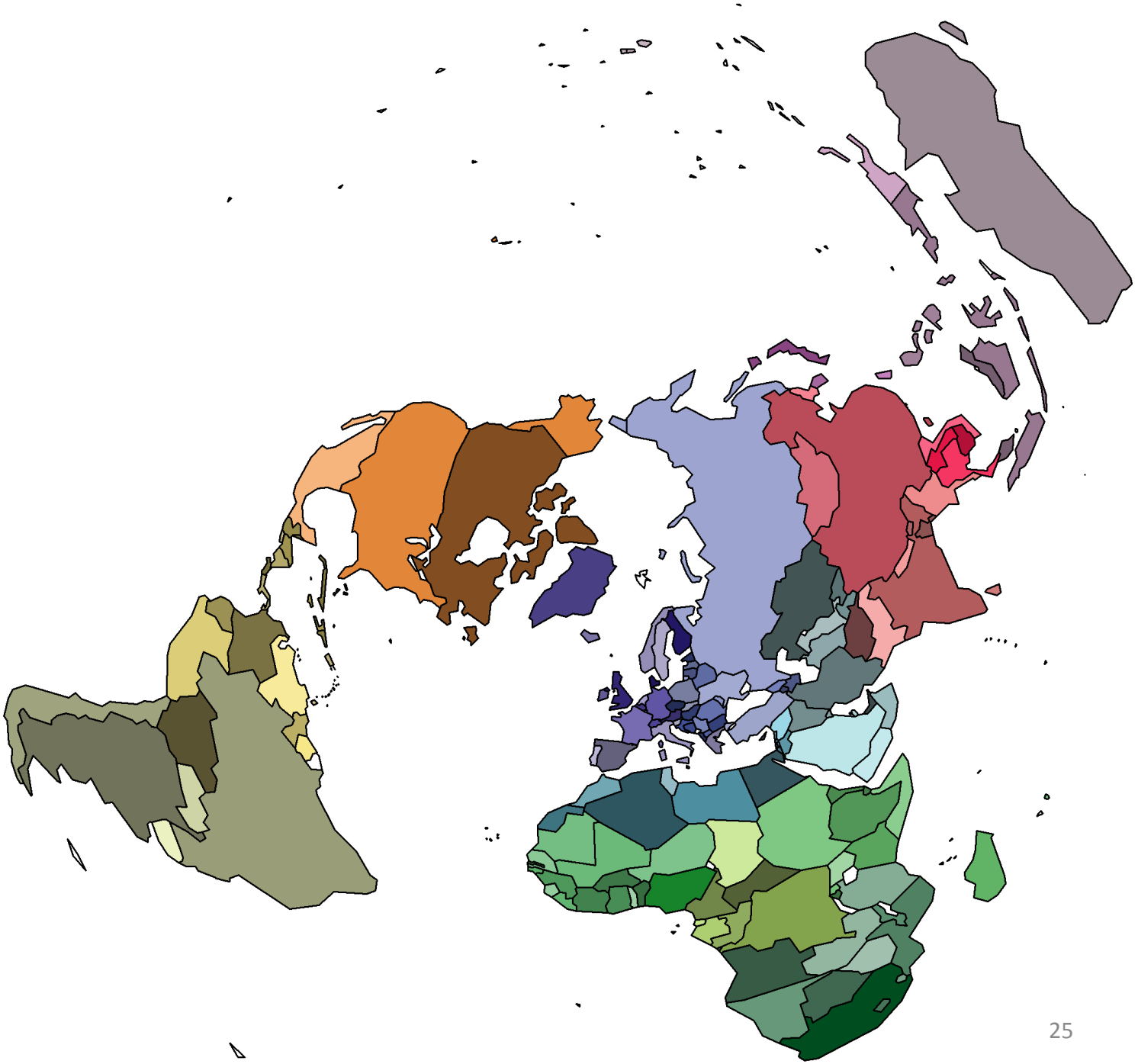


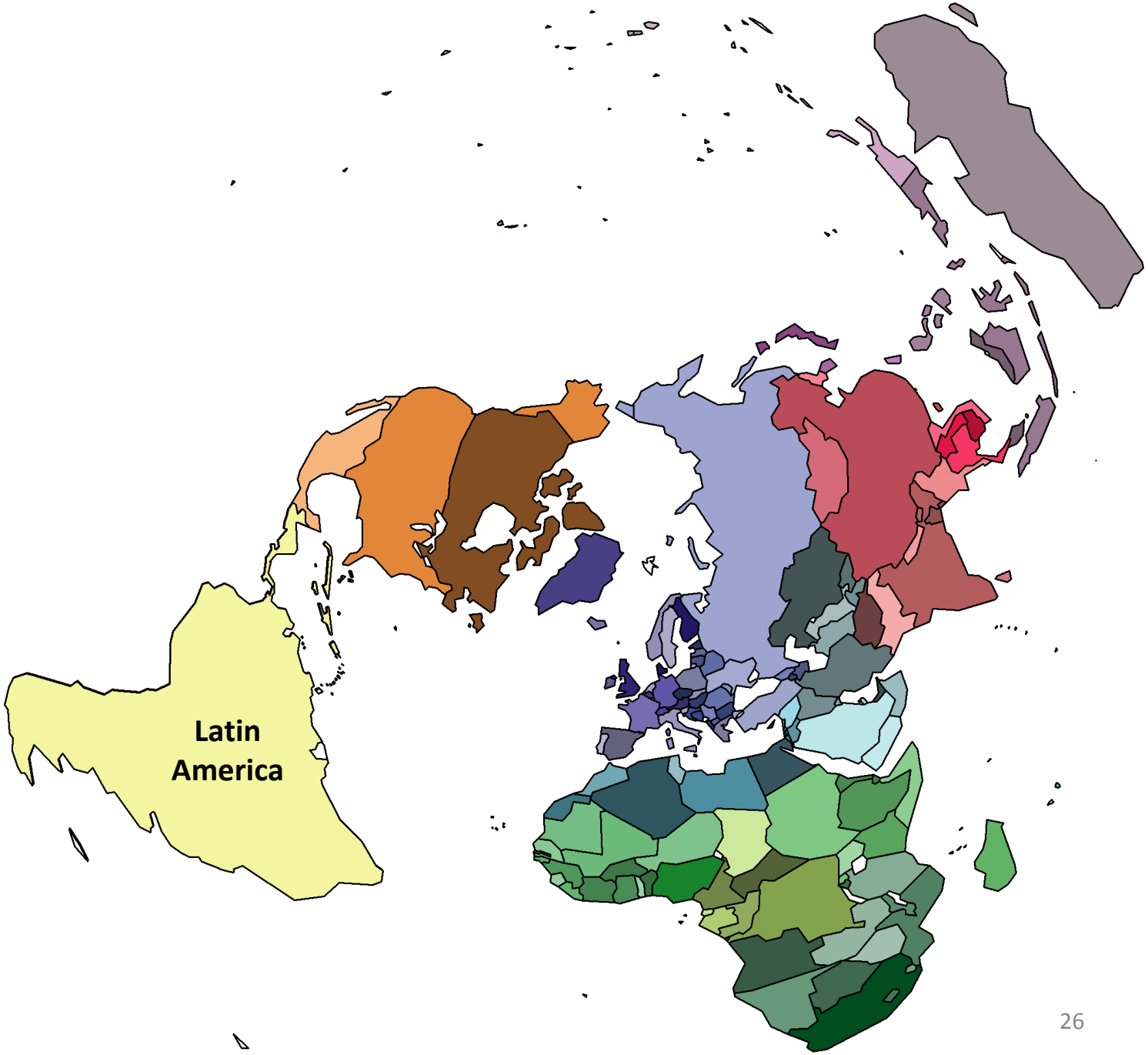
Microscopic level

?

