



Big Data <-> Big Networks

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Big Data  **Big Networks**

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<http://diaz-guilera.net>

@anduviera


complexity lab barcelona

 COMPLEXITAT

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Mid 20th century

- Applications to matter: physics and chemistry
- Phase transitions: concept of universality

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Late 20th century

- Applications to biology
- Concept of **complexity**
- There were other stories too: chaos, synergetics,

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Complexity

- The whole is not the sum of its constituents
- Emergent behaviors from individual behaviors of the units that form it
- Applications to social sciences

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Complexity

I think the next [21st] century will be the century of complexity. We have already discovered the basic laws that govern matter and understand all the normal situations. We don't know how the laws fit together, and what happens under extreme conditions. But I expect we will find a complete unified theory sometime this century. There is no limit to the complexity that we can build using those basic laws.

[Answer to question: Some say that while the twentieth century was the century of physics, we are now entering the century of biology.
What do you think of this?]

— Stephen W. Hawking



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Interdisciplinariety

- Physics
- Chemistry
- Geology
- Biology
- Mathematics
- Computation
- Social sciences

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Early 21st century

- Complex networks
- How this affects previous knowledge?

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Research in complex networks

- Fundamentals:
 - Mathematics
 - Computer sciences
 - Physics
- Applications:
 - Wide disciplinar spectrum

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Complex networks

- Many examples

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Simple networks?

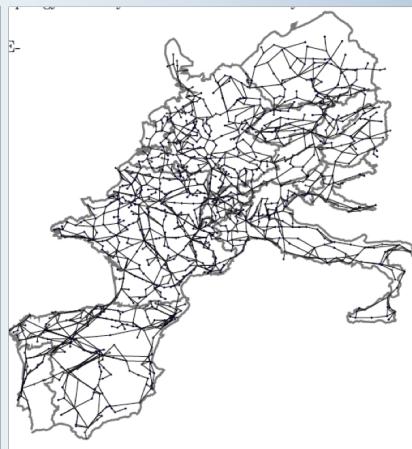
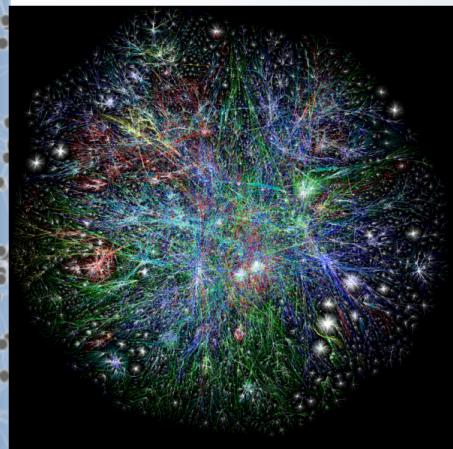


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Examples

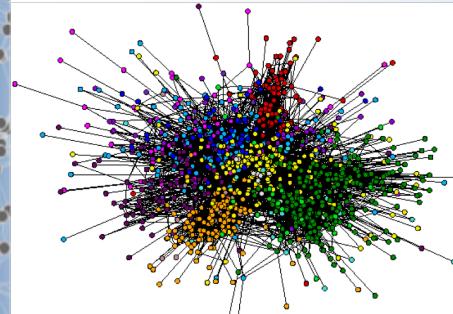


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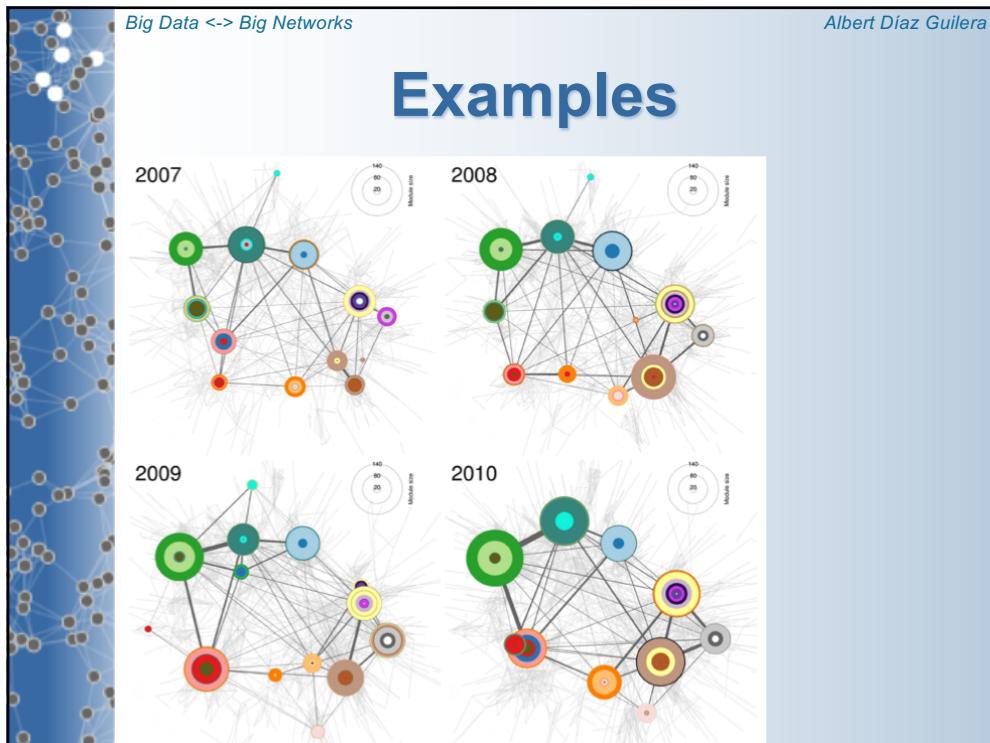
Examples



