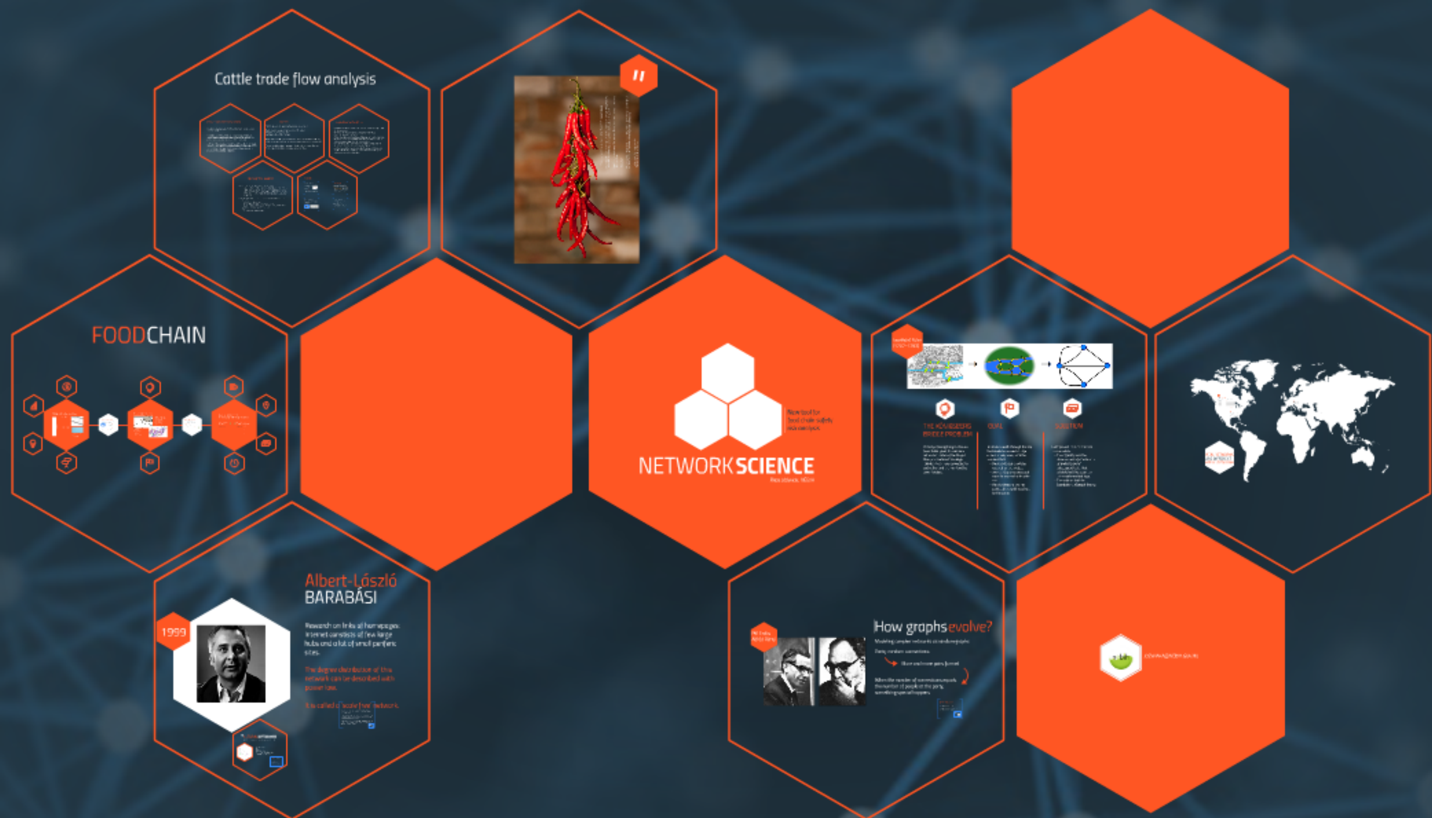


Cattle trade flow analysis
FOODCHAIN
NETWORKSCIENCE
Albert-László
BARABÁSI
1999
How graphs evolve?

Prezi

NETWORK SCIENCE

New tool for
food chain safety
risk analysis

Ákos Jóźwiak, NÉBIH

New tool for
food chain safety
risk analysis


Cattle trade flow analysis
FOODCHAIN
New tool for food chain safety risk analysis
NETWORK SCIENCE
Albert-László
BARABÁSI
1999
Research on links of homepages: Internet constists of few large hubs and a lot of small periferic sites.
The degree distribution of this network can be described with power low.
It is called a "scale free" network.
How graphs evolve?
Prezi

Leonhard Euler
(1707-1793)

THE KÖNIGSBERG BRIDGE PROBLEM

The city of Königsberg in Prussia (now Kaliningrad, Russia) was set on both sides of the Pregel River, and included two large islands which were connected to each other and the mainland by seven bridges.

GOAL

To devise a walk through the city that would cross each bridge once and only once, with the provisos that:

- the islands could only be reached by the bridges
- every bridge once accessed must be crossed to its other end
- the starting and ending points of the walk need not be the same.

SOLUTION

Euler proved that the problem has no solution.

- The difficulty was the development of a technique of analysis and of subsequent tests that established this assertion with mathematical rigor.
- The solution laid the foundations of graph theory.

Pál Erdős
Alfréd Rényi

How graphs evolve?

Modeling complex networks as random graphs

Party: random connections

More and more pairs formed

When the number of connections equals the number of people at the party, something special happens

GIANT Component

Every point can be reached from any point

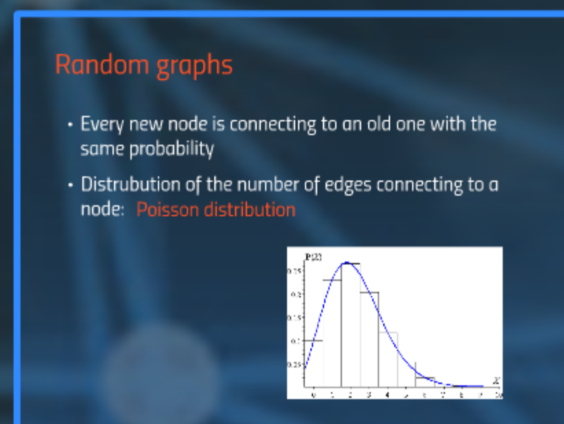
Physicists: phase transition (e.g. water (freezes))
Sociologists: a community is formed

Prezi

GIANT Component

Every point can be reached from any point

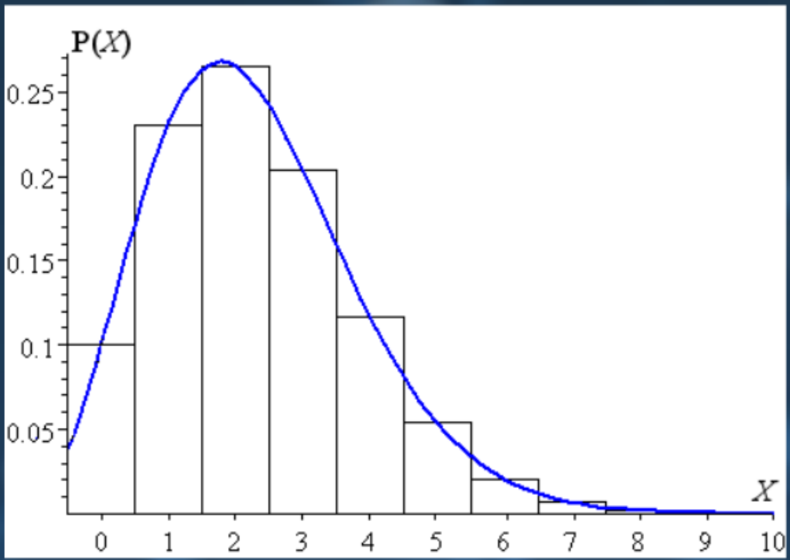
Physicists: phase transition (e.g. water freezes)
Sociologists: a community is formed



Prezi

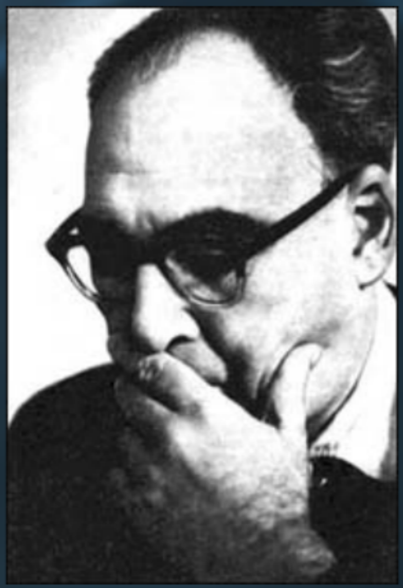
Random graphs

- Every new node is connecting to an old one with the same probability
- Distrubution of the number of edges connecting to a node: Poisson distribution



How graphs evolve?