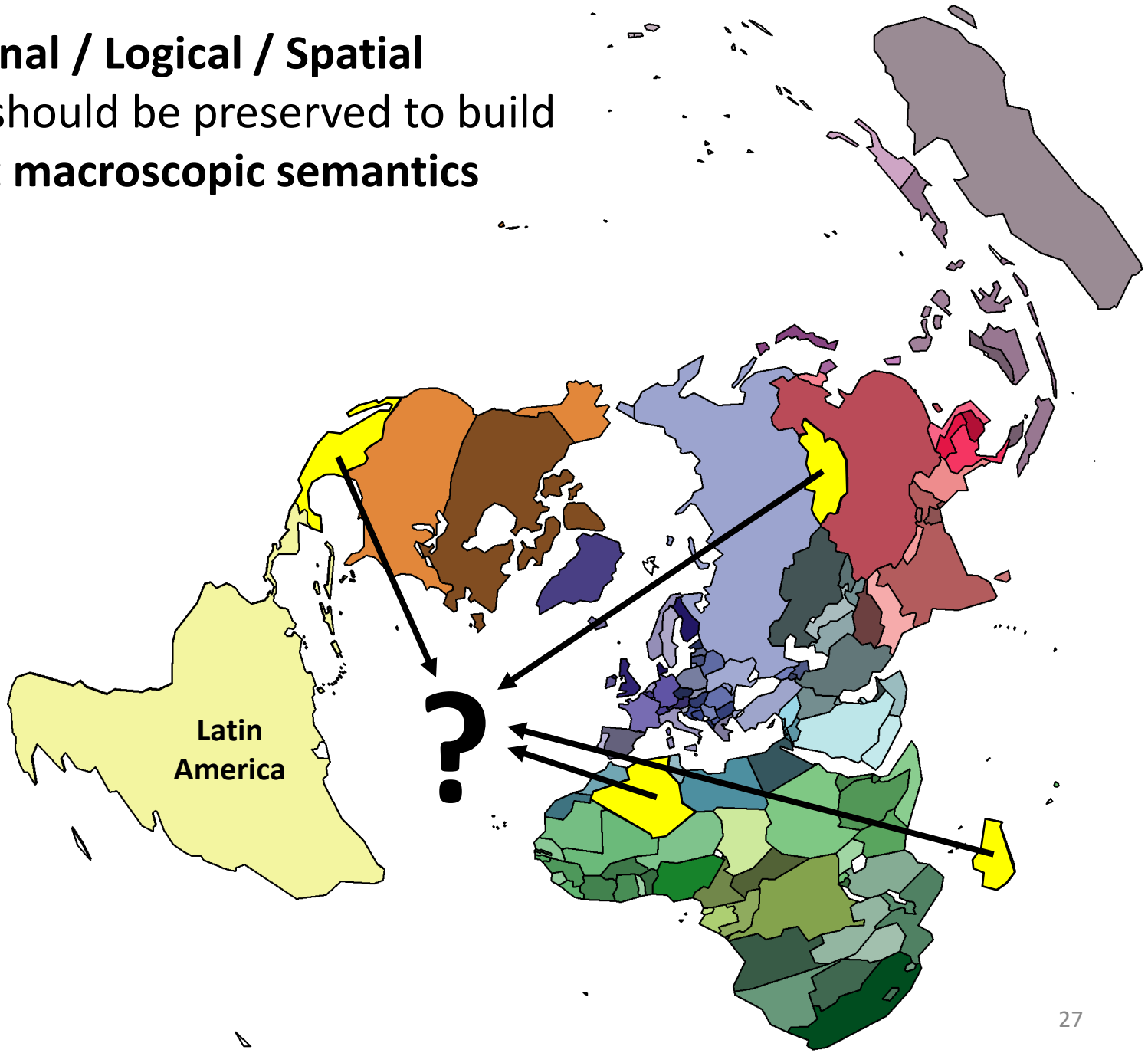
Full aggregation

MACROSCOPIC SEMANTICS

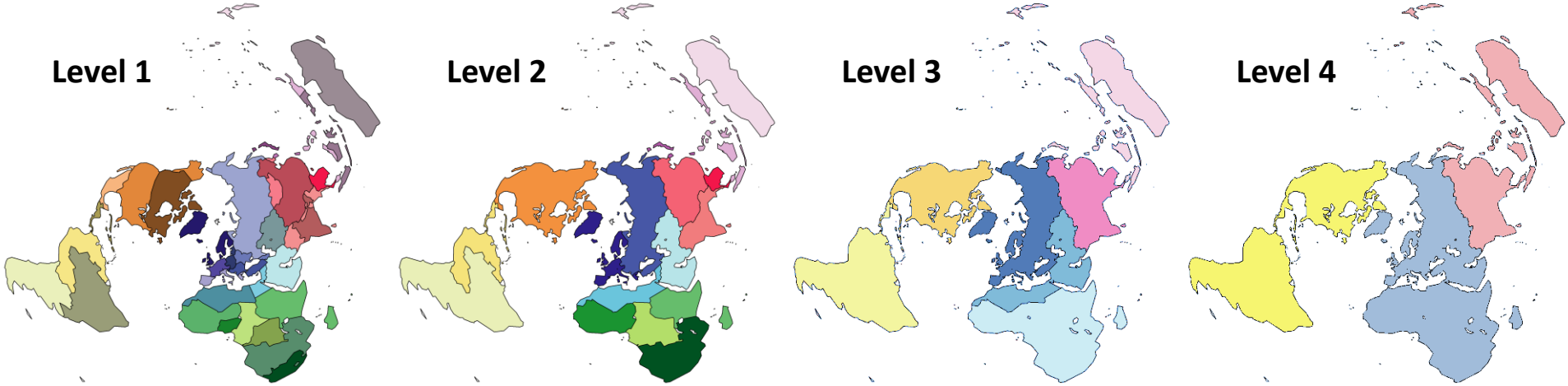


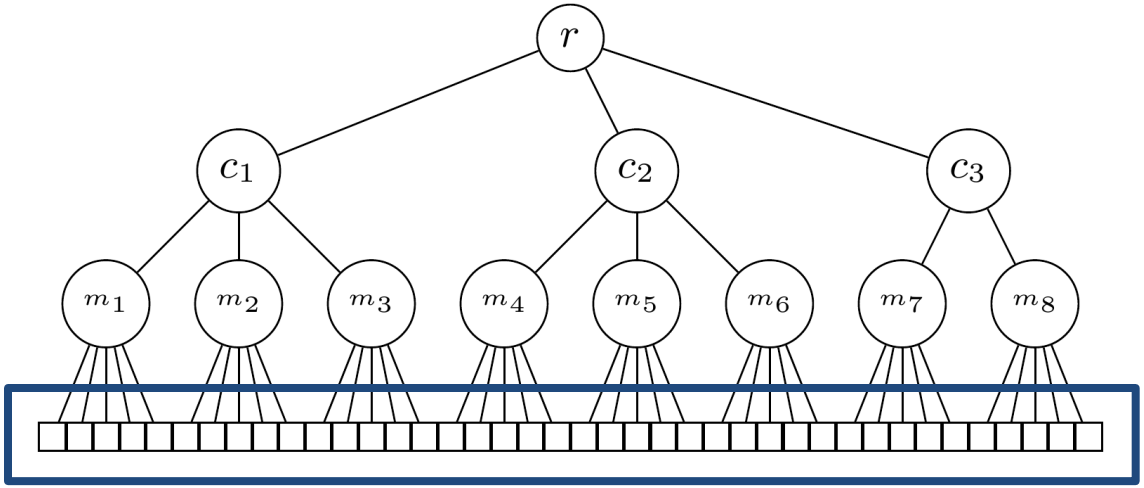

Latin
America

Organisational / Logical / Spatial properties should be preserved to build a consistent **macroscopic semantics**