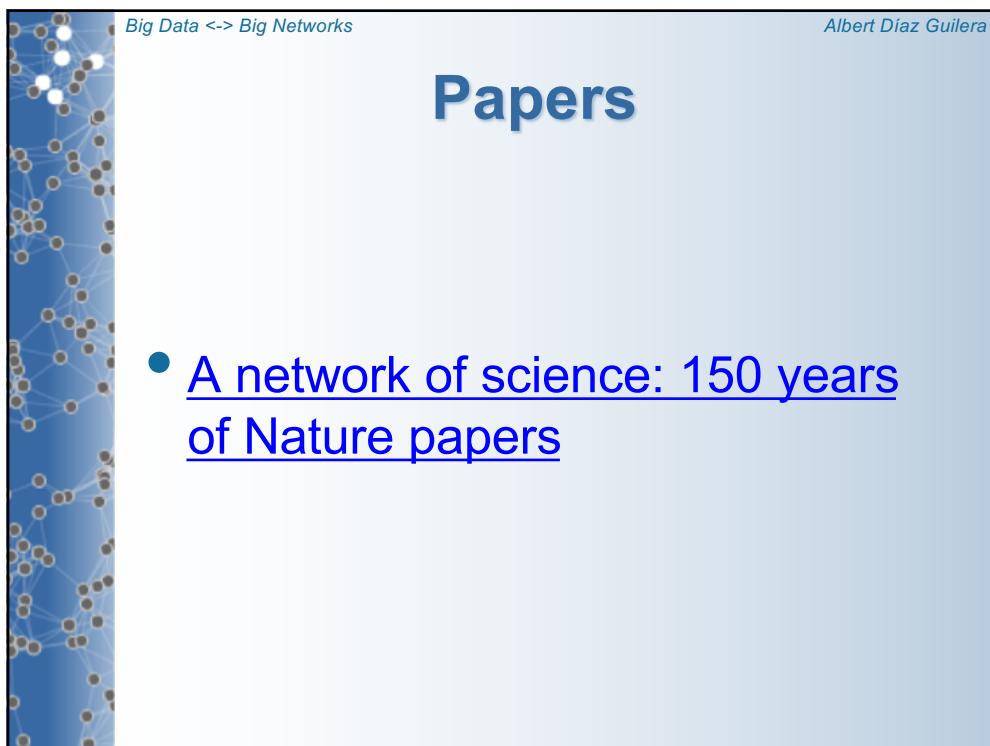
Red de transporte metropolitano de Barcelona



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What do they have in common?

- Nodes: entities
- Links: real connections (physically wired)

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Data

- Not always the data has the structure of a network
- We generate relational or functional patterns
- Structure vs. functionality

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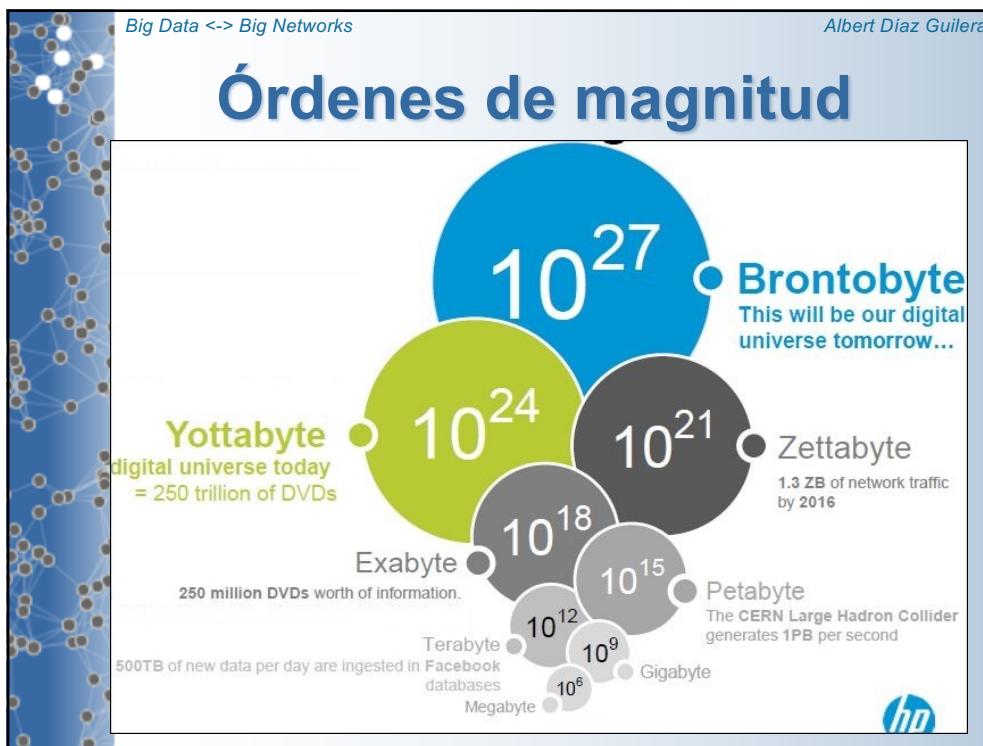
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Big Data: origin

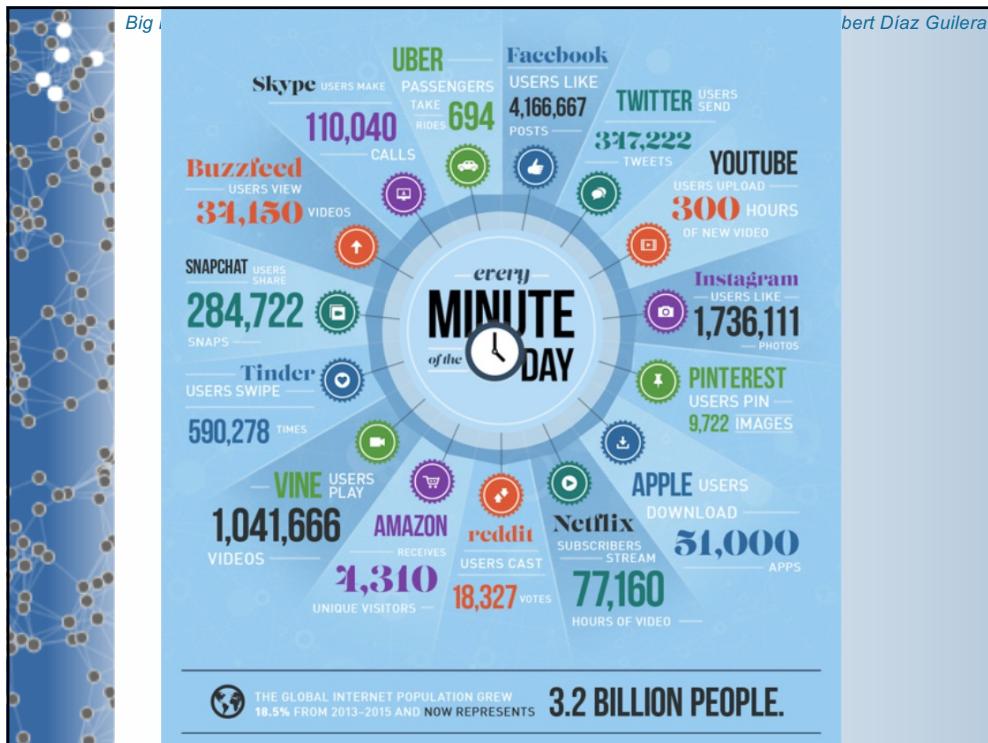
- Life sciences: -omics
- Social sciences:
 - mobility
 - Communication, with machines and other humans
 - Economical transactions



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How we get the data?