Pál Erdős
Alfréd Rényi



Modeling complex networks as random graphs

Party: random connections

More and more pairs formed

When the number of connections equals the number of people at the party, something special happens

GIANT Component

Every point can be reached from any point

Physicists: phase transition (e.g. water freezes)
Sociologists: a community is formed

Prezi

Stanley MILGRAM
REAL NETWORKS
ARE DIFFERENT
ARE NOT RANDOM
Prezi

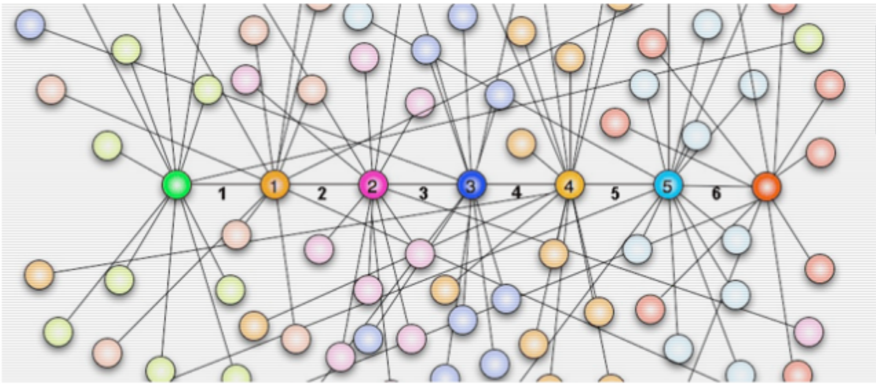
1967

Stanley MILGRAM

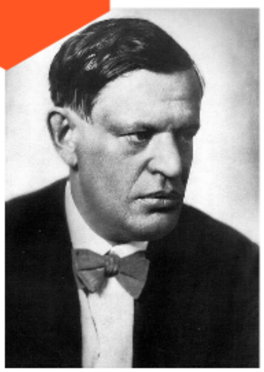
In 1967 asked 300 people from USA to send a letter to an unknown person via their friends.

In case of the letters reaching the addressee the averagre path length was...

... 5.5 steps!



USA: small world



Frigyes KARINTHY

In 1929 he published a volume of short stories titled Everything is Different. One of these pieces was titled "Chains," or "Chain-Links." The story investigated in abstract, conceptual, and fictional terms many of the problems that would captivate future generations of mathematicians, sociologists, and physicists within the field of network theory.

Due to technological advances in communications and travel, friendship networks could grow larger and span greater distances. In particular, Karinthy believed that the modern world was 'shrinking' due to this ever-increasing connectedness of human beings. He posited that despite great physical distances between the globe's individuals, the growing density of human networks made the actual social distance far smaller.

As a result of this hypothesis, Karinthy's characters believed that any two individuals could be connected through at most five acquaintances. In his story, the characters create a game out of this notion.

2016

Each person in the world (at least among the 1.59 billion people active on Facebook) is connected to every other person by an average of three and a half other people.

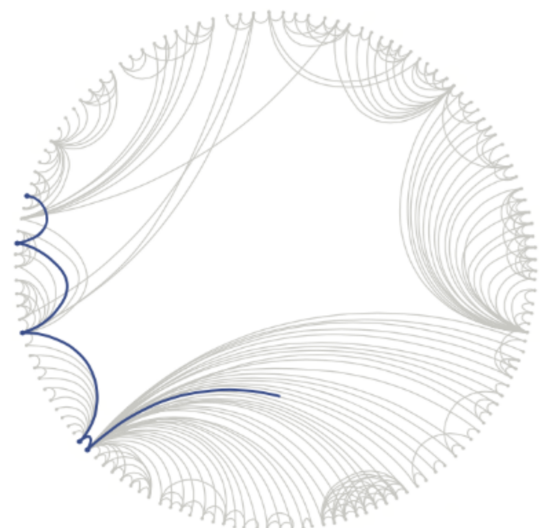
The average distance we observe is 4.57, corresponding to 3.57 intermediaries or "degrees of separation."

Within the US, people are connected to each other by an average of 3.46 degrees.

Facebook

Published on 4th February, 2016

Three and a half degrees of separation



https://research.facebook.com/blog/three-and-a-half-degrees-of-separation/


REAL NETWORKS
ARE DIFFERENT
ARE NOT RANDOM
1967
Stanley MILGRAM
USA: small world
Prezi

REAL NETWORKS
ARE DIFFERENT
ARE NOT RANDOM

Prezi

Cattle trade flow analysis
FOODCHAIN
NETWORK SCIENCE
Albert-László
BARABÁSI
1999
Research on links of homepages: Internet consists of few large hubs and a lot of small periferic sites.
The degree distribution of this network can be described with power law.
How graphs evolve?
Prezi

Albert-László BARABÁSI

1999

Research on links of homepages: Internet constists of few large hubs and a lot of small periferic sites.

The degree distribution of this network can be described with power law.

It is called a 'scale free' network.

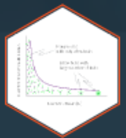
The scale-free name captures the lack of an internal scale, a consequence of the fact that nodes with widely different degrees coexist in the same network.

This feature distinguishes scale-free networks from lattices, in which all nodes have exactly the same degree, or from random networks, whose degrees vary in a narrow range.

This divergence is the origin of some of the most intriguing properties of scale-free networks, from their robustness to random failures to the anomalous spread of viruses.

NATURALNETWORKS

All follow power law distribution, and are very similar to each other



- social networks
- Internet
- neural networks
- epidemiological spreading routes
- cellular biochemical reactions
- ...

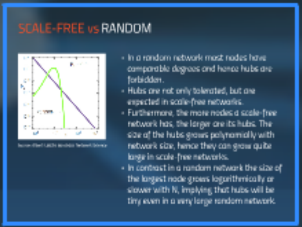
SCALE-FREEPROPERTIES

'scale free'

The scale-free name captures the lack of an internal scale, a consequence of the fact that nodes with widely different degrees coexist in the same network.

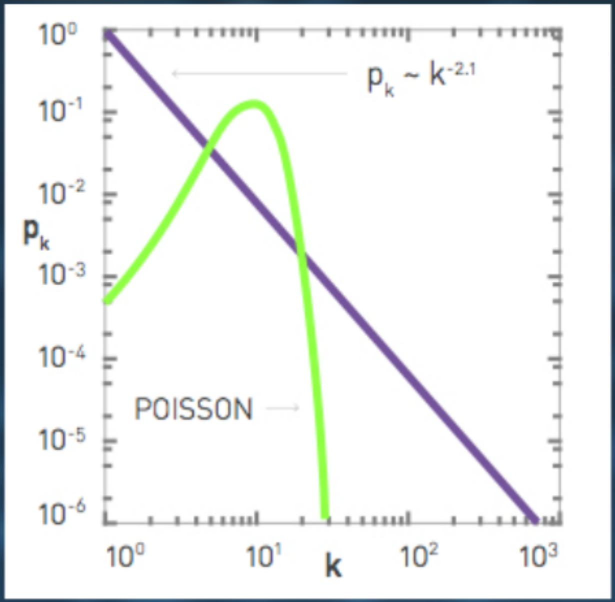
This feature distinguishes scale-free networks from lattices, in which all nodes have exactly the same degree, or from random networks, whose degrees vary in a narrow range.

This divergence is the origin of some of the most intriguing properties of scale-free networks, from their robustness to random failures to the anomalous spread of viruses.



Prezi

SCALE-FREE vs RANDOM



Source: Albert-László Barabási: Network Science

- In a random network most nodes have comparable degrees and hence hubs are forbidden.
- Hubs are not only tolerated, but are expected in scale-free networks.
- Furthermore, the more nodes a scale-free network has, the larger are its hubs. The size of the hubs grows polynomially with network size, hence they can grow quite large in scale-free networks.
- In contrast in a random network the size of the largest node grows logarithmically or slower with N, implying that hubs will be tiny even in a very large random network.

Albert-László BARABÁSI

1999

Research on links of homepages: Internet constists of few large hubs and a lot of small periferic sites.

The degree distribution of this network can be described with power law.

It is called a 'scale free' network.

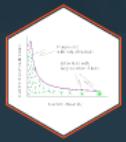
The scale-free name captures the lack of an internal scale, a consequence of the fact that nodes with widely different degrees coexist in the same network.

This feature distinguishes scale-free networks from lattices, in which all nodes have exactly the same degree, or from random networks, whose degrees vary in a narrow range.

This divergence is the origin of some of the most intriguing properties of scale-free networks, from their robustness to random failures to the anomalous spread of viruses.