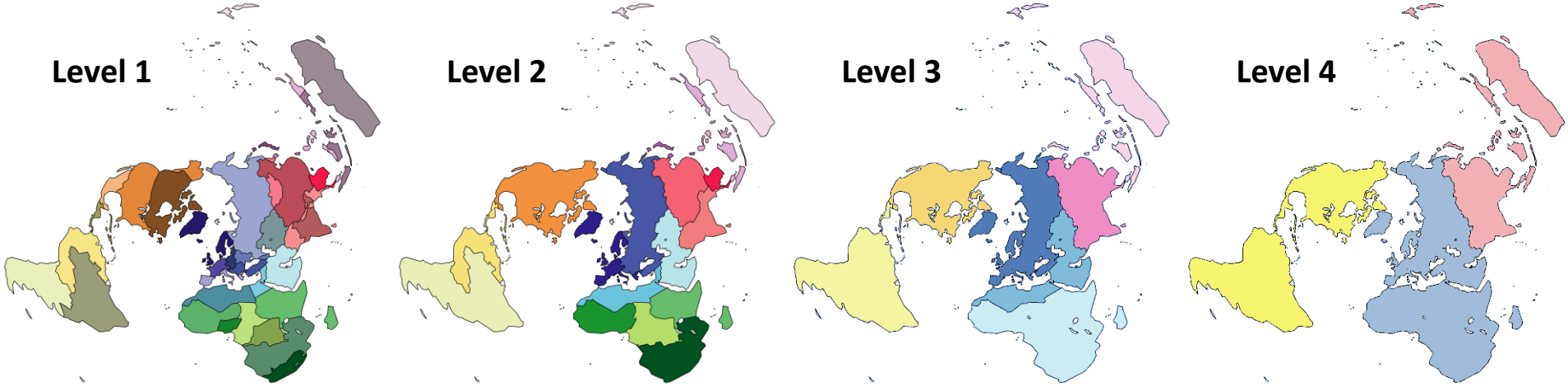
Hierarchical MAS

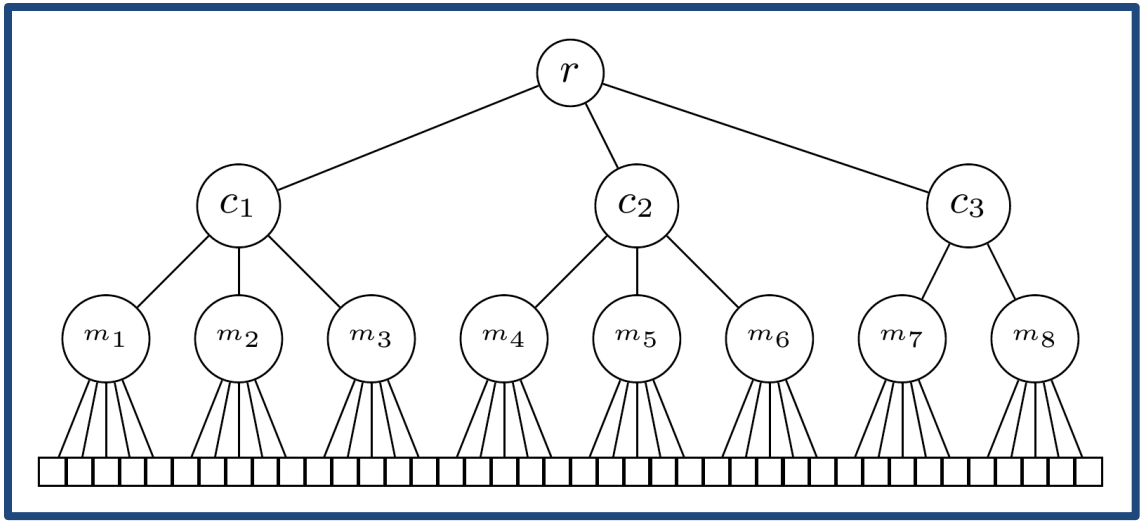




$p = 0$

Hierarchical MAS

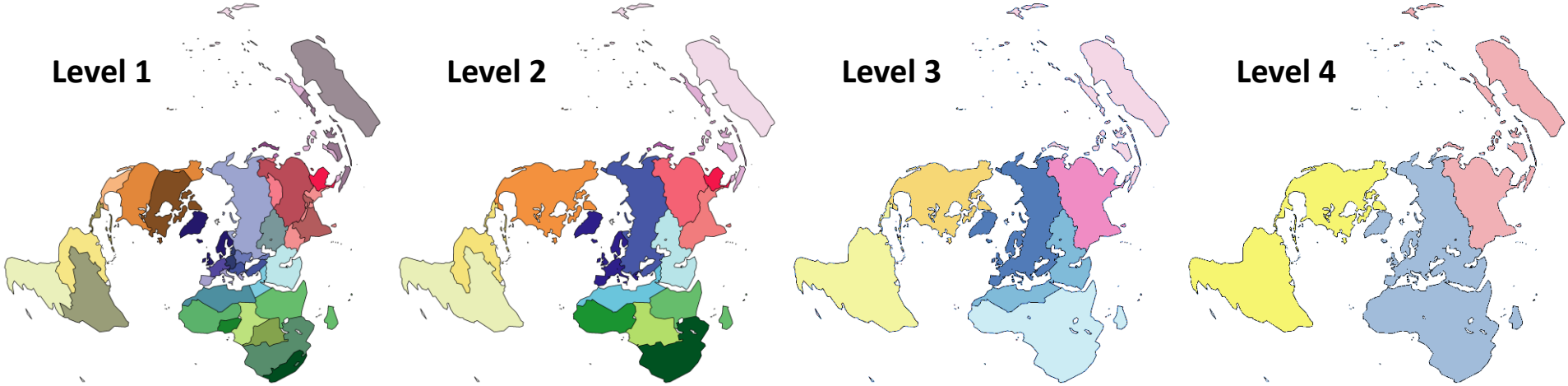


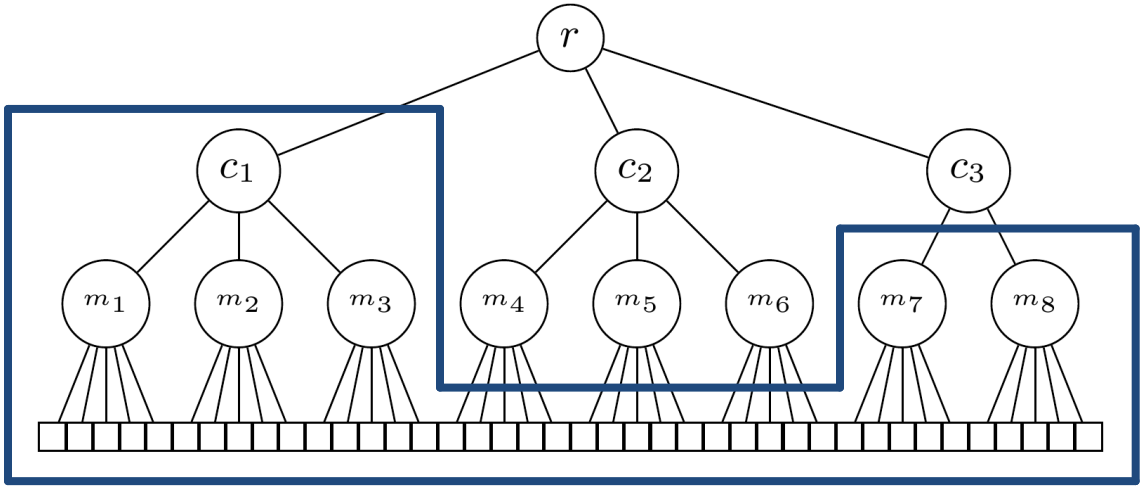


$p = 1$

$p = 0$

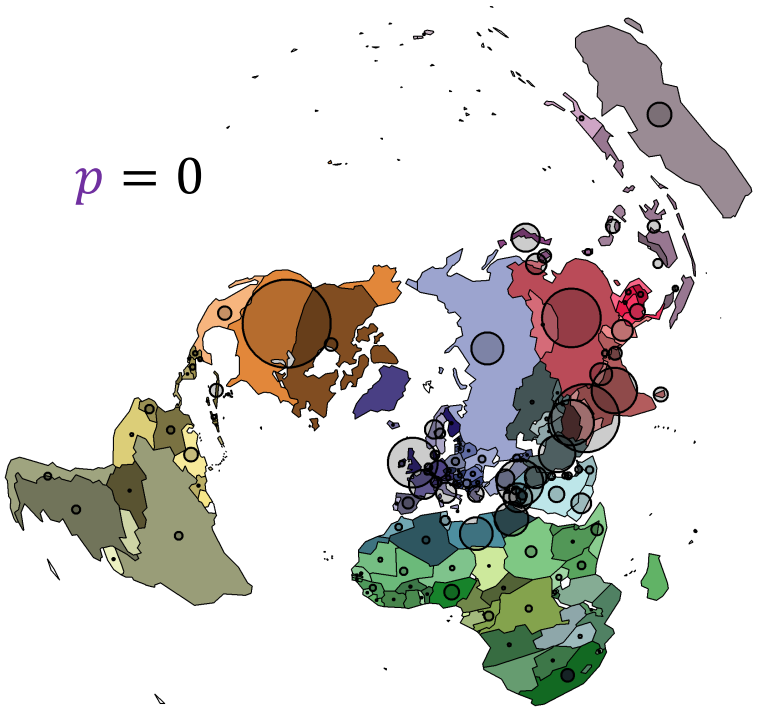
Hierarchical MAS

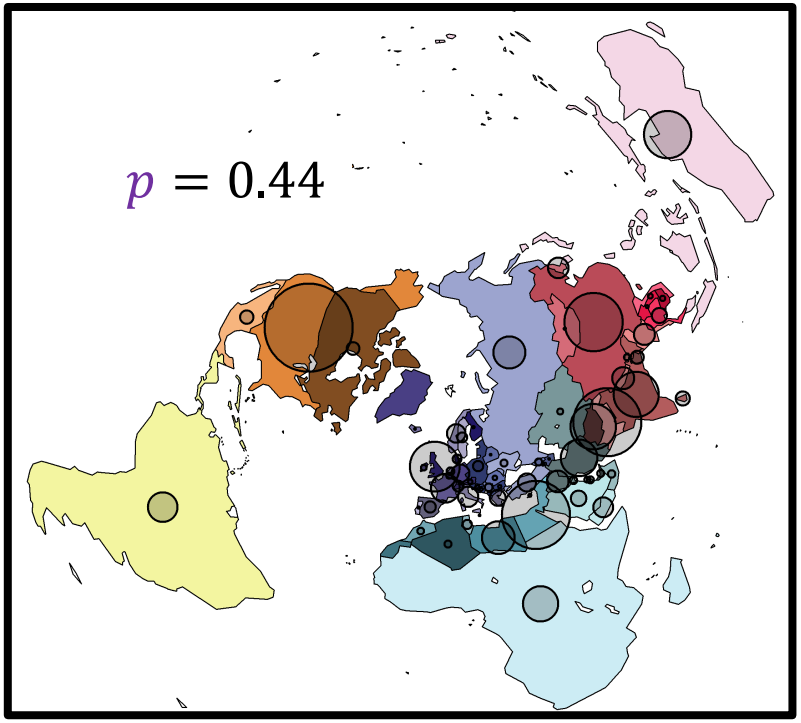


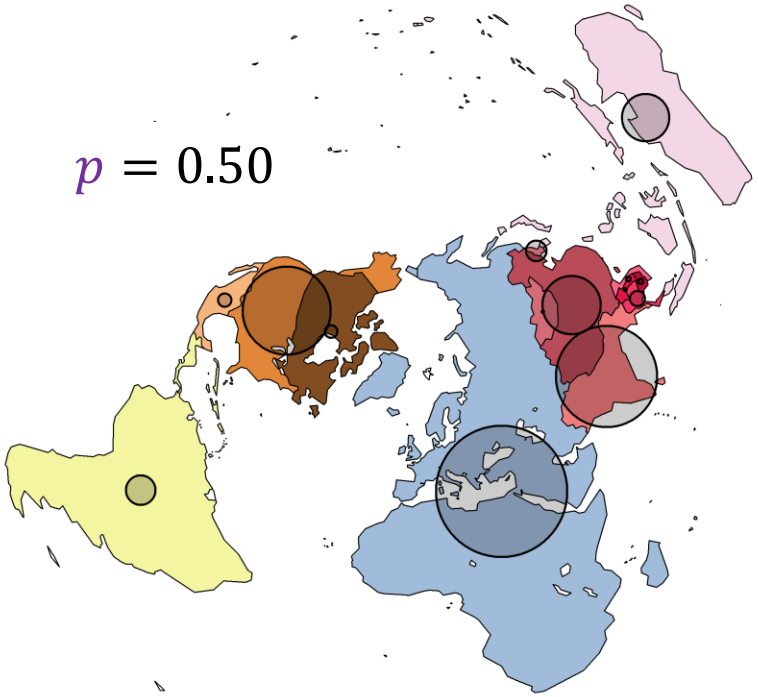


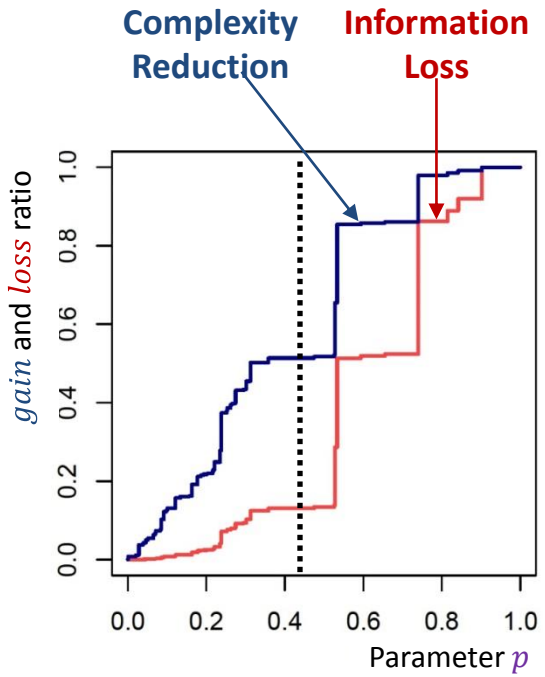
$p = 1$

$p = 0$


$p = 0$


$p = 0.44$


$p = 0.50$


Complexity Reduction
Information Loss
gain and loss ratio
0.0
0.2
0.4
0.6
0.8
1.0
Parameter p