- Data from Big Networks:

- Facebook
- Twitter
- Google
- Instagram

<https://dev.twitter.com/>
<https://developers.google.com/maps/>
<https://developers.google.com/+api/>
<http://developers.facebook.com/>

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Data => Networks

- We collect data and convert it into networks

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Big Data => Big Networks

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What to do when there is missing data?

- Forget about them?
- Statistical inference
- Incomplete sampling

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What about networks?

- Do we always know the real links?
- False negatives and false positives
- Inference

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Complex networks

- Not always links correspond to real wired connections
- Structural networks vs. Functional networks
 - Brain networks: structure & function

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- The Brain Connectome Explained Through Graph Theory

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Transportation network

vs.

Mobility network

- Static data from maps
- Dynamic data from records:
 - GPS
 - Origin-destination polls
 - Phone calls

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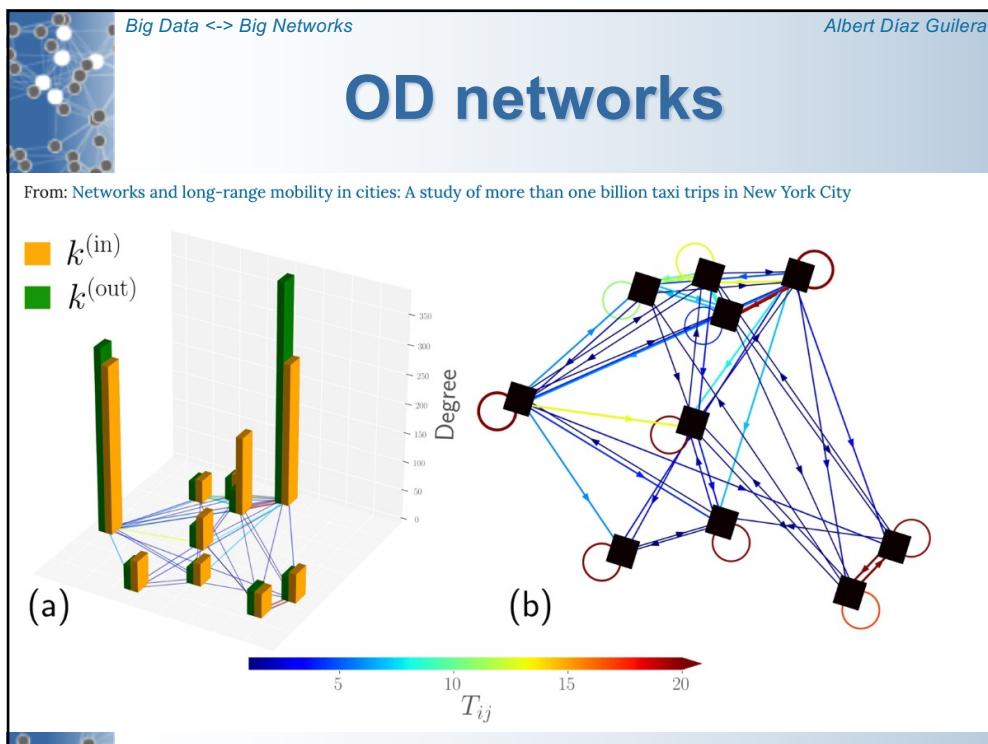
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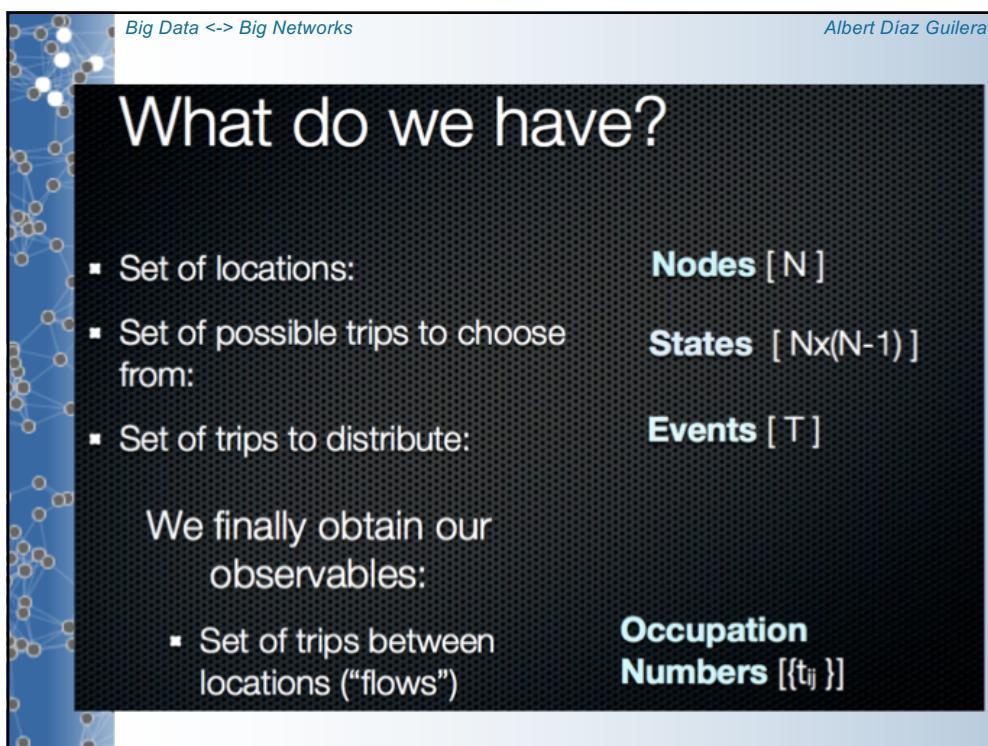
Mobility network

- Table with origins and destinations?
- Can we go further?