NATURALNETWORKS

All follow power low distribution, and are very similar to each other



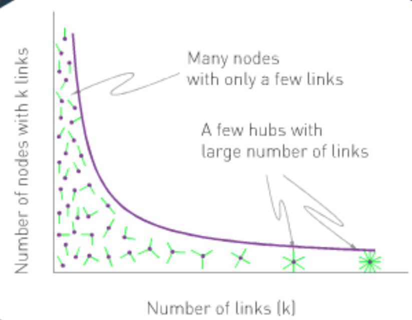
- social networks
- Internet
- neural networks
- epidemiological spreading routes
- cellular biochemical reactions
- ...

SCALE-FREEPROPERTIES

Prezi

NATURAL**NETWORKS**

All follow power law distribution, and are very similar to each other



- social networks
- Internet
- neural networks
- epidemiological spreading routes
- cellular biochemical reactions
- ...

SCALE-FREE**PROPERTIES**

Scale-free networks have small world properties.

The low-degree nodes form dense subgraphs, inteconnected by large hubs.

Scale-free networks are very fault-tolerant towards random failures (randomly removing a node will have no significant effect on the network structure).

However, they are very sensitive to targeted attacks: removing the hubs will result in quick collapsing.

SCALE-FREE PROPERTIES

Scale-free networks have small world properties.

The low-degree nodes form dense subgraphs,
inteconnected by large hubs.

Scale-free networks are very fault-tolerant towards random failures (randomly removing a node will have no significant effect on the network structure).

However, they are very sensitive to targeted attacks: removing the hubs will result in quick collapsing.

Albert-László BARABÁSI

1999

Research on links of homepages: Internet constists of few large hubs and a lot of small periferic sites.

The degree distribution of this network can be described with power law.

It is called a 'scale free' network.

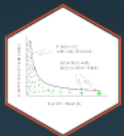
The scale-free name captures the lack of an internal scale, a consequence of the fact that nodes with widely different degrees coexist in the same network.

This feature distinguishes scale-free networks from lattices, in which all nodes have exactly the same degree, or from random networks, whose degrees vary in a narrow range.

This divergence is the origin of some of the most intriguing properties of scale-free networks, from their robustness to random failures to the anomalous spread of viruses.

NATURALNETWORKS

All follow power law distribution, and are very similar to each other



- social networks
- Internet
- neural networks
- epidemiological spreading routes
- cellular biochemical reactions
- ...

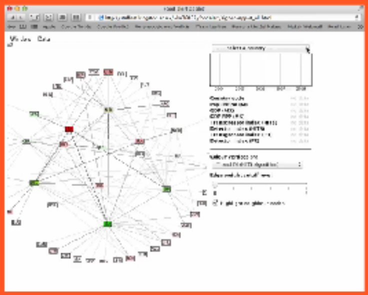
SCALE-FREEPROPERTIES

Prezi


FOODCHAIN
Network of countries
Network of animal farms
Which farm is the most probable place being a hub in future epidemics?
Which network science mechanisms fit reality the most?
Which trade routes are the most risky?
Elaboration of spreading models
Fight against terrorism –
Protecting the critical infrastructures
Usual food network risk analysis
Risk analysis from critical infrastructure point of view
unintentional
intentional
Prezi

Network of countries

RASFF notifications



Export-import (trade)

Ercsey-Ravasz, M., Toroczkai, Z., Lakner, Z., & Baranyi, J. (2012). Complexity of the International Agro-Food Trade Network and Its Impact on Food Safety. (V. Colizza, Ed.)PLoS ONE, 7(5), e37810. doi:10.1371/journal.pone.0037810

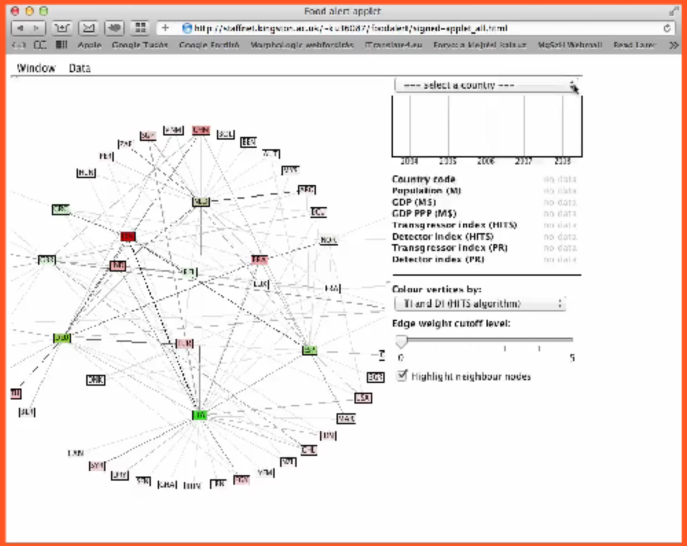
- Find patterns
- Observe sudden changes
- Choose higher risk nodes or link

Network of countries

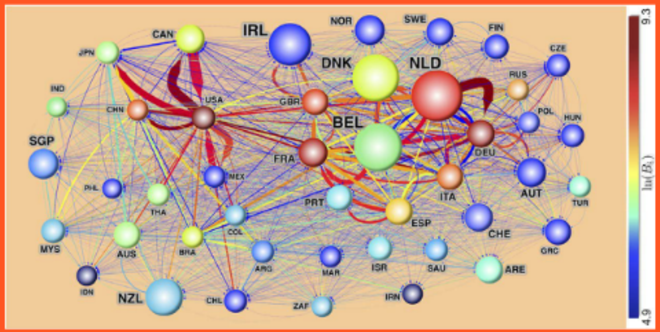
Our aim is to protect this network

Scale-free networks: allows for a fault tolerant behaviour but on the other hand, if we choose few major hubs and take them out of the network, it simply falls apart and is turned into a set of rather isolated graphs.

RASFF notifications

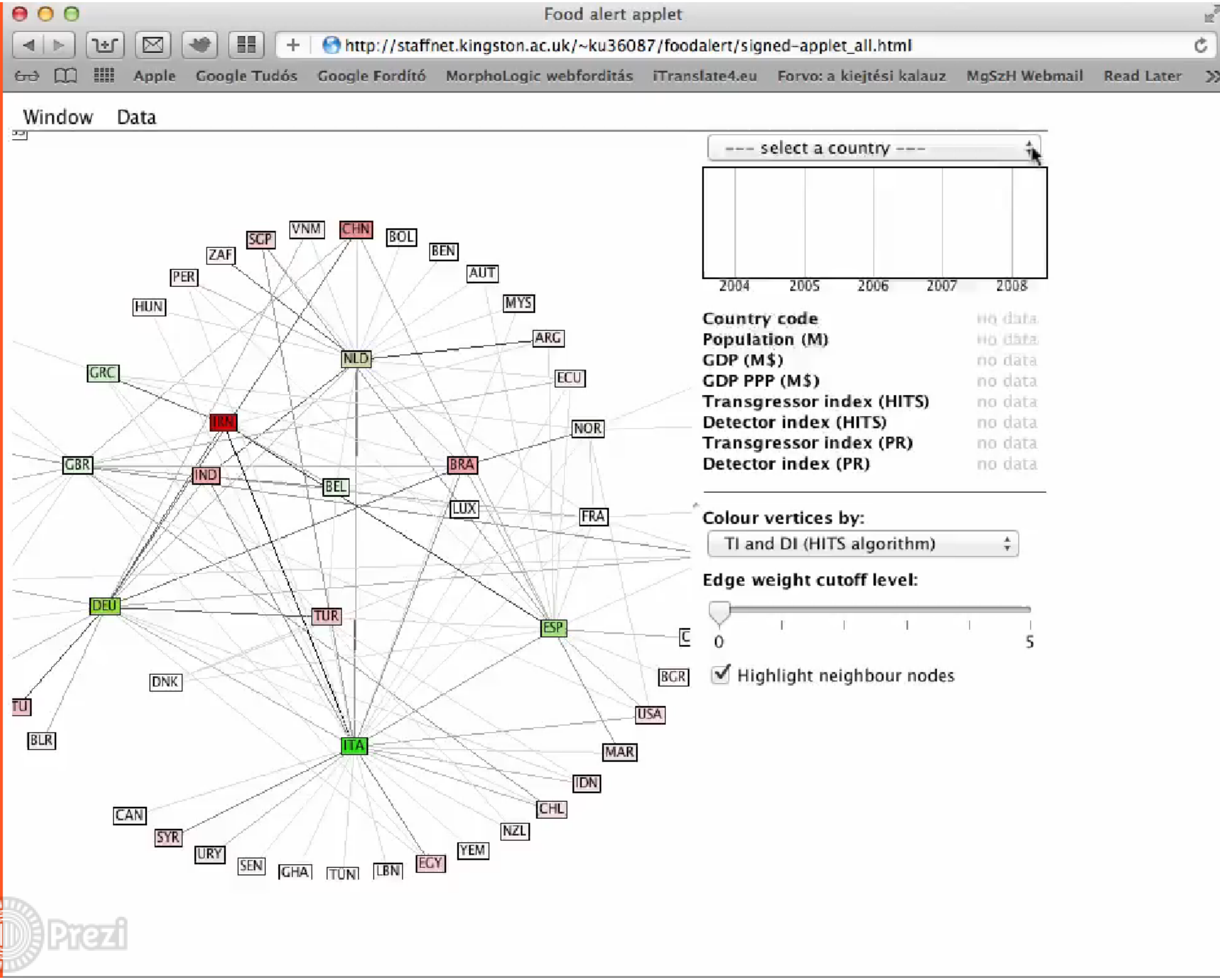


Export-import (trade)