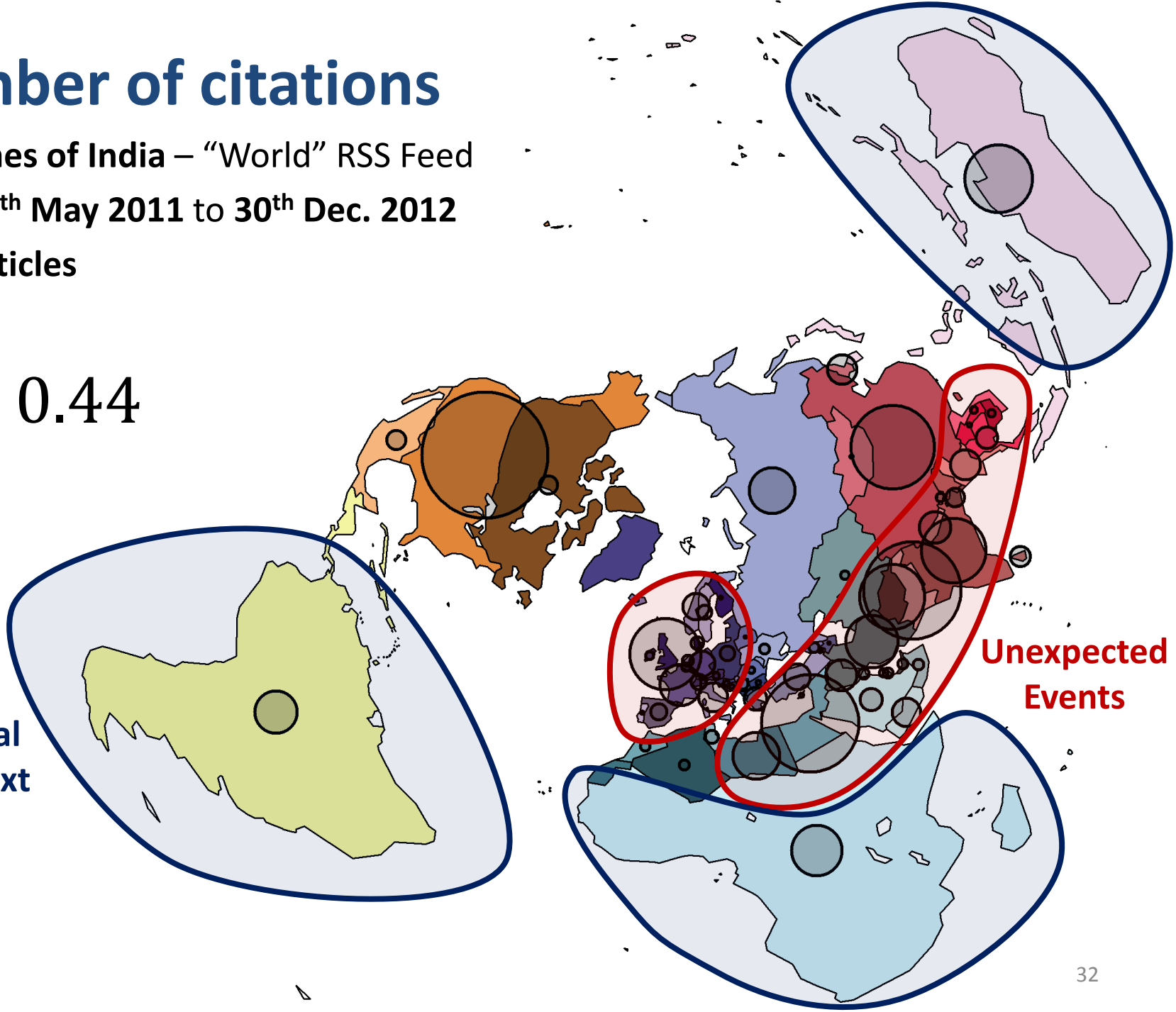
Number of citations

The Times of India – "World" RSS Feed

from **30th May 2011** to **30th Dec. 2012**

8710 articles

$p = 0.44$



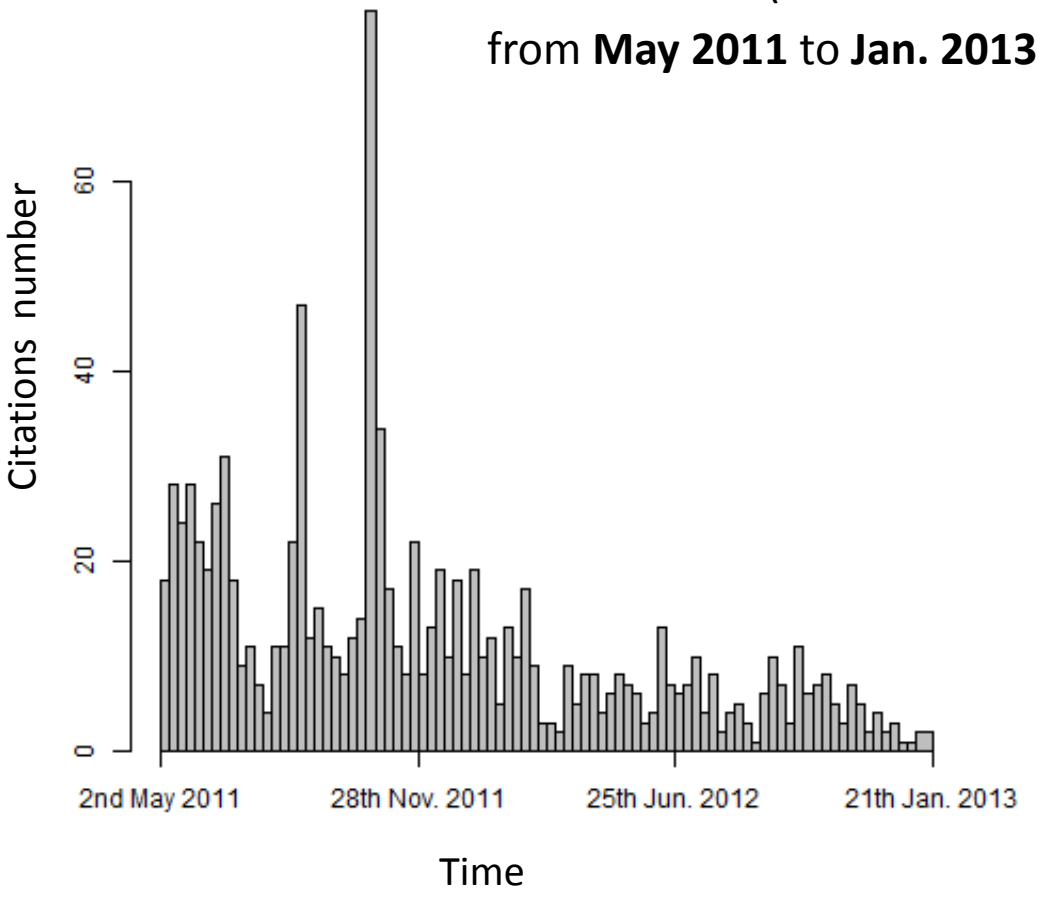
TEMPORAL AGGREGATION

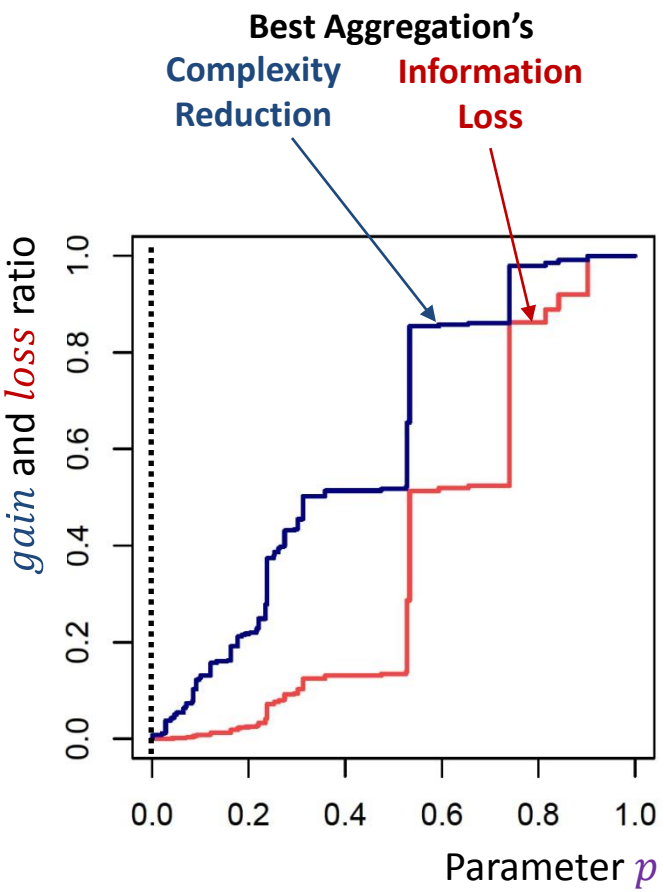
Temporal Aggregation

Citations of "Tunisia"

The Guardian (60.000 articles)

from **May 2011** to **Jan. 2013**





Temporal Aggregation

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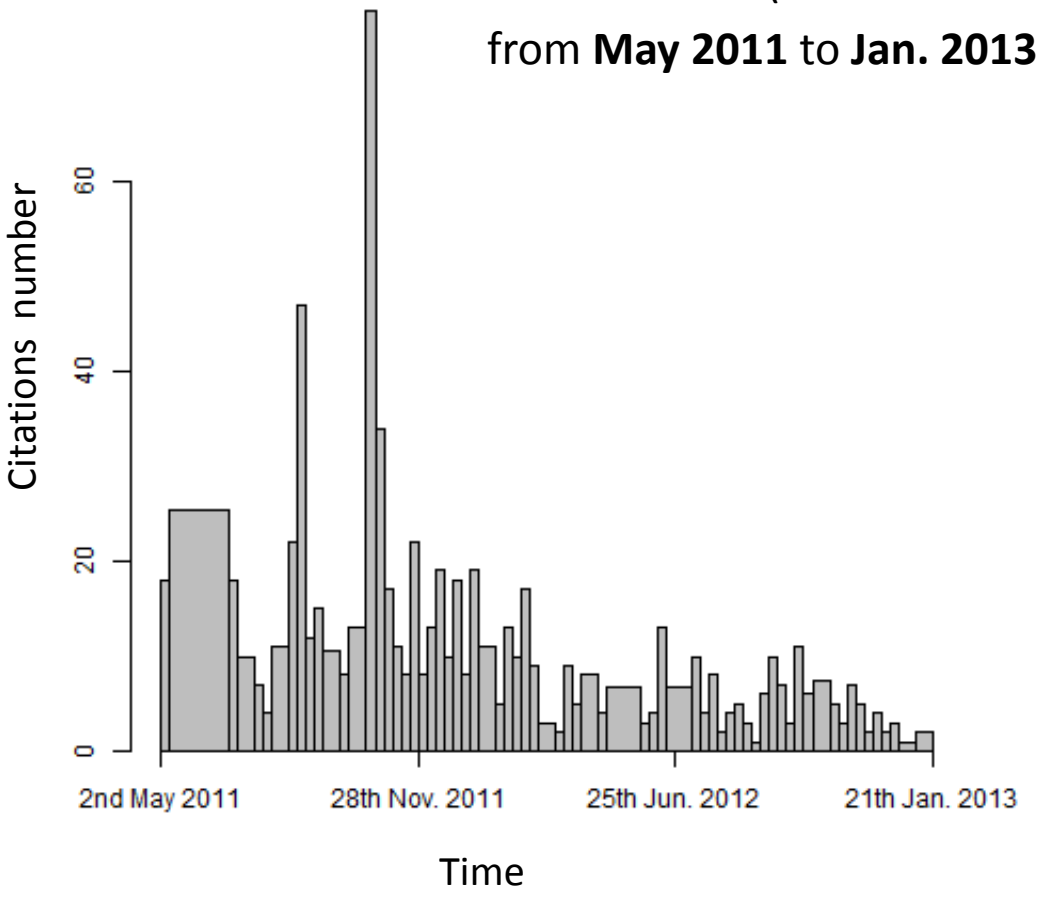