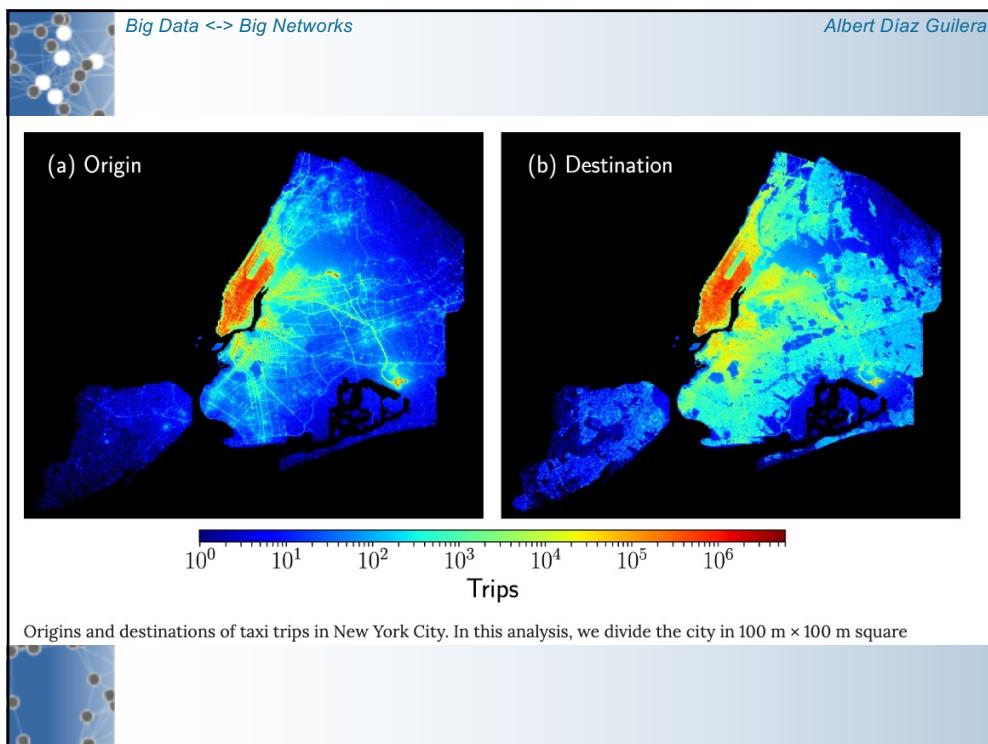
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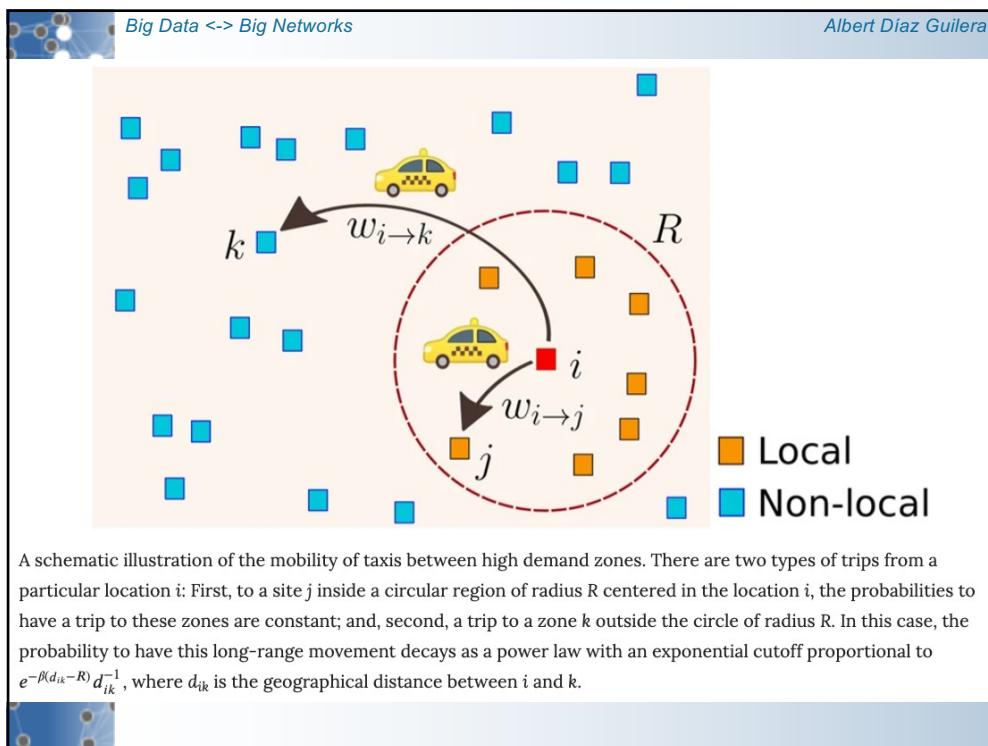
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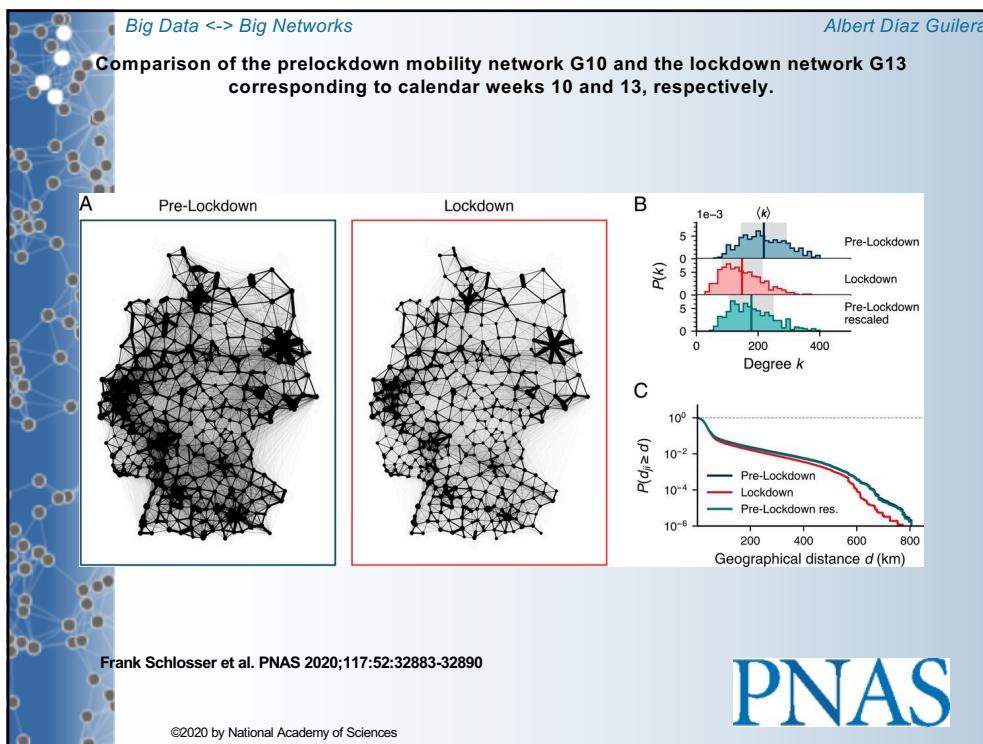
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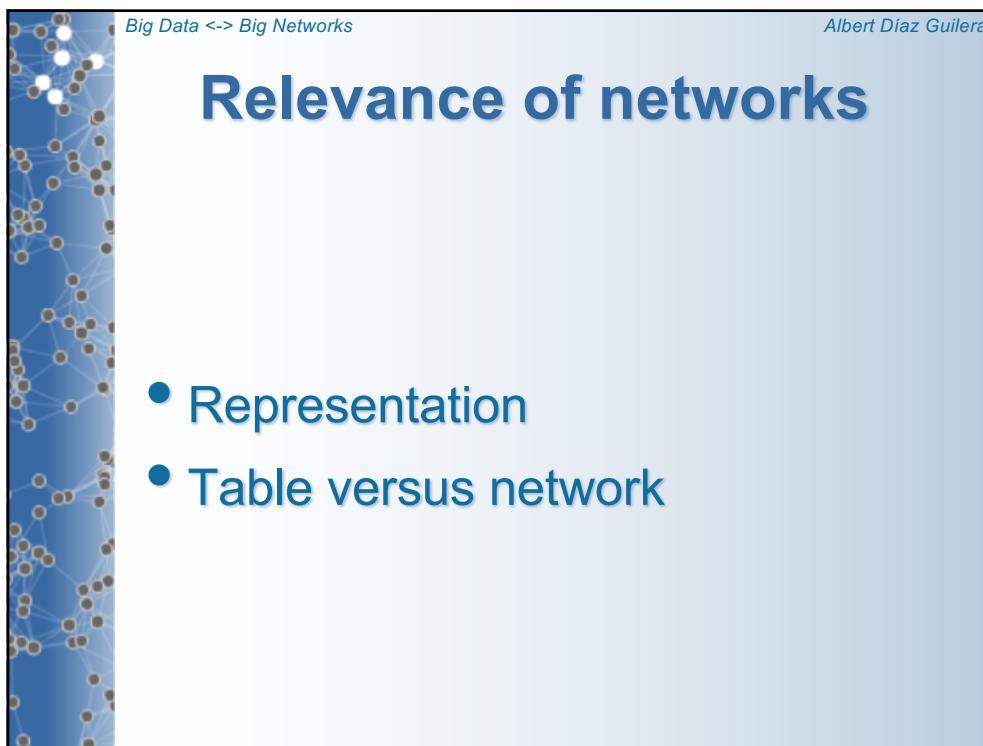
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Network helps to visualize