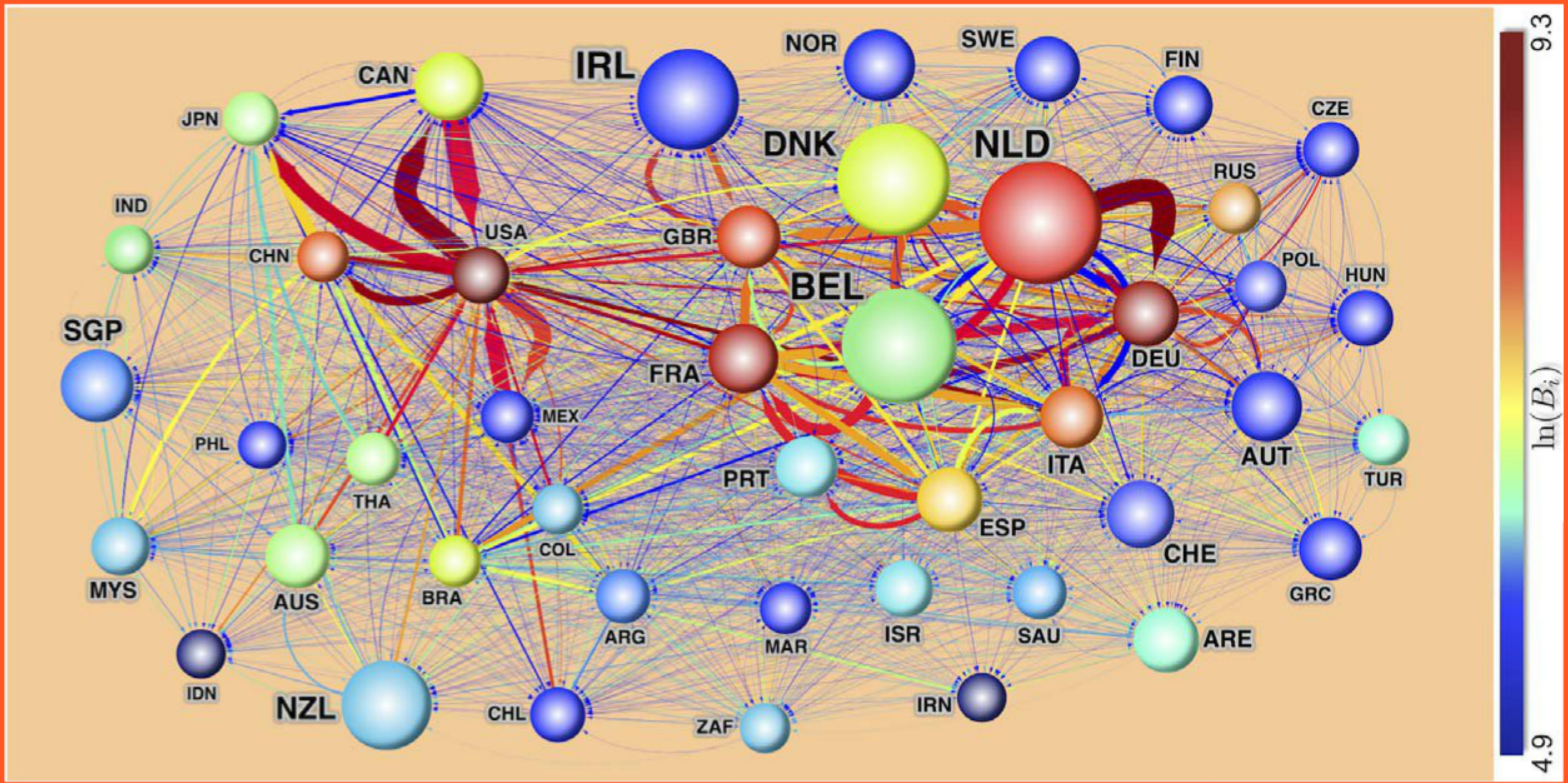


Ercsey-Ravasz, M., Toroczkai, Z., Lakner, Z., & Baranyi, J. (2012). Complexity of the International Agro-Food Trade Network and Its Impact on Food Safety. (V. Colizza, Ed.)PLoS ONE, 7(5), e37810. doi:10.1371/journal.pone.0037810

- Find patterns
- Observe sudden changes
- Choose higher risk nodes or link



Food alert applet
http://staffnet.kingston.ac.uk/~ku36087/foodalert/signed-applet_all.html
Apple
Google Tudós
Google Fordító
MorphoLogic webfordítás
iTranslate4.eu
Forvo: a kiejtési kalauz
MgSzH Webmail
Read Later
Window
Data
--- select a country ---
2004
2005
2006
2007
2008
Country code
Population (M)
GDP (M$)
GDP PPP (M$)
Transgressor index (HITS)
Detector index (HITS)
Transgressor index (PR)
Detector index (PR)
no data
Colour vertices by:
TI and DI (HITS algorithm)
Edge weight cutoff level:
0
5
Highlight neighbour nodes
VNM
CHN
SGP
BOL
ZAF
BEN
PER
AUT
HUN
MYS
ARG
NLD
GRC
ECU
IRN
NOR
GBR
IND
BRA
BEL
LUX
FRA
DEU
TUR
ESP
DNK
BGR
USA
BLR
ITA
MAR
IDN
CAN
CHL
SYR
NZL
URY
YEM
SEN
GHA
TUN
LBN
EGY



Ercsey-Ravasz, M., Toroczkai, Z., Lakner, Z., & Baranyi, J. (2012). Complexity of the International Agro-Food Trade Network and Its Impact on Food Safety. (V. Colizza, Ed.)PLoS ONE, 7(5), e37810. doi:10.1371/journal.pone.0037810

- Find patterns
- Observe sudden changes
- Choose higher risk nodes or link

Our aim is to protect this network

Scale-free networks: allows for a fault tolerant behaviour
but on the other hand, if we choose few major hubs and take them out of the network, it simply falls apart and is turned into a set of rather isolated graphs.

Network of businesses

From the aspect of food-chain control: global network → optimization & planning at world level would be needed