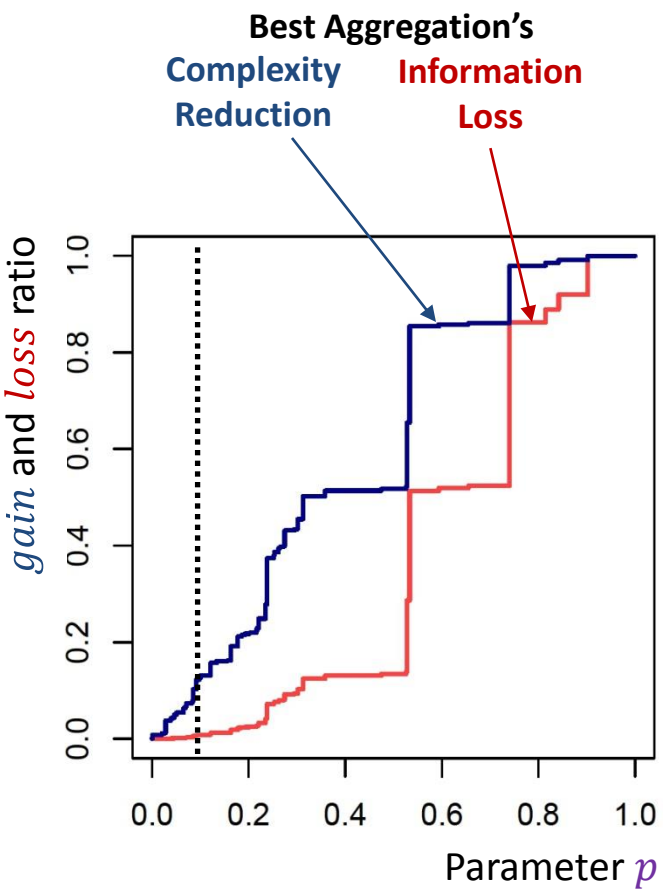

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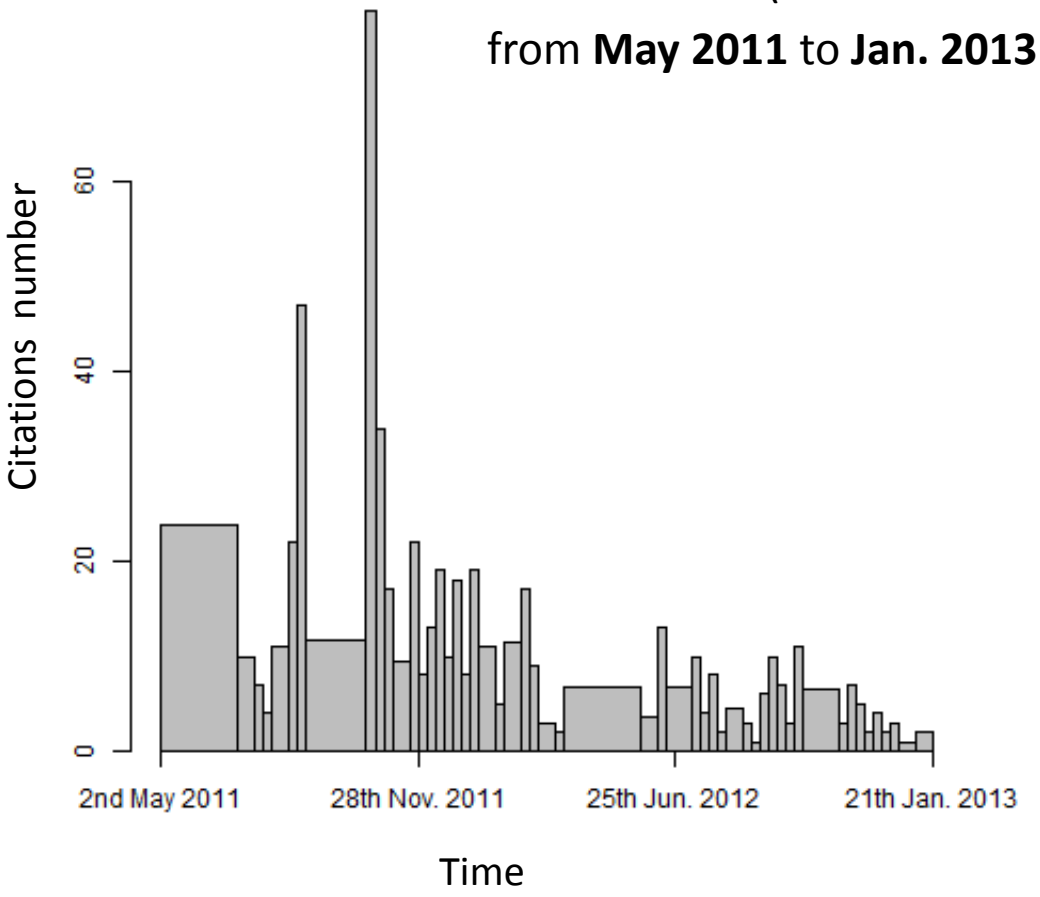

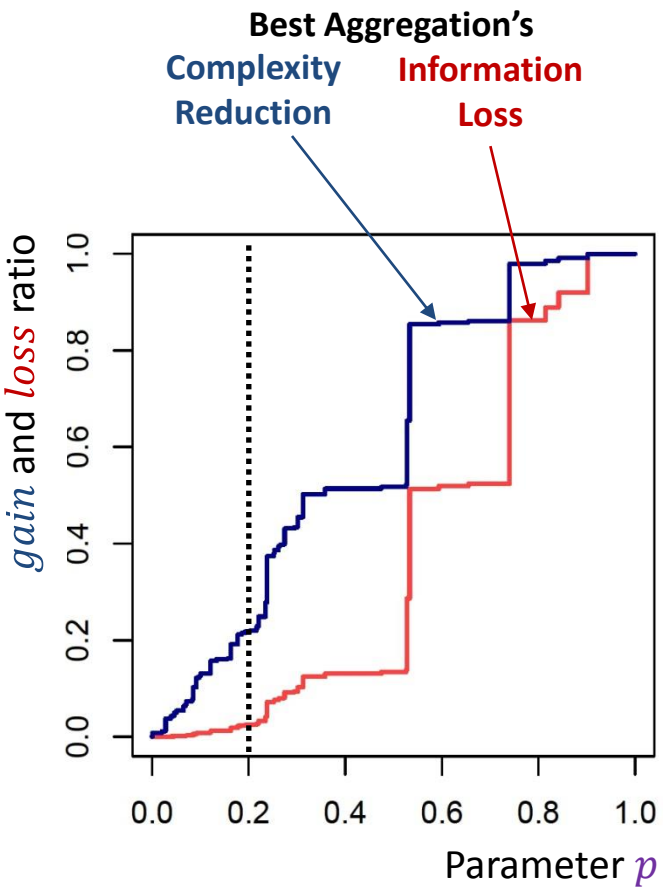

Temporal Aggregation

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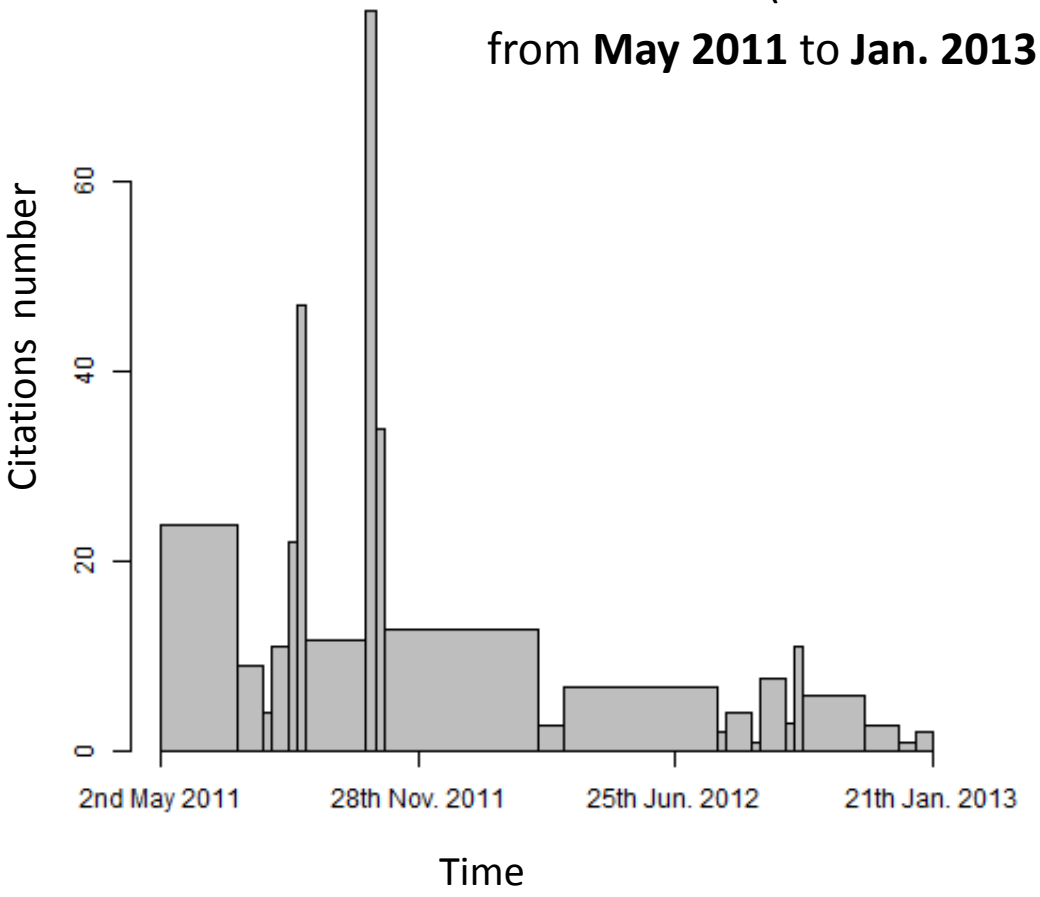