- [Redes UB \(our project\)](#)

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Also to characterize

- **Centrality measures**
 - local: who collaborates with whom
 - global: who is closer to the rest?
 - Why Google became so famous? Google Page Rank: centrality measure (I am more popular if my neighbors are also popular)

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Roles of different actors

- Individual by individual
- Who is who in the structure and in the functionality

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At global level

- How can we characterize a network?
- Forget individual roles
- Statistics

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Statistics

- Distributions: power law distributions far from Poisson-like
- Divergencies of some features of the distributions

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Complexity

- Normal statistics: a few and they are not very interesting
- Long tails: power laws and all its implications

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Scales



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All scales are relevant (simultaneously)

- Local: microscale
- Global: macroscale
- Mid: mesoscale



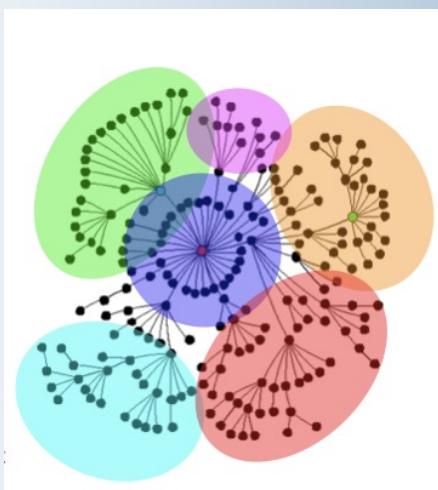
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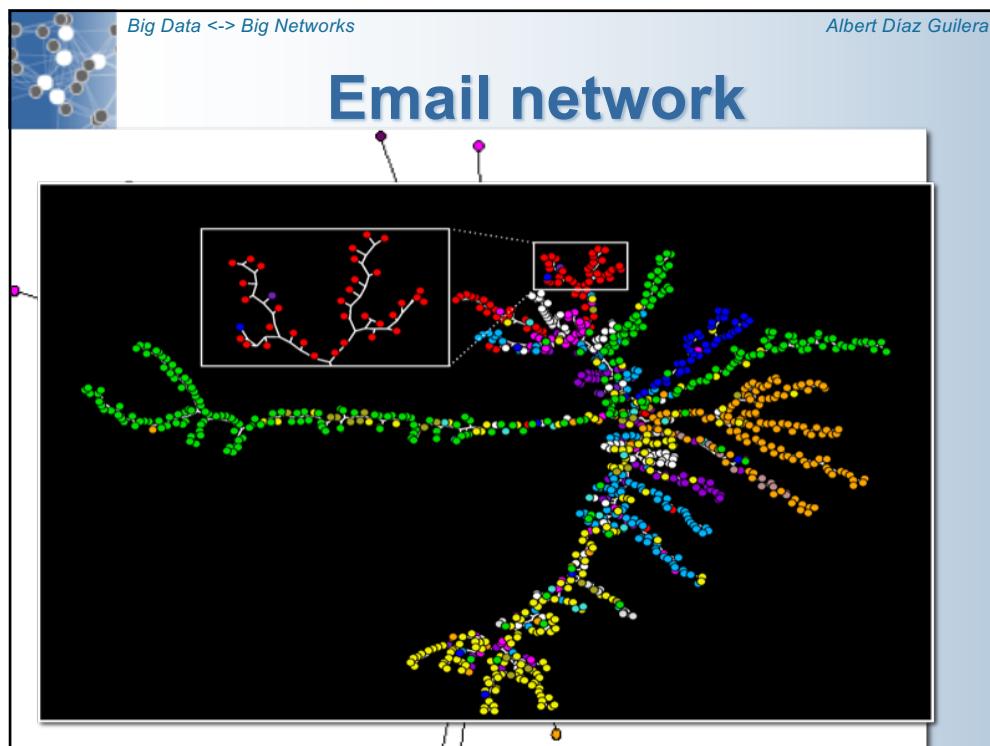
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Communities