↓

but no world level, even not EU level optimization exists, just MS level

↓

Key players: FBOs → Network mapping of food businesses

↑

Prezi

Network of businesses

From the aspect of food-chain control: global network

optimization & planning at world level would be needed

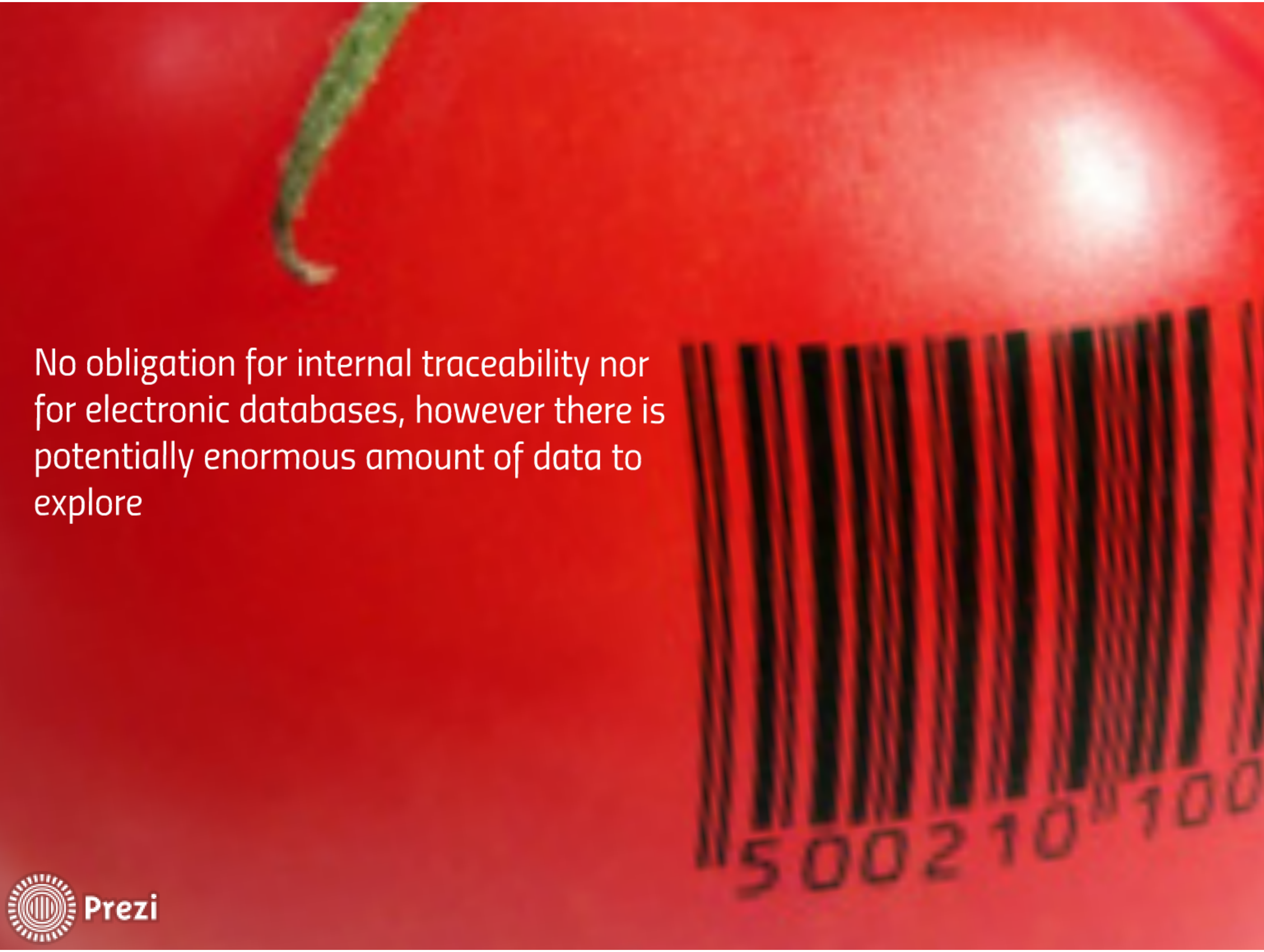
but no world level, even not EU level optimization exists, just MS level

Key players: FBOs

Network mapping of food businesses

Traceability

'one step back –
one step forward'


No obligation for internal traceability nor for electronic databases, however there is potentially enormous amount of data to explore
Prezi

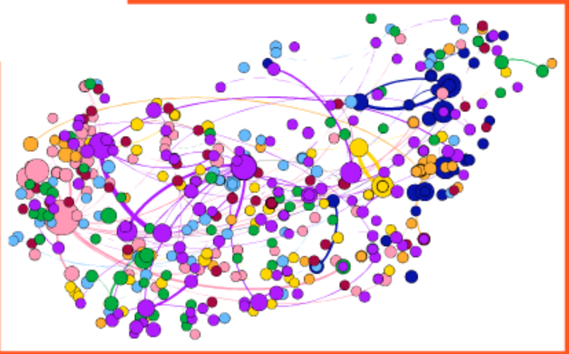
Network of animal farms

Which farm is the most probable place being a hub in future epidemies?

Which network science measures fit reality the most?

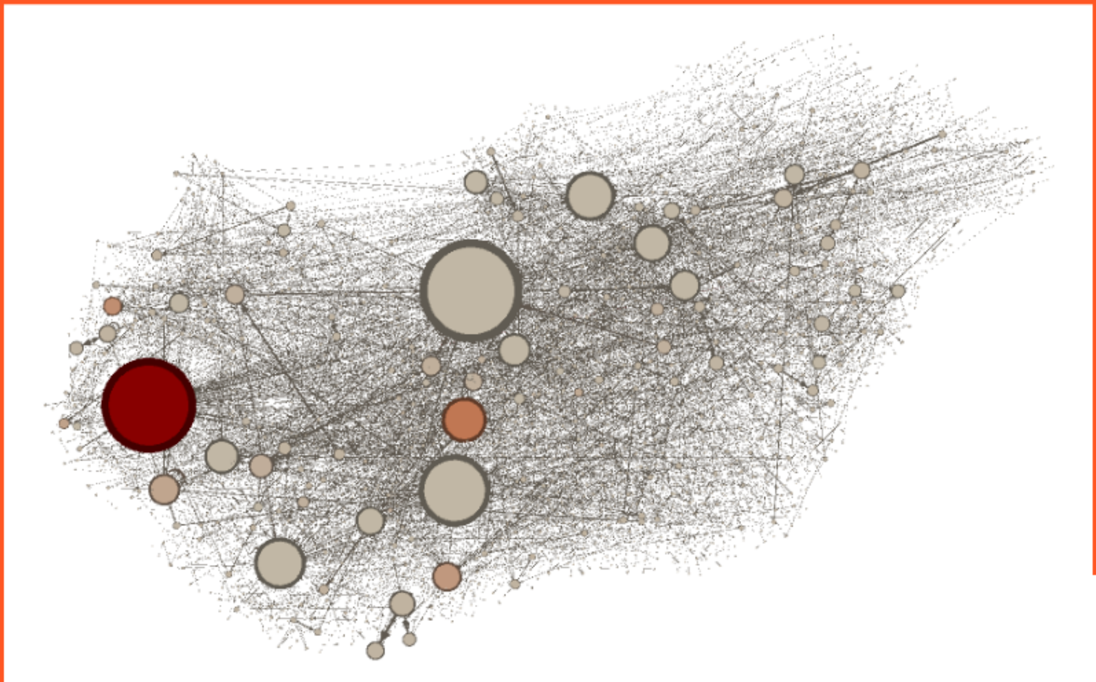
Which trade routes are the most risky?

Elaboration of spreading models



Prezi

Network of animal farms

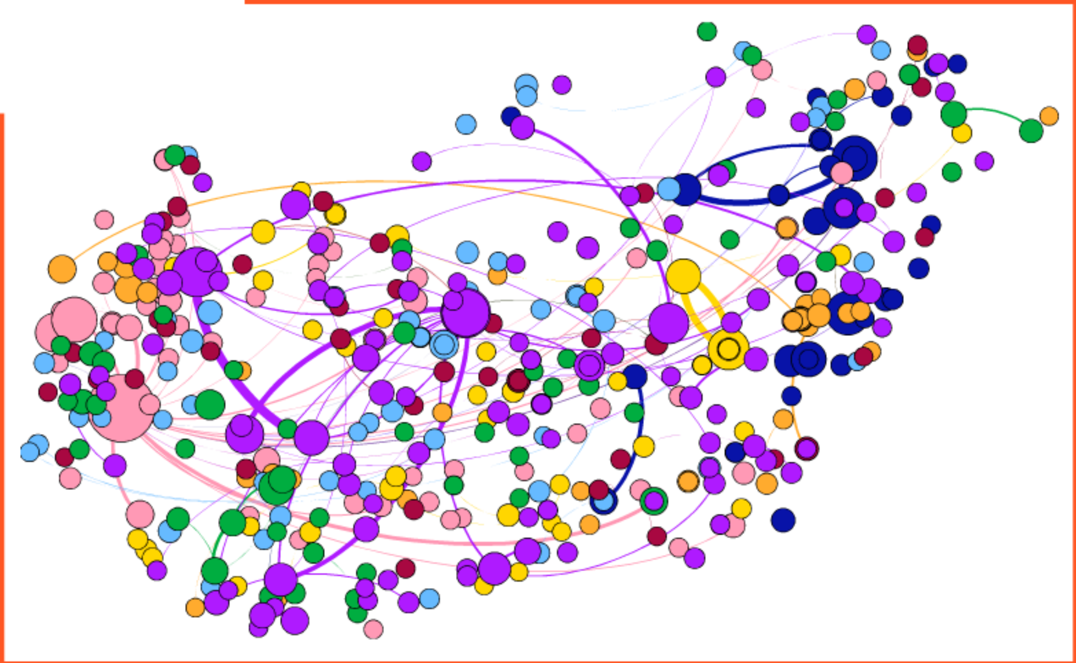


Which farm is the most probable place being a hub in future epidemies?

Which network science measures fit reality the most?

Which trade routes are the most risky?

Elaboration of spreading models



Prezi

Network with consumers

- Market basket analysis
- Investigation of food-chain incidents
- Loyalty cards?

Embedded networks!

Non-food epidemic outbreaks:
people-to-people

↔

Food incidents:
food-to-people

The epidemiologic investigation has the most significant importance till the moment of the identification of the food causing the incident (e.g. German EHEC).

Are we able to draw the network at the point when we do not know exactly the nodes and links (i.e. source food)?

Is network science a helpful tool in those situations?

Actually, yes:

Network with consumers

- Market basket analysis
- Investigation of food-chain incidents
- Loyalty cards?

