# **Complex Networks I**

### **Plan of the lectures**

#### I. Introduction

- II. Networks: basic definitions
- III. Models
- IV. Community Detection

## References

#### • Evolution of networks

S.N. Dorogovtsev, J.F.F. Mendes, Adv. Phys. 51, 1079 (2002), cond-mat/0106144

- Statistical mechanics of complex networks
   Reka Albert, Albert-Laszlo Barabasi
   Reviews of Modern Physics 74, 47 (2002), cond-mat/0106096
- The structure and function of complex networks M. E. J. Newman, SIAM Review 45, 167-256 (2003), condmat/0303516
- Complex networks: structure and dynamics
   S. Boccaletti, V. Latora, Y. Moreno, M. Chavez, D.-U. Hwang Physics Reports 424, 175-308 (2006)

## What is a network

Network=set of nodes joined by links



very abstract representation

very general

convenient to describe many different systems

## Some examples

	Nodes	Links
Social networks	Individuals	Social relations
Internet	Routers AS	Cables Commercial agreements
WWW	Webpages	Hyperlinks
Protein interaction networks	Proteins	Chemical reactions

and many more (email, P2P, foodwebs, transport....)

### Two main classes

Natural systems: Biological networks: genes, proteins... Foodwebs Social networks

*Infrastructure networks:* Virtual: web, email, P2P Physical: Internet, power grids, transport...



#### GENOME

protein-gene interactions

#### PROTEOME protein-protein interactions

METABOLISM

Bio-chemical reactions

### Metabolic Network

**<u>Nodes</u>**: metabolites <u>**Links</u>**:chemical reactions</u>



### **Protein Interactions**

Nodes: proteins Links: interactions



### **Regulatory Network**

**<u>Nodes</u>**: T. F. and target genes **<u>Directed Links</u>**: Regulatory interactions

### **Protein Interactions**

**<u>Nodes</u>**: proteins <u>**Undirected Links**</u>: interactions





## Scientific collaboration network

Nodes: scientists Links: co-authored papers

Weights: depending onnumber of co-authored papersnumber of authors of each papernumber of citations...

### Actors collaboration network

Nodes: actors

Links: co-starred movies



### World airport network



#### complete IATA database

- V = <u>3100</u> airports
- *E* = <u>17182</u> weighted edges
- *w<sub>ij</sub>* #seats / (time scale)

> 99% of total traffic

## **Networks characteristics**

Networks: of very different origins



the abstract character of the graph representation and graph theory allow to answer....