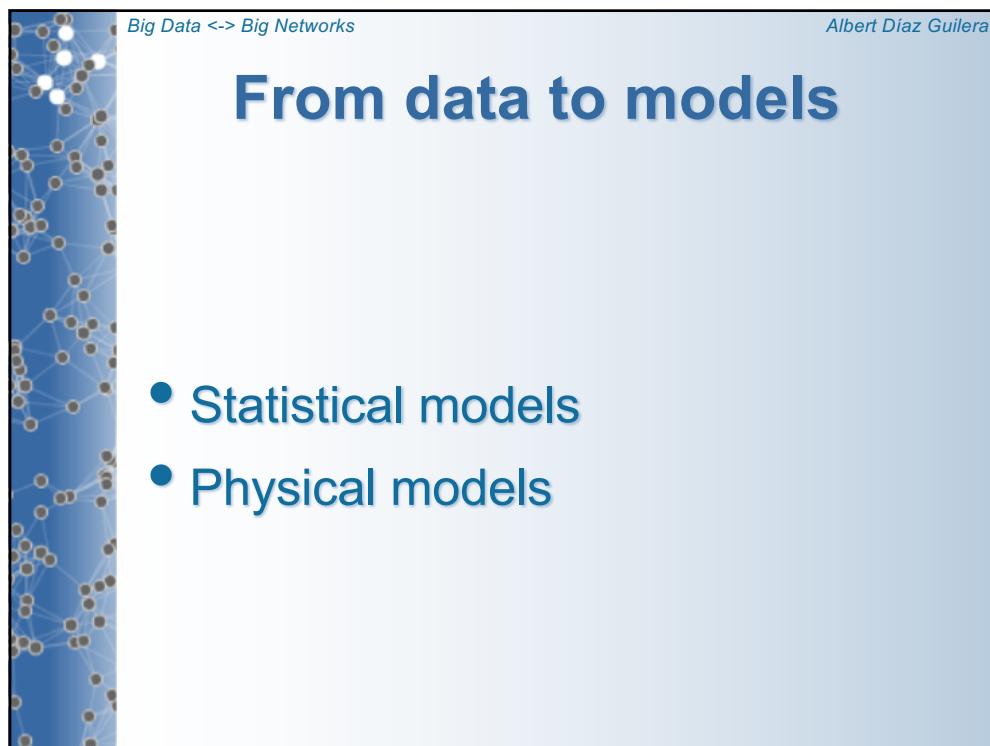
- Groups that have more internal links than with the rest of the nodes (on average)



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Network models

- Erdös-Reny: Random graphs
- Watts-Strogatz: small worlds
- Barabasi-Albert: scale free networks

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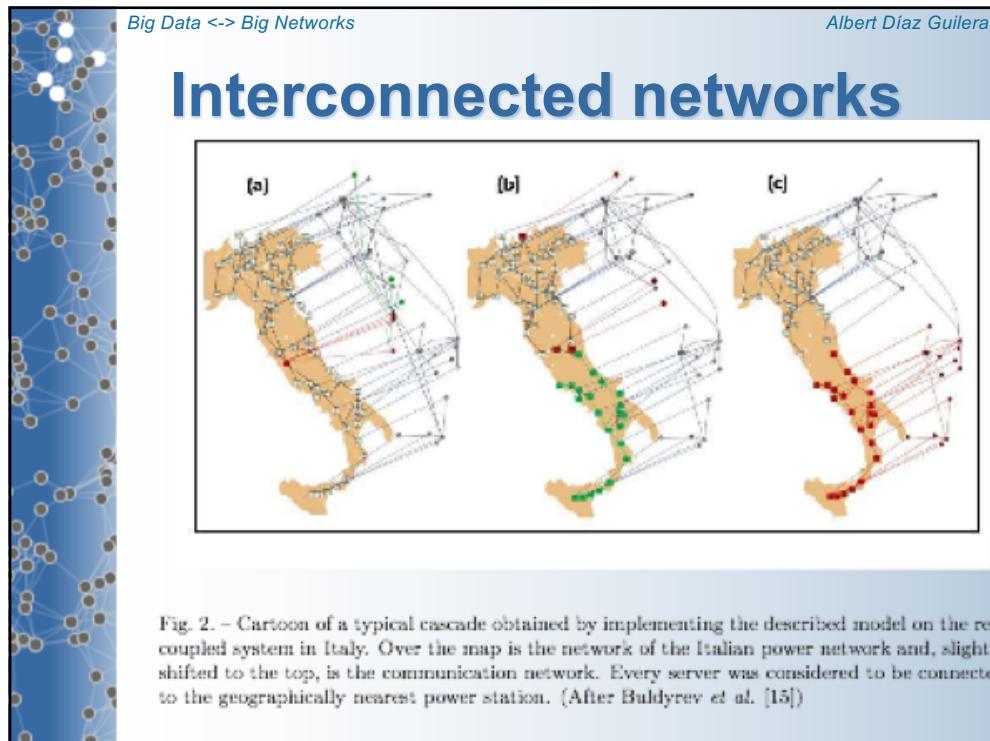
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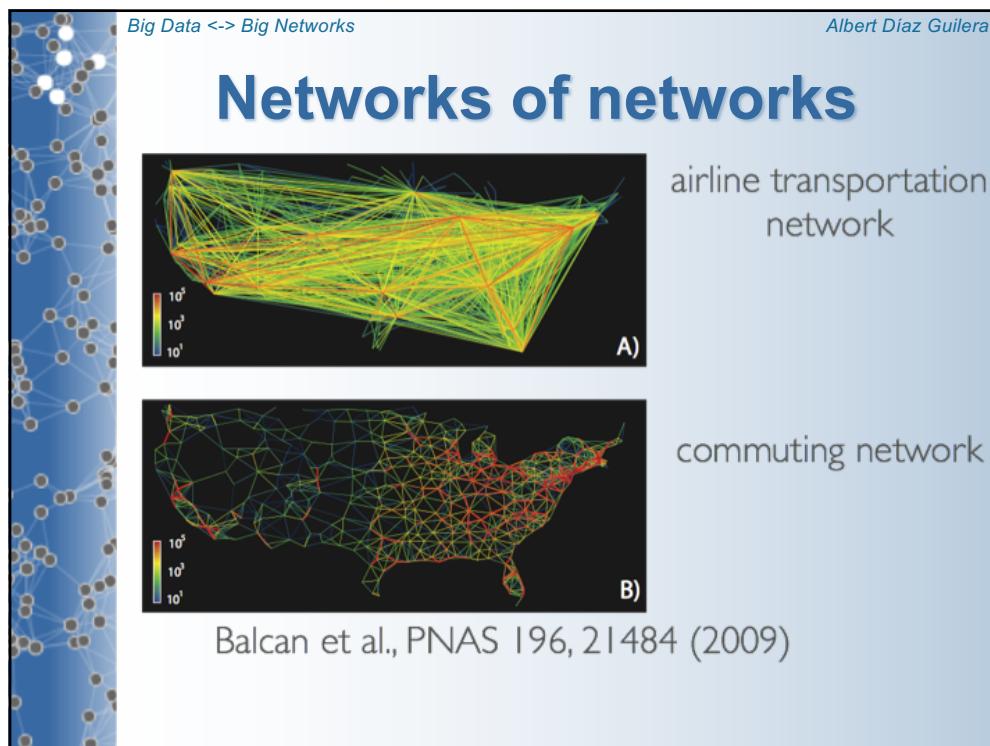
Big data => more complex networks