Embedded networks!

Non-food epidemic outbreaks:
people-to-people

↔

Food incidents:
food-to-people

The epidemiologic investigation has the most significant importance till the moment of the identification of the food causing the incident (e.g. German EHEC).

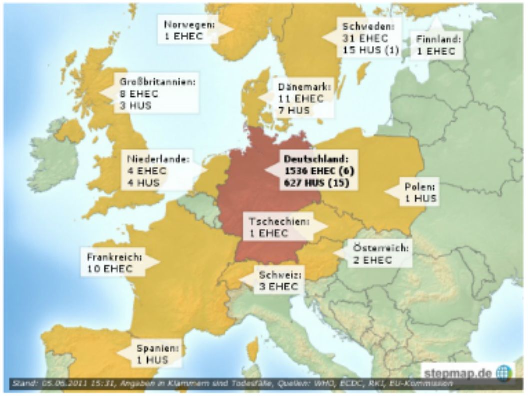
Are we able to draw the network at the point when we do not know exactly the nodes and links (i.e. source food)?

Is network science a helpful tool in those situations?

Actually, yes: Wilking H. et al.: Identifying Risk Factors for Shiga Toxin-producing Escherichia coli by Payment Information (2012)

Food incidents: food-to-people

The epidemiologic investigation has the most significant importance till the moment of the identification of the food causing the incident (e.g. German EHEC).



Are we able to draw the network at the point when we do not know exactly the nodes and links (i.e. source food)?

Is network science a helpful tool in those situations?

Actually, yes: Wilking H. et al.: Identifying Risk Factors for Shiga Toxin-producing Escherichia coli by Payment Information (2012)

Fight against terrorism –
Protecting the critical infrastructures

Usual food network risk analysis ↔ Risk analysis from critical infrastructure point of view

unintentional

intentional

Same food network
different outcomes for risk assessment
↓
different vulnerable points

Fight against terrorism – Protecting the critical infrastructures

Usual food network risk analysis ↔ Risk analysis from critical infrastructure point of view

unintentional

intentional

Same food network

different outcomes for risk assessment

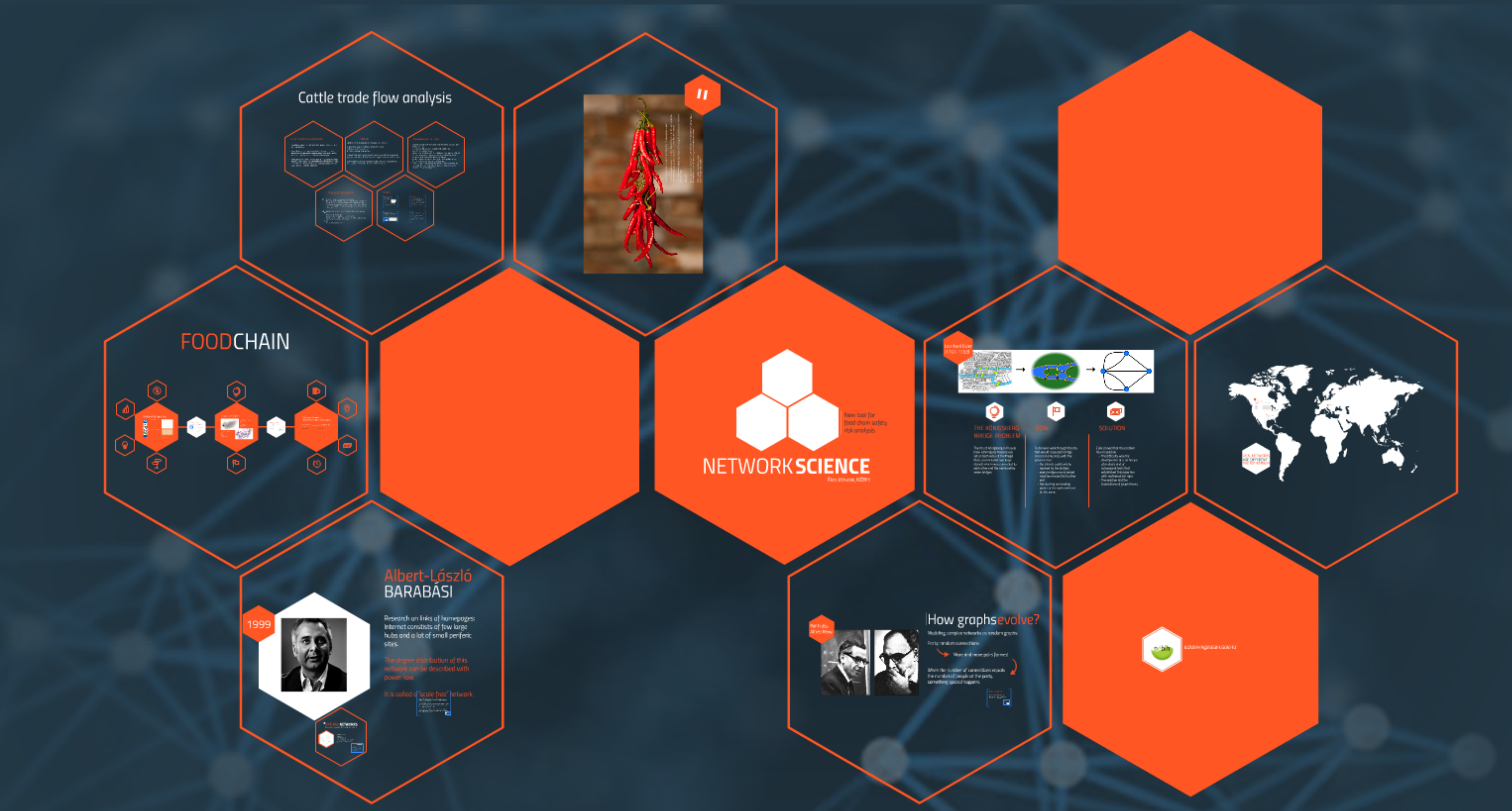
↓

different vulnerable points

Same food network

different outcomes for risk assessment → different vulnerable points


FOODCHAIN
Network of countries
Network of businesses
Network of animal farms
Which trade routes are the most risky?
Fight against terrorism –
Protecting the critical infrastructures
unintentional
intentional
YOURTITLE
Prezi



Cattle trade flow analysis
FOODCHAIN
NETWORK SCIENCE
Albert-László
BARABÁSI
1999
Research on links of homepages: Internet consists of few large hubs and a lot of small periferic sites.
The degree distribution of this network can be described with power law.
How graphs evolve?

Prezi

Cattle trade flow analysis

Conventional risk based planning

- The data needed for the substantiated risk assessment are in many cases not available
- The problem with the conventional risk based approach is that it **doesn't take into account the network flow, the dynamics**, just the pure output or production data and other static risk factors.
- With application of network analysis tools, it is possible to add a **new, dynamic, science based** and **standardized layer of information** to the assessment and planning methodology, **resulting in different** - and presumably more **realistic** - **outcomes**

Methods

Static and dynamic properties of the network were defined.

Degree: the number of relations or edges of the nodes
In-Degree: incoming connections
Out-Degree: outgoing connections

Degree has generally been extended to the sum of weights when analysing weighted networks and labelled as node strength: number of animals moved.

To understand the relative importance of different hubs in cattle flow, we had to apply the Centrality concepts of network analysis.

Implications for the future

- contributes to determination of the most vulnerable parts of a cattle holding network;
- increases effectiveness of the control of the cattle-flow;
- reveals the interdependencies;
- helps in working out an optimised strategy of the inspection of herds;
- increases preparedness against outbreaks and intentional attacks;
- enhances epidemiological modelling simulations;
- provides information on the source of possible infections so that preventive and control measures can be applied;
- serves the food chain safety and network science community with analysable data and helpful descriptions of the methodology to enhance cross-border cooperation.

Inputs of the research

- National Cattle Identification System and Database (ENAR)
  - able to follow the animals along the whole life cycle, from birth to slaughterhouse or from entering to the territory of Hungary to exporting
  - each movement record reports the unique identifier of the animal, the codes of the holdings of origin and destination, and the date of the movements
- Cattle holding network consists of a set of vertices (nodes) and a set of edges.
  Nodes:
  (1) cattle exporter countries
  (2) the importers, buying living cattle from Hungary
  (3) the various economic organizations (e.g. farms, slaughterhouses, logistic/distribution centers, markets, etc...)
  Edges:
  the cattle-flows between vertices

Results

Structural properties

Centrality measures

Dynamic properties

Outputs: control plans

Prezi

Conventional risk based planning

- The data needed for the substantiated risk assessment are in many cases not available

- The problem with the conventional risk based approach is that it **doesn't take into account the network flow, the dynamics**, just the pure output or production data and other static risk factors.