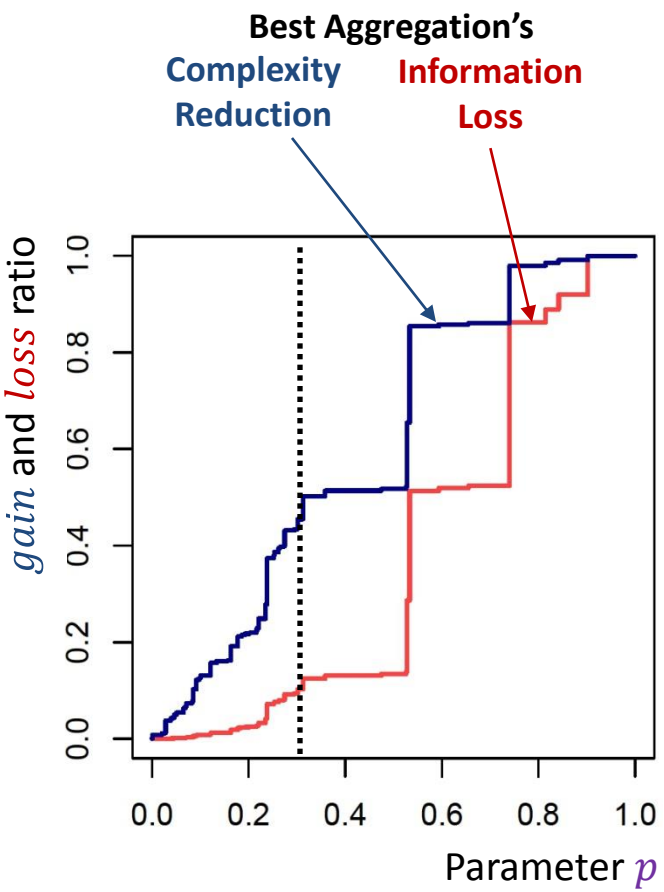

Temporal Aggregation

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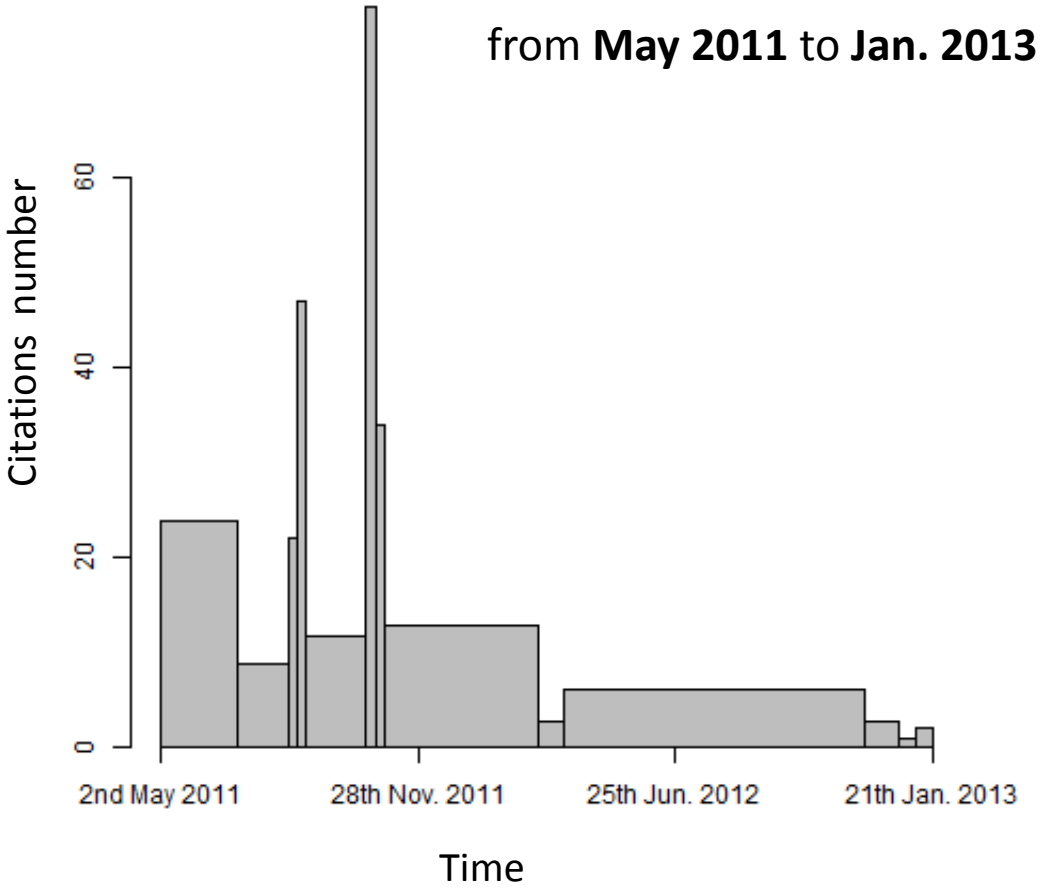
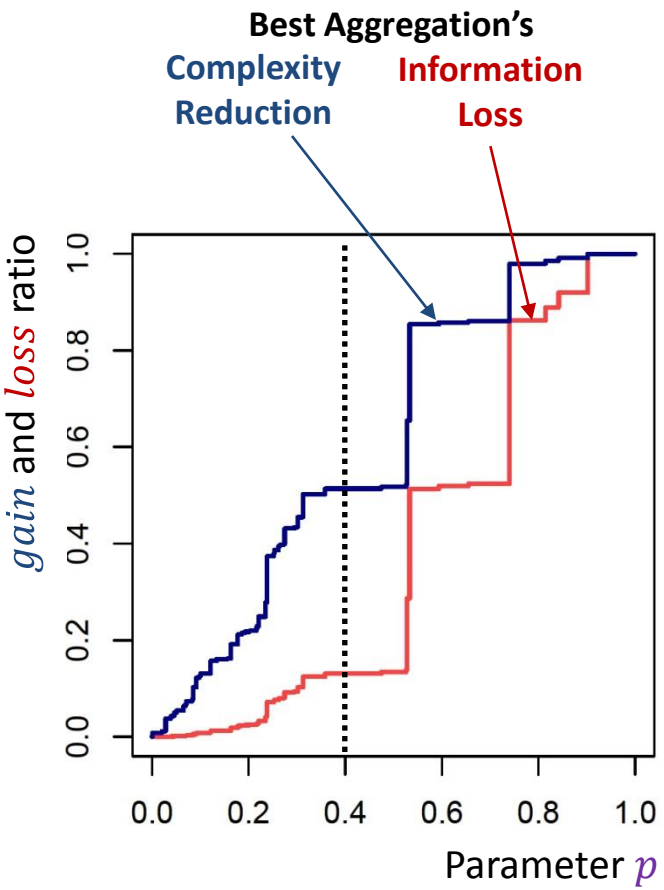
The Guardian (60.000 articles)