- New paradigms:
 - Networks of networks
 - Time dependent networks
 - Interconnected networks
 - Networks in multiple layers (multiplex)

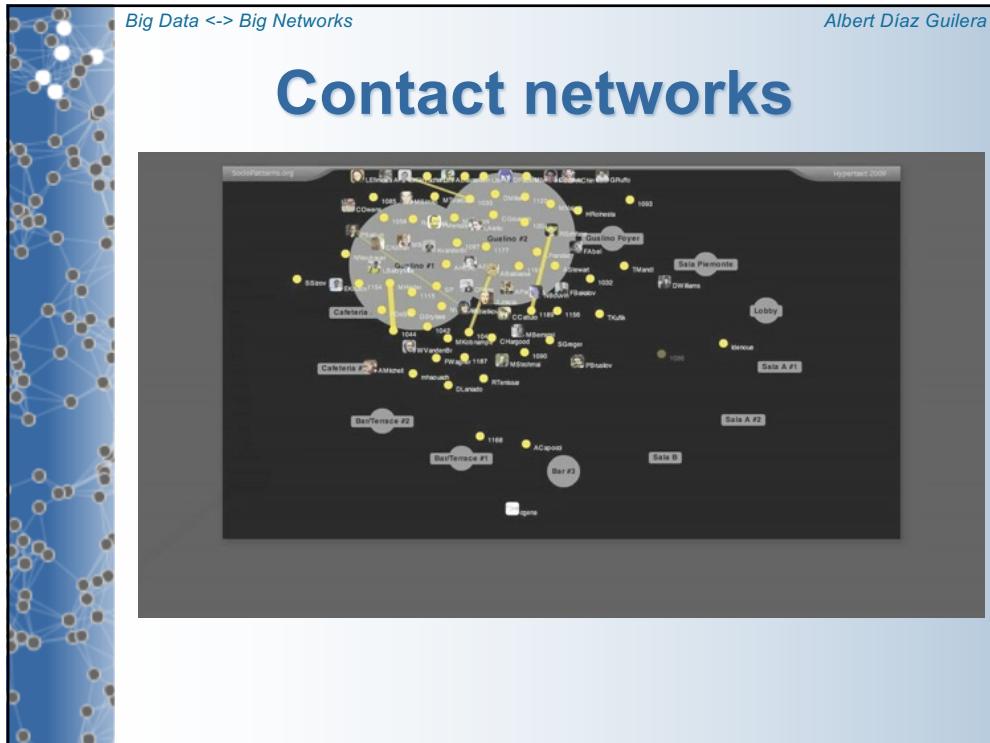
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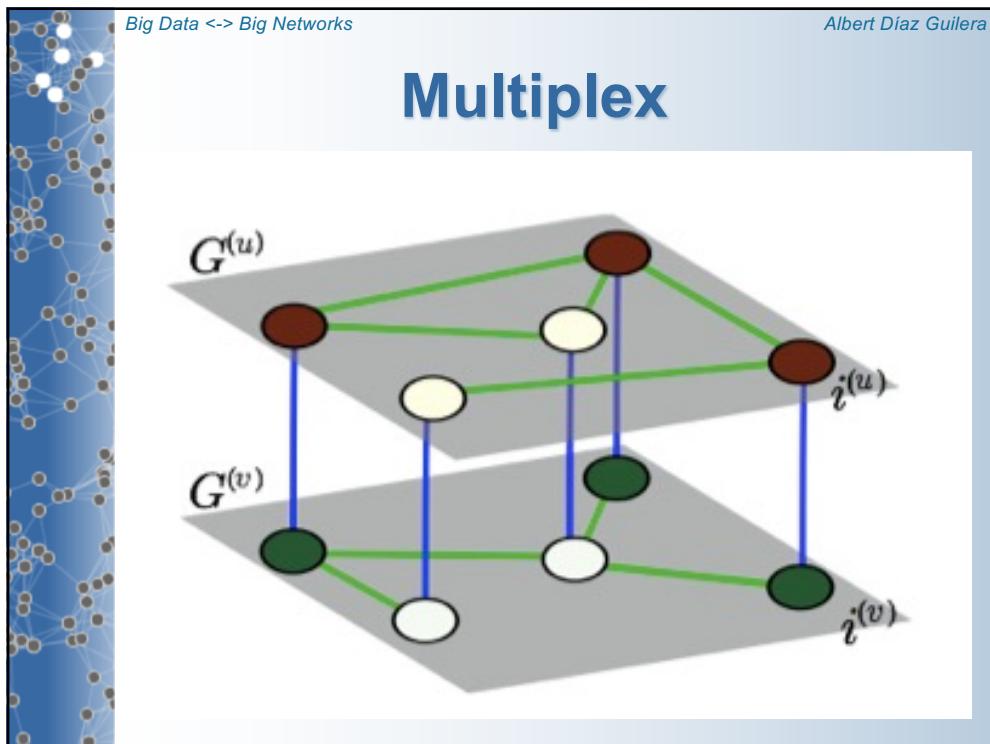
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Big big networks