- With application of network analysis tools, it is possible to add a **new, dynamic, science based** and **standardized layer of information** to the assessment and planning methodology, **resulting in different** - and presumably more **realistic** - **outcomes**

Inputs of the research

- National Cattle Identification System and Database (ENAR)
  - able to follow the animals along the whole life cycle, from birth to slaughterhouse or from entering to the territory of Hungary to exporting
  - each movement record reports the unique identifier of the animal, the codes of the holdings of origin and destination, and the date of the movements

- Cattle holding network: consists of a set of vertices (nodes) and a set of edges.

  Nodes:

  (1) cattle exporter countries

  (2) the importers, buying living cattle from Hungary

  (3) the various economic organizations (e.g. farms, slaughterhouses, logistic/distribution centers, markets, etc...)

  Edges:

  the cattle-flows between vertices

Methods

Static and dynamic properties of the network were defined.

Degree: the number of relations or edges of the nodes
In-Degree: incoming connections
Out-Degree: outgoing connections

Degree has generally been extended to the sum of weights when analysing weighted networks and labelled as node strength: number of animals moved.

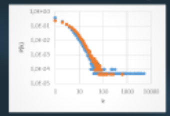
To understand the relative importance of different hubs in cattle flow, we had to apply the Centrality concepts of network analysis.

Results

Structural properties

Based on the degree distribution the Hungarian cattle holdings network shows scale-free network characteristics: it is a network whose degree distribution follows a power law.

The degree exponent for the Hungarian cattle holdings network is 2,24.



Therefore it shows small world properties, meaning that only few steps are needed to get from a random point to another random point, having large implications in case of spreading of different diseases.

Centrality measures

The most vulnerable points of a network are not necessarily their largest hubs. To extract information on the nodes playing central role in the network, different centrality measures were calculated: betweenness, closeness, authority and hub centralities were defined.

There is a big difference between those centralities: in case of the authority and hub centrality a central node can be any node in the network, but in the case of betweenness and closeness centralities (as the names indicate) the central nodes can not be source-vertex or sink-vertex. The vertices of high betweenness centrality value are usually logistic centres, transloading places or major livestock farms.

These nodes have important role in epidemiological investigations, because of the high risk of cross-infections.

Dynamic properties

The simplest approach is to observe the number of animals moving per month. The results indicated, that the trade becomes very active in June-July with a peak of activity at the end of the year.

The trend of increasing activity in the second half of the year seems to be stable. This should have an impact on the control time schedules, assigning increased control frequencies to those periods.

Outputs: control plans

The results presented above all contribute to network analysis based risk based control plans.

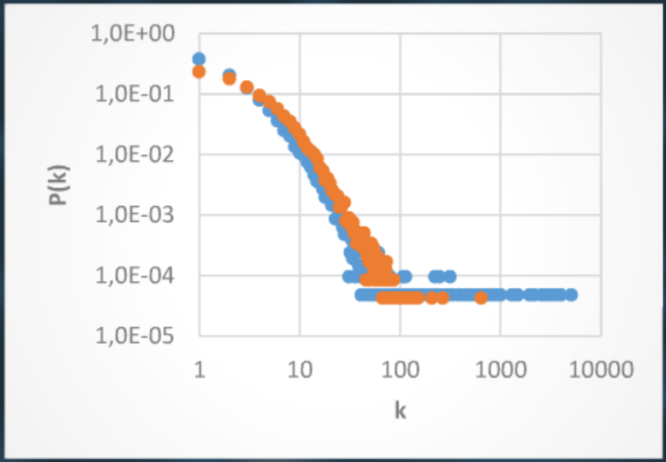
(1) Control plan aiming to control the epidemiological, hygiene, animal welfare, etc. properties ('food chain safety control'), as defined by the Regulation 882/2004/EC

(2) Control plan aiming to control the requirements posed by Regulation 1760/2000/EC on animal identification ('animal identification control')

(3) Control plan for 'critical infrastructures' (critical from food security perspectives).

Structural properties

Based on the degree distribution the Hungarian cattle holdings network shows scale-free network characteristics: it is a network whose degree distribution follows a power law.



The degree exponent for the Hungarian cattle holdings network is 2,24.

Therefore it shows small world properties, meaning that only few steps are needed to get from a random point to another random point, having large implications in case of spreading of different diseases.

Prezi

Centrality measures

The most vulnerable points of a network are not necessarily their largest hubs. To extract information on the nodes playing central role in the network, different centrality measures were calculated: betweenness, closeness, authority and hub centralities were defined.

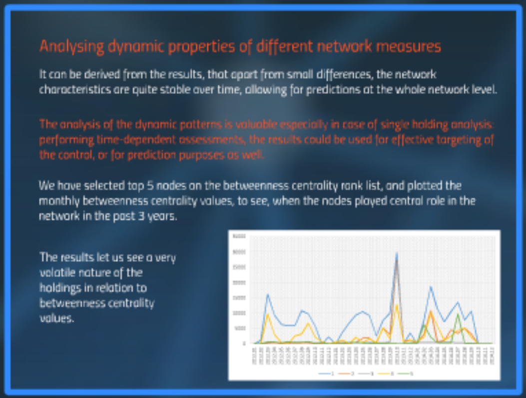
There is a big difference between those centralities: in case of the authority and hub centrality a central node can be any node in the network, but in the case of betweenness and closeness centralities (as the names indicate) the central nodes can not be source-vertex or sink-vertex. The vertices of high betweenness centrality value are usually logistic centres, transloading places or major livestock farms.

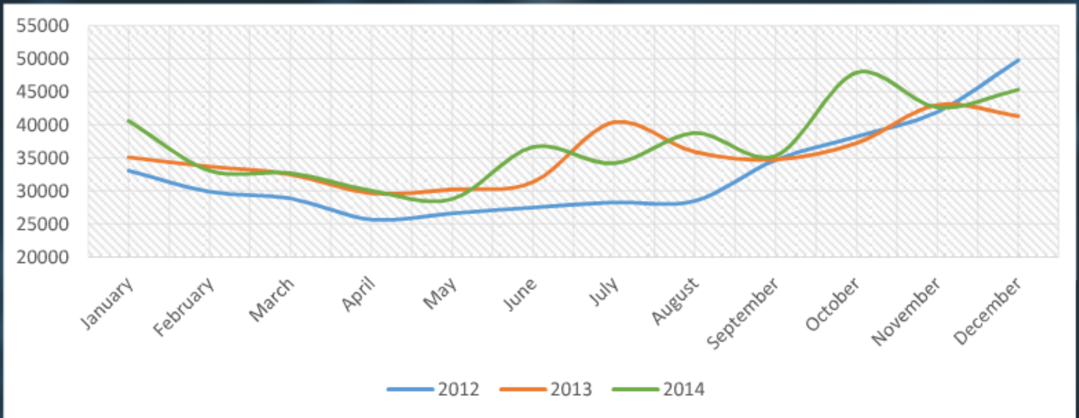
These nodes have important role in epidemiological investigations, because of the high risk of cross-infections.

Dynamic properties

The simplest approach is to observe the number of animals moving per month. The results indicated, that the trade becomes very active in June-July with a peak of activity at the end of the year.

The trend of increasing activity in the second half of the year seems to be stable. This should have an impact on the control time schedules, assigning increased control frequencies to those periods.





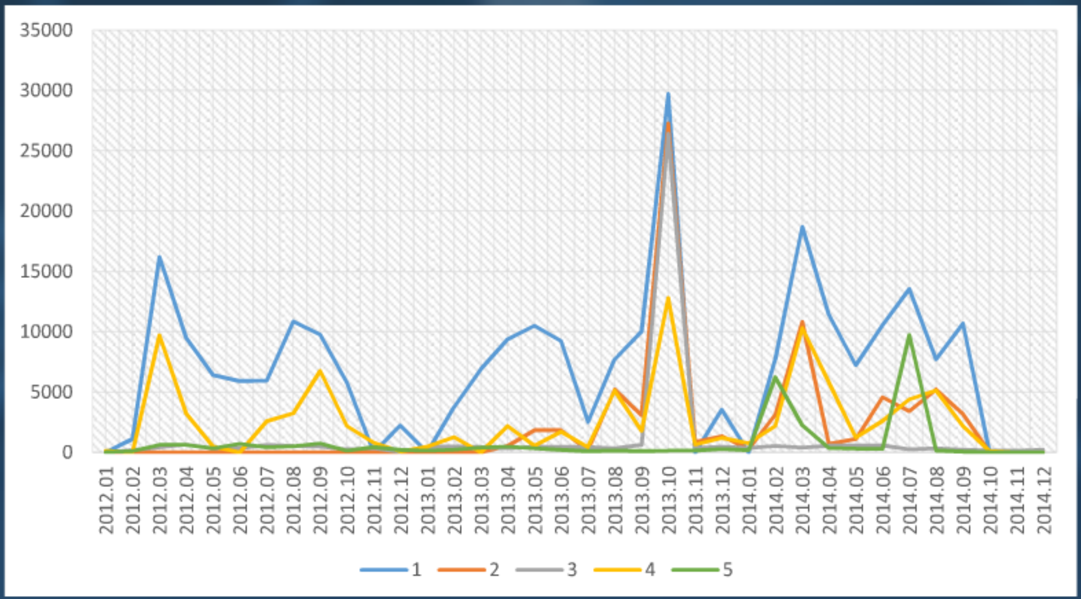
Analysing dynamic properties of different network measures

It can be derived from the results, that apart from small differences, the network characteristics are quite stable over time, allowing for predictions at the whole network level.