from **May 2011** to **Jan. 2013**





Temporal Aggregation

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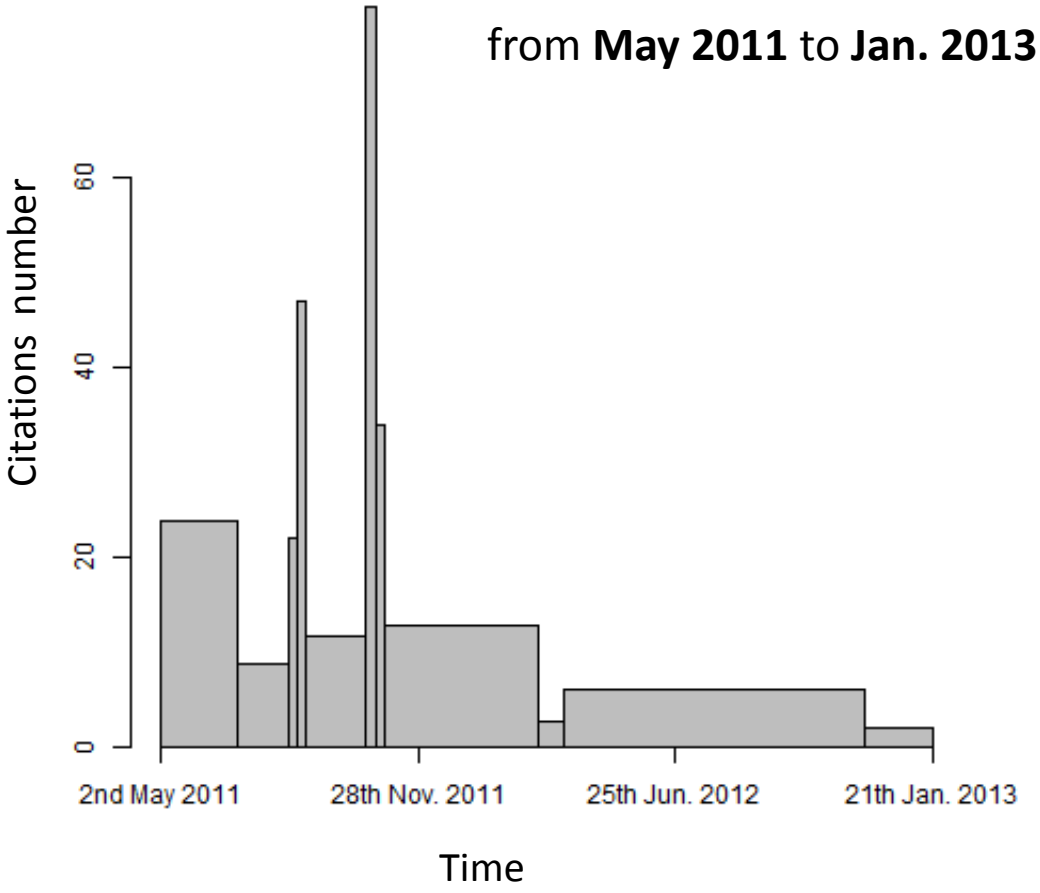
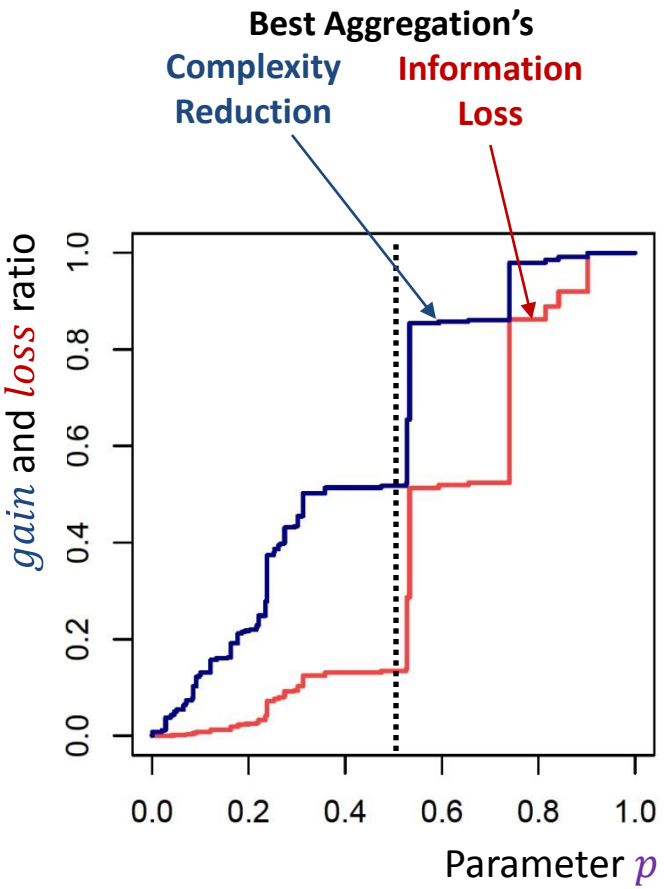
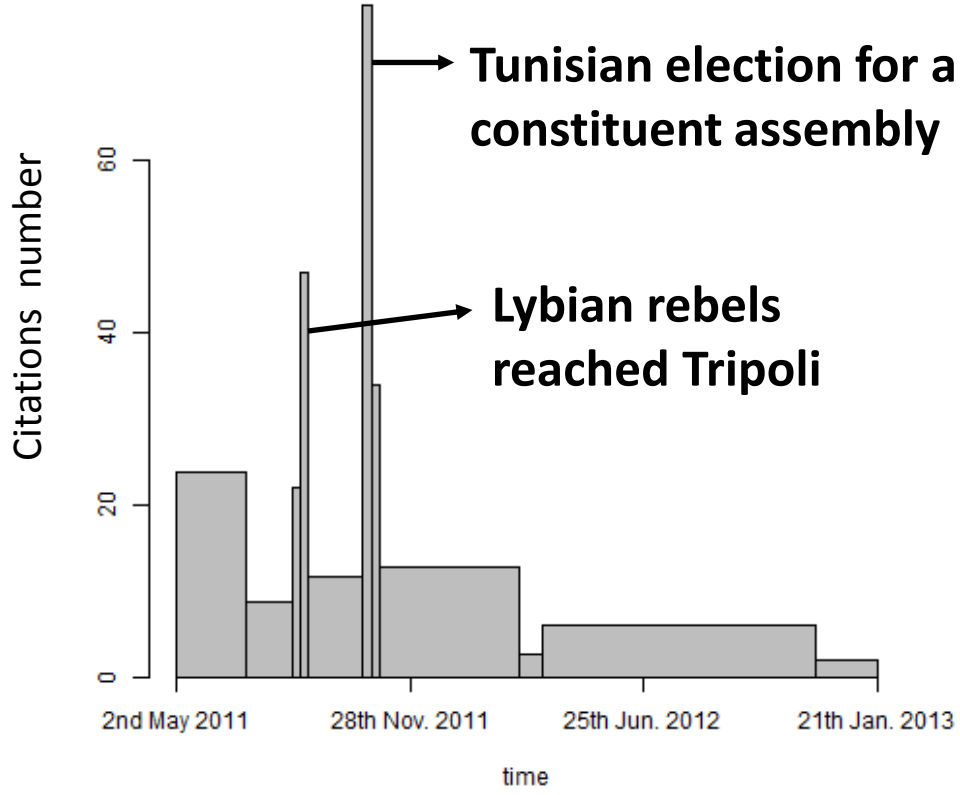
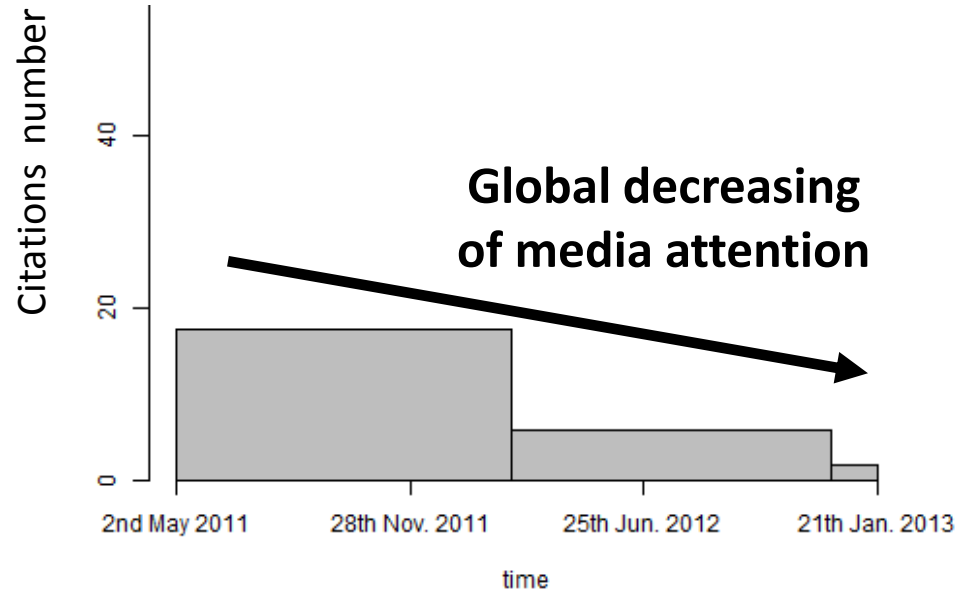
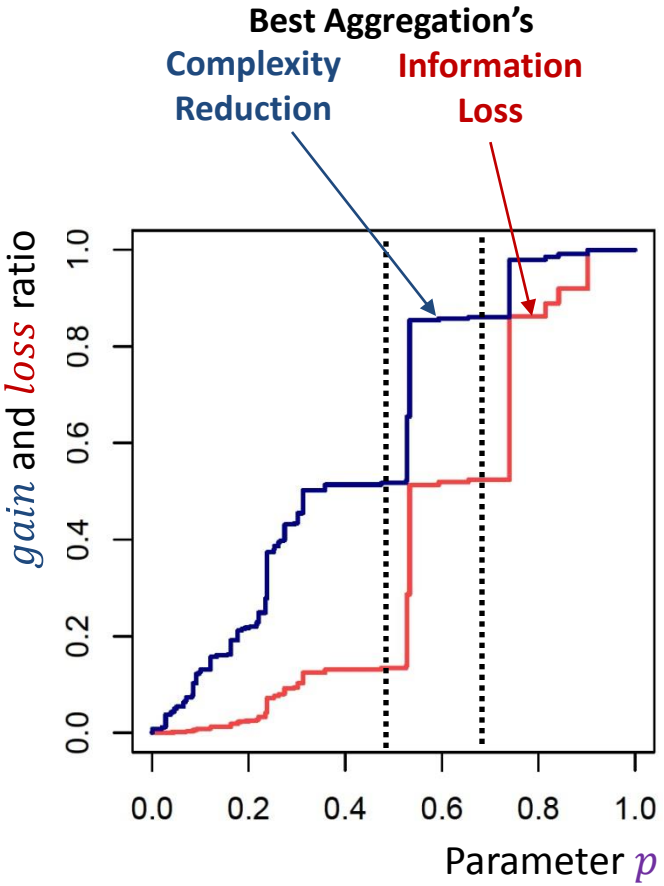





Tunisian election for a constituent assembly
Lybian rebels reached Tripoli
Citations number
0
20
40
60
2nd May 2011
28th Nov. 2011
25th Jun. 2012
21th Jan. 2013
time


Global decreasing of media attention
Citations number
0
20
40
2nd May 2011
28th Nov. 2011
25th Jun. 2012
21th Jan. 2013
time


Best Aggregation's
Complexity Reduction
Information Loss
gain and loss ratio
0.0
0.2
0.4
0.6
0.8
1.0
Parameter p

CONCLUSION AND PERSPECTIVES

Results

Multi-resolution descriptions of systems
from **data aggregation**

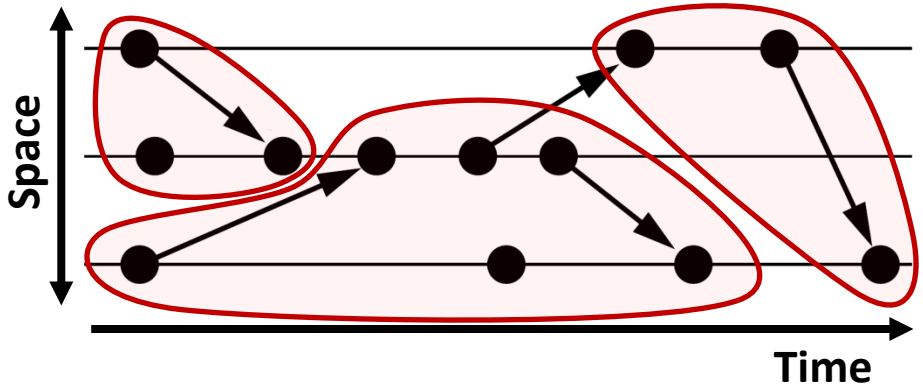
needs the careful control of

Information Content

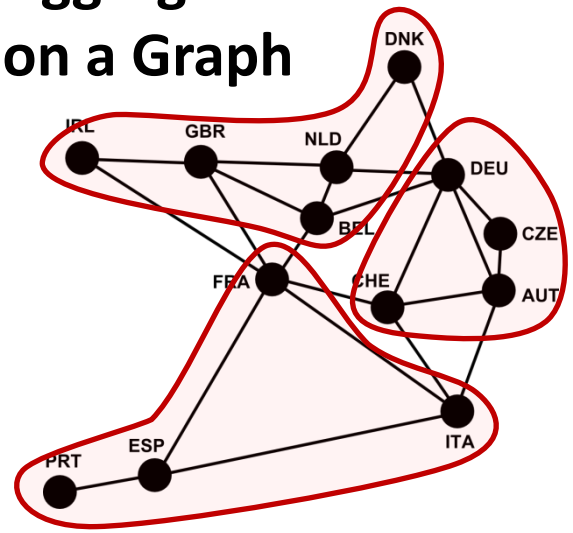
Macroscopic Semantics

Perspectives

Aggregation of Events



Aggregation on a Graph

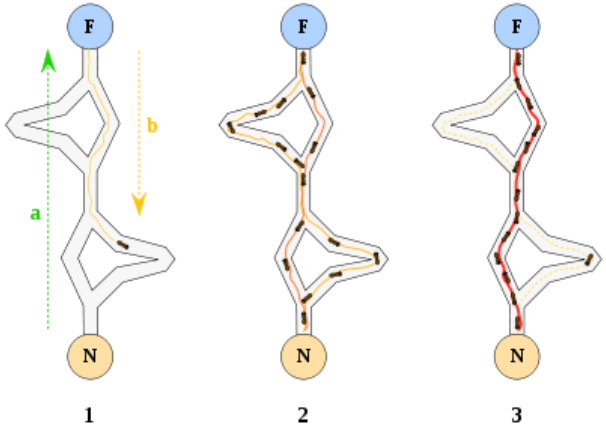


Aggregation of Interactions

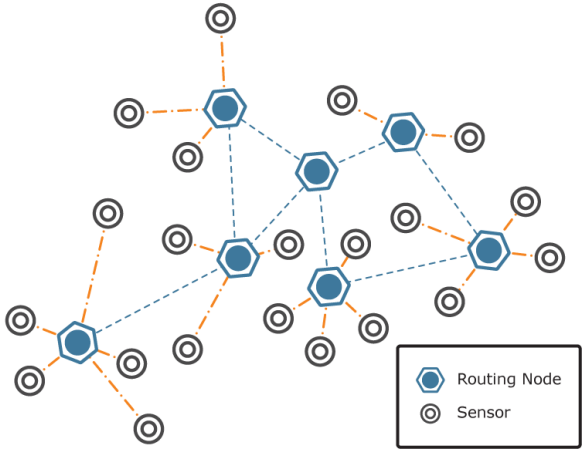
	ESP	FRA	GBR	BEL	CHE
ESP	X	12	11	10	4
FRA	14	X	12	12	5
GBR	20	11	X	6	9
BEL	15	9	6	X	5
CHE	10	16	17	9	X