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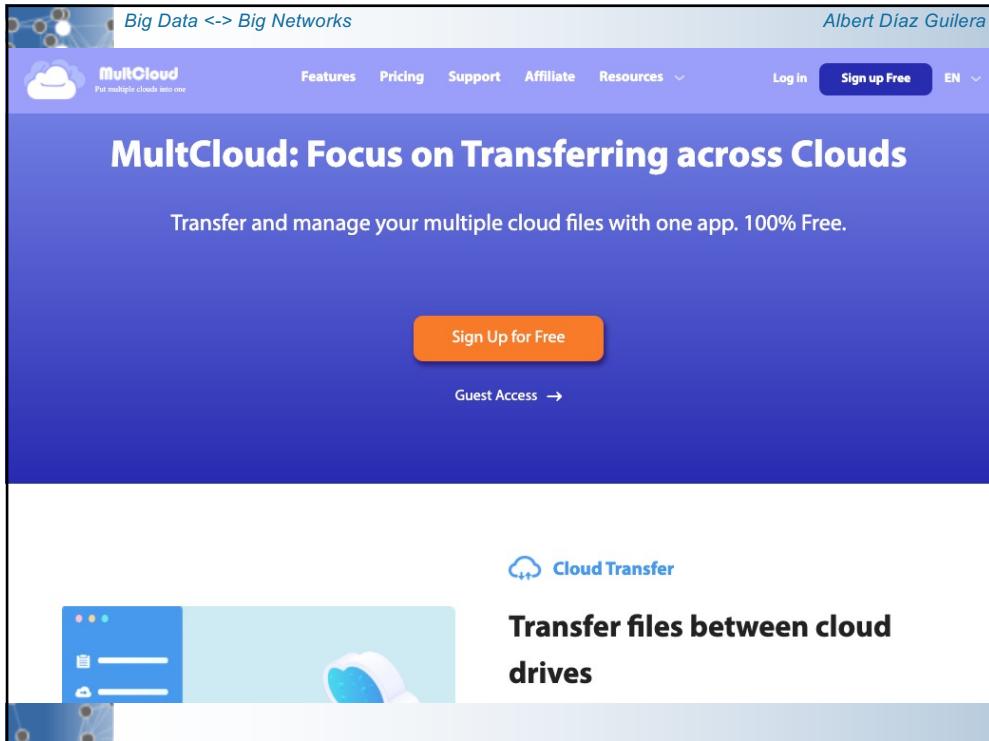
Franz

Add a new service

Slack	Messenger	WhatsApp
Skype	WeChat	Telegram
Hangouts	HipChat	ChatWork
Discord	Steam Chat	GroupMe
Gitter	Grape	

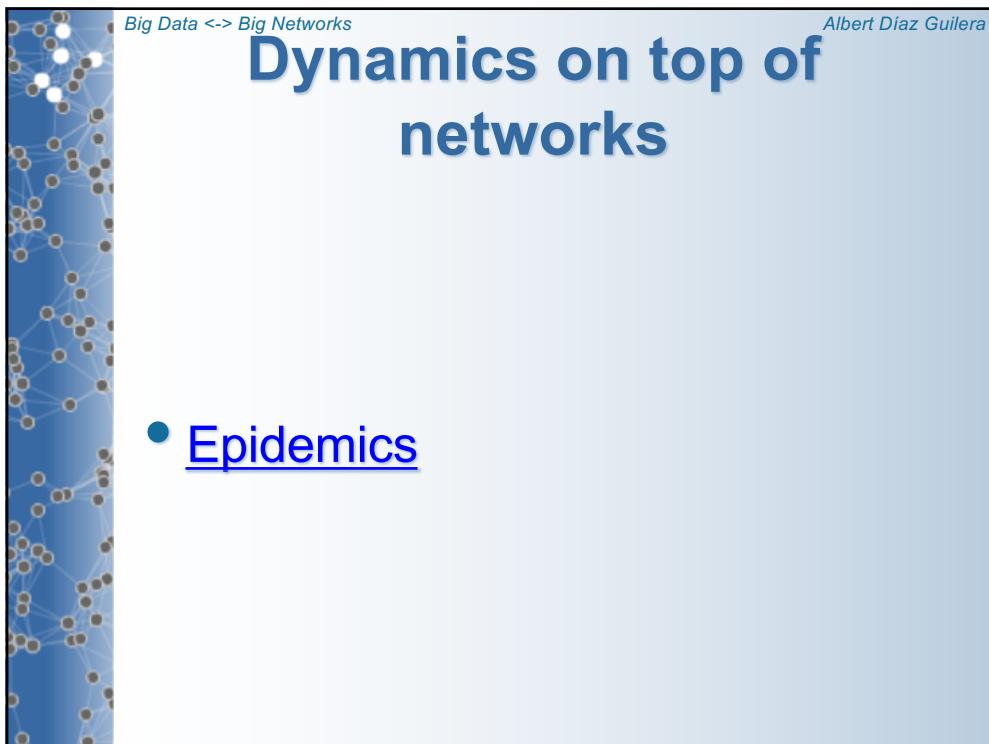
Franz is made with ❤
www.meetfranz.com

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The screenshot shows the MultCloud homepage. At the top, there's a navigation bar with links for Features, Pricing, Support, Affiliate, Resources, Log in, Sign up Free, and EN. The main title is "MultCloud: Focus on Transferring across Clouds". Below it, a subtitle reads "Transfer and manage your multiple cloud files with one app. 100% Free." There are two prominent buttons: "Sign Up for Free" (orange) and "Guest Access →" (grey). The central part of the page features a "Cloud Transfer" icon and the text "Transfer files between cloud drives".

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The slide has a blue background with a network graph on the left side. The main title is "Dynamics on top of networks". Below it, there's a bullet point with the text "Epidemics".

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Motivation for the course

- Big Data <=> Big Networks
- Importance of networks
 - Methodologically
 - Application
- Data availability and responsibility
- We are (part of) the data