

Exercise package 3 (20 points)

The exercises are intended to be done working in pairs. This package contains four exercises and an optional turbo challenge. During the course there will be three sets of exercises. The course book and the lectures contain some answers, but searching for outside sources too is encouraged.

Return your answers by email to juhani.toivonen@cs.helsinki.fi as an attached PDF or TXT document. Use "Overlay Exercise 3" as the subject line. The document should include:

- The title "Overlay exercise package 3"
- The name and student number of both writers
- The answers to the exercises

There are two types of exercise sessions: Clarification sessions, where you can ask questions about the exercises or other matters about the course; and Answer sessions, where some answers to the exercises are presented and discussed.

- Clarification session: Wednesday 17.2. at 12:15
- **Exercise deadline:** Tuesday 23.1. at 23:59
- Answer session: Wednesday 24.2. at 12:15

Assignments

Assignment 1 - Power law (5 points)

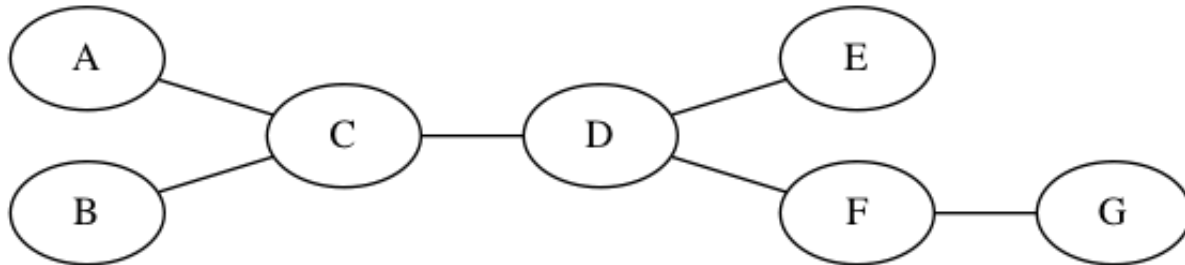
Power laws describe a setting where one property varies as the power of another. This is seen often in many kinds of networks, and has implications for overlay networks as well. Describe:

- If the degree (number of connections) of nodes in a network follows a power law, what does this mean?
- What are Small worlds and Scale-free networks? What features do they exhibit?
- Assume that nodes on a scale-free network are removed one at a time. How does it affect robustness if the removed nodes are chosen at random, or in a coordinated way? Which nodes' removal causes the largest impact?

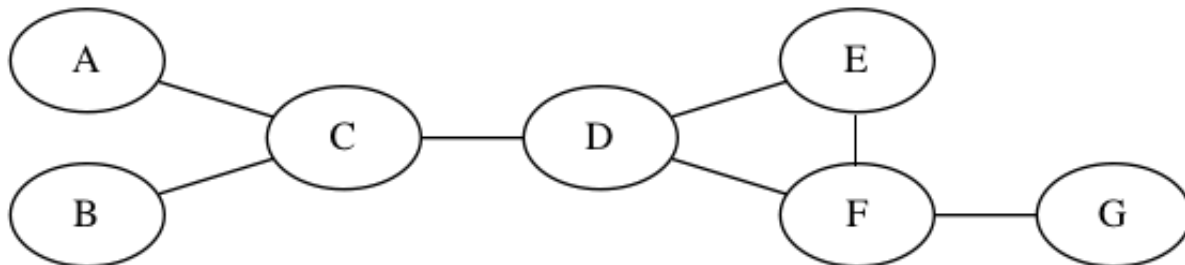
Assignment 2 - Clustering coefficient (5 points)

Small world networks tend to form clusters, i.e. have tightly connected subgraphs that are loosely connected to other graphs. The clustering coefficient reflects the level of clustering occurring in the network. What are the average clustering coefficients of these networks:

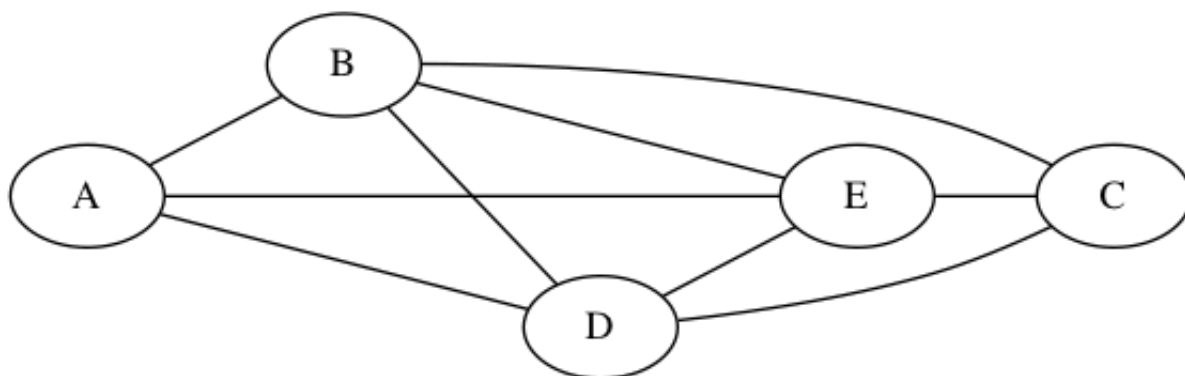
A) Acyclic graph



B) Some clustering



C) Almost full mesh



The local clustering coefficient is not defined for leaf or isolated vertices. There are three strategies being used in the wild: use 0, or use 1 as the coefficient, or ignore them. **In this exercise, use 0 as the coefficient for leaf vertices.**

Assignment 3 - Freenet (5 points)

The Freenet Project has created a model and software for an overlay network with the goal of enhancing online privacy and preventing censorship.

- What is Freenet? What services does it provide to its users? (not what content can be found)
- When a user requests for a file, how does Freenet route the request?
- What steps does Freenet take to protect the anonymity of the requester and the data holder?
- What is Freenet's darknet operating mode, and how is it different from the default setup, the opennet?

The basic operation of Freenet is described in the journal article "*Protecting Free Expression Online with Freenet*" by Ian Clarke, Scott G. Miller, Theodore W. Hong, Oskar Sandberg and Brandon Wiley. It was published in *IEEE Internet Computing journal*, volume 6, issue 1, year 2002. <https://freenetproject.org/assets/papers/freenet-ieee.pdf>

Assignment 4 - Future of overlays and P2P (5 points)

Cloud computing pertains to the virtualization of hardware and software resources that they can be provided in an elastic and on-demand manner. Typically cloud platforms reside in large, centralized data centers. Some of them are federated over to multiple data centers in different geographical areas, and some are hybrids of commercial and privately owned setups. To take the idea a step further, P2P and overlay technologies have been proposed to build a cloud platform on off-the-shelf desktop computers scattered around the office.

Software Defined Networking (SDN) introduces programmability into the network. It is based on the idea of separating the control- and data planes. The control plane can be implemented as an overlay network that interacts with the network-level routers and switches.

- How is a P2P cloud different from a centrally hosted cloud? What are the benefits and the drawbacks?
- How can SDN and overlays be integrated and what benefits can be obtained from their integration?
- How could a P2P cloud benefit from SDN-compatible networking?

References:

- History of SDN: <http://www.cs.princeton.edu/courses/archive/fall13/cos597E/papers/sdnhistory.pdf>
- P2P Cloud Prototype: <http://www.cs.unibo.it/babaoglu/papers/pdf/acm-sac-2012.pdf>

Turbo challenge - Tor (5 points)

The turbo challenge allows you to recover lost points from other assignments, but will not increase the maximum points available. You can get full points from the exercise set without the turbo challenge. The turbo challenge points will carry over to other exercise sets.

Tor is another overlay system for increasing anonymity and circumventing censorship on the internet. Unlike Freenet, Tor can be used to anonymise browsing of the regular World Wide Web.

- How does Tor anonymise the browsing?
- How does *Onion routing* work? i.e. What happens while a message travels across the Tor network.
- In addition to regular WWW, Tor can be used to access so called *hidden services*. How are they different from browsing regular WWW sites?
- Tor provides anonymity. Does it also mean security? How can anonymity get compromised on Tor?