Perspectives

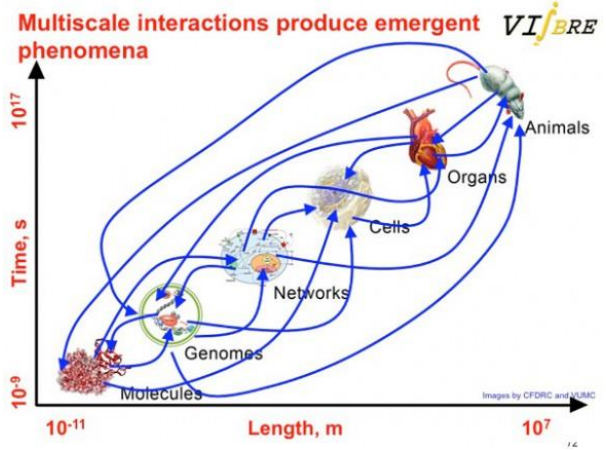
Emergent Computation



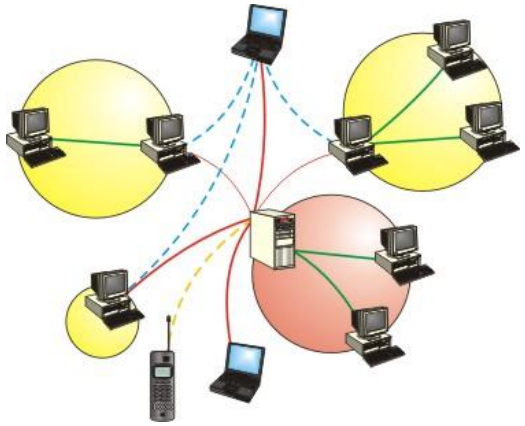
Sensor Networks



Multi-scale Agent-based Simulation



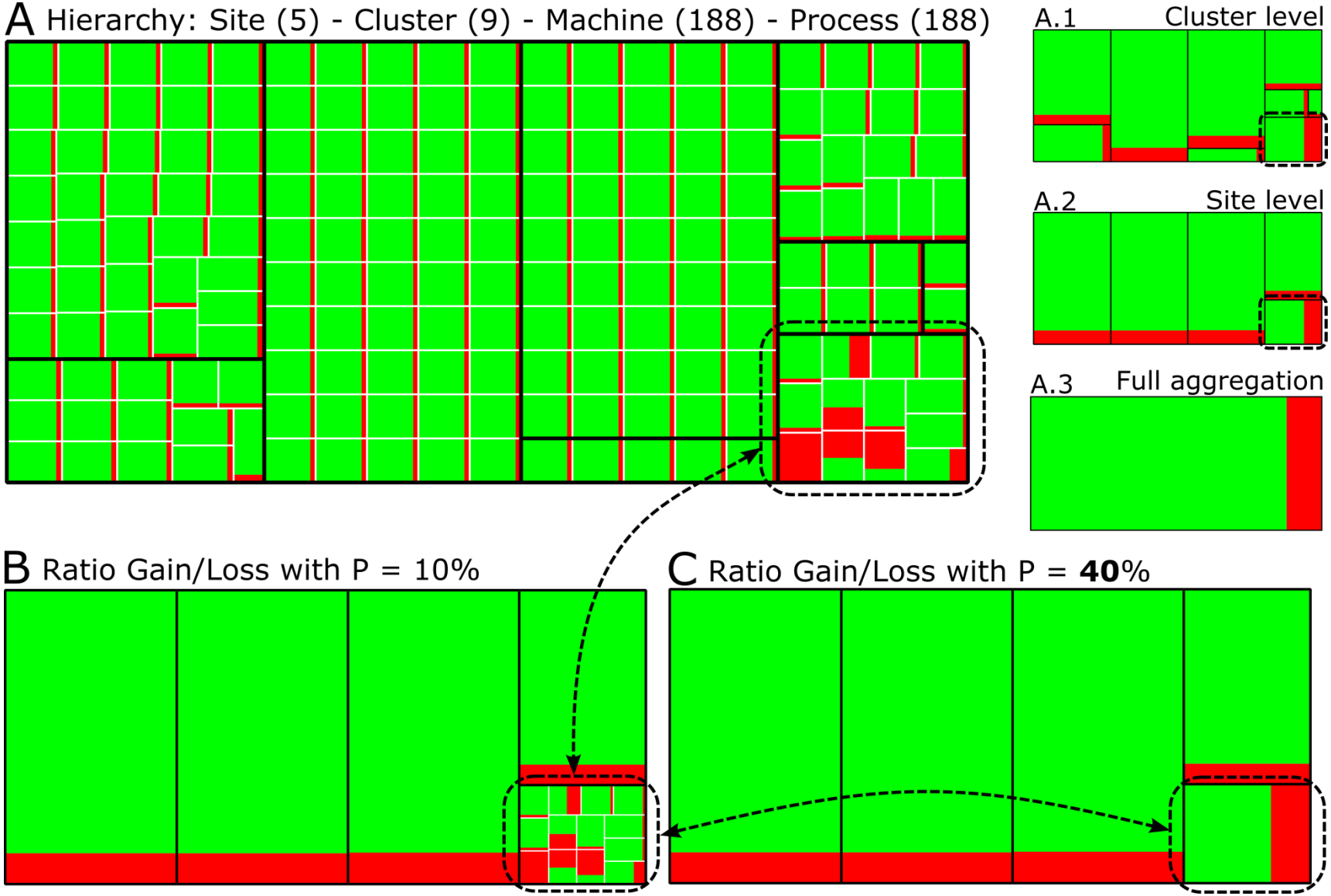
Grid Computing

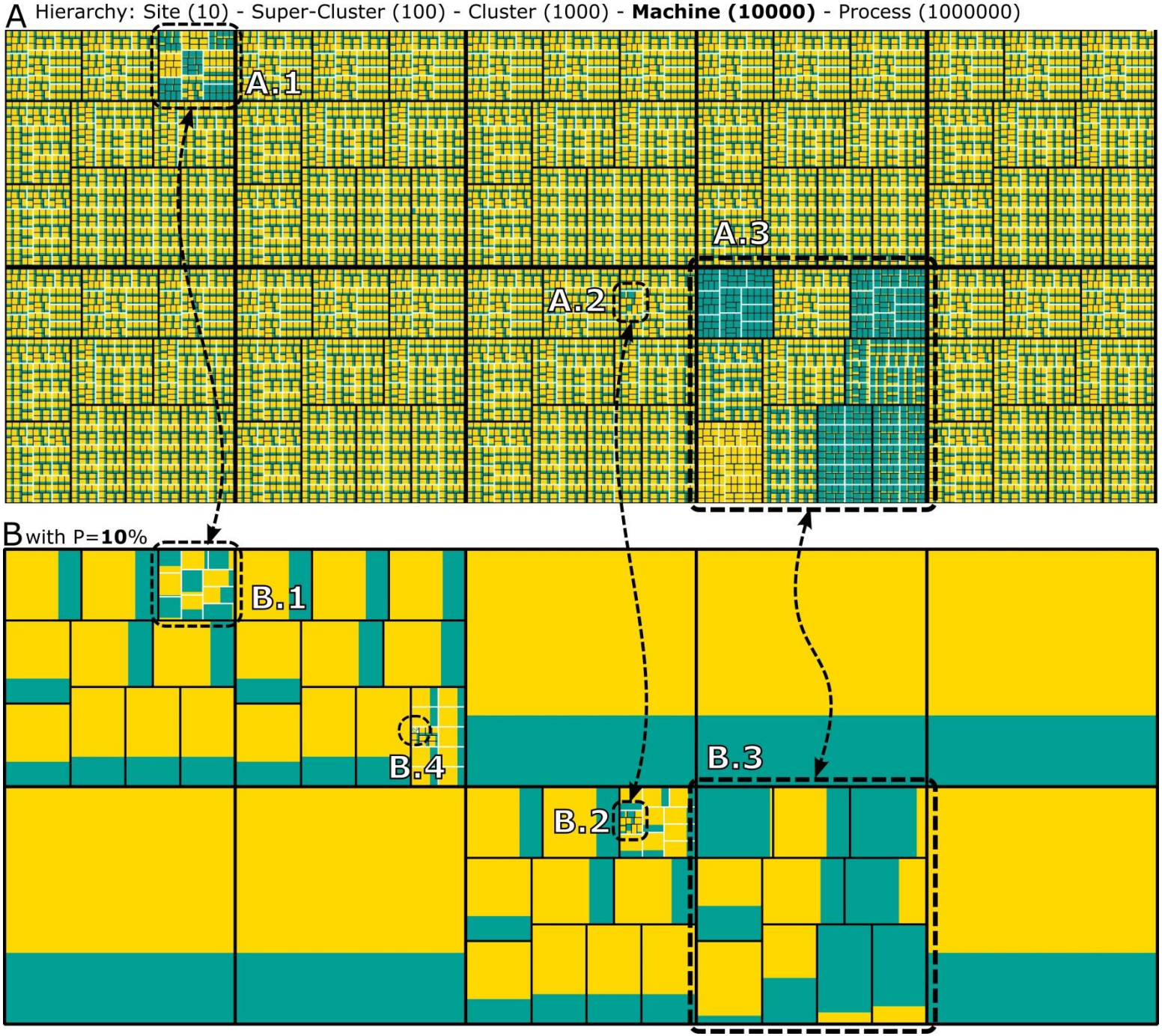


DEMO SESSION TODAY
17:30-18:00

THANK YOU FOR YOUR ATTENTION

Email: Robin.Lamarche-Perrin@imag.fr
Page: magma.imag.fr/content/robin-lamarche-perrin


A Hierarchy: Site (5) - Cluster (9) - Machine (188) - Process (188)
A.1 Cluster level
A.2 Site level
A.3 Full aggregation
B Ratio Gain/Loss with P = 10%
C Ratio Gain/Loss with P = 40%


A Hierarchy: Site (10) - Super-Cluster (100) - Cluster (1000) - **Machine (10000)** - Process (1000000)
A.1
A.2
A.3
B with P=**10**%
B.1
B.2
B.3
B.4