The analysis of the dynamic patterns is valuable especially in case of single holding analysis: performing time-dependent assessments, the results could be used for effective targeting of the control, or for prediction purposes as well.

We have selected top 5 nodes on the betweenness centrality rank list, and plotted the monthly betweenness centrality values, to see, when the nodes played central role in the network in the past 3 years.

The results let us see a very volatile nature of the holdings in relation to betweenness centrality values.



Prezi

Outputs: control plans

The results presented above all contribute to network analysis based risk based control plans.

(1) Control plan aiming to control the epidemiological, hygiene, animal welfare, etc. properties ('food chain safety control'), as defined by the Regulation 882/2004/EC

(2) Control plan aiming to control the requirements posed by Regulation 1760/2000/EC on animal identification ('animal identification control')

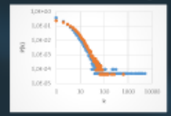
(3) Control plan for 'critical infrastructures' (critical from food security perspectives).

Results

Structural properties

Based on the degree distribution the Hungarian cattle holdings network shows scale-free network characteristics: it is a network whose degree distribution follows a power law.

The degree exponent for the Hungarian cattle holdings network is 2,24.



Therefore it shows small world properties, meaning that only few steps are needed to get from a random point to another random point, having large implications in case of spreading of different diseases.

Dynamic properties

The simplest approach is to observe the number of animals moving per month. The results indicated, that the trade becomes very active in June-July with a peak of activity at the end of the year.

The trend of increasing activity in the second half of the year seems to be stable. This should have an impact on the control time schedules, assigning increased control frequencies to those periods.

Centrality measures

The most vulnerable points of a network are not necessarily their largest hubs. To extract information on the nodes playing central role in the network, different centrality measures were calculated: betweenness, closeness, authority and hub centralities were defined.

There is a big difference between those centralities: in case of the authority and hub centrality a central node can be any node in the network, but in the case of betweenness and closeness centralities (as the names indicate) the central nodes can not be source-vertex or sink-vertex. The vertices of high betweenness centrality value are usually logistic centres, transloading places or major livestock farms.

These nodes have important role in epidemiological investigations, because of the high risk of cross-infections.

Outputs: control plans

The results presented above all contribute to network analysis based risk based control plans.

(1) Control plan aiming to control the epidemiological, hygiene, animal welfare, etc. properties ('food chain safety control'), as defined by the Regulation 882/2004/EC

(2) Control plan aiming to control the requirements posed by Regulation 1760/2000/EC on animal identification ('animal identification control')

(3) Control plan for 'critical infrastructures' (critical from food security perspectives).

Implications for the future

- contributes to determination of the most vulnerable parts of a cattle holding network;
- increases effectiveness of the control of the cattle-flow;
- reveals the interdependencies;
- helps in working out an optimised strategy of the inspection of herds;
- increases preparedness against outbreaks and intentional attacks;
- enhances epidemiological modelling simulations;
- provides information on the source of possible infections so that preventive and control measures can be applied;
- serves the food chain safety and network science community with analysable data and helpful descriptions of the methodology to enhance cross-border cooperation.

Cattle trade flow analysis

Conventional risk based planning

- The data needed for the substantiated risk assessment are in many cases not available
- The problem with the conventional risk based approach is that it **doesn't take into account the network flow, the dynamics**, just the pure output or production data and other static risk factors.
- With application of network analysis tools, it is possible to add a **new, dynamic, science based** and **standardized layer of information** to the assessment and planning methodology, **resulting in different** - and presumably more **realistic** - **outcomes**

Methods

Static and dynamic properties of the network were defined.

Degree: the number of relations or edges of the nodes
In-Degree: incoming connections
Out-Degree: outgoing connections

Degree has generally been extended to the sum of weights when analysing weighted networks and labelled as node strength: number of animals moved.

To understand the relative importance of different hubs in cattle flow, we had to apply the Centrality concepts of network analysis.

Implications for the future

- contributes to determination of the most vulnerable parts of a cattle holding network;
- increases effectiveness of the control of the cattle-flow;
- reveals the interdependencies;
- helps in working out an optimised strategy of the inspection of herds;
- increases preparedness against outbreaks and intentional attacks;
- enhances epidemiological modelling simulations;
- provides information on the source of possible infections so that preventive and control measures can be applied;
- serves the food chain safety and network science community with analysable data and helpful descriptions of the methodology to enhance cross-border cooperation.

Inputs of the research

- National Cattle Identification System and Database (ENAR)
  - able to follow the animals along the whole life cycle, from birth to slaughterhouse or from entering to the territory of Hungary to exporting
  - each movement record reports the unique identifier of the animal, the codes of the holdings of origin and destination, and the date of the movements
- Cattle holding network: consists of a set of vertices (nodes) and a set of edges.

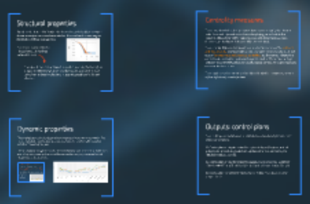
  Nodes:

  (1) cattle exporter countries
  (2) the importers, buying living cattle from Hungary
  (3) the various economic organizations (e.g. farms, slaughterhouses, logistic/distribution centers, markets, etc...)

  Edges:

  the cattle-flows between vertices

Results



Prezi

Cattle trade flow analysis
FOODCHAIN
NETWORK SCIENCE
New tool for food chain safety risk analysis
Albert-László BARABÁSI
1999
Research on links of homepages: Internet consists of few large hubs and a lot of small periferic sites.
The degree distribution of this network can be described with power law.
It is called a "scale free" network.
How graphs evolve?
Prezi

„If we tie a lot of cherry-peppers on a string, they'll make a pepper-wreath.

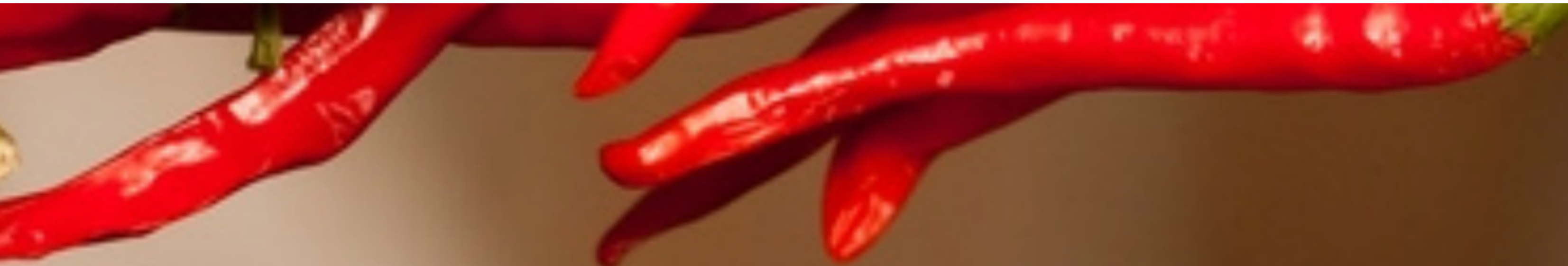
However, if we don't tie them on a string, they won't make a wreath. Although it's the same amount of peppers, just as red and just as hot. But still no wreath.

Does it only lie in the string? No, it doesn't. That string, as we all know, is an incidental, third-rate thing.

Then what?

People capable of brooding over it and taking care not to let their mind wander about, but keep them on the right track may get a scent of eternal verities."

Örkény István: The meaning of life
Translated by N. Ullrich Katalin



„If we tie a lot of cherry-peppers on a string, they'll make a pepper-wreath.

However, if we don't tie them on a string, they won't make a wreath. Although it's the same amount of peppers, just as red and just as hot. But still no wreath.

Does it only lie in the string? No, it doesn't. That string, as we all know, is an incidental, third-rate thing.

Then what?

People capable of brooding over it and taking care not to let their mind wander about, but keep them on the right track may get a scent of eternal verities."

Örkény István: The meaning of life
Translated by N. Ullrich Katalin

JOZWIAKA@NEBIH.GOV.HU